2008

The cost of government: how taxes affect economic health and social well-being

Joseph Eugene Mcphail
Iowa State University

The cost of government: how taxes affect economic health and social well-being

by

Joseph Eugene McPhail

A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Economics

Program of Study Committee:
Peter Orazem, Major Professor
Rajesh Singh
Brent Kreider

Iowa State University

Ames, Iowa

2008

DEDICATION

I dedicate this thesis to my wife Lihong Lu McPhail, my exception to the law of diminishing marginal utility.

ACKNOWLEDGEMENTS

Thank you family for all your love and support throughout my graduate studies. You have all played a role in shaping my life and hold a special place in my heart.

Thank you Dr. Peter Orazem and Dr. Rajesh Singh for always being available to answer questions and provide direction. Some of the more technical aspects of this paper would have been difficult without your insight.

Thank you Dr. Brent Kreider for giving me the opportunity to teach economics so early in my academic career. This work would not have been possible without the encouragement and trust you have given me since taking your class five years ago.

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ABSTRACT

All government services require funding through taxes, but not all taxes have the same effect on the economy. Even when the amount raised is equal, taxes may have very different distortionary impacts on economic decisions. This thesis estimates this cost in the context of a dynamic general equilibrium model, which is fitted to a panel data set covering the 48 contiguous United States over the period 1977 to 2004. Taxes on wealth (property), income, consumption (sales), and capital gains are all compared in terms of their impacts on labor productivity, gross state product, and household welfare.

Elasticities are estimated for labor productivity, gross state product, and household welfare. The theoretical model is calibrated using estimates for model parameters found in the state growth literature. Tax rates are not found to be on the wrong side of the Laffer curve, but state tax policies are estimated to rely too heavily on property tax revenues and too little on income and consumption taxes.

The empirical model regresses state labor productivity, defined as output per worker, on state tax policy, six control groups, fixed state effects, and between year effects. The average state is estimated to lose 9.49% of its labor productivity annually because of its tax policy. Taxes on property are estimated to have the most disruptive effect on the economy, while taxes on consumption are found to have little effect if any.

State tax policies are ranked according to their support for economic productivity using historical tax rates and estimates from the empirical model. Nevada, Tennessee, and Washington are found to have the least costly tax policies while Nebraska, Iowa, and Vermont are found to have the most costly. A state's tax policy is found to account for 10% of the variation in productivity from state to state.

CHAPTER 1. What Is the Cost of Government?

All public services must be purchased using tax receipts. Each tax, however, comes at a cost to the economy in the form of market distortions that create dead weight losses, loss of business from tax competition, black markets, and additional administration. These costs are largely ignored by policy makers in part because the magnitudes are not known. Without knowing the cost of levying additional taxes, policy makers can only guess whether the benefit of a proposed service is worth its price to the economy. Knowing the cost of government is therefore essential to making good tax policy.

Market distortions occur when prices do not accurately reflect the true cost of a good or service. A price that is too low will lead consumers to buy more than the socially optimal amount of the product. This happens any time a government *subsidizes* a good that has no *positive* externality not already captured by the natural market price. A price that is too high will lead consumers to buy less of that product than would be optimal. This happens any time a government *taxes* a good that has no *negative* externality not already captured by the natural market price. The result in both cases is that the society as a whole is less well off than it would be if the prices of all goods and services reflected their true cost of production distribution, and consumption.

The effects of tax competition contribute to the cost of government at the county, state, and national level. Holcombe (2004) compared income growth rates in counties on state borders with neighboring counties in other states. He estimated that when states raise their income tax rates more than their neighbors they suffer from slower income growth, and an average reduction of 3.4% in per capita income. Multinational corporations are affected by the same incentives that lead households and firms to live and work in states with lower income tax rates.

The United States federal corporate tax rate is second only to Japan in the world. Some states, including California, Iowa, and New Jersey have state levied corporate tax rates high enough to exceed Japan! The result of high taxes on an economy, although not universally recognized by economists, is that counties, states, and countries with high tax rates lose business from firms who can choose their location.[1]

Black Markets make up another set of costs that taxes impose on the economy. If given the choice, people will not pay taxes. Economic theory suggests that most people agree to paying taxes only because they believe others in the society will pay taxes as well. Black Markets give people the choice to avoid taxes, but not without the risk of getting caught. Increasing a tax rate lowers the threshold required by a firm or consumer in the economy to participate in a black market. When this happens the burden of paying for public services is placed more heavily on those who pay their taxes. Goods that are potentially harmful to consumers, such as meats and drugs, require inspection by the Food and Drug Administration. Services such as tree felling require licensing in most counties to ensure that the managers are properly trained. When these goods and services are traded and performed on a black market, there is a greater risk to consumer health along with a loss in tax receipts.[2]

The act of collecting taxes is a cost in itself. It costs money to process tax returns. It costs more money to pay politicians to debate how taxes will be spent. It takes time and money for households and firms to prepare tax forms. Costs on the government side are referred to as administrative costs whereas costs on household's and firm's are referred to as compliance costs. Both add significantly to the cost of government.[3]

[1]Devereux (2008) looks at the effects of tax competition at the international level. Feld (2003) gives another view of the cost of tax competition at the local level.

[2]Erard (2001) identifies who is most likely to illegally avoid paying their taxes and estimates how much the federal budget suffers as a consequence of illegal tax evasion. Nordblom (2006) studies how families avoid paying taxes on transfer payments.

[3]Godwin (2003) "reviews the existing body of research into compliance costs, considers the methodological problems revealed by research, and assesses the significance of compliance costs to public policy." Olken (2006) attempts to quantify the administrative costs of levying taxes in the context of Indonesia.

1.1 Approaching the question of optimal tax policy

Tax receipts come at a cost to economic health and social well-being. However, tax receipts are required in order to pay for public goods necessary for the survival and prosperity of the state. The quest for an optimal tax policy must therefore address both the costs and the benefits of each tax levy. This work argues that for a tax policy to be optimal it must first provide tax receipts in a manner that minimizes cost. A tax levy that produces greater marginal receipts can still be inferior to another tax levy if the cost of those receipts are greater in terms of their effect on economic health and social well-being.

The quest for the best tax policy is an old one and its literature is vast. Some scholars [4] take a "golden bullet" approach; seeking to find the one tax levy that is the best or worst. A well published example of the golden bullet approach is the argument for a zero-tax-on-capital-income, favoring instead taxes on consumption and wage income. Other scholars[5] take a "best basket" approach; arguing that multiple tax levies should be used and try to find the optimal weights for each tax levy. Many of the scholars participating in the debate over a zero-tax-on-capital-income tax policy are cited in this work. Due to its relevance, a summary of the debate is located in appendix B.

The intuition behind the shape of a Laffer Curve suggest that the best basket approach is more useful than the golden bullet approach. Tax levies provide no tax receipts at a rate of 0% or 100%, which means that there is a maximum somewhere along side this function. It is possible that for some range of a tax rate, the marginal gains in tax receipts are increasing, however, this cannot be true over the entire range because maximum receipts are generated from some tax rate between 0% and 100%. This fact implies that for any tax levy, their exists some rate for marginal receipts gained from increasing the tax rate are zero. Other tax rates rely on a different subset of market transactions. For this reason they are likely to still generate some positive marginal receipts from an increased rate. The best tax policy can

[4] Chari (1999), Chamley (1986), Judd (2002). All three papers are discussed in the appendix discussion, "The zero-tax-on-capital debate".

[5] Zodrow (2006), "Should Capital Income Be Subject to Consumption-based Taxation?"
ColemanII (2000), "Welfare and optimum dynamic taxation of consumption and income".
Helms (1985), "The effect of state and local taxes on economic growth: A time series-cross section approach".

therefore be characterized by two necessary conditions. First, the marginal efficiency of all tax levies available must be equal. If any is greater than the other, the tax policy is costing too much in terms or economic health and societal well-being per dollar gained in tax receipts. A second necessary condition is that the marginal gain in tax receipts, when spent on public goods, produces a benefit equal to the cost. If both conditions are met the tax policy is optimal. The creation of an optimal tax policy thus requires an understanding of both the cost and benefit of government.

This work does not attempt to quantify the benefit of government. The cost of government is much easier to quantify because there are only a few ways that a government can levy a tax. In contrast, politicians never run out of new ways to spend money. Even so, the process of developing an optimal tax policy is simple. For an instructive thought experiment, think of all the ways that a government could spend its tax receipts. Now rank them in terms of their usefulness to an economy. At one extreme, there are public goods whose benefits easily justify the cost of levying additional taxes, such as providing national security and property rights. At the other extreme are those comparatively useless projects, such as building the world's largest toaster, which would not be worth the cost of levying additional taxes.[6] Somewhere between these two extremes are all those public goods whose value is currently up for debate, such as the value of providing single-payer health care and punishing victimless criminals.

Without a ball park estimate of the cost of levying additional taxes, policy decisions are nothing more than guess work. Estimating the value of public goods like single-payer health care is hard enough without knowing the threshold needed for the public good to realize a net benefit to society.

1.2 Measuring economic health and social well-being

The goal of any benevolent government is to increase the well-being of its citizens. This goal is multi-faceted, complicated, and at times impossible to quantify (or qualify). For this reason, coming up with a measure for social well-being is both challenging and subjective.

[6]Unless the state in question has an unusually strong preference for large toast.

The vast majority of economists believe that economic health plays a vital role in determining social well-being. However, there is a debate over whether economic health is synonymous with social well-being. This debate is discussed in the next subsection.

Governments use a number of different indicators for measuring both economic health and social well-being. These three measures all attempt to quantify an economy's economic health; gross domestic product (GDP), productivity (output per unit of labor), and green GDP[7]. Measures of social well-being include public welfare, the Human Development Index, the Genuine Progress Indicator, and Gross National Happiness to name just a few.

This analysis focuses primarily on productivity as a measure for both economic health and well-being, however, the theoretical model constructed in chapter 2 also includes two additional measures including GDP and household welfare.[8] Productivity is defined in this work as GDP per working person.[9] The key benefit of productivity is that it is tied to wages. The productivity of a state can be interpreted as the average value of goods and services produced per working person. Productivity is the measure of economic health most often used in the United States.[10] Productivity normalizes gross domestic product by the working population, allowing a better comparison between states of different sizes.

The debate over GDP

Productivity is equal to GDP per working person. Although generally excepted as the best measure of an economy, GDP is not without its imperfections. GDP's role as the primary indicator of economic health has come under heavier scrutiny this year, particularly by the

[7]Green GDP is calculated by adjusting GDP for permanent changes in natural resources and environmental health.

[8]Defined using a Cobb-Douglas utility function where the household's utility is increased from consumption and leisure.

[9]The Census Bureau defines productivity as gross domestic product per hour worked. This analysis focuses on the contiguous United States. Only since the year 2000 has the Census Bureau started collecting data on state level hours worked so this work approximates by substituting number of hours worked with number of working people.

[10]The National Bureau for Economic Research (NBER) "does not define a recession in terms of two consecutive quarters of decline in real GDP." The NBER, a nonpartisan research organization, defines a recession as "a significant decline in economic activity spread across the economy, lasting more than a few months, normally visible in real GDP, real income, employment, industrial production, and wholesale-retail sales."

This distinction made by the NBER implies that GDP should not be used independently as a measure for economic health.

French government. Nobelist Joseph Stiglitz and Professor Anthony de Jasayan offer opposing views on how well GDP reflects both economic health and social well-being.

Anthony de Jasay, author of "The State" (Oxford, 1985), believes that GDP is a better indicator because "it has nothing to do with the opinions of the indexer". Jasayan argues that GDP "is the objective result of the subjective choices of billions of consumers and producers who jointly determine world prices...with GDP, it is impossible for a left-leaning statistician to overweigh welfare provisions or public health-care or a right-wing one to overweight police services." The use of GDP as the standard was called into question recently by Nicolas Sarkozy, the president of France. France has slipped compared to other European countries when viewed according to GDP, but does well when viewed by alternative indicators such as Gross National Happiness. It is likely for this reason that President Sarkozy asked Nobelists Amartya Sen and Joseph Stiglitz earlier this year to head up the creation of an alternative to GDP. Jasay compares Sarkozy's actions to that of "shooting the messenger" and argues that changing its indicator away from GDP won't fix France's economy. Justin Fox, a writer for Time Magazine, agrees with Jasay pointing out that, "Over the years, GNP and GDP have proved spectacularly useful in tracking economic change, both short-term fluctuations and long-run growth. Which isn't to say GDP doesn't miss some things."

Joseph Stiglitz, an advocate of alternative measures of social well-being, recently pointed out many of the things that GDP misses in a speech he made to the Asia Society in New York on February 5, 2008. He argues that because "accounting frameworks do effect behavior", any aspect of well-being ignored by GDP will also be ignored by policy makers. To illustrate he gives four areas where GDP fails to measure social well-being properly. "GDP doesn't tell you anything about what happens to the typical citizen." If income inequality is rising then the average citizen could have a lower standard of living while GDP increases. "GDP also tells you nothing about stability." As an example, Stiglitz points out that a significant portion of China's recent economic growth came at a significant cost to the environment and required a permanent depletion of China's natural resources. Some areas of well-being ignored by GDP make living in the United States look better on paper than in reality. "The United States has about ten times as many people per capita in prison than other advanced industrialized countries. That contributes to GDP because we have to spend more money incarcerating them... We spend more on health care than any other country as a percent of GDP, and our health outcomes are much lower than in other advanced industrialized countries...the extra money we spend on health care shows up as a contribution to GDP. If we got more efficient (at providing health care) our GDP could go down."

Stiglitz also argues that GDP may not be as objective a measure of well-being as thought by economists like Anthony de Jasay. Stiglitz points out that the switch from gross national product (GNP) to GDP had a "political context". The new focus on GDP made the United States look better then it would have under the old focus, GNP. While GDP measures the total product of the country, GNP measures the total income of people from a country. The reason for the switch, Stiglitz says, is that "When you start outsourcing a great deal, you have economic activity within the country, but the income from that economic activity, more and more, going to people outside the country."

Although the shortcomings of GDP are numerous, GDP (and its closely related measure productivity) is still the most commonly accepted measure of economic health and social well-being used in the United States. There are many alternatives to GDP, but no particular alternative seems to be far superior to the rest. Choosing an alternative from the many in existence would require a separate thesis altogether. Any interpretation of this work's results should, however, be made knowing both the strengths and weaknesses of using productivity as a proxy for economic health and assuming that economic health is analogous to social well-being.

