Holding Taxachusetts at Bay

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Jonathan Haughton
Tija Kurian
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Executive Summary

Massachusetts is among the many states that are experiencing a much-touted fiscal crisis. As a shortfall in expected tax revenues materializes, proposals to raise taxes abound. Such proposals have been offered by key state legislators, most candidates for governor and by the Massachusetts Taxpayers Foundation. Meanwhile, Acting Governor Swift has put forward a proposal to manage the state through the “crisis” without tax increases. This report examines the merits of the Governor’s proposal and assesses the economic consequences of the most prominently mentioned proposals to raise taxes.

The Swift Proposal

Our first finding is that the fiscal crisis is, in fact, a short-term problem solvable, as the Governor recommends, through the appropriate use of reserves and moderation in spending. Governor Swift’s plan manages the current and anticipated state budget deficits by using $1,206 million of the total reserves in 2002 and $797 million in 2003 and by moderating spending growth. In our judgment, the state can, under her plan, weather the crisis and reach 2005 with reserves to spare. No tax increases will be necessary.

How Tax Hikes Worsened the Last Recession

Our second finding has to do with how a tax increase would affect the state economy, should the legislature, contrary to the foregoing advice, decide to adopt that course of action. Using Mass-STAMP (the Massachusetts State Tax Analysis Modeling Program, developed by BHI to identify the economic effects of tax changes), we find that tax increases deepened the last recession. Over the period, 1988-91, the state legislature raised the personal income tax from 5.00% to 6.25% in an effort to increase tax revenues that had begun to fall because of slowing economic activity. Over the same period, the state lost 267,205 jobs. Of this amount, 117,029 jobs were lost because of increases in the income tax. In addition, the state missed out on $529 million in capital spending that would otherwise have taken place. Raising taxes now would similarly slow economic recovery.

How Tax Hikes Would Worsen This Recession

Using Mass-STAMP, we consider the economic effects of four alternative proposals to raise taxes. The proposals are:

1. Increase the personal income tax rate from 5.0% to 5.3% in 2003.
2. Increase the personal income tax rate from 5.0% to 5.6% in 2003.
3. Halve the personal exemption allowance.
4. Increase the tax on long-term capital gains.

Table A summarizes the economic consequences of the four proposals.
### Table A: Economic Effects of Changing Tax Rates

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Change in Number of Workers</th>
<th>Change in Capital Stock ($ millions)</th>
<th>Change in Payroll ($ millions)</th>
<th>Static Change in Tax Revenue ($ millions)</th>
<th>Dynamic Change in Tax Revenue ($ millions)</th>
<th>Net Change in Tax Revenue ($ millions)</th>
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<tbody>
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<td>-265</td>
<td>-1,561</td>
<td>543</td>
<td>-86</td>
<td>457</td>
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</table>

#### Raise Personal Income Tax Rate from 5.0% to 5.3% beginning January 2003

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Change in Number of Workers</th>
<th>Change in Capital Stock ($ millions)</th>
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<td>2003</td>
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#### Halve Personal Exemption beginning January 2003

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<th>Change in Capital Stock ($ millions)</th>
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#### Raise Tax on Long-Term Capital Gains by $80 million beginning July 2002

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<td>80</td>
<td>-11</td>
<td>69</td>
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**Raise the Income Tax to 5.3% in 2003**

This would cause the loss of 31,742 jobs the first year. By the second year, the loss would rise to 32,059 jobs. As a result of these job losses, payrolls would shrink by $1,421 million the first year and by $1,489 the second.

The shrinkage in payrolls would reduce the amount of revenue that the state was able to raise by increasing the tax rate. Ignoring this shrinkage, the state would raise an additional $492 million in the first year (the “static” estimate). However, the shrinkage in payrolls would reduce the net increase in tax revenue by $78 million (the “dynamic” change) to $414 million.

The tax increase would cause the capital stock to be smaller, as well. In the first year, the capital stock would be $244 million smaller than it would have been without the tax hike.

**Raise the Income Tax to 5.6% in 2003**

Beacon Hill Institute, *Holding Taxachusetts at Bay* 2
Here the effects are about twice as large as they would be under the preceding proposal. First-year job losses would be 63,195, payrolls would shrink by $2,830 million and the capital stock would shrink by $487 million. The net change in tax revenue would be $820 million.

**Halve the Personal Exemption**

In the first year, this would destroy 39,004 jobs and shrink payrolls by $1,746 million. The capital stock would fall by $300 million. The state would experience a net revenue gain of $508 million.

**Raise the Tax on Long-Term Capital Gains by $80 million**

Finally, we consider a proposal to increase capital gains tax collections by $80 million. The effect would be to shrink the capital stock by $928 million in the first full calendar year of implementation. The state would realize a net revenue gain of only $69 million, owing to the negative effect of this tax increase on the economy.

Contrary to a popular myth, an increase in the capital gains tax would not fall mainly on the rich. In 1999, the fraction of state taxpayers with an adjusted gross income of less than $20,000 reporting capital gains or losses was almost twice the fraction with an adjusted gross income of $200,000 or more.

Under the proposal considered here, the poorest taxpayers would experience a tax rate increase greater than that experienced by the richest taxpayers. Taxpayers with an income less than $20,000 would pay 0.22% of their taxable income in increased capital gains taxes, while taxpayers with an income of $200,000 or more would pay substantially less – 0.16%. See Figure A.

**Figure A: Increase in the Effective Capital Gains Tax Rate by Income Group**
I. Introduction

Massachusetts is facing a budgetary problem, as tax revenues prove insufficient to cover state expenditures at levels consistent with past growth rates. In this report we discuss the source of this problem and consider Governor Swift's proposal for its merits. Further, we consider other options offered by members of the legislature and evaluate their effects on the state's economy.

We recommend that the legislature adopt Governor Swift’s proposal and avoid any increase in taxes. At a minimum, tax increases should not be undertaken without a careful consideration of the substantial economic harm that they would inflict. Faced with the steep recession of the early 1990s, from December 1988 to April 1992, Massachusetts raised taxes sharply. As explained below, this action caused the recession to be deeper than it would have had to be.

Clearly, it is important to avoid making the same mistake this time around. The current budgetary “crisis” is a short-term problem, solvable through judicious use of reserves and through adjustments in spending. Raising taxes would impose permanent harm and, in doing so, limit the state’s ability to sustain a high standard of living for its residents.

Massachusetts has made great progress over the years toward repairing its reputation as “Taxachusetts.” Responding to the current revenue falloff with tax increases that will, in all likelihood, prove unnecessary in just a few months, would worsen the long-term economic health of the state.

According to the National Bureau of Economic Research, which is the official arbiter of the timing of recessions and recoveries, the most recent national recession began in March 2001. Insofar as U.S. GDP increased over the last quarter of 2001, the recession will probably be deemed to have ended in November. The more optimistic economy watchers are suggesting that there never was a “true” national recession.

The Massachusetts slowdown began slightly earlier than the national slowdown. Employment peaked in January 2001. Employment has since fallen by 62,000, compared to 85,000 during the first twelve months of the 1988-92 recession. See Figure 1.

Figure 1: Employment in Massachusetts by Year
There is some evidence that employment has now ceased to fall. The seasonally adjusted unemployment rate remained at 4.4% in February 2002 (see Figure 2), and the Massachusetts Consumer Confidence Index rose sharply between October 2001 and January 2002. It is clear that this latest Massachusetts slowdown, though perhaps deeper than the national slowdown, is still shallow and short, in comparison to the long and deep Massachusetts recession of the early 1990s. This diagnosis is important, because it affects the way in which the state should react to the budgetary squeeze.

**Figure 2: Massachusetts' Unemployment Rate by Year**

**Budget Scenario Based on Governor Swift's Plan**

The key figures of the Governor's plan are summarized in Table 1. The most recent administration forecasts indicate that total revenue would drop from $23,531 million in FY 2001 to $21,599 million in
FY 2002, before rising to $22,051 million in FY 2003. Meanwhile, spending is projected to be at $22,805 million in FY 2002 and will increase marginally in FY 2003.

The numbers show deficits of $1,206 million in FY 2002 and of $797 million in FY 2003. These are large and serious deficits, although they fall far short of the “gaping $3 billion hole in the side of the FY 03 ship” that House Ways and Means chairman John Rogers believes to exist.

How will the deficits be handled? The Swift plan proposes financing these deficits largely by dipping into the rainy day fund, which was established for this purpose, and which had a balance of $2,294 million as of July 1, 2001 (the beginning of the current fiscal year). In addition to using the $806 million authorized by the legislature, the Governor proposes using a further $400 million in FY 2002.

The Swift plan projects deficit budgets until FY 2005. The plan is predicated on the assumption that there are sufficient funds available in the rainy day fund and other funds to cover these shortfalls. Table 1 illustrates the Swift plan through FY 2006.

### Table 1: Budgetary Scenario Based on the Governor's Plan, FY 2002-FY 2006

<table>
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<tbody>
<tr>
<td>Total revenue</td>
<td>21,599</td>
<td>22,051</td>
<td>22,799</td>
<td>23,978</td>
<td>25,271</td>
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<tr>
<td>Total expenditures</td>
<td>22,805</td>
<td>22,848</td>
<td>23,482</td>
<td>24,157</td>
<td>24,855</td>
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<tr>
<td>Surplus/Deficit</td>
<td>-1,206</td>
<td>-797</td>
<td>-683</td>
<td>-179</td>
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<td>Funds set aside by the legislature</td>
<td>806</td>
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<tr>
<td>Hence: net needed</td>
<td>-400</td>
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<td>Memo: net needed, MTF scenario</td>
<td>-944</td>
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<tr>
<td>Memo items: revenue</td>
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<tr>
<td>Net taxes</td>
<td>14,820</td>
<td>14,922</td>
<td>15,368</td>
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<td>Total non tax revenues</td>
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<td>Rainy Day fund</td>
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<td>Transitional Escrow Fund</td>
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<td>Caseload Mitigation</td>
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<td>Interest Earnings</td>
<td>70</td>
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<tr>
<td>Total Reserves</td>
<td>2,071</td>
<td>1,274</td>
<td>591</td>
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</table>

Note: * - After appropriations of $.806 billion (as approved by the legislature) is made and further $400 million of the deficit is accounted for.