1.3 Contributions of this work

The theoretical model's contribution

This work combines a theoretical and empirical model in order to quantify the cost of government. The theoretical model is a dynamic general equilibrium model designed exclusively to compare the distortionary effects of four tax levies. Tax competition, black markets, and administrative costs are not considered. Simulations of the model provide an in-depth picture of how each tax levy is unique in its effects on the equilibrium wage rate, consumption, labor market participation, and capital accumulation. These macroeconomic variables are combined into three measures for economic health and social well-being including productivity, gross domestic product (GDP), and household welfare. Each of these measures provides a different metric for measuring the cost of taxes. Taxes on wage income, property, consumption, and capital income are generally found to have negative effects on all measures, but their marginal effects differ. Taxes on capital are estimated to be more disruptive then taxes on wage income or consumption.

The policy recommendation in chapter 9 constructs an optimal tax policy in the context of this dynamic general equilibrium model. The method places an emphasis on comparing tax levies based on their efficiency, defined as the marginal gain in tax revenues divided by the marginal loss in some welfare measure. The idea behind tax efficiency is that a tax's ability to generate revenue is not the only criterion needed to assess the value of a tax. Marginal Laffer curves are constructed for each of the four tax levies to test whether aggregated state and national tax rates are on the "wrong side" of the Laffer curve.[11]

The empirical model's contribution

The empirical side tests the theoretical model's estimates of the magnitude of each tax effect on productivity. Four tax levies are considered in the empirical model including taxes on property, capital gains, income (both wage income and capital gains), and consumption.

Most of the studies mentioned in the literature review study only one or two groups of tax levies at a time,[12] or they study taxes as a group but ignore individual effects[13]. Including four tax levies allows an easier comparison with the real world which includes many more options for funding public goods.

This work is similar to Bartik (1992) who also looks at how taxes effect state economic

[11] Tax rates can be so high that decreasing the rate actually increases revenue.
[12] Chari (1999), Chamley (1986), Zodrow (2005), Jones (1997).
[13] Bauer (2006), for example, looks at the tax effect as a whole only.

health using computable model simulations and an empirical analysis. Combining both approaches into the same work can give a more complete picture than previous studies[14] which rely solely on the strengths of one approach.

[14]Bartik (1992), Bauer (2006), Bauer (2005), Chamley (1986), Chari (1999), Jones (1997), Modifi (1990), Phillips (1995), Zodrow (2005)

CHAPTER 2. A Dynamic General Equilibrium Model with Solutions

The purpose of this model is to quantify and compare the market distortions caused by taxes on wage income, wealth, consumption and capital income. The model economy takes the form of a single state containing a representative household and firm. A dynamic general equilibrium framework is used to solve for five endogenous variables including the wage rate, consumption, labor, rental rate, and savings. Taxes are imposed exogenously. There is no government in this model actively choosing an optimal tax policy. Instead, different tax policies are simulated and compared based on their marginal impact on productivity, gross domestic product (GDP), household welfare and tax efficiency.

2.1 The representative household

The state has one rational and infinitely lived household meant to represent all the households in the state. The household chooses consumption, c, work level, l, and savings, k, in every period , t, so as to maximize its utility function.

$$\Psi = \sum_{t=0}^{\infty} \beta^t \left(c_t\right)^{\alpha} \left(1 - l_t\right)^{(1-\alpha)} + \sum_{t=0}^{\infty} \beta^t \lambda_t \begin{bmatrix} (1-\tau_w)\, w_t l_t + (1-\tau_k) r_t k_t + G_t \\ -c_t - k_{t+1} + (1-\delta-\tau_p) k_t \end{bmatrix} \tag{2.1}$$

Household utility is a function of consumption and leisure with a discount on future utility captured by β. The household is assumed to prefer consumption in the present by restricting β to values between zero and one. The Cobb-Douglas form assumes constant returns in utility from consumption and leisure. The household's time is normalized to one, $l_t + L_t = 1$, where $L_t = (1 - l_t) = leisure$. There is no uncertainty in future wages or savings.

All earnings must be consumed or rented to the firm for a return of r. The household's uses of cash cannot exceed its earnings in any one period as depicted in the households budget constraint.

$$c_t - k_{t+1} + (1 - \delta - \tau_p)k_t \leq w_t l_t + (1 - \tau_k) r_t k_t + G_t \tag{2.2}$$

Uses of cash include consumption, c_t, and savings, $k_{t+1} - (1 - \delta)k_t$, where savings are equivalent to the economy's capital stock and the household's total wealth. Household savings equal the difference between next period's capital stock, k_{t+1}, and this period's capital stock net of depreciation, $(1 - \delta)k_t$. Earnings before taxes are imposed include wage income, $w_t l_t$, and interest received from savings lent to the firm, rk_t.

Consumption, c, and savings, k, are restricted to the set of all positive real numbers. The depreciation rate, δ, is bounded between zero and one.

2.2 The representative firm

The state has one representative firm that acts as if in a perfectly competitive market. The result is that the firm always makes zero profits. The firm hires the household to work l hours of labor and borrows all the household's capital stock (wealth), k, in order to produce good, Y, using a Cobb-Douglas production function. The firm can only get capital from the household. Profits for the firm equal its revenues minus its costs as represented by the firm's problem.

$$\max_{\{k_t, l_t\}} \pi_t = (1 - \tau_s) A \left(k_t\right)^{\theta} \left(l_t\right)^{1-\theta} - w_t l_t - r_t k_t \tag{2.3}$$

The parameter A is an exogenous parameter representing all inputs into production besides capital and labor. The parameter θ is bounded between zero and one, imposing some level of diminishing marginal product for each input.

The household and firm problems make up the entire economy. Endogenous variables w, c, l, r, and k can be solved for as a function of exogenous parameters α, θ, β, A, and δ. The economy has an incomplete capital market with two goods, labor and capital.

Four taxes are levied in the economy. Taxes on wealth, τ_p, are levied on the households property (capital stock). Taxes on capital income, τ_k, are levied on the household's return on savings. Taxes on consumption, τ_s, are levied on the firm's sale of goods to the household. Taxes on wage income, τ_w, are levied on the household. All tax revenues are given back to the household each period t in the form of a lump sum rebate G.

$$G_t = (\tau_w)\, w_t l_t + \tau_s A\,(k_t)^{\theta}\,(l_t)^{1-\theta} + \tau_p k_t + \tau_k r_t k_t \tag{2.4}$$

The good produced by the firm is sold back to households at a price of one. Equations 2.1, 2.3, and 2.4 are the theoretical model in its entirety. The crucial element of the model is how the exogenously set taxes on wage income, wealth, consumption and capital income affect endogenous variables, measures of economic health, measures of social well-being, and tax efficiency.

2.3 Solving the model

Household first order conditions in steady state

The first order conditions (FOCs) of the household's problem with respect to c_t, l_t, k_t and Lagrangian multiplier λ_t are given in equations 2.5 through 2.8.

$$\lambda = \alpha\,(c)^{\alpha-1}\,(1-l)^{(1-\alpha)} \tag{2.5}$$

Equation 2.5 requires that the marginal benefit from consumption equal the price of the consumable good. λ_t is the shadow price of consumption.

$$(1-\alpha)\,(c)^{\alpha}\,(1-l)^{(-\alpha)} = (1-\tau_w)\,w\lambda \tag{2.6}$$

Equation 2.6 requires that the marginal benefit from leisure equals the opportunity cost of leisure.

$$r = \frac{\beta^{-1} - 1 + \delta + \tau_p}{1 - \tau_k} \tag{2.7}$$

Equation 2.7 is the Euler equation which immediately solves for r, the equilibrium rate of return on capital rented by the firm from the household.

$$c = wl + \tau_s A\left(k\right)^{\theta}\left(l\right)^{1-\theta} + (-\delta + r)k \tag{2.8}$$

Equation 2.8 restates the households budget constraint. [1]

Firm first order conditions in steady state

The FOCs of the firm's problem with respect to k and l are given in equations 2.9 and 2.10.

$$r = \theta(1 - \tau_s)A\left(k\right)^{\theta-1}\left(l\right)^{1-\theta} \tag{2.9}$$

Equation 2.9 requires the marginal revenue from renting capital from the household to equal the rental rate of capital.

$$w = (1 - \theta)\left(1 - \tau_s\right)A\left(\frac{k}{l}\right)^{\theta} \tag{2.10}$$

Equation 2.10 requires the marginal revenue from hiring additional labor is equal the wage rate. Note that the wage rate, q over l, is proportional to labor productivity.

Rental rate of capital

The rental rate of capital is given in 2.7.

Household's wage rate

The household's wage rate, w, is solved by substituting a ratio of 2.9 and 2.10, into 2.10.

[1] In the steady state k_{t+1} equals k.

$$
\begin{aligned}
w &= (1-\theta)\,(1-\tau_s)A\left(\frac{k}{l}\right)^{\theta} \\
w &= (1-\theta)\,(1-\tau_s)A\left(\frac{w\theta}{r(1-\theta)}\right)^{\theta}
\end{aligned}
$$

Substitute in 2.7 to get productivity as a function of tax levies.

$$
w = (1-\theta)\,(1-\tau_s)A\left(\frac{w\theta}{\left(\frac{\beta^{-1}-1+\delta+\tau_p}{1-\tau_k}\right)(1-\theta)}\right)^{\theta}
$$

$$
w = (1-\theta)\left((1-\tau_s)A\right)^{\frac{1}{1-\theta}}\left(\frac{\theta\,(1-\tau_k)}{(\beta^{-1}-1+\delta+\tau_p)}\right)^{\frac{\theta}{1-\theta}} \tag{2.11}
$$

Shadow price of consumption

The endogenous variable λ is the shadow price of consumption. To solve for, λ, start by setting 2.5 equal to $\left(\frac{c}{1-l}\right)^{\alpha-1}$.

$$
\begin{aligned}
\alpha\,(c)^{\alpha-1}\,(1-l)^{(1-\alpha)} &= \lambda \\
\left(\frac{c}{1-l}\right)^{\alpha-1} &= \frac{\lambda}{\alpha}
\end{aligned}
$$

Then set 2.6 equal to $\frac{c}{1-l}$.

$$
\begin{aligned}
(1-\alpha)\,(c)^{\alpha}\,(1-l)^{(-\alpha)} &= (1-\tau_w)\,w\lambda \\
\left(\frac{c}{1-l}\right)^{\alpha} &= \frac{(1-\tau_w)\,w\lambda}{(1-\alpha)} \\
\left(\frac{c}{1-l}\right) &= \left(\frac{(1-\tau_w)\,w\lambda}{(1-\alpha)}\right)^{(1/\alpha)}
\end{aligned}
$$

Then substitute $\frac{c}{1-l}$ from 2.6 into 2.5.

$$
\begin{aligned}
\left(\frac{c}{1-l}\right)^{\alpha-1} &= \frac{\lambda}{\alpha} \\
\left(\left(\frac{(1-\tau_w)\,w\lambda}{(1-\alpha)}\right)^{\frac{1}{\alpha}}\right)^{\alpha-1} &= \frac{\lambda}{\alpha} \\
\lambda^{\frac{\alpha-1}{\alpha}}\left(\frac{(1-\tau_w)\,w}{(1-\alpha)}\right)^{\frac{\alpha-1}{\alpha}} &= \frac{\lambda}{\alpha} \\
\lambda^{\frac{1}{\alpha}} &= \alpha\left(\frac{(1-\tau_w)\,w}{(1-\alpha)}\right)^{\frac{\alpha-1}{\alpha}}
\end{aligned}
$$

$$
\lambda = \left(\alpha\left(\frac{(1-\tau_w)\,w}{(1-\alpha)}\right)^{\frac{\alpha-1}{\alpha}}\right)^{\alpha} = \alpha^{\alpha}\left(\frac{(1-\tau_w)\,w}{(1-\alpha)}\right)^{\alpha-1} \tag{2.12}
$$

Labor

Households choose labor supply based on the condition that the marginal rate of substitution between leisure and consumption should equal the consumer's net wage rate. This equality is constructed by taking the ratio of 2.6 and 2.5.

$$
\begin{aligned}
\frac{\alpha\,(c)^{\alpha-1}\,(1-l)^{(1-\alpha)}}{(1-\alpha)\,(c)^{\alpha}\,(1-l)^{(-\alpha)}} &= \frac{\lambda}{(1-\tau_w)\,w\lambda} \\
(1-\tau_w)\,w &= \frac{(1-\alpha)\,c}{\alpha\,(1-l)} \\
\frac{\alpha\,(1-l)\,(1-\tau_w)\,w}{(1-\alpha)} &= c
\end{aligned}
$$

To solve for labor, l, set 2.9 equal to capital.

$$
\begin{aligned}
\theta(1-\tau_s)A\,(k)^{\theta-1}\,(l)^{1-\theta} &= r \\
\theta(1-\tau_s)A(\frac{k}{l})^{\theta-1} &= r \\
\left(\frac{r}{\theta(1-\tau_s)A}\right)^{\frac{1}{\theta-1}} &= \frac{k}{l}
\end{aligned}
$$

$$l\left(\frac{r}{\theta(1-\tau_s)A}\right)^{\frac{1}{\theta-1}} = k$$

From the household's budget constraint 2.8, substitute c from the ratio of 2.6 and 2.5.

$$\begin{aligned}
c &= wl + \tau_s A\left(k\right)^{\theta}\left(l\right)^{1-\theta} + (-\delta + r)k \\
\frac{\alpha\left(1-l\right)\left(1-\tau_w\right)w}{\left(1-\alpha\right)} &= wl + \tau_s A\left(k\right)^{\theta}\left(l\right)^{1-\theta} + (-\delta + r)k
\end{aligned}$$

Then substitute this ratio in for every k in 2.9.

$$\begin{aligned}
\frac{\alpha\left(1-l\right)\left(1-\tau_w\right)w}{\left(1-\alpha\right)} &= wl + \tau_s A\left(k\right)^{\theta}\left(l\right)^{1-\theta} + (-\delta + r)k \\
\frac{\alpha\left(1-l\right)\left(1-\tau_w\right)w}{\left(1-\alpha\right)} &= wl + \tau_s A l^{\theta}\left(\frac{r}{\theta(1-\tau_s)A}\right)^{\frac{\theta}{\theta-1}}\left(l\right)^{1-\theta} + (-\delta + r)l\left(\frac{r}{\theta(1-\tau_s)A}\right)^{\frac{1}{\theta-1}} \\
\alpha\left(1-l\right)\left(1-\tau_w\right)w &= \left\{\begin{array}{c} \left(1-\alpha\right)wl + \left(1-\alpha\right)\tau_s A\left(\frac{r}{\theta(1-\tau_s)A}\right)^{\frac{\theta}{\theta-1}}\left(l\right) + \\ \left(1-\alpha\right)\left(-\delta + r\right)l\left(\frac{r}{\theta(1-\tau_s)A}\right)^{\frac{1}{\theta-1}} \end{array}\right\} \\
\left(1-l\right) &= \frac{\left\{\begin{array}{c} \left(1-\alpha\right)w + \left(1-\alpha\right)\tau_s A\left(\frac{r}{\theta(1-\tau_s)A}\right)^{\frac{\theta}{\theta-1}} + \\ \left(1-\alpha\right)\left(-\delta + r\right)\left(\frac{r}{\theta(1-\tau_s)A}\right)^{\frac{1}{\theta-1}} l \end{array}\right\}}{\alpha\left(1-\tau_w\right)w} \\
\frac{1}{l} &= \frac{\left\{\begin{array}{c} \left(1-\alpha\right)w + \left(1-\alpha\right)\tau_s A\left(\frac{r}{\theta(1-\tau_s)A}\right)^{\frac{\theta}{\theta-1}} + \\ \left(1-\alpha\right)\left(-\delta + r\right)\left(\frac{r}{\theta(1-\tau_s)A}\right)^{\frac{1}{\theta-1}} \end{array}\right\}}{\alpha\left(1-\tau_w\right)w} + 1
\end{aligned}$$

Substitute in the rental rate of capital and the wage rate to get the closed form solution for labor

$$l = \frac{\alpha\left(1-\tau_w\right)w}{\left(\begin{array}{c} \left(1-\alpha\right)\left(1+\tau_w\right)w + \left(1-\alpha\right)\tau_s A\left(\frac{r}{\varphi\theta(1-\tau_s)A}\right)^{\frac{\theta}{\theta-1}} + \\ \left(1-\alpha\right)\left(-\delta + r\right)\left(\frac{r}{\varphi\theta(1-\tau_s)A}\right)^{\frac{1}{\theta-1}} + \alpha\left(1-\tau_w\right)w \end{array}\right)}$$

Consumption

Start with the ratio of the consumer's FOCs with respect to consumption and leisure given in 2.5 and 2.6.

$$c = \frac{(1-l)\,(1-\tau_w)\,\alpha w}{(1-\alpha)}$$

Then substitute in the solution for labor, wage rate, and rental rate of capital.[2]

$$c = 1 - \left(\frac{\alpha\,(1-\tau_w)\,w\left(1-\tau_w^h\right)\alpha w\,(1-\alpha)^{-1}}{\left\{(1-\alpha)\,w + (1-\alpha)\,\tau_s A\left(\frac{r}{\theta(1-\tau_s)A}\right)^{\frac{\theta}{\theta-1}} + (1-\alpha)\,(-\delta+r)\left(\frac{r}{\theta(1-\tau_s)A}\right)^{\frac{1}{\theta-1}} + \alpha\,(1-\tau_w)\,w\right\}} \right) \tag{2.13}$$

Capital

Start with the firm's FOCs with respect to capital and then substitute in the solution for labor, wage rate and rental rate of capital.[3]

$$k = \left[\frac{\alpha\,(1-\tau_w)\,w\left(\frac{r}{\theta(1-\tau_s)A}\right)^{\frac{1}{\theta-1}}}{(1-\alpha)\,w + (1-\alpha)\,\tau_s A\left(\frac{r}{\theta(1-\tau_s)A}\right)^{\frac{\theta}{\theta-1}} + (1-\alpha)\,(-\delta+r)\left(\frac{r}{\theta(1-\tau_s)A}\right)^{\frac{1}{\theta-1}} + \alpha\,(1-\tau_w)\,w} \right]$$

[2] Only the solution for labor is substituted here.
[3] Only the solution for labor is substituted here.

CHAPTER 3. Calibrating the Model for Simulations

The purpose of the dynamic general equilibrium model just constructed is to give some insight into how taxes affect economic health and social well-being. To do this, the model's parameters are fitted with values reflecting the economic environment of a state in the United States. The productivity elasticity of each tax levy can be estimated and compared to empirical model estimates in chapter 8. The next chapter discusses the tax effects on productivity, gross domestic product, and household welfare summarized in table 4.1.

3.1 Substituting values for model parameters

The productivity elasticity of a tax estimated from the theoretical model depends on the values given to model parameters representing multi-factor productivity, A, output elasticity of capital, θ, household elasticity of consumption, α, the household's discount factor β, and depreciation rate δ. The bounds given for these parameters in the model's construction are not restrictive enough to draw any direct conclusions about which tax levies are less distortive than others. For this reason, model parameters are given a stricter range of admissible values meant to better represent the economic reality of the United States from 1977 to 2004.

Multi-factor productivity, A, is measured by the Bureau of Labor statistics (BLS) as a growth rate. This model includes A, but only as a level. The level of A captures all the other factors of production besides capital and labor, such as human capital and technology which affect the representative firm's production capability. The level of A does not change in this model and can therefore not be fitted with values estimated by the BLS. For this reason, multi-factor productivity is given the neutral value of 1. This value is neutral because the elasticities calculated in the next chapter are not affected by the value of A.

Output elasticity of capital, θ, for a typical firm in the United States is estimated by Romer (1994) to be between .3 and .4.[1] These values determine how marginal output is affected by changes in the firm's inputs, labor and capital. These values imply that if capital is increased by 1%, output increases between .3% and .4%. Output elasticity of labor is equal to $(1-\theta)$. Therefore output elasticity of labor is estimated to be between .6 and .7.[2] If labor increases by 1%, output increases by .6% to .7%. The value of θ does not change the direction (first derivative) of the relationship between taxes and the model's endogenous variables. However, the concavity/convexity (second derivative) of the relationship between tax rates and model's endogenous variables is often sensitive to changes in the value of θ. For example, the second derivative of the wage rate with respect to the capital income tax, given in equation 3.1, shows that if θ is less than .5, the sign is negative.

$$\frac{\partial" w}{\partial \tau_k"} = \frac{\theta^3 \left(-1+\frac{\theta}{1-\theta}\right)\left(\frac{\theta(1-\tau_k)}{-1+(1/\beta)+\delta+\tau_p}\right)^{-1+\frac{\theta}{1-\theta}} \left(A*(1-\tau_s)\right)^{\frac{1}{1-\theta}}}{\left(-1+\frac{1}{\beta}+\delta+\tau_p\right)^2} \left\{\begin{array}{c} <0\, if\, \theta<.5 \\ >0\, if\, \theta>.5 \\ =0\, if\, \theta=.5 \end{array}\right\} \tag{3.1}$$

If θ is less than .5, an increase in the capital income tax rate decreases the wage rate but at a *decreasing* rate. If θ is greater than .5, an increase in the capital income tax rate decreases the wage rate at an *increasing* rate. Assuming θ to be greater than .5 will change the sign of the second derivative of endogenous variables with respect to tax rates in many cases.

Restricting the household elasticity of consumption, α, to any particular value between zero and one does not affect the sign of the second derivative of endogenous variables with respect to tax rates. The value of α is assumed to be the neutral value of 0.5, giving equal preference to consumption and leisure all else equal.

A wide range of values could be used for the household's discount factor, β, with at least some empirical support. Frederick (2002) compiles a list of studies estimating β factors with

[1] Romer (1999), finds .4 to be a good estimate for θ but also finds this number to be "a bit smaller" for industrialized countries. This work assumes "a bit smaller" to mean .3.

[2] The cobb-douglas form has constant returns to scale; scaling inputs by X scales outputs by X.

estimates ranging from 0 to 1.06. The variation in these estimates can be mostly explained by the time horizon used in the study, the shortest being only a few days, the longest being 57 years.[3] Studies with time horizons longer than a few years estimate β to be between .9 and .97. This model's household lives forever making the range of .9 to .97 more suitable than estimates under shorter time horizons. The parameter β is nothing more than a scalar in the model's solution and does not change the signs of any of the first or second derivatives of endogenous variables with respect to tax rates.

Empirical estimates for the depreciation rate, δ, depend on the type of capital in question. The household's capital stock is its wealth which it loans to the firm. The capital good can be effortlessly transformed from a consumable good into an input for production implying that the good is not physical and resembles something like cash or corn. However, to reflect the nature of capital in the United States, the household's capital stock is assumed to be a physical capital. Estimates of physical capital depreciation, δ, range from .034 and .126, meaning that the capital stock looses around 8% of its value every year. This range of estimates is based on five studies at different points in the time period used in the empirical analysis, 1977 - 2004.[4] Changing the value of δ does not change the sign of the first or second derivatives of endogenous variables with respect to tax rates. Details on how parameter values affect the endogenous variables of the model are discussed in appendix A.

Estimating historical tax rates

The marginal effect of a tax on productivity is a function of its own rate. For this reason, a proper comparison between results from the theoretical model and the empirical models requires that the theoretical model be fitted with the tax parameters equal to average tax rates for the United States from 1977 to 2004. This requires an estimate for both the federal and state rates on income, property, consumption, and capital gains.

The Congressional Budget Office estimates the average effective federal income tax rate for the years 1979 - 2004 to be 10.36%. Department of Treasury has estimates for the capital gains

[3] All studies normalized beta to a period of one year.

[4] Nadiri (1993), Musgrave (1992), Bischoff (1987), Kollintzas (1985), and Epstein (1980)

effective tax rates for the years 1977 - 2004. These federal estimates are added together with average effective state and local tax rates using tax receipts per percent income for taxes on income, sales plus excise, and property. The capital gains estimate for effective tax rate uses the average maximum marginal rate from 1977 to 2004. Using these estimates, the average effective tax rate imposed at the federal, state and local level for income, wealth, sales plus excise and capital gains are 12.2%, 3.7%, 3.4% and 23.4% respectively. These taxes rates are assumed to be roughly analogous to the tax levies in the model.

CHAPTER 4. Theoretical Model Results

The purpose of the theoretical model is to estimate the cost of taxes on income, consumption, property, and capital gains. Labor productivity, defined as output per unit of labor, is the primary metric of interest in estimating the cost of each tax. The productivity elasticity for a 10% increase in each tax (say 5% to 5.5%) is summarized in table 4.1. Model parameters A, θ, α, β, and δ are given the "Average"[1] values 1, .35, .5, .935, and .08 respectively. Tax parameters are given values nearly equal to the average effective tax rates faced by a typical American household, aggregating tax rates at the federal, state, and local level.[2]

Two additional metrics for quantifying the cost of the four tax levies are included in table 4.1. These metrics are called household welfare and gross domestic product. All three measures are used repeatedly throughout the literature on tax policy as a means of quantifying economic health and social well-being. Additional sets of model parameter values are also included in table 4.1 to test the robustness of results calculated using an average of the parameter values calculated in chapter 3.

4.1 Productivity, household welfare, and gross domestic product

Productivity

Productivity is average output produced by a state per unit of labor. Productivity is proportional to the wage rate.

$$w = (1-\theta)\left((1-\tau_s)A\right)^{\frac{1}{1-\theta}} \left(\frac{\theta\,(1-\tau_k)}{(\beta^{-1}-1+\delta+\tau_p)}\right)^{\frac{\theta}{1-\theta}}$$

[1] Average because, as noted in chapter 3, these values are calculated by taking the average of multiple estimates found in the state growth literature for substituting with model parameters.

[2] There is a slight variation in this aggregation for each tax rate. See chapter 3 for details.

Productivity equals total output divided by labor.

$$\frac{Y}{l} = \left(\left(1 - \tau_s\right) A\right)^{\frac{1}{1-\theta}} \left(\frac{\theta\left(1 - \tau_k\right)}{\beta^{-1} - 1 + \delta + \tau_p}\right)^{\frac{\theta}{1-\theta}}$$

Of the four tax levies addressed by the model, all negatively affect labor productivity except for the wage income tax. This result is not robust to alternative forms of the production function.

Household welfare

Welfare is the total utility of the household plus firm profits. By assumption, the firm always makes zero profits. Household Welfare is given by the utility function.

$$U = \beta^t \left(c_t\right)^{\alpha} \left(1 - l_t\right)^{(1-\alpha)} \tag{4.1}$$

Gross domestic product

Starting in 1992, United States used gross domestic product (GDP) in its national accounts. GDP is the total value of all final goods and services produced in the economy. The capital, k, rented to the firm is not a final service since it is used in the production of Y. The only final good or service produced in the economy is Y. Therefore, real GDP can be calculated as the value of the firm's total output.

$$GDP_{real} = A\left(k_t\right)^{\theta} \left(l_t\right)^{1-\theta} = Y \tag{4.2}$$

GDP can also be constructed from the expenditure side.[3]

$$GDP_{real} = c + \delta * k = Y$$

The United States used Gross National Product (GNP) in its national accounts until 1992.

[3] In the steady state the total amount of capital, k, does not change from period to period. That is why the additional capital savings rate equals the depreciation rate.

While GDP measures the total product of the country, GNP measures the total output of people from a country. There is only a difference between GDP and GNP when citizens of the state produce goods or services abroad, or when foreigners produce goods or services in the state. GDP and GNP are the same in this model because there is only one state.

4.2 Elasticities of welfare measures and tax levies

Three simulations

Using current tax rates, the model estimates the productivity elasticity of taxes on income, property, consumption, and capital gains. Three different sets of model parameters are used to gauge the robustness of results. The first simulation is called the "Average" because it substitutes model parameters A, θ, α, β, and δ with an average of estimates for the parameters cited in the literature.[4] For example, estimates for the depreciation rate for physical capital, δ, range from .034 to .126. The "Average" model assumes a depreciation rate of $(.034 + .126)/2 =$ .08. The two other simulations, called the "High" and "Low", substitute model parameters with the most extreme estimates found in the literature to gauge the sensitivity of results from the simulation using "Average" parameter estimates. The low model does not use the smallest value cited in the literature, but instead uses the value that minimizes the productivity elasticities of the tax levies. The "Average" simulation substitutes parameters A, θ, α, β, and δ with values 1, .35, .5, .935, and .08 respectively.