1 In FY 2003 a deficit of $797 million is projected following a $700 million reduction by the Governor's office from the initial House 1 budget proposal (from $23.55 billion to 22.84 billion).
2 At the end of FY 2001, the total in the rainy day and the transitional escrow funds amounted to $2,294 million ($1,715 million + $579 million). For convenience we lump the two funds together when we refer to rainy day funds in the text.
The $806 million in funds already set aside by the legislature is the sum of $350 million to be taken from the rainy day fund, $422 million from the transitional escrow fund and $34 million from the tax reduction fund. The rainy day fund balance at the start of FY 2002 was $1,715 million. After the appropriation of $350 million, the balance will fall to $1,365 million. The remaining $157 million in the transitional escrow fund is to be transferred to the rainy day fund, bringing that fund to zero and the rainy day fund to $1,522 million. To provide for the additional $400 million in funds, the Governor proposes to draw on total reserves, which will most likely come out of the rainy day fund, leaving the fund with a balance of $1,122 million.\(^3\)

Total reserves are projected to be $2,071 million on July 2002 of which $797 million will be needed to close the budget gap. The Governor's plan sets aside reserves to cover the deficits projected for FY 2004 and FY 2005, leaving the state with reserves to spare in FY 2006. (See Table 1.)

The low amount of tax revenue collected in January 2002 raises the concern that the revenue estimates are still too optimistic. The Massachusetts Taxpayers Foundation believes that the unfunded shortfall for FY 2002 will be $944 million (rather than $400 million as predicted by the administration) and $1,412 million in FY2003 (rather than $797 million).

Shortfalls of this size would quickly exhaust the rainy day fund, making tax increases politically unavoidable (if still, economically undesirable). We believe that these scenarios are too pessimistic and that tax increases are unnecessary.

\(^3\) Total reserves are the total of all available reserve funds at the government's disposal (as shown in Table 1).
II. The Economic Consequences of Tax Increases

The current debate over tax increases has focused almost entirely on the revenue effects. But tax increases also have serious consequences for employment, investment and income. The weight of evidence shows that state-level tax increases have significant negative effects on state economic activity.\(^4\) It is especially important to be mindful of these effects when the economy is fragile, because unwise tax increases can deter employers from renewing their hiring, and so delay recovery.

In order to appreciate the potential harm of undertaking tax increases at this time, it is worth considering the last recession. Over the period 1988 to 1991, Massachusetts lost 267,205 jobs. Over the same period, the personal income tax was raised from 5.00% to 6.25%, as the legislature acted to staunch the loss of tax revenues.

The Beacon Hill Institute has developed an econometric model for determining the effects of tax changes on the Massachusetts economy. This model, Massachusetts State Tax Analysis Modeling Program (or “Mass-STAMP”), makes it possible to separate the number of jobs that were lost as a result of the economic downswing from the number that were lost because of concurrent tax hikes. Applying Mass-STAMP, we find that, had the state kept the tax rate at 5.0%, the state would have lost only 150,176 jobs, a difference of 117,029. We also find that it would have accumulated $529 million in additional private nonresidential fixed capital. It follows that, while the state would have still suffered a substantial recession had it not resorted to increases in the income tax, the recession would have been far less severe.

In this section, we summarize the economic effects of the most important tax changes that are currently under consideration. The theoretical underpinnings of the Mass-STAMP are described in Section 3, where the estimating equations are also derived. The sources of data and methods used to construct the variables are the focus of Section 4. This section also presents and evaluates the equation estimation. The technical details are provided in a series of appendixes.

**An increase in the personal income tax rate from the set 5.0% to 5.3% in 2003**

The state tax on personal earned income is currently (in 2002) 5.3% and is scheduled to fall to 5.0% on January 1, 2003 and to remain at that level thereafter. One widely touted proposal would keep the tax rate at 5.3% in 2003. Mass-STAMP shows that this tax increase would lead to 32,000 fewer jobs in the state,

---

reduce the capital stock by over $240 million, and cut payrolls by $1.4 billion, as the first panel in Table 2 shows. The tax increase would yield $414 million in additional state revenue. This increase is actually made up of two parts – a static increase of $492 million (estimated by applying the tax increase to the current tax base) and a dynamic decrease of $78 million (which occurs because fewer people would be employed and paying taxes).

Table 2: Economic Effects of Changing Tax Rates

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Change in Number of Workers</th>
<th>Change in Capital Stock ($ millions)</th>
<th>Change in Payroll ($ millions)</th>
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<tbody>
<tr>
<td>Raise Personal Income Tax Rate from 5.0% to 5.3% beginning January 2003</td>
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<tr>
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<td>Halve Personal Exemption beginning January 2003</td>
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<tr>
<td>2002</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>2003</td>
<td>-39,004</td>
<td>-300</td>
<td>-1,746</td>
<td>606</td>
<td>-97</td>
<td>508</td>
</tr>
<tr>
<td>2004</td>
<td>-37,845</td>
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<td>611</td>
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<td>513</td>
</tr>
<tr>
<td>2005</td>
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<td>-1,770</td>
<td>616</td>
<td>-98</td>
<td>518</td>
</tr>
<tr>
<td>Raise Tax on Long-Term Capital Gains by $80 million beginning July 2002</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2002</td>
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<td>0</td>
<td>0</td>
<td>40</td>
<td>-5</td>
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<tr>
<td>2003</td>
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<td>-928</td>
<td>0</td>
<td>80</td>
<td>-11</td>
<td>69</td>
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<tr>
<td>2004</td>
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<td>-922</td>
<td>0</td>
<td>80</td>
<td>-11</td>
<td>69</td>
</tr>
<tr>
<td>2005</td>
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<td>-914</td>
<td>0</td>
<td>80</td>
<td>-11</td>
<td>69</td>
</tr>
</tbody>
</table>

An increase in the personal income tax rate from the set 5.0% to 5.6% in 2003

In a letter sent to his fellow state representatives on February 27, 2002, John Rogers, Chairman of the House Ways and Means Committee, floated the possibility of raising the personal income tax to 5.6% in January 2003. Mass-STAMP shows that this would be associated with 63,000 fewer jobs and a reduction in payroll payments of $2.8 billion (see the second panel in Table 2). We find that this tax increase would raise state revenue by $820 million annually, or by about $410 million in FY 2003 (which begins on July 1, 2002). Our estimate of the revenue effect in FY 2003 is somewhat lower than the $460 million cited by Representative Rogers, mainly because we take the dynamic revenue effects into account.
A halving of the personal exemptions

Currently, a single adult taxpayer is exempt from paying state income tax on the first $4,400 of income ($8,800 for couples filing jointly). Households may also take an additional $1,000 exemption for each dependent.

Another proposal floated by Chairman Rogers would halve this personal exemption. This would be a highly regressive change, in the sense that it would lead to a disproportionately large increase in tax payments by low-income households, who would now find themselves caught in the tax net. The change would yield about $508 million in revenue, but at the expense of destroying 39,000 jobs and causing the payrolls in the state to shrink by $1.7 billion (see the third panel in Table 2).

A higher tax on long-term capital gains.

The state tax rate on capital gains varies according to the length of time that one has owned the asset. The tax rate on assets that have been held for 6 years or more is zero, but it is 12% on assets held for less than a year. The schedule is as follows:

<table>
<thead>
<tr>
<th>Years the asset is held:</th>
<th>% of capital gains by category, 2000</th>
<th>Applicable capital gains tax rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>under 1</td>
<td>5.7</td>
<td>12.00</td>
</tr>
<tr>
<td>1 under 2</td>
<td>20.9</td>
<td>5.00</td>
</tr>
<tr>
<td>2 under 3</td>
<td>12.0</td>
<td>4.00</td>
</tr>
<tr>
<td>3 under 4</td>
<td>7.8</td>
<td>3.00</td>
</tr>
<tr>
<td>4 under 5</td>
<td>6.4</td>
<td>2.00</td>
</tr>
<tr>
<td>5 under 6</td>
<td>2.1</td>
<td>1.00</td>
</tr>
<tr>
<td>6 or more</td>
<td>45.0</td>
<td>0.00</td>
</tr>
</tbody>
</table>

In his letter of February 27, Chairman Rogers suggests that an increase in capital gains taxes would raise an additional $80 million for the state. Turning to the capital gains tax for this purpose would mean raising the average tax rate on capital gains by about a quarter, from 2.60% to 3.25%.

The economic effects of such a change, implemented on July 1, 2002, are shown in the last panel of Table 2. The main effect would be to reduce the capital stock by over $900 million, as would-be investors are deterred by the tax from investing in Massachusetts. There are no immediate effects on employment, but presumably a smaller capital stock would, in time, be associated with reduced employment.
There is a common misconception that the current tax treatment by the state represents a “loophole” that mainly favors the rich. The assumption behind this misconception is that capital gains are just like earned income and should therefore be taxed at the same rate. In fact, however, there is an important difference between the two kinds of income: Whereas taxes on earned income fall on income the first time it is received, taxes on capital gains fall on income only after it has been already taxed as earnings. If a taxpayer buys an asset today for $1,000, she buys that asset out of taxable earnings. If she expects to sell that asset six years from now for, say, $2,000 and pay 5% on the difference, she, in effect, incurs a second tax for choosing to save, in this fashion, rather than merely go out and buy a new stereo. Thus exempting certain capital gains from taxation is no “loophole,” but merely an effort to avoid double taxation of earnings.

Furthermore, the capital gains tax does not fall mainly on the rich. Taxpayers all across the income spectrum realize capital gains and pay capital gains taxes. Moreover, the increase in the capital gains tax brought about by the above proposal would fall more heavily on capital gains filers in the lowest income group than on capital gains filers in the highest income group.

Here are the facts: Of the 791,722 Massachusetts taxpayers who reported capital gains or losses in 1999 (the latest year for which data are available), 42% were taxpayers with an adjusted gross income (AGI) less than $50,000. Only 29% had an AGI greater than $100,000. The fraction of taxpayers with an income less than $20,000 was almost twice the fraction with an income of $200,000 or more. See Figure 3.

Insofar as low-income filers reporting capital gains or losses realize high capital gains relative to their taxable income, a rise in the capital gains tax will impose a relatively heavy economic burden on those taxpayers. It turns out that the Rogers proposal imposes just such a burden.

---

The proposal would raise the average tax rate on capital gains by 0.65 percentage point from 2.60% to 3.25%. By applying this tax increase to state taxpayers reporting capital gains or losses, it is possible to determine, by income group, the increase in the effective tax rate that these taxpayers would bear under this proposed scenario. Figure 4 shows the increase in tax for each income group.  

As shown, the lowest income group would suffer the highest tax hike. Taxpayers reporting capital gains with an AGI less than $20,000 would pay 0.22% more of their taxable income in taxes, as compared to taxpayers reporting capital gains with an AGI of $200,000, who will pay 0.16% more.

---

8 *Ibid.* The methodology underlying these estimates is as follows: Let CG be the ratio of total capital gains to the number of filers reporting capital gains or losses in a given income group. Let TI be the ratio of total taxable income to the number of all filers in that income group. Then the effective increase in tax rate is: \((0.0065*CG)*(1-\text{Federal marginal tax rate})/(TI - 0.0065*CG)\) percentage point. This assumes that average taxable income is the same for taxpayers reporting capital gains as it is for all taxpayers in a given income group. Inasmuch as low-income taxpayers reporting capital gains are likely to dissave, owing to their having very little earned income, this assumption seems to bias downward the estimated tax hike for low-income taxpayers. 
While this result might seem counterintuitive, it is easily explained. Low-income households often sell assets in order to support themselves over periods of economic hardship (unemployment, for example). If a household sees its income fall, say from $40,000 per year to $20,000 per year, it is not likely to reduce its consumption by half. Rather, it is likely to finance part of its consumption out of capital gains, on which it will be compelled to pay taxes. Raising the capital gains tax imposes a greater burden on this household than it would on a wealthier household that might sell assets in order, say, to finance retirement.

Among Massachusetts taxpayers who would be affected by the tax hike, there are many more in the lowest AGI group than there are in the highest AGI group. Of Massachusetts taxpayers who reported taxable income and whose AGI was less than $20,000, 152,705 reported capital gains or losses. The figure for taxpayers with an AGI of $200,000 or more was 76,463. There were therefore almost twice as many low-income as high-income taxpayers reporting capital gains or losses.
III. The Structure of the Massachusetts STAMP Model

History of STAMP

BHI developed its State Tax Analysis Modeling Program, STAMP, in 1994 in recognition of a need for a dynamic modeling capability in Massachusetts. Mass-STAMP was first applied to a state ballot initiative that would have replaced the existing flat tax with a graduated income tax. STAMP showed that the proposed graduated income tax would have destroyed about 80,000 jobs and more than $1 billion in wages. The voters overwhelmingly rejected the initiative.

In 1995, BHI applied Mass-STAMP to a proposed reduction in corporate income taxes. The finding: that application would create jobs if applied to all corporations but destroy jobs if applied only to manufacturing.\(^\text{10}\) The model detailed in this report represents an updated and expanded version of these earlier versions of Mass-STAMP.

Subsequently, at the request of the Oklahoma Office of State Finance, BHI developed a STAMP for Oklahoma. In 1997, BHI provided evidence supporting the view held by state officials that a cut in income or sales taxes would increase personal income. Also in 1997, BHI built a New Jersey-STAMP that showed how recent income tax cuts had resulted in the creation of about 25,000 new jobs and of more than $2 billion in new capital spending.

In January 1998, BHI released the results of an Ohio-STAMP showing how a proposed increase in the state sales tax from 5% to 6% would destroy about 100,000 jobs and $3 billion in wages. The governor had proposed the tax hike as a way of raising $1 billion in new revenue to fund education spending. The state legislature rejected the tax hike, as did the voters overwhelmingly in a subsequent referendum.

In December 1998, BHI completed a Texas-STAMP. The project was funded by Texas Public Policy Foundation (TPPF) for use in analyzing Governor Bush’s tax proposals and other tax policy proposals before the state legislature. This year, BHI built a computable general equilibrium STAMP for TPPF.

Other tax analyses performed by BHI have included an evaluation, in 1997, of a proposed reduction in the Iowa income tax and, in 1998, of a proposed oil processing tax in Louisiana. In addition, STAMP models

\(^{10}\) The Beacon Hill Institute, “Corporate Tax Proposal Would Mean More Jobs, Higher Wages for Massachusetts Workers”, October 3, 1995; available from: http://www.beaconhill.org/FaxSheets/FaxSCorptax.html. See also
have been completed for Arizona, California, Maryland, Michigan, Minnesota, New Mexico, New York, Pennsylvania, Texas, Virginia, and New York City. CGE-STAMPs are under construction for Wisconsin and Kansas.

**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.\(^{11}\) Mass-STAMP is a structural model, in that it is rooted in the optimizing behavior of households and firms.

The wellbeing 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.

The strength of the STAMP family of 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.

---


\(^{11}\) See, for example, Bartik.
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.

The formal structure of the model is described in detail below, where the reduced form equations are also derived. Readers more interested in other aspects of the model may turn directly to the discussion of the data that is given in Chapter 4 or to the estimation and simulation results in Chapter 5.

**Labor Supply by Households**

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

\[
\text{(1.1)} \quad \text{Max} U = AC^{\theta} \ell^{1-\theta}
\]

subject to

\[
\text{(1.2)} \quad C + \ell w(1-t_f)(1-t_s) = wL(1-t_f)(1-t_s) + G_r,
\]

where

- \(C\) = the consumption of goods and services;
- \(\ell\) = the consumption of leisure;
- \(w\) = the wage rate;
- \(t_f\) = the federal tax rate on labor income;
- \(t_s\) = the state tax rate on labor income;
- \(G_r\) = government transfer payments; and
- \(L\) = fixed labor endowment.
The problem in (1.1) may be rewritten as:

\[
\begin{align*}
\text{Max. } \Psi &= AC^{\theta} \ell^{(1-\theta)} - \lambda [C + \ell w(1-t_{fl})(1-t_{sl}) - \bar{w}L(1-t_{fl})(1-t_{sl}) - G_r]. \\
\end{align*}
\]

Maximizing \( \Psi \) with respect to \( C, \ell \) and \( \lambda \) yields the solution for \( \ell \) and \( C \) as:

\[
\begin{align*}
\ell &= \frac{(1-\theta)C}{\theta w(1-t_{fl})(1-t_{sl})}. \\
C &= \theta [\bar{w}L(1-t_{fl})(1-t_{sl}) + G_r].
\end{align*}
\]

And substituting \( C \) in (1.5) into (1.4) yields the demand for leisure:

\[
\ell = (1-\theta) \left[ \bar{L} + \frac{G_r}{w(1-t_{fl})(1-t_{sl})} \right].
\]

The individual supply of labor, \( L_i^s \), is \( \bar{L} - \ell \) and is written as:

\[
L_i^s = \theta \bar{L} - \frac{(1-\theta)(G_r)}{w(1-t_{fl})(1-t_{sl})}.
\]

Then, the aggregate supply of labor for the state, \( L' \), is specified as the state’s working age population, \( PW \), times the individual supply of labor.

\[
L' = (PW)^* \left[ \theta \bar{L} - \frac{(1-\theta)(G_r)}{w(1-t_{fl})(1-t_{sl})} \right].
\]

A log-linear approximation of the \( L' \) function in (1.8) gives: \(^{12}\)

\[
\ln L_s^* \approx a_0 + a_1 \ln(PW) + a_2 \ln(G_r) + a_3 t_{fl} + a_4 t_{sl} + a_5 \ln w,
\]

where \( a_0 \) is a constant, \( a_1 > 0, a_2 < 0, a_3 < 0, a_4 < 0, \) and \( a_5 > 0. \) \(^{13}\)

---

\(^{12}\) A detailed derivation of (1.9) from (1.8) appears in Section 1a of David G. Tuerck et al. (1996), *An Application of the BHI State Tax Analysis Modeling Program to the State of Oklahoma*, Suffolk University, Boston, MA.

\(^{13}\) The derivation of the signs of the coefficients is available upon request.
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.\(^{14}\) In addition to \(r\), we include the local tax rate on commercial and industrial property and treat it as an ad valorem tax on use of capital service.

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. This effect is picked up by a variable, \(q\), that could be instrumented by the national unemployment rate, or by an index of nonstate economic activity. We assume a Cobb-Douglas production function of the following form:

\[
Q = HqL^\alpha K^\beta.
\]

where \(q\) is the U.S. economic indicator, \(0<\alpha, \beta<1\), and \(H\) is a parameter. The profit-maximizing problem of producers may be written as:

\[
\text{Max. } \Pi = HqL^\alpha K^\beta - w(1+v)L - r(1+t_{pc})K.
\]

where \(t_{pc}\) is the tax rate on commercial and industrial property. Maximizing \(\Pi\) with respect to \(L\) and \(K\) yields demand for labor and capital as:\(^{15}\)

\[
\ln L^d = \lambda_q \ln q + \lambda_v \ln w + \lambda_v v + \lambda_r \ln r + \lambda_{t_{pc}} t_{pc}
\]

\(^{14}\) A detailed derivation of cost of capital appears in Appendix 3.

\(^{15}\) The log-approximation of \(\ln(1+v) \approx v\) for a small value of \(v\) is applied, and similarly for \(\ln(1+t_{pc})\).
where $\lambda_q > 0, \lambda_w < 0, \lambda_r < 0, \lambda_{pc} < 0$, and also

\[(1.13) \quad \ln K^d = \kappa_0 + \kappa_q \ln q + \kappa_w \ln w + \kappa_r \ln r + \kappa_{pc} t_{pc}\]

where $\kappa_q > 0, \kappa_w < 0, \kappa_r < 0, \kappa_{pc} < 0$.

**Equilibrium in the Labor Market**

By solving the system of structural equations (1.9), (1.12) and (1.13) simultaneously, one arrives at a set of reduced form equations that express employment, the wage rate, and the stock of capital as functions of the remaining set of exogenous variables. These reduced form equations can then be estimated econometrically.

In equilibrium the labor market clears, which implies that labor supply (equation 1.9) equals labor demand (equation 1.12). Setting these equal and solving for $\ln(w)$ gives

\[(1.14) \quad \ln w = \sigma_0 + \sigma_{pw} \ln PW + \sigma_q \ln q + \sigma_r \ln r + \sigma_g \ln G_r + \sigma_f t_{lw} + \sigma_s t_{sw} + \sigma_{pc} t_{pc}\]

where $\sigma_{pw} < 0, \sigma_q > 0, \sigma_r < 0, \sigma_g > 0, \sigma_f > 0, \sigma_s > 0$, and $\sigma_{pc} < 0$.

Substituting (1.14) into (1.12) gives the reduced-form equation for equilibrium labor.

\[(1.15) \quad \ln L = \eta_0 + \eta_{pw} \ln PW + \eta_q \ln q + \eta_r \ln r + \eta_g \ln G_r + \eta_f t_{lw} + \eta_s t_{sw} + \eta_{pc} t_{pc}\]

where $\eta_{pw} > 0, \eta_q > 0, \eta_r < 0, \eta_g < 0, \eta_s < 0, \eta_f < 0$, $\eta_s < 0$ and $\eta_{pc} < 0$.