A ranking of which tax is most disruptive is not sensitive to the values given to model parameters within the range being considered. However, the magnitude of the marginal effects are sensitive. The highs for all elasticities occur when model parameters A, θ, α, β, and δ are assumed to be 1, .4, .4, .97, and .034 respectively. The lows for all elasticities occur when model parameters A, θ, α, β, and δ are assumed to be 1, .3, .6, .9, and .126 respectively. No other set of model parameters are necessary because the "High" and "Low" set of model parameters exhaust the range of estimates that can be made from parameter estimates cited

[4] Average because, as noted in chapter 3, these values are calculated by taking the average of multiple estimates found in the state growth literature for substituting with model parameters.

from the literature. For example, all tax effects increase if depreciation rates are assumed to be lower. Thus, the "Low" set of model parameters uses .034 as the depreciation rate, the lowest estimate for depreciation cited in the state growth literature.

A ranking of which tax is most disruptive is only marginally sensitive to different metrics used to measure economic health and social well-being. Taxes on capital gains and property are always ranked as being more disruptive than taxes on income or consumption. For instance, the elasticity of gross domestic product with "High" parameter values finds that a 10% increase in taxes on wealth (say from 5% to 5.5%) will cause gross domestic product to fall by 2.14%. This estimate is greater than the estimated drop in gross domestic product from the same increase in taxes on capital gains, a drop of only 1.85%. All measures of economic health and social well-being find taxes on capital gains to be more costly than taxes on wealth. Differences in estimates from one metric to the next emphasize the importance of testing one's definition of economic health and social well-being.

Metric		**Productivity**			**GDP**			**Welfare**	
Parameter Set	**Low**	**Avg**	**High**	**Low**	**Avg**	**High**	**Low**	**Avg**	**High**
Income*	-0.20%	-0.25%	-0.31%	-0.18%	-0.42%	-0.69%	-0.22%	-0.25%	-0.26%
Consumption	-0.51%	-0.55%	-0.59%	-0.12%	-0.22%	-0.33%	-0.11%	-0.12%	-0.13%
Capital Income	-1.32%	-1.65%	-2.04%	-1.02%	-1.38%	-1.85%	-0.62%	-0.69%	-0.73%
Wealth	-0.58%	-1.06%	-2.36%	-0.44%	-0.89%	-2.14%	-0.27%	-0.44%	-0.85%

Table 4.1 **Metric elasticities of tax levies:** Each tax rate is increased by 10% in order to calculate the metric's elasticity, where a 10% increase in a tax rate of 5% is 5.5%, not 15%. *Income in the United States is composed of both wage income and short term capital gains. To adjust for this fact, all tax effects on income are defined as a weighted average of effects on capital income and wage income such that income = 84.7% wage income + 15.3% capital income; The values come from a report by taxfoundation.org for the year 2005.

CHAPTER 5. Discussion of Theoretical Model Assumptions

This model is designed to give insights into how each tax levy affects productivity by creating market distortions. In order to focus on this goal many assumptions are made; some more realistic than others. This section discusses the stronger assumptions used to simplify the model and how these simplifications may bias the results.

5.1 Exogenous taxes

Chari (1999) and Chamley (1986) both endogenize tax rates by adding a government. The government chooses tax rates that maximize some function, usually a welfare function. By endogenizing tax rates they are able to make an argument for which tax policy is the “best” with the best tax policy being the one that maximizes some welfare function.

The purpose of the theoretical model is to quantify and compare the market distortions caused by taxes on wage income, wealth, consumption and capital income. To isolate these distortionary effects, the positive effects of government spending are removed from the model. In this way, the cost of each tax levy can be compared using a variety of measures for economic health and social well-being. Any model that utilizes a government agent must give the agent a clear optimization problem. Only one measure for economic health or social well-being can be used in such a problem. By not using a government agent, this model can evaluate the effects of different tax policies using multiple measures for economic health and social well-being. By incorporating multiple definitions of social well-being, this methods approach adds an additional robustness check to the results.

5.2 Firms can not buy capital

Firms are not given the option of buying their own capital. If firms had a choice, the household would lose its monopoly on capital. This model sets the rental rate of capital independent of firm demand. Changing the firm's demand for capital would therefore have no effect on the rental rate of capital. It would mean that the household could not rent all its capital to the firm. With no benefits from saving beyond what can be rented, the household will consume more in the present, decreasing its savings rate.

5.3 Household savings must be invested

Household savings are rented to the firm at an interest rate r. The household is assumed to have no other options for storing its wealth other than investing. In reality, only a portion of a household's savings are invested. By assuming all savings are invested, productivity is overestimated. This assumption also magnifies the effect of the wealth tax because taxes on wealth are taken away from firm.

5.4 Taxes are paid back in a lump sum rebate

To isolate the distortionary effects of taxes, the positive effects of government spending are removed from the model. The benefits of public goods and services could be included in a number of different ways. Instead of giving back tax receipts in a lump sum rebate, receipts could also be invested in a public good, ρ, that would enter into the household's utility function.

$$\sum_{t=0}^{\infty} \beta^t U^i(c_t^i, 1 - l_t^i, \rho^i) \tag{5.1}$$

The addition of a public good would, by construction, require some level of government investment in the public good in order for the household to receive any utility at all.

Governments could also be allowed to invest in infrastructure, Ω.[1] Spending on infrastruc-

[1] Either alternative treatment of tax receipts could be used in conjunction with the other. A most realistic treatment would be to split government tax receipts into spending on public works, infrastructure and lump sum rebates.

ture could be modeled into the firm production function.

$$Y(k, l, \Omega) \tag{5.2}$$

Modeling publicly funded infrastructure in this way halts any firm production unless some tax receipts are invested in infrastructure.[2] Mofidi (1990) argues that ignoring the role of government spending assumes away any rationale for having taxes in the first place. With no difference between the government giving back all tax receipts and government spending, the role of government is reduced to an inhibitor of otherwise efficient markets. Chari (1999) and Chamley (1986) also assume receipts are given back in a lump sum.

5.5 Other assumptions

Market efficiency

In this economy, both the labor and capital markets are efficient. If markets are not efficient then one could argue that the government has a duty to try to fix it. This is the argument that president George W. Bush made to the congressional leadership on September 25^{th}, 2008. The United States federal government passed a bill giving them the power to spend upwards of 700 billion dollars to buy up sub-prime mortgage related assets in order to ease the credit crunch. Such a strong government role in the financial markets would not be necessary if markets were naturally efficient.

Market efficiency is a by-product of perfect information and other assumptions. A household will only insure itself against unforeseen losses if it faces uncertainty and a decreasing returns to scale utility function. This model's household faces neither, and the effect is an underestimation of the savings rate. Lower savings causes lower productivity.

All these alternatives, however, make the mathematics much more complicated.

[2] Examples of infrastructure might include roads, property rights, and a fair judicial process.

Income equality

In the real world, investment comes primarily from those households with wealth. One could argue that having a concentration of wealth in an economy helps investment. This model has only one household and therefore ignores the issue of income inequality along with other issues associated with assuming that heterogenous households can be modeled as a representative agent.

Balanced budget

Households and firms are not allowed to borrow. In the steady state, this simplification should not be as much of an issue since neither agent will be in perpetual debt.

Homogenous human capital

Using a single representative household assumes that there is only one level of human capital. The model assumes that only the mean level of human capital is important in determining productivity. Yu (2008) shows that varying degrees of human capital at the firm level can have an effect which is not entirely captured by the mean.

CHAPTER 6. The Empirical Model

6.1 The ideal empirical model

The purpose of this section is to build an empirical model that accurately characterizes all the relevant factors of a state that influence the value of labor within that state. The value of labor is of interest because the value of labor largely determines the wage rate received for the labor. A higher wage rate means a higher quality of life, or at least a more comfortable one. The ideal model would use a measure for the value of labor that includes the jobs in a state including those often overlooked but very important jobs around the house like cooking, cleaning, and raising children. This measure for the value of labor would also discount labor used in the production of goods that cause pollution or otherwise harm the environment. The ideal model would then regress this perfect measure for the value of labor on perfect measures for a state's tax policy as well as other relevant characteristics of a state that influence the state's value of labor. The models constructed in this section attempt to emulate the ideal model just described, but will, like all empirical models, ultimately be restricted by less than ideal measures for the value of labor and other state characteristics. Even without perfect measures the results of the models constructed do give at least some insights into how each state can create a more efficient tax policy.

The value of a unit of labor is not necessarily easy to quantify. Trouble begins with defining the word "value". If the "value" of labor is taken to mean the market value then a measure called productivity is most useful. Productivity is a common measure of the market value of labor and is calculated by dividing gross national product (GDP) by the total number of hours worked in the United States. A state version of productivity divides gross state product (GSP) by the working population.[1] Productivity, however, is not a perfect measure of the value of labor. GSP does not include many forms of labor that most certainly have value like cooking at home. GSP also fails to discount labor used in the production of goods that harm the environment or use up non-renewable resources. Productivity, even with all its shortcomings, is used in this study because it is the best measure of the value of labor for which there is data.

A number of characteristics important in determining a state's value of labor have already been identified in previous research. These characteristics include education, urbanization, technology, capital, and many others. Each characteristic represents a concept that in itself is not always easy to quantify. Take education for example. Without question, a more educated individual can create more value per unit of labor than an uneducated one, all else equal; but what is the best way to measure a state's level of education? The ideal measure would include all forms of education including experiences on the job and leisure study at home. Of course, no such measure exists. The measure typically used in the state growth literature relies on aspects of education that are easily quantifiable such as the the percent of a state's population that graduated from high school. This measure ignores any knowledge they picked up at home or on the job, but probably a good indicator of all other aspects of education that a more perfect measure would capture. Every empirical modeler must substitute less than perfect control variables (like the percent of population with high school diplomas) for less quantifiable concepts (like education). These substitutions are useful because while the controls may not be perfect, a good one can capture the main idea of what it is trying to represent.

6.2 Constructing the base model

The purpose of the base model is to come as close to the ideal model at explaining the factors of a state's value of labor as possible given current availability of data. The base model regresses state labor productivity on four tax rates characterizing a state's tax policy and six controls. All measures are constructed from panel data of the 48 contiguous United States for

[1] Data on the total number of hours worked by state have also been made available by the Bureau of Labor Statistics for the years following 1999.

the years 1977 through 2004. The lower 48 states serve as a natural experiment in tax policy research. Each state is allowed to set its own tax policy including taxes on property, income, sales, excise, and capital gains. The null hypothesis of this experiment is that the value of labor in a state is not significantly affected by the differences in each state's tax policy. The alternative hypothesis is that each state's tax policy matters. The base model used for testing this hypothesis takes the following form.

$$w_{t+4} = \beta_0 + \sum_{y=1}^{4} \beta_y \left(\tau_y\right)_t + \sum_{n=5}^{10} \beta_n \left(C_{n-4}\right)_t + \sum_{m=11}^{57} \beta_m \left(S_{m-10}\right) + \sum_{j=58}^{84} \beta_j \left(Y_{j-58}\right)_t + \epsilon_t \qquad (6.1)$$

Labor productivity, w_{it}, is a scalar dependent variable for state i at time t. All controls are lagged by four years with intervening years omitted. Tax levies on property, income, sales, excise, and capital gains are represented by τ.[2] The model's six control groups represented by C include: percent of a state's population with a high school diploma plus the percent with a four year college degree,[3] percent of the population that is in the work force, manufacturing share of GSP, population density measured as people per square mile, union density measured as the percent of employees in a state who are members of a union, and an index of real energy prices. The variable S stands for the 47 binary variables used to control for state fixed effects. These effects include state characteristics like geography that do not change much over time. The variable Y represents the set of 27 year dummies used to capture national trends such as the business cycle, inflation, technology, and federal tax policy. The construction of every variable is explained in detail in the next chapter.

6.3 Overcoming autocorrelation and endogeneity

Most time series models have to overcome difficulties with autocorrelation and endogeneity. The base model just constructed is no exception. Autocorrelation refers to the correlation

[2]These tax rates are equivalent to the tax levies addressed in the theoretical model with one exception. Taxes on wage income in the theoretical model do not include income from capital gains while income taxes used in the base model include all capital gains from assets with a duration of less than one year.

[3]This value can add up to more than 100%.

between data points from year to year. Business cycles and trends in control variables tend to be highly correlated from year to year. This poses a technical problem for the regression model because the error term no longer follows a normal distribution. To reduce the amount of autocorrelation the base model uses only every fourth year with intermittent years omitted. This creates a break between years that significantly diminishes the correlation from period to period. Endogeneity refers to the possibility that policy makers take into account the current economic environment when making tax policy decisions. It is commonly thought among both policy makers and economists that tax rates should be lower during times of economic hardship. Having lower taxes is thought to stimulate growth.[4] For this reason, tax rates and controls are lagged by four years to the previous data point after omitting all but every fourth year in the base model. The possibility that labor productivity levels are actually causing changes in tax policy is reduced when the independent variables in the model are lagged.

There is also the question of how long it takes a change in tax policy to impact the economy, if there is significant impact at all. The answer to this question will depend on the tax levy in question. Most families don't have the flexibility to simply move in the year when property tax rates go up. Likewise, taxes on income may take longer than a year to significantly affect employee and employer decisions in the labor market. Most employees and employers can't easily take up jobs in another state or move their place of business overnight. On the other hand, taxes on consumption may have some effect immediately. This is especially likely for businesses near the border of another state with a smaller tax on sales. Chapter 8 includes alternative specifications of the base model that use lags from 2 to 6 years. These alternative specifications are used to show how robust the estimated effects of a state's tax policy are as well as provide a wider range of estimates.

Control groups are also suspect for endogeneity. The length of time that it takes for any particular control to affect productivity will depend on the controls in question. Some controls, like energy prices, may have immediate effects that would be better captured by a shorter lag, say one or two years. Other controls, perhaps union density, may have effects that take many

[4]For example, reducing taxes on sales encourages consumption. Reducing taxes on corporate profits encourages investment.

more years before its complete effect on productivity is actualized.

6.4 Method for choosing controls

Studies of how taxes effect any measure of the economy are notoriously sensitive to the selection of controls used in the regression model.[5] If a tax rate is correlated to both the omitted variable and productivity, the tax rates estimated effect on productivity will be biased. Including additional controls reduces the likelihood of omitted variable bias.

Crain and Lee (1999) implement an extreme-bounds analysis to assess the sensitivity of numerous control variables identified in the state growth literature. All the controls used in this study are taken directly from the study by Crain.