We assume that the state economy is a price-taker in the market for capital. Stocks issued by corporations in a state (equivalently, capital goods demanded by those corporations) is not necessarily bought by in-state savers, just as stock bought by (capital supplied by) savers in the state is not necessarily issued (used) by in-state corporations. We assume that the supply of capital to firms in a state is perfectly elastic, meaning that firms can obtain whatever level of capital they need at the market price for capital, $r$. 

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Then the equilibrium capital stock is obtained by substituting (1.14) into (1.13) and gives the reduced-form equation for capital:

\[
\ln K = \gamma_0 + \gamma_{pw} \ln PW + \gamma_q \ln q + \gamma_v \ln v + \gamma_r \ln r + \gamma_g \ln G_p + \gamma_f t_R + \gamma_s t_sl + \gamma_{ps} t_{ps},
\]

(1.16)

where \(\gamma_{pw} > 0, \gamma_q > 0, \gamma_v < 0, \gamma_r < 0, \gamma_g < 0, \gamma_f < 0, \gamma_s < 0\) and \(\gamma_{ps} < 0\).

**Determination of Population**

We postulate that migration into a state, and thus its population, is determined by job market conditions as well as the attractiveness of its living and working environment. In our study the employment level reflects current job market conditions. We also consider the state tax rate on earned income, \(t_{sl}\), the state tax rate on investment (or capital) income, \(t_{sk}\), and the local residential property tax rate, \(t_{pr}\), to be policy variables that attract or deter people from moving into or out of the state. Then, the variable of working age population is specified as:

\[
\ln PW = \pi_0 + \pi_L L + \pi_{sl} t_{sl} + \pi_{pr} t_{pr} + \pi_{sk} t_{sk},
\]

(1.17)

where \(\pi_L > 0, \pi_{sl} < 0, \pi_{pr} < 0\) and \(\pi_{sk} < 0\).
IV. Data Considerations and Estimation

STAMP Data

The Mass-STAMP model was estimated based on equations (1.14) – (1.17). 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, are given in Table 2. A value for each variable was constructed for each year from 1970 through 1998. All the dependent variables and some independent variables are for each of six sectors of the economy. Some of the variables, including the measures of employment, wages and the state tax rate on the use of labor services, are straightforward. However several of them are difficult to construct. This is the most challenging and time-consuming part of the modeling exercise. Details are presented in Appendices 1-3. For our analysis here, the most important variable is the state tax rate on income.

Table 4: Description of Variables and Their Sources

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>L Employed on payroll by sector</td>
<td>Number of workers on payroll (in thousands).</td>
<td>BLS</td>
</tr>
<tr>
<td>w Wage rate by sector</td>
<td>Total payroll divided by number of workers.</td>
<td>BLS and BEA</td>
</tr>
<tr>
<td>K Capital stock by sector</td>
<td>See Appendix 2.</td>
<td>Census &amp; other sources</td>
</tr>
<tr>
<td>PW Working age population</td>
<td>Population of age 16-64.</td>
<td>Census</td>
</tr>
<tr>
<td>u Index of U.S. economic activities</td>
<td>U.S. unemployment rate (in %).</td>
<td>BLS</td>
</tr>
<tr>
<td>(G_{tr}) Real government transfer payments per nonworking adult aged 16-64</td>
<td>Federal income maintenance transfers and unemployment insurance. Sum of unemployment insurance tax rate and the workers compensation insurance rate. (in %).</td>
<td>BEA, BLS and Census</td>
</tr>
<tr>
<td>v State tax rate on use of labor services</td>
<td>See Appendix 3. Also, see Appendix 1 for measurement of the components of (r). (in %).</td>
<td>BLS and WCRI</td>
</tr>
<tr>
<td>r Cost of capital by sector</td>
<td>See Appendix 3. Also, see Appendix 1 for measurement of the components of (r). (in %).</td>
<td>BEA, IRS and other sources</td>
</tr>
<tr>
<td>(t_{sl}) State marginal tax rate on labor income</td>
<td>Statutory tax rate on earned income (in %).</td>
<td>DOR</td>
</tr>
<tr>
<td>(t_{ft}) Average marginal federal tax rate on labor income applied to Mass. residents</td>
<td>See Appendix 1.</td>
<td>SOI</td>
</tr>
<tr>
<td>(t_{pc}) Local tax rate on commercial and industrial property</td>
<td>Average tax rate. See Appendix 1.</td>
<td>Division of Local Services, DOR and MTF</td>
</tr>
<tr>
<td>(t_{pr}) Local tax rate on residential property</td>
<td>Average tax rate. See Appendix 1.</td>
<td>Division of Local Services, DOR and MTF</td>
</tr>
<tr>
<td>(t_{sk}) State income tax on personal capital income</td>
<td>See Appendix 1.</td>
<td>SOI and DOR</td>
</tr>
</tbody>
</table>

Sources:

16 These sectors are construction, manufacturing, trade, services, TPU (transport and public utilities) and FIRE (finance, insurance and real estate).

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The estimation of the model was based on equations (1.14) - (1.17), which constitute a series of simultaneous interdependent equations. For example, the endogenous variables, $w, L, K$, are affected by $PW$, which is in turn simultaneously determined by $L$. We estimated this model using a two-step generalized least squares procedure. First, we estimated the coefficients of the three equations for employment, the wage rate, and the capital stock, respectively, as functions of a common set of variables (shown in equations (1.14) - (1.16)) and the exogenous variables included in the equation of $PW$. In the next step, we estimated the $PW$ equation as a function of the fitted value of $L$, which was obtained in the first step, and other regressors in equation (1.17).

We applied a pooled time-series cross-section data estimation method, for the time period of 1970-1997. The estimation method corrects for common econometric problems arising from a pooled data including autocorrelation and groupwise heteroscedasticity.

The estimation results for the working-age population are presented in Table 5. The results of estimating the employment, wage rate and capital stock equations are described in Table 6.

**Table 5: Estimating the State Working Age Population Equation**

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln (working age population)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Independent variables:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment (fitted value)</td>
<td>0.0418</td>
<td>6.20***</td>
</tr>
<tr>
<td>State tax rate on labor income</td>
<td>-0.0042</td>
<td>-1.71***</td>
</tr>
<tr>
<td>Tax rate on residential property</td>
<td>-0.0095</td>
<td>-4.30***</td>
</tr>
<tr>
<td>State tax rate on unearned income</td>
<td>-0.0003</td>
<td>-0.40</td>
</tr>
</tbody>
</table>

***Indicates significance at the 1% level.
### Table 6: Results of Estimating the Employment, Wage Rate and Capital Stock Equations

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Employment Equation</th>
<th>Wage Equation</th>
<th>Capital Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(employment)</td>
<td>-0.0127</td>
<td>0.0035</td>
<td>-0.0050</td>
</tr>
<tr>
<td>ln(wage)</td>
<td>0.0035</td>
<td>-0.0062</td>
<td>0.0249</td>
</tr>
<tr>
<td>ln(capital stock)</td>
<td>-0.0018</td>
<td>-0.0056</td>
<td>-0.0169</td>
</tr>
</tbody>
</table>

**Independent variables:**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
<th>Coefficient</th>
<th>t-statistic</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. unemployment rate</td>
<td>-0.0127</td>
<td>-5.89</td>
<td>0.0035</td>
<td>1.59</td>
<td>-0.0050</td>
<td>-2.14</td>
</tr>
<tr>
<td>Welfare payment per nonworking adult</td>
<td>0.0032</td>
<td>0.09</td>
<td>-0.0062</td>
<td>-0.17</td>
<td>0.0249</td>
<td>0.63</td>
</tr>
<tr>
<td>State tax rate on use of labor/cost of hiring labor</td>
<td>-0.0118</td>
<td>-3.28</td>
<td>-0.0056</td>
<td>-1.56</td>
<td>-0.0169</td>
<td>-4.35</td>
</tr>
<tr>
<td>Cost of capital</td>
<td>0.0001</td>
<td>0.14</td>
<td>0.0013</td>
<td>2.52</td>
<td>-0.0001</td>
<td>-0.17</td>
</tr>
<tr>
<td>State tax rate on labor income</td>
<td>-0.0305</td>
<td>-2.78</td>
<td>-0.0155</td>
<td>-1.39</td>
<td>0.0054</td>
<td>0.45</td>
</tr>
<tr>
<td>Federal tax rate on labor income</td>
<td>0.0002</td>
<td>0.12</td>
<td>-0.0034</td>
<td>-1.62</td>
<td>0.0014</td>
<td>0.64</td>
</tr>
<tr>
<td>Tax rate on residential property</td>
<td>-0.0275</td>
<td>-2.46</td>
<td>-0.0326</td>
<td>-2.78</td>
<td>0.0117</td>
<td>0.95</td>
</tr>
<tr>
<td>State tax rate on unearned income</td>
<td>0.0003</td>
<td>-0.12</td>
<td>0.0052</td>
<td>1.10</td>
<td>-0.0087</td>
<td>-1.71</td>
</tr>
</tbody>
</table>

**Notes:**
- t-statistic > 1.98 denotes coefficient is statistically significant at 5% level or better.
- The estimated sector-specific intercept terms are not reported in this table.
V. Simulating the Effect of Changes in Taxes

Three steps are needed in order to simulate the effect of the tax changes on the variables of interest – these variables being the number of workers $L$, the wage rate $w$, the capital stock $K$, working-age population $PW$, and state tax revenues from various sources.

1. First, establish baseline values for the variables, projecting them out through 2005.

2. Second, measure the effect of the tax changes on the variables of interest, using the estimated equations.

3. Finally, use the STAMP results from the previous section to estimate and project the above-mentioned variables of interest in the presence of the tax changes.

Baseline Projections of Wages, Number of Workers, Capital Stock and Population

The baseline projections are shown in Table 5 and were constructed as follows. Information on the number of workers is available through 1999, and on employment through 2001. We assume that the number of workers in 2000 and 2001 grew at the same pace as employment. For 2002 we believe that the number of workers will be 60,000 below the level of 2001 (employment in January 2002 was 62,000 below that of the peak in January 2001). After 2002 we assume that the number of workers will rise by 1% annually, in line with recent historical experience.

The baseline wage rate is estimated by dividing the projected payroll for each year by the projected baseline number of workers. Payroll data are available through 1999; for subsequent years we extrapolated using the historical growth rates of payroll. We also assume that the capital stock grows at the same speed as the total payroll, so that the capital-to-labor ratio does not change. Since information on the capital stock in Massachusetts is available through 1998, we use the 1994-1998 growth-rate of payroll to generate the capital stock for 1999, and again for 2000, which is a capital stock of $237,632 million. The same procedure is repeated for calculating the capital stock for subsequent years.

Table 7: Baseline Projections for 2000 - 2005

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Workers ('000)</th>
<th>Wage Rate ($ p.a.)</th>
<th>Capital Stock (in millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>3,500</td>
<td>38,255</td>
<td>237,632</td>
</tr>
<tr>
<td>2001</td>
<td>3,513</td>
<td>40,242</td>
<td>248,514</td>
</tr>
<tr>
<td>2002</td>
<td>3,453</td>
<td>43,029</td>
<td>256,999</td>
</tr>
<tr>
<td>2003</td>
<td>3,488</td>
<td>44,776</td>
<td>269,078</td>
</tr>
<tr>
<td>2004</td>
<td>3,523</td>
<td>46,460</td>
<td>280,918</td>
</tr>
<tr>
<td>2005</td>
<td>3,558</td>
<td>48,208</td>
<td>292,435</td>
</tr>
</tbody>
</table>
Effects of Tax-Law Changes on Tax Rates on Labor and Capital Income

In this section we work out the effects of a change in the personal income tax rate from 5.0% to 5.3%, starting in January 2003. Under the current arrangements, the 5% rate is due to come into effect at the start of 2003, and this has already been taken into account in our baseline projections.

In our estimation, the marginal tax rate on labor income, $ts_l$, is equal to the statutory rate. Under the tax cut proposal, the change in $ts_l$ in 2003 would be +0.3 percentage points

$$\Delta ts_l = 5.30 - 5.00 = 0.30.$$  

The tax increase would also affect the tax rate on certain types of unearned income. In calculating the change in the tax rate on unearned income, $tsky$, we use the weight of each type of capital income in total capital income: Income A and B interest, as well as dividends comprise 35.41% of capital income and are taxed at the same rate as earned income. The term, $tsky$, is then computed as a weighted average of the tax rates on unearned income.  

We can calculate how a change in state income tax effects the total tax rate on unearned income. The change in $tsky$ for the 2001 is:

$$\Delta tsky = 0.3541 \times 0.30 = 0.10623.$$  

Effects of an Income-Tax Increase on the Economy of Massachusetts

The tax cut would change both $ts_l$ and $tsky$. The results in Table 3 show that employment is significantly affected by $ts_l$ and the coefficient, -0.0305, indicates that an increase in $ts_l$ by one percentage point would decrease the number of workers by 3.05%. Then, combining the effect of the change in $ts_l$ with that of $tsky$, the tax cut would affect employment and capital stock in 2003 (relative to the baseline) as follows:

$$\Delta L_{2003} = L_{\text{baseline}} \times (-0.0305) \times (\Delta ts_l)$$
$$= 3.488 \text{ million} \times (-0.0305) \times (0.30)$$
$$= 31,742 \text{ (after allowing for rounding).}$$

$$\Delta K_{2003} = K_{\text{baseline}} \times (-0.0087) \times (\Delta tsky)$$
$$= 269,078 \text{ million} \times (-0.0087) \times (-0.10623)$$
$$= 244 \text{ million.}$$

17 Dividends and interest A income were $3,870 million in 1999, and capital gains (taxable capital gains under the old law which allows 50% long-term capital gains deduction) was $4,569 million, according to the DOR. Also the DOR provided us with the assumed distribution of capital gains by holding period; gains from capital held less than a year is 14% of total gains; 1-2 years, 11%; 2-3 years, 8%, 3-4 years, 6%, 4-5 years, 5%, 5-6 years, 4%; and more than 6 years, 52%. Then, we arrived at the total realized capital gains for 1999 of $8,016 million (=4,569/(0.14+(0.86*0.50))). The 1999 Income B interest is not available, so we estimate it by applying the growth rates of dividends and income A interest projected by the DOR for 1996-1998 on the 1998 data. The resulting figure is $2,213 million.

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The resulting increase in the number of workers in the state would also raise the state’s payroll. Since neither \( t_{sl} \) nor \( t_{sk} \) significantly affect the wage rate (according to our regression results), we supposed that the wage rate remained at the baseline level. Then, the change in payroll is:

\[
\Delta \text{payroll}_{2003} = \Delta L \cdot w_{\text{baseline}} \\
= 31,742 \times 44,776 \\
= 1,421 \text{ million.}
\]

Similarly for 2004 and forward. The economic effects of raising the state income tax from 5.0% to 5.3% are summarized in Table 8.

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Change in Number of Workers</th>
<th>Change in Capital Stock (in millions)</th>
<th>Change in Payroll ($m)</th>
<th>Change in Static Tax Revenue ($m)</th>
<th>Change in Dynamic Tax Revenue ($m)</th>
<th>Change in Net Tax Revenue ($m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2003</td>
<td>-31,742</td>
<td>-244</td>
<td>-1,421</td>
<td>492</td>
<td>-78</td>
<td>414</td>
</tr>
<tr>
<td>2004</td>
<td>-32,059</td>
<td>-254</td>
<td>-1,489</td>
<td>517</td>
<td>-82</td>
<td>435</td>
</tr>
<tr>
<td>2005</td>
<td>-32,380</td>
<td>-265</td>
<td>-1,561</td>
<td>543</td>
<td>-86</td>
<td>457</td>
</tr>
</tbody>
</table>

**Effects on State Tax Revenues**

In assessing the change in tax revenues, we distinguish the static from the dynamic effect. The static revenue effect measures the change in tax revenue as a result of a tax-law change, under the assumption that the tax-law change does not affect the behavior of economic agents. Thus, static revenue loss (or gain) is measured by the decrease (or increase) in tax rate times the tax base. However, the static measure would overstate the true loss or gain in the presence of a dynamic revenue effect that takes into account the impact of a tax-law change on the variables that in turn affect the tax base. For example, our regression results show that an increase in the tax rate on labor income leads to a decrease in the number of workers and the total payroll, and increases the tax revenue from payroll. In this report, we present both static and dynamic tax revenue effects, to arrive at the net tax effect. We simulated the effects on tax revenues by various sources of interest: payroll, capital income, residential property, commercial/industrial property and sales.

**Static Tax Revenue Gain:**

The static revenue gain from the tax increase was measured as the increase in the tax rate on earned income, 0.30%, times the earned-income-tax base for 2003. In order to determine these, we first
projected the baseline tax bases. The baseline earned income tax base was based on the tax withheld, as reported by the Massachusetts Department of Revenue (DOR). The DOR provided the data through January 2002, and we used projections for subsequent years from House Bill 1 of January 2002. We found the static tax increase from earned income, $\Delta TR^S_L$, to be $492$ million.

**Dynamic Tax Revenue Loss:**

The dynamic revenue loss comes through two channels – decreases in personal income tax (because fewer people are now employed) and in corporation income tax (because corporate incomes, tied to the capital stock, shrink). In the current context, personal income tax fell by $75$ million, and corporation tax by $3$ million. Thus the initial static increase in tax revenue of $492$ million was offset in part by dynamic revenue losses of $78$ million, or about $15\%$ of the original “naïve” revenue estimate.

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

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

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

\[
(A1.1) \quad \max U = AC^\alpha L^{1-\alpha} \tag{A1.1}
\]

subject to

\[
(A1.2) \quad C + \ell w(1-t_f)(1-t_s) = w\bar{L}(1-t_f)(1-t_s) + G_r, \tag{A1.2}
\]

where

- \( C \) = the consumption of goods and services;
- \( \ell \) = the consumption of leisure;
- \( w \) = the wage rate;
- \( t_f \) = the federal tax rate on labor income;
- \( t_s \) = the state tax rate on labor income; and
- \( G_r \) = government transfer payments.

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

\[
(A1.3) \quad \max \Psi = AC^\alpha L^{1-\alpha} - \lambda \left[ C + \ell w(1-t_f)(1-t_s) - w\bar{L}(1-t_f)(1-t_s) - G_r \right]. \tag{A1.3}
\]

Differentiating \( \Psi \) with respect to \( C, \ell \) and \( \lambda \) yields:

\[
(A1.4) \quad \frac{\partial \Psi}{\partial C} = \frac{\partial U}{C} \theta - \lambda = 0, \tag{A1.4}
\]
By solving (A1.4) and (A1.5) simultaneously for $\ell$ one obtains:

(A1.7)  
$$\ell = \frac{(1-\theta)C}{\theta w(1-\tau_{g})(1-\tau_{s})}.$$  

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

(A1.8)  
$$C = \theta \left[ w\bar{L}(1-\tau_{g})(1-\tau_{s}) + G_{v} \right].$$  

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

(A1.9)  
$$\ell = (1-\theta) \left[ \bar{L} + \frac{G_{v}}{w(1-\tau_{g})(1-\tau_{s})} \right].$$  

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

(A1.10)  
$$L = \theta \bar{L} - \frac{(1-\theta)G_{v}}{w(1-\tau_{g})(1-\tau_{s})}.$$  

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

(A1.11)  
$$\ln L' = q_{0} - q_{1} \ln G_{v} + q_{1} \ln w - q_{1} \tau_{g} - q_{1} \tau_{s} + q_{1} \ln PW$$  

where $q_{i} > 0$ for all $i = 0...5$. 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, $L'$), the state tax on labor income ($\tau_{g}$), and the residential property tax rate ($\tau_{prop}$). This gives:

(A1.12)  
$$\ln PW = e_{0} + e_{1} \ln L' + e_{1} \tau_{g} + e_{1} \tau_{prop}.$$  

Economic foundations predict that $e_{2}$, $e_{3}$, and $e_{4}$ will be negative. Substituting equation (A1.12) into the previous equation gives

(A1.13)  
$$\ln L' = c_{0} + c_{1} \ln G_{v} + c_{2} \ln w + c_{3} \tau_{g} + c_{4} \tau_{s} + c_{4} \tau_{prop},$$  

where

$$c_{0} = (q_{0} + q_{1}e_{0}) / \tau'$$;  

$c_{i} < 0$;
\begin{align*}
  c_i &> 0; \\
  c_i &< 0; \\
  c_i = (q_i e_i - q_i) / z < 0; \\
  c_i = (q_i e_i) / z < 0
\end{align*}

where $z$ equals $(1 - q_i e_i)$ and is assumed to be positive.

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.