Crain recommends nine distinct control groups for inclusion in a state growth model. Of the nine groups, three are not included in this study. These three groups are *cultural/ethnic characteristics*, *fiscal policy*, and *public and private capital*. The first group is ignored because it isn't relevant in determining a state's value of labor. The second control group includes controls for a state's fiscal policy, but the proxies suggested by Crain are already controlled for by the state's tax policy.[6] A measure of a state's capital accumulation would cause problems for this model. If taxes affect productivity it will do so in part by reducing the capital invested in the state. Including capital as a control would diminish the tax effect on productivity by not allowing the tax effect on capital accumulation to take its toll of productivity.

The six remaining groups recommended by Crain are included in the base model. These control groups are called *education*, *size of work force*, *energy prices*, *industrial composition*, *pressure groups*, and *public choice*. Of these six control groups the first three include only one proxy to choose from, again referencing Crain. The last three groups contain three proxies each. For example, the three proxies proposed by Crain for controlling for a state's *industrial composition* include an index called industrial diversity, the manufacturing share of GSP, and service share of GSP. For those three groups that contain multiple proxies, only one proxy

[5] For example, Mofidi (1990) argues that government expenditures play a significant role in determining accurate tax effects on productivity.

[6] State tax expenditures are highly correlated with state tax revenues.

can ultimately be chosen for inclusion in the base model due to the high level of correlation between proxies in a group. No special analysis tool is used to choose from between the multiple proxies proposed by Crain in each control group. Each proxy is considered based only on its interpretability and relevance. A description and discussion of every proxy considered for the base model is included in the next chapter.

6.5 Discussion of unobservables

The base model includes six control groups, four tax rates, and dummies for states and years. However, there may still be important factors that are not controlled for in the base model. These factors could, by their omission, bias the estimated tax effects on productivity produced by the base model. The study conducted by Crain and Lee (1999) is used to narrow the scope of controls considered to only those that are the most relevant. The base model does not consider any other measures because Crain's analysis, which claims to be comprehensive, does not find any other measure to be relevant enough to include in his recommendation. Even still, the vast literature on tax policy includes many other variables that are not included in this analysis.

A nearly exhaustive literature review finds the following papers to include controls in a state growth model that were not used in this analysis. Glaeser (1992) uses a wider variety of controls for industrial composition that he finds to be significant. Barro (1996) finds lower fertility rates to increase productivity. Chirinko (2006) finds a relationship between capital and productivity. Modifi (1990) argues that government expenditures play a significant role in determining accurate tax effects on productivity, although doing so in this study would be difficult because tax collection and use have such a high correlation (ex. local property taxes typically fund local schools). Hseih (2006) strengthens the argument that costs of real investment hamper productivity. Bauer (2006) argues that "knowledge stocks", which include patents owned within the state in addition to human capital, are the biggest factor in determining productivity.

CHAPTER 7. Constructing Empirical Model Variables

This chapter outlines the construction of every variable used in the empirical section of the thesis. A complete list of data sources and summarized methods for constructing each variable considered for the empirical models can be found at the end of the chapter in table 7.3. Descriptive statistics for all variables can be found at the end of the chapter in table 7.2.

7.1 Constructing labor productivity

The Census Bureau defines labor productivity as gross domestic product per hour worked. Unfortunately, hourly data by state is unavailable. As a substitute, state gross domestic product is divided by the working population instead of total hours worked. For this approximation to be accurate, the average number of hours worked per working person must be equal across states.

Figure 7.1 shows how the average growth in state productivity, gross state product, and working population change over time from 1977 to 2004. The average state labor productivity growth rate was 1.26% with a range of 0.21% in Montana to 2.51% in Delaware. The standard deviation of average state growth rates in any given year is 2.48%. Productivity growth rates for any one year range from -11.08% in Wyoming (1985) to 17.64% in North Dakota (1980).

Productivity has a smaller average growth rate than gross domestic product because of the 1.88% average growth rate in the working population. In a single year, average productivity growth got as low as -1% from 1981 to 1982, and as high as 3.46% from 1983 to 1984. The volatility of state productivity has decreased since 1984.

Bauer (2006) discusses the construction and summary of state productivity data for the years 1977 - 2004 in more detail.

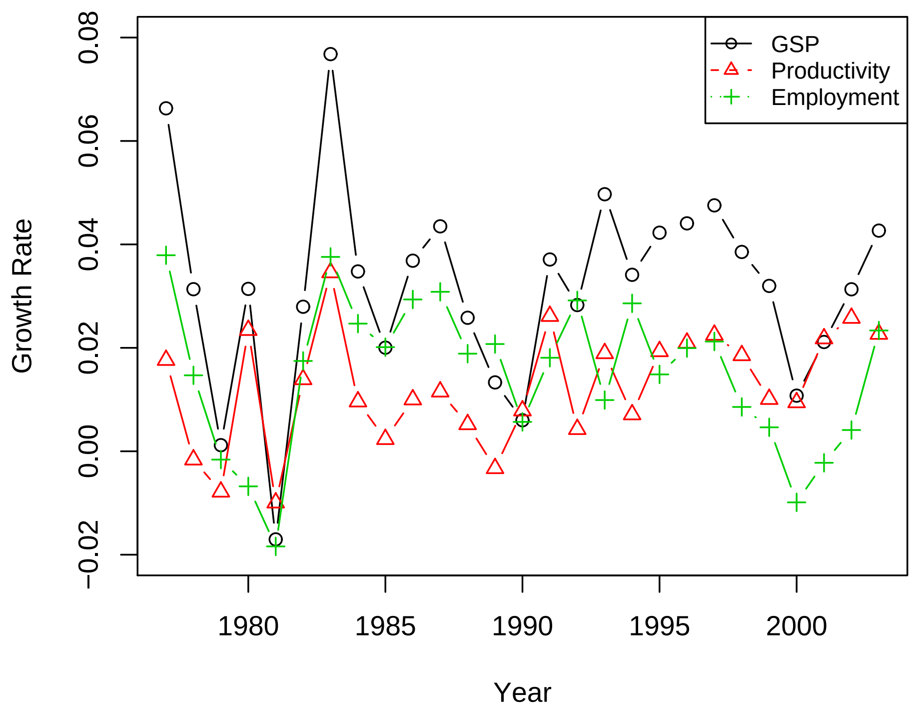

Figure 7.1 **Average productivity over time:** Each data point is the average of the 48 contiguous United States. A state's productivity is calculated by dividing gross state product by the state's working population.

7.2 Constructing a state's tax policy

State and local governments are free to make up whatever tax laws they see fit within fairly loose bounds set by the federal government. The result is a plethora of different tax laws and little hope of a simple tax proxy. Households and firms are subject to different tax rates and exemptions. Loopholes and fine print are plentiful enough for many lifetimes of study.

The purpose of this section is to construct measures for tax levies on income, property, capital gains, and consumption that are meaningful and as close to capturing the average marginal tax rate faced by households and firms in each state as possible. Taxes on income and capital gains are proxied by maximum marginal rates imposed by the state. Taxes on property and consumption are proxied by a rate roughly proportional to the average effective rate. Taxes on corporate profits are controlled for using a dummy variable for if the state imposes any corporate taxes at all. Table 7.4 summarizes each state's choice to use the five tax levies considered in this analysis.

Capital gains

The proxy used for the capital gains tax rate is the maximum marginal rate imposed at the state level. The maximum rate must be a good indicator of other rates for this measure to be an unbiased estimator of the underlying effective marginal tax rate. If some states have extremely high maximum tax rates relative to their other rates, such as their minimum rate, this estimator will consistently overestimate the average marginal capital gains tax rate. For example, say a state has three tax brackets; 1% for people making less than \$10,000, 2% for people making between \$10,000 and \$1,000,000, and a maximum income tax rate of 10% for people making more than \$1,000,000. Using the maximum marginal tax rate of 10%, in this case, would not be a good indicator of the state's income tax rate. This is an extreme case. Marginal tax rates generally increase, but do not usually "jump" as this example supposes.

Defining taxes on capital gains is complex because some capital gains are considered income, and thus subject to income taxes, while others fall under the capital gains tax. The definition of income has changed repeatedly since 1977. From 1979 to 1986 only 40% of short term capital gains were considered as part of income.[1] After the 1986 tax reform act, all short term capital gains were considered to be a part of income, however, long-term capital gains on assets sold after May 1997 fall under the capital gains tax. This issue is complex.[2]

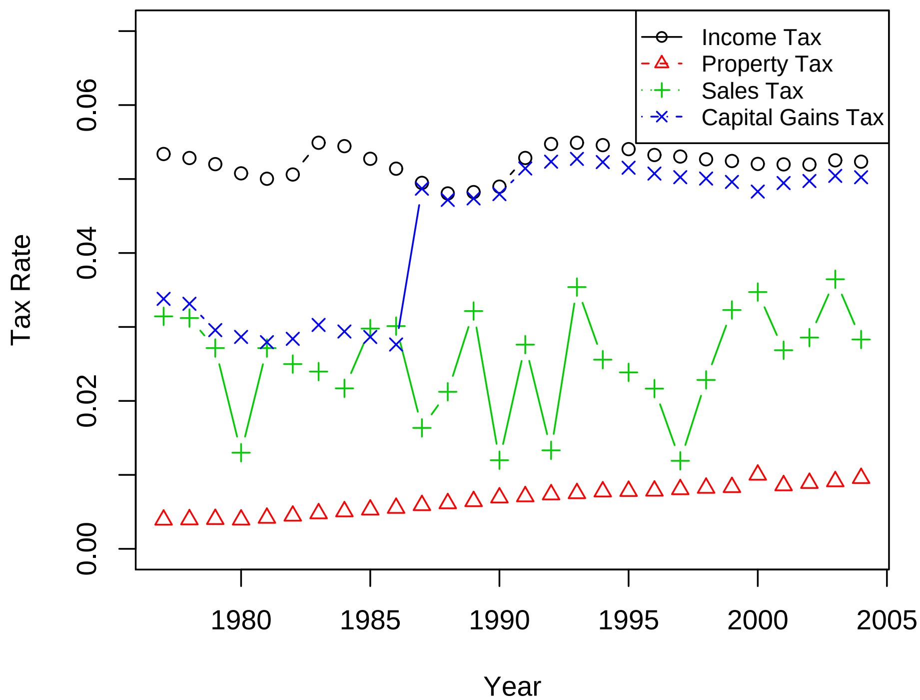

Figure 7.2 **Average state tax rates over time:** Each data point is the average tax rate of all 48 contiguous states in a given year. The jump in capital gains taxes in due to the tax reform act of 1986. The one year jump in the property tax rate is due to a one year drop in housing value that quickly recovered.

[1]Short term generally refers to assets that have a duration of less than one year
[2]For a detailed understanding of what is included in the income tax see Auten (1999).

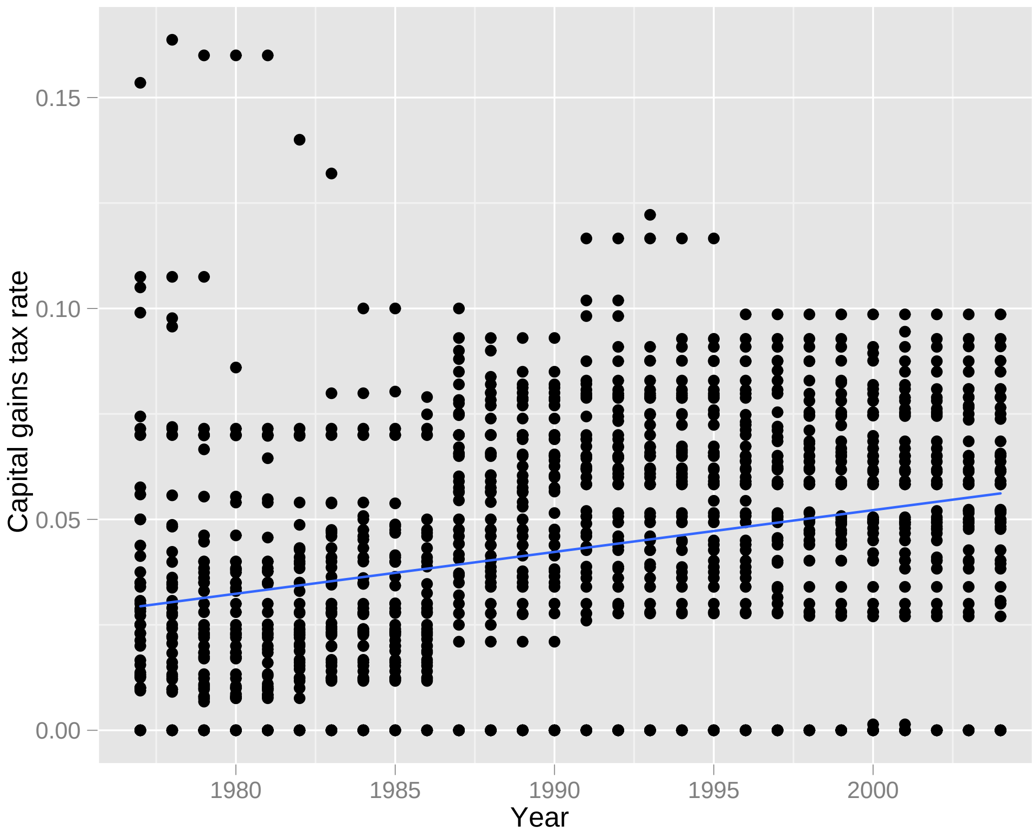

Figure 7.3 **Capital gains tax rates:** States without any tax on capital gains include Florida, Nevada, New Hampshire, South Dakota, Tennessee, Texas, Washington, and Wyoming. These states never levied a capital gains tax from 1977 to 2004. No other state removed their capital gains tax, even for a year. State level capital gains taxes have stayed below 12% except for Wisconsin whose capital gains tax rate rose to above 15% until 1982.

Corporate profits

Taxes on corporate profits are controlled for using a binary variable. If a state levies any taxes on corporate profits then the state receives a “1”. This measure is used because accurate marginal and average corporate tax rates could not be constructed given the current availability of data. Corporations often span multiple states. This makes it easy for them to take advantage of differences in each states tax code, and perhaps allocate more revenue to the lowest taxed states. If corporations regularly take advantage of differences in state tax codes, any constructed average using corporate tax revenues would be inaccurate. For these reasons this work controls for the effects of corporate taxes using a binary variable for whether the state levies any corporate income tax at all. The corporate tax dummy can only be included in a version of the empirical model that uses random instead of fixed state effects to avoid multicollinearity.