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 observed that “the effects of a general sales tax are approximately equivalent to those of a proportional tax on all

\[19\] A detailed derivation of cost of capital appears in Appendix 4.
factor incomes. Consumers, as such, do not bear the burden of the tax."\textsuperscript{20} 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.”\textsuperscript{21}

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

\begin{equation}
Q = Hq^\alpha L^\beta K^\delta.
\end{equation}

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 parameter that measures how far below its production frontier the state economy is actually producing. The profit-maximizing problem of producers may be written as:

\begin{equation}
\max \pi = p Hq (1-t_s)L^\alpha K^\beta - w(1+v)L - rK ,
\end{equation}

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

The first-order conditions for a profit maximum are:

\begin{equation}
\frac{\partial \Pi}{\partial L} = \alpha Hq \frac{L^\alpha}{L} K^\beta - w(1+v) = 0 \quad \text{and}
\end{equation}

\begin{equation}
\frac{\partial \Pi}{\partial K} = \beta Hq L^\alpha \frac{K^\beta}{K} - r = 0 .
\end{equation}

Some manipulation gives

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

Then
\[ \alpha Hq \left( \frac{w(1+v) L \beta}{r \alpha} \right)^\beta = w(1+v), \]
so
\[ L^{\alpha \beta} = w^\beta (1+v)^{\gamma \beta} r^\beta \alpha^{\beta-1} \beta^{-\gamma} H^{-1} q^{-1}. \]

Assuming \( \alpha + \beta < 1 \) and using the approximation that \( \ln(1+x) \approx x \), we get
\[ \ln L = \frac{\beta-1}{1-\alpha-\beta} \ln w + \frac{\beta-1}{1-\alpha-\beta} v - \frac{\beta}{1-\alpha-\beta} \ln r + \frac{1}{1-\alpha-\beta} \ln q - \frac{1}{1-\alpha-\beta} t, \]
which may be simplified to give
\[ \ln L' = \lambda_q + \lambda_i \ln q + \lambda_r \ln r + \lambda_v \ln w + \lambda_v v. \]

Similarly,
\[ \beta Hq(1-t) \left( \frac{r \alpha K}{w(1+v) \beta} \right)^\alpha K^{\beta-1} = r, \]
and so
\[ K^{\alpha + \beta - 1} = r^{-\alpha} w^\alpha \beta^\alpha \alpha^{\beta-1} H^{-1} q^{-1}. \]

This gives
\[ \ln K = \frac{\alpha-1}{1-\alpha-\beta} \ln r - \frac{\alpha}{1-\alpha-\beta} \ln w - \frac{\alpha}{1-\alpha-\beta} v + \frac{1}{1-\alpha-\beta} \ln q - \frac{1}{1-\alpha-\beta} t, \]
\[ \ln K = \kappa_q + \kappa_i \ln r + \kappa_v \ln w + \kappa_v v + \kappa_v \ln q. \]

### d. Deriving the Reduced Form Equations

Setting labor supply (A1.13) equal to labor demand (A1.19) gives
\[ c_q + c_v \ln G_v + c_v \ln w + c_v t_y + c_v t_y + c_v t_{prop}. \]

\[ \text{Beacon Hill Institute, Holding Taxachusetts at Bay} \]

\[ 32 \]

\[ 21 \text{ Richard E. Wagner, Public Finance: Revenues and Expenditures in a Democratic Society (Boston: Little, Brown} \]
\[ = \lambda_i + \lambda_4 \ln q + \lambda_5 \ln r + \lambda_6 \ln w + \lambda_6 v. \]

Collecting terms, yields the following:

(A1.23) \[ (c_1 - c_2) \ln w \approx (\lambda_0 - c_0) + \lambda_2 \ln q + \lambda_4 \ln r + \lambda_6 v \]
\[-c_1 \ln G_v - c_1 t_{fr} - c_4 t_{sl} - c_4 t_{proper}, \]

or, more simply,

(A1.24) \[ \ln w = \pi_0 + \pi_1 \ln q + \pi_2 \ln r + \pi_3 v + \pi_4 G_v + \pi_5 t_{fr} + \pi_6 t_{sl} + \pi_7 t_{proper}, \]
\[ + + + - - + + + ? \]

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

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

(A1.25) \[ \ln L = \lambda_0 + \lambda_2 \ln q + \lambda_4 \ln r \]
\[ + \lambda_6 \left( \pi_0 + \pi_1 \ln q + \pi_2 \ln r + \pi_3 v + \pi_4 G_v + \pi_5 t_{fr} + \pi_6 t_{sl} + \pi_7 t_{proper} \right) + \lambda_6 v, \]

or, more concisely,

(A1.26) \[ \ln L = b_0 + b_1 \ln q + b_2 \ln r + b_3 v + b_4 G_v + b_5 t_{fr} + b_6 t_{sl} + b_7 t_{proper}. \]
\[ ? \quad ? \quad ? \quad ? \quad - \quad - \quad - \]

Finally, for the capital demand equation we have

(A1.27) \[ \ln K = \kappa_0 + \kappa_1 \ln r + \kappa_2 \left( \pi_0 + \pi_1 \ln q + \pi_2 \ln r + \pi_3 v + \pi_4 G_v + \pi_5 t_{fr} + \pi_6 t_{sl} + \pi_7 t_{proper} \right) \]
\[ + \kappa_6 v + \kappa_7 \ln q + \kappa_8 t_l. \]

Simplification gives

(A1.28) \[ \ln K = d_0 + d_1 \ln r + d_2 v + d_3 \ln q + d_4 G_v + d_5 t_{fr} + d_6 t_{sl} + d_7 t_{proper}. \]
\[ ? \quad ? \quad ? \quad ? \quad - \quad - \quad - \]

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 Massachusetts residents;
(b) the state tax rate on labor income;
(c) the state tax rate on individual capital income
(d) the state tax rates on the use of labor service – unemployment insurance tax rate and workers compensation tax rate combined; and

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 Massachusetts;
(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.22

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.23 Since the average marginal tax rate is the weighted average of the marginal tax rates for each income group, weighted by the total income for each group, the marginal tax rates for each group are first calculated. The marginal tax rates are defined differently depending on the availability of data.

a. Average Marginal Federal Tax Rate on Labor Income for Massachusetts 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:

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

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 $Y_{f,i} =$ 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 Massachusetts, $t_{fl}$, 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.

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

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

**b. Effective State Tax Rate on Capital Gains Income**

The effective state tax rate on capital income is calculated as the weighted average of different types of capital income, with the weight being the fraction of each type of income in the total realized capital income. Capital income consists of Massachusetts bank interest income, dividend income, long-term capital gains, short-term capital gains, and non-Massachusetts bank interest income. The first one is subject to the income B tax rate; the rest, to the income A tax rate, with a deduction allowed for long-term capital gains.

We used data obtained from both the federal and Massachusetts *Statistics of Income (SOI)* publications. The Massachusetts *SOI* reported income B interest for the years from 1978 to 1995. The Federal *SOI* reported all income, including interest income, for Massachusetts for the years 1970 to 1998. We estimated income B interest for the years 1970-1977 by using as a proxy the ratio of total interest reported in the Fed *SOI* to the Income B interest reported in the Mass *SOI* for the years 1978-1982. This proxy ratio of 1.5 was then applied to the Fed *SOI* data for 1970-1977 to arrive at our estimates for income B interest for the period 1970-1977. Then, income A interest was computed by subtracting the income B interest from the total interest in the Fed *SOI*.
The Mass SOI also did not report data on capital gains income, \( CG \), or interest and dividend income for the years 1970-1977. Thus, we retrieved all data on capital gains and interest and dividend income from the Fed SOI.

We calculated the realized capital gains income for each year by taking the capital gains income as reported in the Fed SOI. Until 1978, 50% of net capital gains, defined as long-term gains less short-term losses, were excluded from income for federal tax purposes; after 1978, 60% of net capital gains was excluded from income. The 60% federal capital-gains exclusion was eliminated from 1987 onward. Since the amount of capital-gains exclusion is not included in the AGI reported in SOI, we first obtained the amount of the exclusion in order to obtain the capital gains that were actually realized. The amount of capital gains excluded in SOI for Massachusetts residents, \( CG_x \), is calculated as:

\[
(A2.3) \quad CG_x = \left(1 - \frac{G_{soi}}{G}\right)\times G
\]

where \( G \) is the capital gains actually realized and \( G_{soi} \) is the capital gains reported in SOI for U.S. residents. The ratio of \( G \) to \( G_{soi} \) was obtained from the Office of Tax Analysis, U.S. Department of the Treasury. By adding \( CG_x \) to the capital gains reported in the SOI for Massachusetts, we obtained the total capital gains realized for Massachusetts residents. Then, we subdivided the total realized capital gains estimate into two categories, short-term and long-term.\(^{24}\)

The formula for calculating the effective tax rate on capital income, \( tsky \), is:

\[
(A2.4) \quad tsky = \frac{(I_B \times \tau_B) \div (I_A + Div + (1 - \delta)CG_L + CG_S) \times \tau_A}{(I_B + I_A + Div + CG_L + CG_S)}
\]

where
- \( I_B = \) income B interest,
- \( I_A = \) estimated income A interest,
- \( Div = \) dividend income,
- \( CG_L = \) actually realized long-term capital gains,
- \( CG_S = \) short-term capital gains,
- \( \delta = \) long-term capital gains deduction rate allowed for state tax return,
- \( \tau_A = \) statutory tax rate on income, and
- \( \tau_B = \) statutory tax rate on income B.

\[c. \quad \text{Average State Property Tax Rate}\]

The data used to calculate the average property tax rate for Massachusetts were obtained from two sources: the Division of Local Services of the Massachusetts Department of Revenue and the

---

\(^{24}\) The data from the Office of Tax Analysis report the total capital gains actually realized, the long-term capital gains exclusions and the exclusion rate for each year. From this information we calculated the short-term capital gains. We assume that this ratio of the short-term capital gains to the total capital gains also applies to Massachusetts residents.
Massachusetts Taxpayers Foundation. DOR provided us with the assessed value and the amount of property tax collected for each of the 351 cities and towns within Massachusetts for the years 1982-1997. These data were broken down into five categories: residential, open space, commercial, industrial and personal property. Since the residential and open space classification had the same tax rates, and the commercial, industrial and personal property classifications had a common tax rate, we combined the five classifications into two categories that we called residential and commercial/industrial. The property tax collections for these years were presented in fiscal years as opposed to calendar years. Most 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.\(^\text{25}\)

After these conversions, we chose a sample of the 50 largest cities and towns in terms of assessed value in 1996, in order to compute property tax rates to serve as an estimate of the property tax rate in the state as a whole.\(^\text{26}\) Next, we calculated the average property tax rate for Massachusetts, \(t_{sp,i}\), for each of the years 1982-1996 for the sample as:

\[
(A2.5) \quad t_{sp,i} = \frac{\sum_k PTC_{i,k}}{\sum_k AV_{i,k}}
\]

where

- \(t_{sp,i}\) = average state property tax rate for ith class,
- \(i\) = class (residential or comm/ind),
- \(k\) = town (one of the top 50 municipalities),
- \(AV\) = assessed value, and
- \(PTC\) = property tax collected.