Income

The income tax rate is proxied by the maximum marginal income tax rate imposed at the state level. Capital gains taxes are also captured by the maximum marginal rate. Both measures ignore taxes levied at the county level. As previously mentioned, the definition of income has always included some amount of short term capital gains. Income also includes retirement benefits and small business income. Retirement benefits and small business income made up lass than 20% of the average household’s income in 2005.[3] The theoretical model definition of wage income does not include capital gains. To adjust for this fact, tax effects on wage income from the theoretical model are recalculated using a weighted average of capital income and wage income such that income = 84.7% wage income + 15.3% capital income.

The states without any tax on income are the same as those that don’t have a capital gains tax with the exception of Connecticut, which had an income tax from 1977 until 1990.

[3]The values come from a report by The Tax Foundation at www.taxfoundation.org for the year 2005.

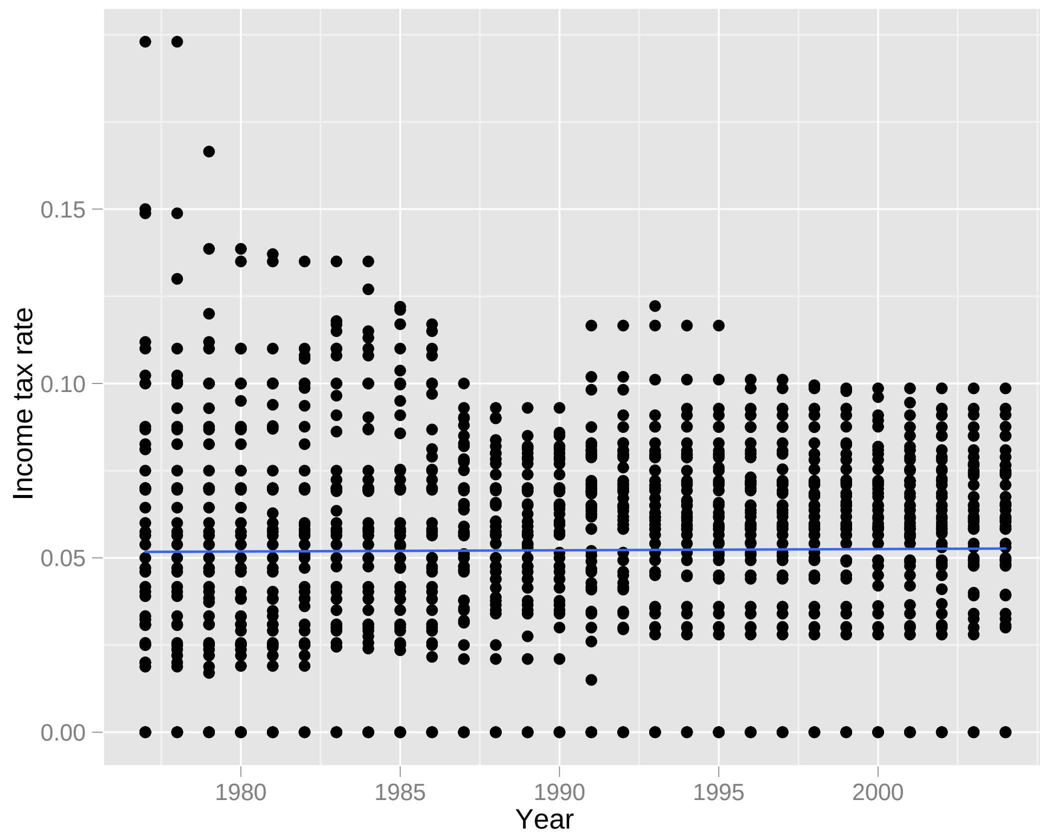

Figure 7.4 **Income tax rates:** The states without any tax on income are the same as those that don't have a capital gains tax. The only addition being the state of Connecticut which had an income tax from 1977 until 1990. Income tax rates at the state level have been under 12% for all states except for Delaware which had an income tax rate between 13% and 20% before 1985.

Sales plus excise

Sales and excise taxes are both taxes on consumption. For this reason, both rates are captured by one proxy. This is done by adding sales and excise receipts at the state and local level together. Sales plus excise tax receipts are then divided by total state income. The proxy for the sales plus excise tax rate is the average portion of total income spent on sales and excise taxes within a state. Figure 7.5 shows the sales plus excise tax rates to be more volatile than other tax rates because sales tax receipts are highly cyclical.

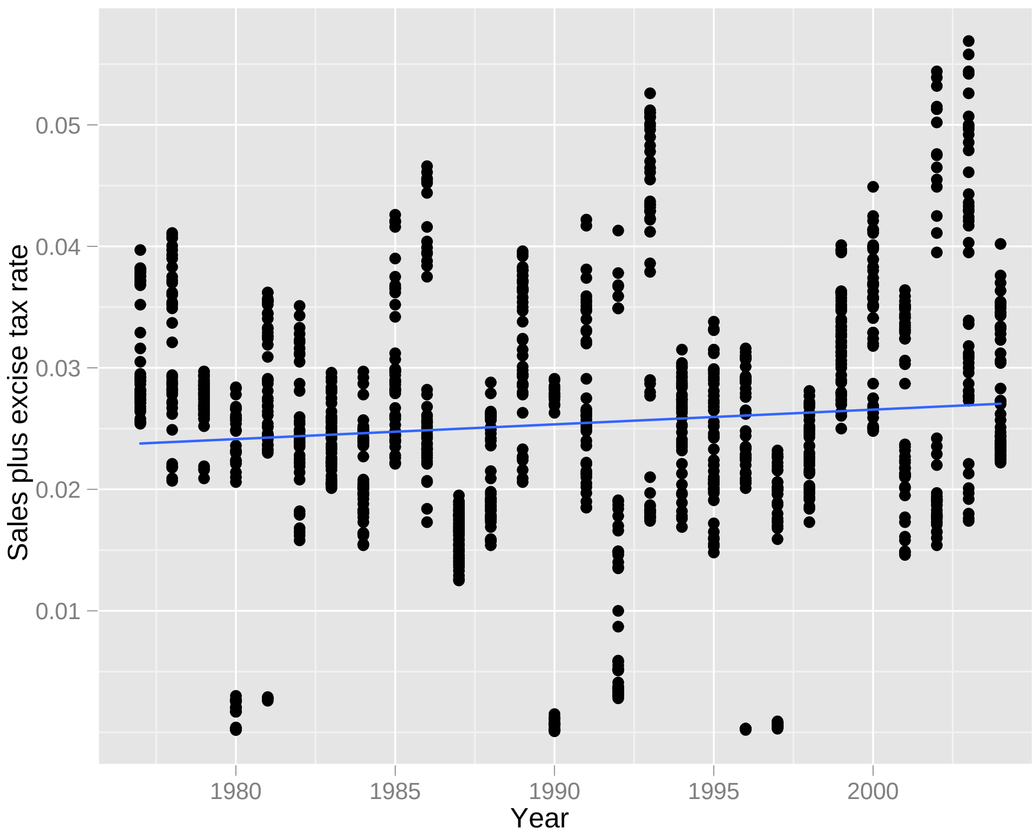

Figure 7.5 **Sales plus excise tax rates:** The spread of sales plus excise tax rates increased from 1977 to 2004.

Property

The proxy used for the property tax rate is an approximation of the state's average effective property tax rate. The property tax rate is calculated by dividing state and local property tax receipts by an approximation of the state's total value of property. A state's total value of property is approximated by the state's median home value, multiplied by the number of households in the state. This approximation underestimates the total value of a state's property because median home values are smaller than average. The census bureau does not report historical data on average home values.

This ranking of state's based on their property tax rate for the year 2004 is compared to a ranking made by Siniavskaia (2007), who estimates property tax rates for the year 2005. Siniavskaia's ranking divides median property tax receipts by median home value. This calculation of a property tax rate is both accurate and easily interpretable. Unfortunately, this calculation cannot be made for all the years in this data set given the lack of data on median tax receipts. However, this problem does not seem to prevent this work's calculation from producing a similar result. The correlation between Siniavskaia's ranking and this work's ranking is .75. The correlation between Siniavskaia's property tax rates and this work's rates is .74. These comparison's are summarized in table 7.1 below. The difference of one year between when Siniavskaia's rankings are estimated and this work's estimation is negligible. Even if the difference were significant, it would only mean that this work's measure for property taxes likely has an even higher correlation with Siniavskaia's rankings.

State	Siniavskaia's Rate* (2005)	Our rate (2004)	Siniavskaia's Ranking	Our Ranking
Alabama	0.31%	1.01%	49	48
Arizona	0.61%	2.09%	37	25
Arkansas	0.53%	1.27%	42	45
California	0.48%	1.27%	45	38
Colorado	0.58%	1.65%	38	35
Connecticut	1.42%	2.71%	10	13
Delaware	0.40%	1.06%	47	47
Florida	0.79%	2.65%	28	17
Georgia	0.71%	2.19%	32	23
Idaho	0.91%	2.09%	24	29
Illinois	1.58%	2.64%	7	15
Indiana	0.94%	2.41%	23	20
Iowa	1.27%	2.86%	12	14
Kansas	1.24%	3.26%	13	6
Kentucky	0.67%	1.35%	36	44
Louisiana	0.17%	1.38%	51	42
Maine	1.12%	3.54%	18	4
Maryland	0.77%	1.86%	29	31
Massachusetts	0.82%	1.90%	25	26
Michigan	1.24%	2.38%	14	21
Minnesota	0.81%	1.92%	27	33
Mississippi	0.50%	2.10%	44	30
Missouri	0.82%	1.89%	26	32
Montana	1.00%	2.43%	20	19
Nebraska	1.67%	2.95%	3	9
Nevada	0.51%	2.17%	43	18
New Hampshire	1.63%	3.55%	5	2
New Jersey	1.60%	3.10%	6	7
New Mexico	0.56%	1.09%	40	46
New York	1.19%	2.71%	16	3
North Carolina	0.76%	1.67%	30	37
North Dakota	1.50%	2.54%	8	16
Ohio	1.23%	2.10%	15	27
Oklahoma	0.71%	1.51%	31	39
Oregon	0.95%	1.60%	22	34
Pennsylvania	1.47%	2.31%	9	22
Rhode Island	1.09%	2.79%	19	8
South Carolina	0.57%	2.29%	39	24
South Dakota	1.38%	2.74%	11	12
Tennessee	0.70%	1.55%	33	40
Texas	1.82%	4.20%	2	1
Utah	0.68%	1.53%	34	41
Vermont	1.64%	3.08%	4	10
Virginia	0.67%	2.02%	35	28
Washington	0.99%	1.55%	21	36
West Virginia	0.46%	1.49%	46	43
Wisconsin	1.82%	2.83%	1	11
Wyoming	0.55%	3.32%	41	5

Table 7.1 **Testing the accuracy of the property tax rate:** Natalia Siniavskaia's (2007) study on property tax rates uses median tax receipt as a percent of median home value for the year 2005. The correlation between our estimates and Siniavskaia's is .756 for the rates and .745 for the rankings.

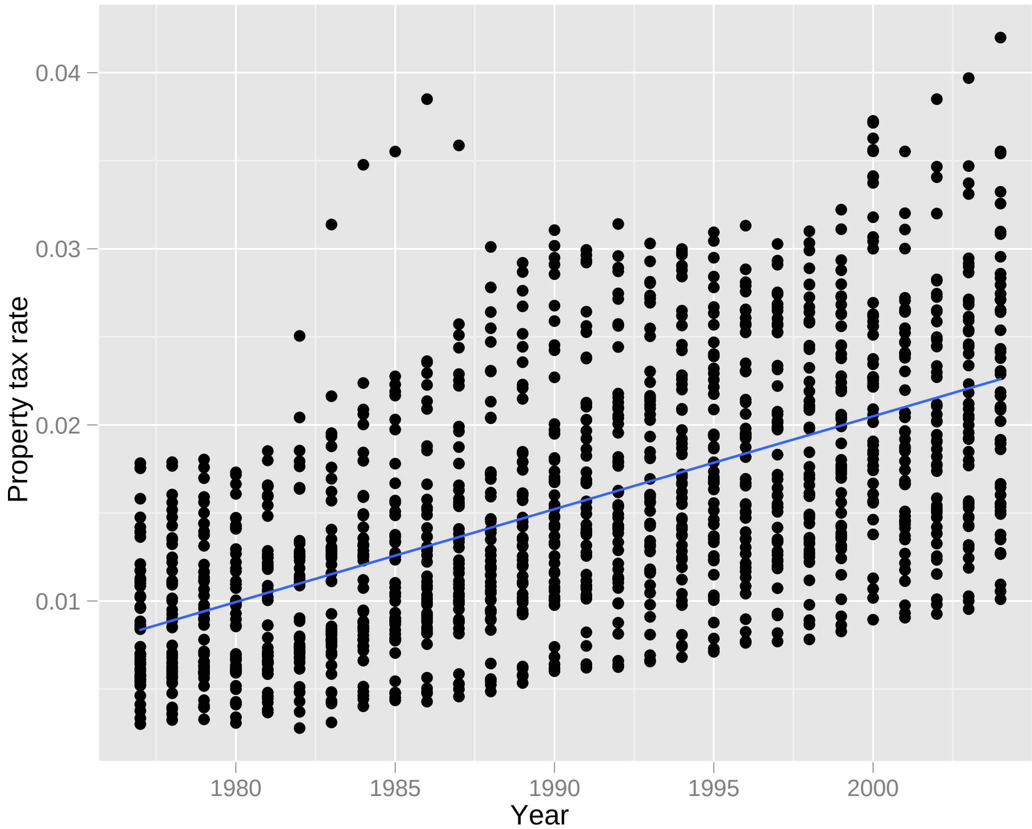

Figure 7.6 **Property tax rates:** As a group, states have increased their property tax rates steadily from 1977 to 2004. Wyoming is the exception, having a property tax rate higher than 6% in 1986. All average state property tax rates have been under 2%, although individual counties may have higher rates.

7.3 Constructing proxies for control groups

Six characteristics of each state are controlled for including education, size of work force, industrial composition, pressure groups, public choice, and energy prices in addition to year and state dummies. These controls are suggested by Crain (1999) who conducts an extreme-bounds analysis to estimate the sensitivity of control variables commonly cited in the state growth literature. Twelve controls are defined and discussed in this section.

Education and size of work force

Crain recommends using controls for education and the size of the state's work force. Work force size is the percent of the total population between the ages 18 and 64. Education is the sum of high school and four year college graduates as a percent of the total population. This aggregation of high school and college graduates allows the percentage to exceed 100%. Both measures are used in the base model.

Industrial composition

Crain suggests three measures of industrial composition including industrial diversity, share of gross state product (GSP) from the manufacturing sector, and share of GSP from services. Industrial diversity is computed using the formula below. The more GSP is evenly spread across sectors the smaller the indicator. Manufacturing and service share of GSP is the portion of GSP produced in that sector.

$$\begin{aligned} Diversity \quad = \quad & \left(\frac{MiningGSP}{PivateIndustry}\right)^2 + \left(\frac{ConstructionGSP}{PrivateIndustryGSP}\right)^2 + \left(\frac{ManufacturingGSP}{PrivateIndustryGSP}\right)^2 + \\ & \left(\frac{Transportation\&UtilitiesGSP}{PrivateIndustryGSP}\right)^2 + \left(\frac{Wholesale\&RetailTradeGSP}{PrivateIndustryGSP}\right)^2 + \\ & \left(\frac{FIREGSP}{PrivateIndustryGSP}\right)^2 + \left(\frac{ServiceGSP}{PrivateIndustryGSP}\right)^2 \end{aligned}$$

Of the three measures for industrial composition, only the share of GSP from manufacturing is used in the base model. The primary reason for this is that the interpretation is straightforward and not nearly as complicated to define as the index for industrial diversity. Share of GSP from the service sector is also straight forward to interpret, but only one measure can be used.

Pressure groups

All the pressure groups analyzed in Crain (1999) are related to unions and include the existence of right-to-work laws, union membership density, and union membership coverage. Right-to-work laws prevent unions and employers from forcing all employees to pay union membership fees. A total of 18 states had right-to-work laws in 1977. Since then, Idaho, Oklahoma and Texas have passed right-to-work laws as well. Union membership density is the percent of each state's non-agricultural employees who are union members. Union membership coverage is the percentage of each state's non-agricultural employees who are covered by a collective bargaining agreement.[4] Union membership density is the variable used to control for pressure groups in the base model. Its definition is simple and it carries more information than a dummy variable like right-to-work laws.

Public choice

Crain suggests three proxies for the control group public choice including population density, urbanization, and interstate commuting. Population density is the number of people per square mile. Urbanization is the percent of the population that is in an urban setting. The definition of interstate commuting is not clear from Crain (1999) and is therefore dropped from consideration. Population density is used in the base model over urbanization because its calculation does not rely on arbitrary cut-off for defining an area as urban versus rural.

Energy prices

Crain suggests only one proxy for energy prices. The energy price proxy is calculated using prices of fuel and electricity for the industrial sector. The precise calculation is explained

[4] Barry T. Hirsch, David A. Macpherson, and Wayne G. Vroman (2001) originally compiled these estimates.

by the United States Energy Information Administration,www.eia.doe.gov/emeu/sep/, in the State Energy Price and Expenditure Report.

7.4 Descriptive statistics, data sources, and state tax policies at a glance

Data	**mean**	**median**	**std**	**min**	**max**
log productivity	10.768	10.747	0.170	10.416	11.431
income	0.052	0.057	0.033	0.000	0.198
sales plus excise	0.025	0.026	0.010	0.000	0.057
capital gains	0.043	0.043	0.030	0.000	0.164
corporate binary	0.917	1.000	0.276	0.000	1.000
property	0.007	0.006	0.003	0.001	0.018
Primary Controls	**mean**	**median**	**std**	**min**	**max**
labor force	0.615	0.616	0.021	0.552	0.661
education	0.959	0.973	0.131	0.553	1.290
manufacturing share of GSP	0.170	0.177	0.098	0.000	0.536
population density	172.042	82.133	238.898	4.238	1170.927
union density	15.313	14.500	6.918	2.800	38.300
real energy prices	11.865	11.469	2.440	6.315	21.665
Extra Controls	**mean**	**median**	**std**	**min**	**max**
industry diversity	0.183	0.181	0.046	0.103	0.576
service share GDP	0.168	0.164	0.045	0.059	0.346
urbanization	0.686	0.690	0.147	0.321	0.961
interstate commuting	0.006	0.001	0.028	-0.075	0.134
union coverage	17.489	16.800	7.199	3.600	39.900
right-to-work laws	0.402	0.000	0.490	0.000	1.000

Table 7.2 **Panel data descriptive statistics**

Variable	Source	Method
log productivity	BEA	logged state GDP
income	NBER	maximum marginal income tax rate at the state level
sales plus excise	taxpolicycenter.org	sales plus excise tax receipts per percent income
capital gains	NBER	maximum marginal capital gains tax rate
corporate binary	taxpolicycenter.org	binary for if state imposes a tax on corporate profits
property	CB	divide state and local property tax receipts by an approximation of the states total value of property
Controls	**Source**	**Method**
Labor Force	BLS	share of total population 18-64 on July 1st
education	CB	data for each decade linearized
manufacturing	BEA	1963-1997 data come from the SIC. 1998-2004
share of GSP	data was estimated using growth rates of NAICS	portion of GSP from service sector
population density	CB	people per square mile
union density	CB	the percentage of each state's nonagricultural employees who are union members. data by decade, intervening years interpolated, 2000 and beyond extrapolated.
real energy prices	EIA	data in dollars per million BTU
Extra Controls	**Source**	**Method**
industry diversity	BEA	index of each sector's share of GDP
service share GDP	BEA	1963-1997 data comes from the SIC. 1998-2004 data was estimated using growth rates of NAICS
urbanization	CS	Percent of population living in an urban area
interstate commuting	BEA	see BEA website
union coverage	Hirsch (2001)	the percentage of each state's nonagricultural employees covered by a collective bargaining intervening years interpolated
right-to-work laws	DOL	Binary for if state has right-to-work laws

Table 7.3 **Panel data sources and methods for construction:**Bureau of Labor Statistics (BLS), National Bureau of Economic Research (NBER), Bureau of Economic Analysis (BEA), Energy Information Administration (EIA), North American Industry Classification System (NAICS), Department of Labor (DOL). Tax Policy Center (taxpolicycenter.org)

State	Property	Income	Capital Gains	Sales or Excise	Corporate Profits
Alabama	Always	Always	Always	Always	Always
Arizona	Always	Always	Always	Always	Always
Arkansas	Always	Always	Always	Always	Always
California	Always	Always	Always	Always	Always
Colorado	Always	Always	Always	Always	Always
Connecticut	Always	**Sometimes**	Always	Always	Always
Delaware	Always	Always	Always	Always	Always
Florida	Always	**Never**	**Never**	Always	Always
Georgia	Always	Always	Always	Always	Always
Idaho	Always	Always	Always	Always	Always
Illinois	Always	Always	Always	Always	Always
Indiana	Always	Always	Always	Always	Always
Iowa	Always	Always	Always	Always	Always
Kansas	Always	Always	Always	Always	Always
Kentucky	Always	Always	Always	Always	Always
Louisiana	Always	Always	Always	Always	Always
Maine	Always	Always	Always	Always	Always
Maryland	Always	Always	Always	Always	Always
Massachusetts	Always	Always	Always	Always	Always
Michigan	Always	Always	Always	Always	Always
Minnesota	Always	Always	Always	Always	Always
Mississippi	Always	Always	Always	Always	Always
Missouri	Always	Always	Always	Always	Always
Montana	Always	Always	Always	Always	Always
Nebraska	Always	Always	Always	Always	Always
Nevada	Always	**Never**	**Never**	Always	**Never**
New Hampshire	Always	**Never**	**Never**	Always	Always
New Jersey	Always	Always	Always	Always	Always
New Mexico	Always	Always	Always	Always	Always
New York	Always	Always	Always	Always	Always
North Carolina	Always	Always	Always	Always	Always
North Dakota	Always	Always	Always	Always	Always
Ohio	Always	Always	Always	Always	Always
Oklahoma	Always	Always	Always	Always	Always
Oregon	Always	Always	Always	Always	Always
Pennsylvania	Always	Always	Always	Always	Always
Rhode Island	Always	Always	Always	Always	Always
South Carolina	Always	Always	Always	Always	Always
South Dakota	Always	**Never**	**Never**	Always	Always
Tennessee	Always	**Never**	**Never**	Always	Always
Texas	Always	**Never**	**Never**	Always	**Never**
Utah	Always	Always	Always	Always	Always
Vermont	Always	Always	Always	Always	Always
Virginia	Always	Always	Always	Always	Always
Washington	Always	**Never**	**Never**	Always	**Never**
West Virginia	Always	Always	Always	Always	Always
Wisconsin	Always	Always	Always	Always	Always
Wyoming	Always	**Never**	**Never**	Always	**Never**

Table 7.4 **State tax policies at a glance:** All states utilize taxes on property and sales or excise, but only some states utilize taxes on income, capital gains, and corporate profits. Connecticut is the only state to have ever removed a tax entirely from its tax policy from 1977 to 2004.

CHAPTER 8. Empirical Model Results and Robustness Checks

The base model constructed in the previous chapter six offer many insights into how state tax policy affects a state's labor productivity. Nine additional versions of the base model are included and discussed to test the robustness of model results to alternative lags and method for modeling state effects.

The base model is designed to test the results of the theoretical model developed in chapters two through five. Among other findings, two results of the theoretical model are confirmed by the base model: Taxes on capital, which include property and capital gains, are more disruptive to productivity than taxes on income and consumption (sales and excise). Property taxes are found by all perturbation of the base model to be the most disruptive to productivity, and taxes on consumption are found to have relatively benign effects compared to all other taxes.

The base model is used to construct a ranking of states based on how seriously their tax policies disrupt productivity. States that tax capital more heavily and have higher tax rates in general are ranked lower than states that rely more heavily on consumption taxes and generally have lower tax rates. More than 10% of the variation in a rankings of state by growth in productivity can be explained by the ranking of states based on tax policy. This correlation implies that state tax policy has an influence on the state's average wage rate.

8.1 Productivity elasticity of each tax

All tax levies except those on consumption are estimated by the base model to disrupt state productivity. Table 8.1 summarizes five versions of the base model. The base model is in bold and is denoted as model number III. Estimates are given as an elasticity for a 10% increase in each tax rate. For example, if income taxes in a state are increased from 5% to 5.5% (10%

increase) then productivity in that state will fall by .25% annually. Productivity is the average market value of an employee in a state and is proportional to wages. If an employee makes \$35,000 annually and income taxes go up from 5% to 7% (40% increase), the employee should expect her salary to fall to \$34,650, a loss of \$350 all else equal.[1] Other versions of the base model presented in table 8.1 are the same as the base model in every respect except for the lag on independent variables. Other estimates for the productivity elasticity of taxes on income range from -.164 (five year lag) to -.425 (six year lag).

Other taxes are interpreted in a similar fashion. If taxes on property increase by 10% (say from 2% to 2.2%) then productivity and wages are predicted by the base model to fall by .648%. This elasticity is 2.6 times greater than the productivity elasticity of the income tax. A 40% increase in the property tax rate (say from 2% to 2.8%) is predicted by the base model to lower productivity in a state by 2.59% within four years. An employee previously making \$35,000 a year would experience a loss of \$907.2 a year from such a tax hike.

The five regressions presented in table 8.1 are also summarized using beta estimates instead of elasticities in table 8.2. The productivity elasticity of a tax is the derivative of logged productivity with respect to the tax multiplied by the average tax rate.

$$E = \beta \times \overline{\tau} = \frac{\partial log(w)}{\partial \tau} \times \overline{\tau} \tag{8.1}$$

Tax effect estimates presented in table 8.2 are given as a beta estimate, meaning that the results estimate what percent change in labor productivity is most likely to follow a 1% (say 2% to 3%) increase in each tax rate.[2] The beta coefficient is interpreted differently for each tax because not all taxes are constructed the same. The income tax proxy is the maximum marginal income tax rate. The property tax proxy is proportional to the effective average property tax rate. A 1% increase in the income tax rate has a different meaning than a 1%

[1] There are many factors that play into deciding what salary any particular person in a state will have. The result of the base model is means to describe the average individual's drop in salary, after accounting for inflation and holding constant all other relevant factors.

[2] Notice that the beta estimate interpretation of a 1% change in the tax rate is different than the interpretation of a 1% change when interpreting an elasticity, where a 1% increase meant that a tax rate of 5% would increase to 5.05%. This is a confusing difference, but crucial to properly understanding what the difference between tables 8.1 and 8.2.

increase in the property tax rate. The coefficient on the income and capital gains tax is the percent change in productivity per percent increase in the maximum marginal tax rate. The coefficient on the sales plus excise tax rate is the percent change in productivity per percent increase in sales tax per dollar of income earned in the state. The coefficient on the property tax is the percent change in productivity per percent increase in the average effective property tax rate.

The estimates in table 8.2 measure an increase of 10% on a tax rate as moving from 4% to 14%, not 4% to 4.4%. For instance, the coefficient for the income tax in table 8.2 estimates that an increase of 1% (say from 5% to 6%) in the maximum marginal income tax rate lowers productivity by -.481%. The average state had a maximum marginal income tax rate of 5.22% between 1977 and 2004. The estimated loss in productivity for the average state is therefore 5.22% $*$ -0.481% $= -2.51\%$. The average tax rates for the rest of the taxes on property, capital gains, and sales plus excise are 1.55%, 4.28%, and 2.54% respectively. Combining these averages with estimates from table 8.2 leads to the result that the average state loses 9.49% of its productivity annually because of its tax policy, according to the base model. This calculation does not include any effects from taxes on corporate profits. Alternative versions of the base model estimate only marginal differences in the average state's annual loss in productivity because of its tax policy as shown in table 8.1.