During the early 1980s, a constitutional amendment changed the property tax laws.\(^\text{27}\) This constitutional amendment required property to be classified by its use and to be assessed at its full and fair market value. Prior to 1982, all property was taxed at the same rate, but property was not always assessed at market value.

State totals for assessed value and property tax collections for 1970-1981 were obtained from Massachusetts Taxpayers Foundation.\(^\text{28}\) Due to the tax-law change mentioned above, the assessed value for 1970-1981 is not compatible with the assessed value for 1982-1996 because the property was not assessed at full market value during 1970-1981 while it was assessed at full market value for 1982-1996.

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\(^{25}\) For instance, calendar year data for 1990 was calculated as an average of FY 90 and FY 91.

\(^{26}\) This proxy is highly representative of the state of Massachusetts. In 1996, the top 50 municipalities accounted for 48.4% of the assessed value in Massachusetts. These same 50 cities and towns also accounted for 48.6% of total value in 1992, and 51.8% of total value in 1989.

\(^{27}\) Article CXII of the Massachusetts Constitution. (http://www.magnet.state.ma.us/legis/const.htm).

\(^{28}\) Massachusetts Taxpayers Foundation, “Municipal Financial Data.”
To remedy this, we applied a housing price index to the fully assessed values. During the transition period of 1982-83, the property value was assessed in a rather unstable manner. For this reason, we took 1984 as the base year. We applied the housing price index to derive a proxy for the market value of property, PMV, in Massachusetts for each of the years 1970 to 1983 as:

\[
t_{sp,j} = \frac{PTC_j}{PMV_j}; \; j = 1970, \ldots, 1983
\]

where \( AV_j \) = assessed value for year \( j \), and \( g_j \) = growth rate of housing price for year \( j \).

After deriving the proxy for assessed value, we calculated the average state property tax rate, \( t_{sp} \), in the same manner as for the 1982-1996 data, the only difference being that there were no separate classifications distinguishing between residential or commercial property for this period. Thus

\[
t_{sp,j} = \frac{PTC_j}{PMV_j}.
\]

The resulting average state property tax rate had the same value for the two classes, residential and commercial/industrial, for the years 1970 to 1981.

d. Average Income Tax Rate for Massachusetts 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 Massachusetts (tsca) by applying the following formula:

\[
tsca = \frac{\text{corporate & business excise collections}}{\text{Massachusetts taxable base}}.
\]

Fiscal year data on the total excise collections were obtained from the Massachusetts DOR publication, *Monthly Report of Tax Collection*. 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 Massachusetts taxable base, we first calculated the taxable base for each of seven primary sectors: agriculture, construction; manufacturing; trade (wholesale and retail); transportation and

29 The housing price index was based on the average sales price of new single houses for each of the years 1970 to 1984 as reported by the U.S. Bureau of the Census.
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 MA apportionment ratio as:

\[ TB_i = ar_i \times Y_i. \]

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:

\[
(\text{A2.10}) \quad ar_i = 0.5 \left( \frac{\text{MA sales}}{\text{US sales}} \right)_i + 0.25 \left( \frac{\text{MA assets}}{\text{US assets}} \right)_i + 0.25 \left( \frac{\text{MA payroll}}{\text{US payroll}} \right)_i.
\]

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.\textsuperscript{30} Since sales data are not available on an annual basis for the United States or the states, we estimated the sales data for the six primary sectors using *census* data published every fifth year.

The estimation method for the sales ratio for construction, trade, manufactures and service sectors is described below. We first estimated the Massachusetts and U.S. sales for nonbase years using the *census* year (or base year)\textsuperscript{31} data on sales and the annual growth rates of the sector-specific U.S. GDP and Massachusetts GSP as follows:

\[
(\text{A2.11}) \quad S_t = S_{t-1} \times \exp \left[ \left( \ln S_0 - \ln S_b \right) \frac{g_t}{\sum_{t=a+1}^{b} g_t} \right], \quad a < t \leq b
\]

where \( S_t = \) U.S. or state sales for year \( t \), 
\( S_a = \) U.S. or state sales for the preceding base year, 
\( S_b = \) U.S. or state sales for the following base year, and 
\( g_t = \) growth rate of U.S. GDP or state GSP for year \( t \).

Using the U.S. and state estimated sales for noncensus years, we calculated the ratios of state sales to U.S. sales for the analysis period (1970-1995).

Census data are not available for FIRE or TPU. Census data for the FIRE sector are available only for 1992,\textsuperscript{32} and Census data are available only for the transportation subsector of the TPU sector. Therefore, U.S. and Massachusetts FIRE sales were estimated by applying the FIRE GDP and GSP growth rates to

\textsuperscript{30} See later in this section for a detailed description of the state capital stock estimation.

\textsuperscript{31} Henceforth, the census year or the year for which sales was available is called the base year.

\textsuperscript{32} FIRE census was first published in 1992.
the actual 1992 data for the period of our analysis, and we used the ratio of state GSP to U.S. GDP in the TPU sector to estimate the sales ratio for TPU.

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: $\text{TB}_{\text{state}} = \sum_i \text{TB}_i$. The last step in the calculation of $t_{\text{sc}}$ was to divide state collection of corporate income taxes by the total state taxable base.

### e. 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.\(^{33}\)

\[
(A2.12) \quad t_{fc,i} = \frac{T_{fc,i} - T_{fc,i-1}}{TY_{fc,i} - TY_{fc,i-1}}
\]

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 $i$.

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

\[
(A2.13) \quad t_{fc} = \frac{\sum_i (TY_{fc,i}) \times (t_{fc,i})}{\sum_i TY_{fc,i}}.
\]

\(^{33}\) 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.
f. **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).\(^{34}\)

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

\[ Y_i = \text{average gross income for AGI group } i, \text{calculated by dividing the total adjusted gross income by the number of returns for AGI group } i. \]

Then, we can calculate the average marginal state tax rate on individual capital income applied to all U.S. residents as:\(^{35}\)

\[
t_{sy,k} = \frac{\sum_i t_{sy,i} \cdot Y_i}{\sum_i Y_i}.
\]

\[ g. \text{ Average Marginal Federal Tax Rate On Capital Income Applied to All U.S. Residents} \]

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.\(^{36}\) 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:

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

\[ \]

\[^{34}\text{See the table of Returns with Itemized Deductions: Source of Income, Adjustments, Itemized Deductions by type, Exemptions, and Tax Items, by Size of Adjusted Gross Income.}\]

\[^{35}\text{Since we assumed that the marginal state tax rate on individual income is the same as that on capital income, } t_{sy,k} \text{ is also the same as the average marginal state tax rate on total individual income.}\]

\[^{36}\text{See section of Selected Historical and Other Data, Individual Income and Tax Data by State and Size of Adjusted Gross Income for the U.S.}\]
where \( T_{f,i} \) = 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 \( i \).

\( h. \) **Average Marginal Federal Tax Rate on Dividend Income**

The average marginal tax rate on dividend income for all states, \( t_{f,k}^g \), 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.

\[
(A2.17) \quad t_{f,k}^d = \frac{\sum_i t_{f,i}^d \cdot Y_i}{\sum_i D_i}
\]

where \( D_i \) = the total dividend income for income group \( i \).

As shown, \( t_{f,k}^d \) 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.

\( i. \) **Average Marginal Federal Tax Rate on Capital Gains**

The average marginal tax rate on capital gains income for all states, \( t_{f,k}^g \), 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, \( t_{f,k}^g \) is calculated as:

\[
(A2.18) \quad t_{f,k}^g = \frac{\sum_i (t_{f,i}^g) \cdot (G_i)}{\sum_i G_i}
\]

Here again, \( t_{f,k}^g \) is the weighted average of the individual AGI group marginal federal tax rates, with the weight being the fraction of total capital gains that fall within each income class.

**Appendix 3:**

**Measuring the Stock of Private Nonresidential Capital in Massachusetts**
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 1970-1998. Net stock is calculated as the cumulative value of past gross investment less the cumulative value of past depreciation.\(^{37}\) The approach taken was to apportion for each year, from 1970 to 1998, the BEA national total for private capital on the basis of various measures of Massachusetts’ economic activity in the following sectors: 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,\(^{38}\) 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, \(K_\tau\), is:

\[
K_\tau = \rho_\tau \cdot K_{US,\tau},
\]

where

\(\rho_\tau\) = apportionment rate for base year \(\tau\), and

\(K_{US,\tau}\) = US capital stock for base year \(\tau\).

Then, we estimated the Massachusetts capital stock for nonbase years using the base year apportionment ratios and the annual growth rates of the U.S. capital stock.\(^{39}\) 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.

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37 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.


39 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 estimate shares 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 bias.
(A3.2) \[ K_t = K_{t-1} \exp[\left(\ln K_b - \ln K_a\right) \sum_{i=a+1}^{t} g_i] \], \quad a \leq 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 Massachusetts to the U.S. In the construction sector, we used the ratio of Massachusetts to U.S. real capital stock, as the apportionment ratio to apply to U.S. capital stock.

\textit{b. Methodology for Nonresidential Assets}


\begin{center}
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline
\hline
% & 2.30\% & 1.57\% & 1.91\% & 2.62\% & 1.97\% & 2.00\% \\
\hline
\end{tabular}
\end{center}


\begin{center}
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline
\end{center}

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.


Beacon Hill Institute, \textit{Holding Taxachusetts at Bay}
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 1997. We obtained these data from *Railroad Facts*. We estimated assets from 1970 to 1979 by applying the 1980 ratio,\(^{42}\) and assets for 1983 with data from the 1982 and 1984.\(^{43}\)

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<tr>
<td>%</td>
<td>0.80</td>
<td>0.65</td>
<td>0.68</td>
<td>0.70</td>
<td>0.33</td>
<td>0.35</td>
<td>0.34</td>
<td>0.39</td>
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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*.\(^{44}\)

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<tr>
<td>%</td>
<td>1.27</td>
<td>1.19</td>
<td>1.31</td>
<td>1.51</td>
<td>1.48</td>
<td>1.69</td>
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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.\(^{45}\)

|------|------|------|------|------|------|------|

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\(^{42}\) 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.


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 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).

### Massachusetts’ Share of U. S. Miles of Wire in Cable

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<tr>
<td>%</td>
<td>3.24</td>
<td>2.97</td>
<td>2.68</td>
<td>2.58</td>
<td>2.62</td>
<td>2.62</td>
<td>2.59</td>
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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). 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.

### Massachusetts’ Share of U. S. Installed Capacity of Electric Energy

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<tr>
<td>%</td>
<td>1.83</td>
<td>1.86</td>
<td>1.56</td>
<td>1.43</td>
<td>1.38</td>
<td>1.43</td>
<td>1.32</td>
<td>1.32</td>
</tr>
</tbody>
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47 Data for installed capacity are not available after 1989. They are replaced with net summer capability.

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.49

Massachusetts’ Share of U. S. Miles of Pipeline and Gas Mains50

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>1.71</td>
<td>1.68</td>
<td>1.59</td>
<td>1.55</td>
<td>1.44</td>
<td>1.53</td>
<td>1.53</td>
<td>1.56</td>
<td>1.58</td>
</tr>
</tbody>
</table>

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.51 We obtained the annual data on gross product for each subsector, for the U.S. and for Massachusetts, from the Bureau of Economic Analysis (BEA).

Massachusetts’ ratio of U.S. GSP in FIRE

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>%</td>
<td>3.02</td>
<td>2.88</td>
<td>2.92</td>
<td>3.15</td>
<td>3.38</td>
<td>3.25</td>
<td>3.43</td>
<td>3.39</td>
</tr>
</tbody>
</table>


Massachusetts’ Share of U. S. Sales in Retail Trade, Wholesale Trade, and Service Industries52

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>%</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retail</td>
<td>2.90</td>
<td>2.55</td>
<td>2.70</td>
<td>2.91</td>
<td>2.81</td>
<td>2.86</td>
<td>2.50</td>
<td>2.34</td>
<td>2.34</td>
<td>2.33</td>
</tr>
<tr>
<td>Wholesale</td>
<td>2.78</td>
<td>2.40</td>
<td>2.49</td>
<td>2.96</td>
<td>n.a.</td>
<td>n.a.</td>
<td>2.68</td>
<td>n.a.</td>
<td>n.a.</td>
<td>2.78</td>
</tr>
<tr>
<td>Service</td>
<td>2.91</td>
<td>2.80</td>
<td>3.12</td>
<td>2.60</td>
<td>n.a.</td>
<td>n.a.</td>
<td>2.36</td>
<td>n.a.</td>
<td>n.a.</td>
<td>3.09</td>
</tr>
</tbody>
</table>

49 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%.
51 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.

Beacon Hill Institute, Holding Taxachusetts at Bay
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:

\[ K = \text{price of capital (e.g., cost of new machine or equipment)}; \]
\[ R = \text{rental charge for capital including tax costs, i.e., rental cost to firms; and} \]
\[ R_n = \text{net of tax rental income to capital owner.} \]

Then, in equilibrium, the following must hold:\(^{53}\)

\[ K = \int_0^{SL} R_n e^{-\rho d}\rho dt, \]

where
\[ SL = \text{service life of capital asset}, \]
\[ \rho = \text{real discount rate}, \]
\[ d = \text{capital consumption rate or replacement rate}. \]

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:

\[ R_n = R - (T_p + T_c + T_k), \]

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:

\[ T_{sc} = t_{sc}(R - T_p - D), \]

where \( t_{sc} = \) state tax rate on corporate income;  
\( t_{fc} = \) federal tax rate on corporate income; and  
\( D = \) depreciation allowed for tax purposes.\(^54\)

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

\[
T_c = (t_{fc} + t_{sc})(R - T_p) - t_{fc} \cdot t_{sc} = \tau_c (R - T_p),
\]

where:

\[
\tau_c = t_{fc} + t_{sc} - t_{fc} \cdot t_{sc}.
\]

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:

\[
T_k = T_{fk} + T_{sk} - T_{fk} \cdot T_{sk}.
\]

Here \( T_{fk} \) is given by

\[
T_{fk} = t_{fk}(R - T_p - D - T_c),
\]

where \( t_{fk} = \) federal tax rate on individual capital income.\(^55\) Hence

\[
T_k = t_{fk}(R - T_p - D - T_c).
\]

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

\[
t_{fk} = t_{fr}^d \cdot (1 - p) + t_{fr}^c \cdot p,
\]

where

\[ t_{fr}^d = \text{federal tax rate on dividend income}; \]
\[ t_{fr}^c = \text{federal tax rates on capital gains}; \] and
\[ p = \text{the ratio of dividend income to the total of dividend income and capital gains}. \]

Now substitute (A4.5) and (A4.9) into (A4.2) to rewrite \( R_n \) as:

\[
R_n = R - T_p - (T_c + T_k)
\]

\(^54\) We assume that the depreciation allowed for federal tax purposes is the same for state tax purposes.  
\(^55\) 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.
\[ R-T_p^e[(R-T_p^e-D)t_{fk}+T_f]+T_f \]
\[ = R-T_p^e[(R-T_p^e-D)t_{fk}+(1-t_{fk})\tau_c(R-T_p^e-D)] \]
\[ = R-T_p^e(R-T_p^e-D)(t_{fk}+(1-t_{fk})\tau_c) \]
\[ = (1-t_{ck})(R-T_p^e)+t_{ck}D \]

where:

(A4.12) \[ t_{ck} = \tau_c + t_{fk} - t_{fk} \tau_c. \]

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

(A4.13) \[ K = \frac{1}{\rho + d} \left((R-T_p^e)(1-t_{ck})\right) e^{-(\rho+d)t} + t_{ck} De^{-\rho t} dt \]

\[ = \frac{-(R-T_p^e)(1-t_{ck})(e^{-(\rho+d)t}-1)}{\rho + d} + t_{ck} \int_0^{\infty} (De^{-\rho t})dt \]

\[ = \frac{(R-T_p^e)(1-t_{ck})}{\rho + d} + t_{ck} \int_0^{\infty} (De^{-\rho t})dt , \]

for \( e^{-(\rho+d)t} \approx 0 \), 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 \( K \),

(A4.14) \[ r \equiv R/K. \]

As shown in (A4.13) and (A4.14), 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 (A4.13) is the present value of the tax benefits of depreciation allowances (TBD), expressed in continuous time. It may be rewritten as

\[ TBD = t_d \int_0^{\infty} (De^{-\rho t})e^{-\rho t} dt \]

\[ = t_d \int_0^{\infty} A e^{-\rho t}, \]

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

\[ TBD = t_d \sum_{t=0}^{\infty} \frac{A_t}{(1+\rho)^t}, \]

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:

\[(A4.15) \quad A_t = \alpha_t K, \text{ for } 1 \leq t \leq DL; \text{ otherwise, 0,} \]

where $\alpha_t$ is the recovery allowance percentage for recovery year $t$. With these changes, equation (A4.13) is modified to give

\[(A4.16) \quad K = \frac{(R-T_p)(1-t_s)}{(\rho+d)} + t_k \sum_{m=1}^{\infty} \frac{\alpha_K}{(1+\rho)^m}. \]

The tax on business property is given by $T_t = \frac{p_c K}{t_k}$. Substituting this into (A2d.16), and solving for $r$ ($=R/K$) yields

\[(A4.17) \quad r = \frac{R}{K} = \frac{(p+d)(1-t_s)C}{(1-t_s)} + t_c, \]

where

\[C=\sum_{m=1}^{\infty} \frac{\alpha_m}{(1+\rho)^m} \text{ and } C<1. \]

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, $\alpha$, are as follows:

<table>
<thead>
<tr>
<th>Recovery Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovery allowance percentages, $\alpha$, in %</td>
<td>14</td>
<td>25</td>
<td>17</td>
<td>13</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>4</td>
</tr>
</tbody>
</table>
Suppose that the discount rate ($\rho$) is 10%, and the depreciation method is based on MACRS with a depreciable life of seven years. Then, we get:

$$C = \sum_{t=1}^{7} \frac{\alpha_t}{(1 + \rho)^t} = 0.14 \cdot \frac{1}{(1 + 0.1)^1} + 0.25 \cdot \frac{1}{(1 + 0.1)^2} + 0.17 \cdot \frac{1}{(1 + 0.1)^3} + \ldots + 0.04 \cdot \frac{1}{(1 + 0.1)^7} = 0.722. \tag{A4.18}$$

Data on $\alpha$

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

<table>
<thead>
<tr>
<th>Depreciation Methods for Federal Tax Purposes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years</td>
</tr>
<tr>
<td>1986-present</td>
</tr>
<tr>
<td>1981-1985</td>
</tr>
<tr>
<td>1954-1980</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Recovery year</th>
<th>3-year %</th>
<th>5-year %</th>
<th>7-year %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>33</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>32</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>12</td>
<td>13</td>
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<tr>
<td>5</td>
<td></td>
<td>11</td>
<td>9</td>
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<td>6</td>
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<td>6</td>
<td>9</td>
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<tr>
<td>7</td>
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<td></td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Recovery year</th>
<th>3-year %</th>
<th>5-year %</th>
<th>10-year %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>38</td>
<td>22</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>37</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
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<td>5</td>
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<td>21</td>
<td>10</td>
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<td>6</td>
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<td>10</td>
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<tr>
<td>7-10</td>
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<td></td>
<td>9</td>
</tr>
</tbody>
</table>

**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:

<table>
<thead>
<tr>
<th>Ownership Year</th>
<th>3-yr %</th>
<th>5-yr %</th>
<th>7-yr %</th>
<th>10-yr %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50.00</td>
<td>33.33</td>
<td>25.00</td>
<td>18.18</td>
</tr>
<tr>
<td>2</td>
<td>33.33</td>
<td>26.67</td>
<td>21.43</td>
<td>16.36</td>
</tr>
<tr>
<td>3</td>
<td>16.67</td>
<td>20.00</td>
<td>17.86</td>
<td>14.55</td>
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<tr>
<td>4</td>
<td>13.33</td>
<td>14.29</td>
<td>12.73</td>
<td></td>
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<tr>
<td>5</td>
<td>6.67</td>
<td>10.71</td>
<td>9.09</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>7.14</td>
<td>9.09</td>
<td></td>
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<td>7</td>
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<td>3.57</td>
<td>7.27</td>
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<td>8</td>
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<td></td>
<td>5.45</td>
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</tr>
<tr>
<td>9</td>
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<td></td>
<td>3.64</td>
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</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td>1.82</td>
</tr>
</tbody>
</table>
About the Authors

David G. Tuerck is Executive Director of the Beacon Hill Institute for Public Policy Research at Suffolk University in Boston, MA, where he also serves as Chairman and Professor of Economics. He holds a doctorate in economics from the University of Virginia, and has written extensively on issues of taxation and public economics.

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