Regression	I	II	**III**	IV	V
State Effects	Fixed	Fixed	**Fixed**	Fixed	Fixed
Lag	2	3	**4**	5	6
Units	Elasticity	Elasticity	**Elasticity**	Elasticity	Elasticity
Income	-0.180	-0.270	**-0.251**	-0.164	-0.425
	(1.84)	(2.14)*	**(1.82)**	(0.91)	(2.27)*
Property	-0.386	-0.495	**-0.648**	-0.315	-0.359
	(3.09)**	(3.11)**	**(3.44)****	(1.44)	(1.74)
Sales + Excise	0.010	0.096	**0.078**	-0.031	0.043
	(0.15)	(1.38)	**(0.77)**	(0.28)	(0.37)
Capital Gains	-0.128	-0.127	**-0.128**	-0.104	-0.006
	(2.14)*	(1.61)	**(1.45)**	(1.01)	(0.06)
Corporate Binary β	only allowed in random effects models				
Education	2.100	3.183	**0.451**	1.141	3.145
	(3.10)**	(3.41)**	**(0.42)**	(1.02)	(2.21)*
Work Force Size	2.016	0.270	**4.690**	2.926	-3.246
	(1.22)	(0.13)	**(1.77)**	(0.87)	(1.30)
Manufacturing	-0.462	-0.307	**-0.404**	-0.158	-0.059
Share GSP	(9.13)**	(4.50)**	**(5.42)****	(1.68)	(0.77)
Pop Density	3.441	3.441	**3.441**	3.441	1.720
	(12.77)**	(9.25)**	**(8.36)****	(5.58)**	(3.91)**
Union Density	0.613	0.153	**0.306**	-0.153	0.153
	(3.16)**	(0.78)	**(1.16)**	(0.43)	(0.78)
Energy Prices	-0.593	-0.356	**-0.593**	-0.356	-0.949
	(1.44)	(0.70)	**(0.96)**	(0.49)	(1.71)
Constant β	10.097	10.184	**10**	10.26	10.76
	(56.38)**	(41.60)**	**(36.13)****	(26.47)**	(37.20)**
Year Dummies	Yes	Yes	**Yes**	Yes	Yes
Observations	672	432	**336**	240	192
R-squared	0.84	0.84	**0.85**	0.84	0.9
Avg Tax Effect	-6.84%	-7.96%	**-9.49%**	-6.15%	-7.46%
Joint Effect (F-Stat)	15.88	14.78	14.90	4.46	5.68
F-Test (F-Stat)	5.64	5.83	5.49	1.23	2.29

Table 8.1 **Base model elasticities:** The level model is in bold with a lag of four years placed on all independent variables. The rest of the regressions are the same except for a change in lag on the independent variables. Estimates are given as elasticity in productivity from a 10% increase in each tax rate.

Regression	I	II	**III**	IV	V
State Effects	Fixed	Fixed	**Fixed**	Fixed	Fixed
Lag	2	3	**4**	5	6
Units	Beta	Beta	**Beta**	Beta	Beta
Income	-0.344	-0.517	**-0.481**	-0.315	-0.814
	(1.84)	(2.14)*	**(1.82)**	(0.91)	(2.27)*
Property	-2.495	-3.195	**-4.186**	-2.037	-2.317
	(3.09)**	(3.11)**	**(3.44)****	(1.44)	(1.74)
Sales + Excise	0.041	0.376	**0.308**	-0.122	0.170
	(0.15)	(1.38)	**(0.77)**	(0.28)	(0.37)
Capital Gains	-0.300	-0.297	**-0.300**	-0.243	-0.013
	(2.14)*	(1.61)	**(1.45)**	(1.01)	(0.06)
Corporate Binary	only allowed in random effects models				
Education	0.219	0.332	**0.047**	0.119	0.328
	(3.10)**	(3.41)**	**(0.42)**	(1.02)	(2.21)*
Work Force Size	0.328	0.044	**0.763**	0.476	-0.528
	(1.22)	(0.13)	**(1.77)**	(0.87)	(1.30)
Manufacturing	-0.272	-0.181	**-0.238**	-0.093	-0.035
Share GSP	(9.13)**	(4.50)**	**(5.42)****	(1.68)	(0.77)
Pop Density	0.0020	0.0020	**0.0020**	0.0020	0.0010
	(12.77)**	(9.25)**	**(8.36)****	(5.58)**	(3.91)**
Union Density	0.004	0.001	**0.002**	-0.001	0.001
	(3.16)**	(0.78)	**(1.16)**	(0.43)	(0.78)
Energy Prices	-0.005	-0.003	**-0.005**	-0.003	-0.008
	(1.44)	(0.70)	**(0.96)**	(0.49)	(1.71)
Constant	10.064	10.155	**9.959**	10.278	10.737
	(56.63)**	(41.76)**	**(36.28)****	(26.71)**	(37.39)**
Year Dummies	Yes	Yes	Yes	Yes	Yes
Observations	672	432	**336**	240	192
R-squared	0.84	0.84	**0.85**	0.84	0.9
Avg Tax Effect	-6.84%	-7.96%	**-9.49%**	-6.15%	-7.46%
Joint Effect (F-Stat)	15.88	14.78	14.90	4.46	5.68
F-Test (F-Stat)	5.64	5.83	5.49	1.23	2.29

Table 8.2 **Base model beta estimates:** The level model is in bold with a lag of four years placed on all independent variables. The rest of the regressions are the same except for the lag on the independent variables. Estimates are given as elasticity in productivity from a 10% increase in each tax rate.

8.2 Fixed v.s. random effects

This section discusses the choice of using fixed effects instead of random effects in the base model. The base model uses fixed effects that assume the characteristics of a state that are not controlled for have the same effect on productivity every year. The alternative would be to assume that the state's characteristics have an effect on productivity that varies some over time.

There are three common methods that can be applied to the base model in order to control for omitted variable bias. These three ways are called fixed, between, and random effects. Fixed effects are simply dummy variables for all but one of the states. Fixed effects are used for controlling omitted variables that differ between states, but are constant for each state over time. A state's geographical characteristics are a great example of characteristics that fixed effects are good at controlling for. Between effects are nothing more than dummy variables for all but one of the years. Between effects are used to control for omitted variables that change over time, but are the same for all states. Federal tax policy and the business cycle are two examples of variables that are easily controlled for by using between effects. The last way is to use random effects. Random effects are a substitute for fixed effects. Fixed effects, by using binary variables, assume that the joint effect of each state's omitted variables doesn't vary over time. Random effects assume that the joint effect of each state's omitted variables can vary over time. Fixed effects are generally used if the modeler is interested in making explicit comparisons between states. Random effects are generally used when the modeler is more interested in measuring the extent to which the random factor (in this case a state's unchanging characteristics) accounts for variance in productivity, the dependent variable, in order to control for it. The key issue between fixed and random effects is whether the effects of a state's omitted characteristics are thought of as being a draw from a probability distribution of such effects. If so, the effect is random.

Many aspects of a state are clearly not fixed from year to year. For example, the weather will always be different and have an impact on the productivity of the agricultural sector. Weather patterns are different in every state, so between effects could not be used in conjunction with fixed effects to perfectly capture this difference in each state. For this reason, five additional versions of the base model are constructed that use random instead of fixed effects. These additional five models, which are summarized in tables 8.3 and 8.4, provide additional insights into the robustness of the base model. The random effects models are also useful because they allow the use of corporate tax dummies. All the states that levy corporate taxes have never changed their policy. For this reason the corporate tax dummy cannot coincide with the state's fixed effects control, which is nothing more than a dummy variable itself.

Regression number VIII in table 8.4 finds that a state that levies any corporate taxes will lose -0.12% productivity annually. If an employee makes $35,000 annually and the state decides to start levying taxes on corporate profits than the employee should expect her salary to fall to $34,958, a loss of $42 all else equal. The amount of the corporate tax will matter of course. If a state levies taxes more than the average state, this loss will be higher. The corporate tax dummy is only capable of measuring the loss sustained by the average average tax rate levied on corporate taxes.

There is at least one problem with using a random effects model. If uncontrolled characteristics of a state are correlated with state tax policy then the tax effect estimates are both biased and inconsistent. This correlation is tested using a Hausman test which finds the random effects model to be biased and inconsistent.

Hausman test

The null hypothesis is that the estimated coefficients under a fixed effects model equal those of the random effects model. This is equivalent to the hypothesis that both estimates are consistent and unbiased. The alternative hypothesis is that the coefficients are not equal. The Hausman statistic is as follows:

$$H = T(b_0 - b_1)'Var(b_0 - b_1)^{-1}(b_0 - b_1) \approx x^2(15)$$

Where T is the number of observations. Variables b_0 and b_1 are vectors of coefficients from the fixed effects model and the random effect model respectively. The computed Hausman statistic is 186.42.

$$P - value = Prob(H > 186.42)^2 = 0.0000$$

The result rejects the null hypothesis in favor of the alternative that coefficients are significantly different under the two models. This means that coefficient estimates using the random effects model are biased and inconsistent due to a correlation between the state's uncontrolled effects and the state's tax policy.

Regression	VI	VII	VIII	IX	X
State Effects	Random	Random	Random	Random	Random
Lag	2	3	4	5	6
	Elasticity	Elasticity	Elasticity	Elasticity	Elasticity
Income	-0.209	-0.269	-0.237	-0.099	-0.360
	(2.03)*	(2.10)*	(1.69)	(0.56)	(2.06)*
Property	-0.489	-0.639	-0.757	-0.687	-0.523
	(4.03)**	(4.00)**	(4.03)**	(3.11)**	(2.48)*
Sales + Excise	0.011	0.053	0.041	-0.023	-0.019
	(0.11)	(0.74)	(0.35)	(0.17)	(0.12)
Capital Gains	-0.102	-0.089	-0.087	-0.080	0.027
	(1.59)	(1.08)	(0.93)	(0.79)	(0.26)
Corporate Binary β	-0.126	-0.118	-0.120	-0.129	-0.106
	(2.47)*	(2.30)*	(2.26)*	(2.44)*	(2.06)*
Education	3.173	3.988	2.291	1.917	3.269
	(4.78)**	(4.70)**	(2.35)*	(1.86)	(2.98)**
Work Force Size	-3.202	-3.614	0.068	0.910	-2.698
	(2.16)*	(1.92)	(0.05)	(0.39)	(1.29)
Manufacturing	-0.557	-0.418	-0.494	-0.244	-0.117
Share GSP	(10.37)**	(5.84)**	(6.35)**	(2.62)**	(1.50)
Pop Density	0.860	0.688	0.688	0.516	0.688
	(8.44)**	(7.40)**	(6.56)**	(5.90)**	(7.01)**
Union Density	0.613	0.306	0.459	0.306	0.306
	(3.84)**	(1.72)	(2.22)*	(1.35)	(1.81)
Energy Prices	-1.424	-1.187	-1.187	-0.831	-0.949
	(3.38)**	(2.34)*	(2.15)*	(1.19)	(2.00)*
Constant β	10.986	10.957	10.92	10.63	10.896
	(60.58)**	(51.04)**	(43.23)**	(37.11)**	(47.89)**
Year Dummies	Yes	Yes	Yes	Yes	Yes
Observations	672	432	336	240	192
R-squared	N/A	N/A	N/A	N/A	N/A
Avg Tax Effect	-7.99%	-9.54%	-10.51%	-9.01%	-8.86%
Joint Effect (F-Stat)	19.40	20.49	18.05	11.05	8.97
F-Test (F-Stat)	25.82	26.05	24.02	14.03	11.55
Hausman Test	0.0439	0	0	0.0001	0

Table 8.3 **Elasticities using random effects:** These five regressions are the same as the base model except that each state's effect on productivity is assumed to be a random variables instead of a fixed value. Estimates are given as an elasticity for a 10% increase in each tax rate (say from 5% to 5.5%). The estimate for the corporate binary variable gives the estimated percentage change in productivity for if the state levies any taxes on corporate profits.

Regression	VI	VII	VIII	IX	X
State Effects	Random	Random	Random	Random	Random
Lag	2	3	4	5	6
Units	Beta	Beta	Beta	Beta	Beta
Income	-0.400	-0.515	-0.455	-0.190	-0.690
	(2.07)*	(2.13)*	(1.74)	(0.61)	(2.10)*
Property	-3.157	-4.126	-4.889	-4.439	-3.381
	(3.78)**	(4.01)**	(4.09)**	(3.53)**	(2.68)**
Sales + Excise	0.045	0.210	0.161	-0.089	-0.075
	(0.15)	(0.72)	(0.38)	(0.19)	(0.16)
Capital Gains	-0.238	-0.209	-0.203	-0.188	0.062
	(1.57)	(1.06)	(0.92)	(0.75)	(0.27)
Corporate Binary	-0.126	-0.118	-0.120	-0.129	-0.106
	(2.47)*	(2.30)*	(2.26)*	(2.44)*	(2.06)*
Education	0.331	0.416	0.239	0.200	0.341
	(4.83)**	(4.77)**	(2.44)*	(2.05)*	(3.05)**
Work Force Size	-0.521	-0.588	0.011	0.148	-0.439
	(2.00)*	(1.85)	(0.03)	(0.33)	(1.29)
Manufacturing	-0.328	-0.246	-0.291	-0.144	-0.069
Share GSP	(10.39)**	(5.83)**	(6.33)**	(2.56)*	(1.47)
Pop Density	0.0005	0.0004	0.0004	0.0003	0.0004
	(8.31)**	(7.26)**	(6.42)**	(5.76)**	(6.91)**
Union Density	0.004	0.002	0.003	0.002	0.002
	(3.78)**	(1.68)	(2.17)*	(1.32)	(1.81)
Energy Prices	-0.012	-0.010	-0.010	-0.007	-0.008
	(3.41)**	(2.39)*	(2.24)*	(1.28)	(2.04)*
Constant	10.954	10.94	10.897	10.643	10.889
	(60.74)**	(51.21)**	(43.47)**	(37.40)**	(48.24)**
Year Dummies	Yes	Yes	Yes	Yes	Yes
Observations	672	432	336	240	192
R-squared	N/A	N/A	N/A	N/A	N/A
Avg Tax Effect	-7.99%	-9.54%	-10.51%	-9.01%	-8.86%
Joint Effect (F-Stat)	19.40	20.49	18.05	11.05	8.97
F-Test (F-Stat)	25.82	26.05	24.02	14.03	11.55
Hausman	0.0439	0	0	0.0001	0

Table 8.4 **Beta estimates using random effects:** These five regressions are the same as the base model except that each state's effect on productivity is assumed to be a random variables instead of a fixed value. Estimates are interpreted as a beta.

8.3 Measuring productivity as a growth rate

The growth model is the same as the base model save two differences. Productivity and the six control groups are measured as a change (or growth rate) over a three year period rather than a level (or total) for the base model. Thus, the growth model takes the following form.

$$\Delta w_{t+3} = \beta_0 + \sum_{y=1}^{4} \beta_y \left(\tau_y\right)_t + \sum_{n=5}^{10} \beta_n \left(\Delta C_{n-4}\right)_t + \sum_{m=11}^{57} \beta_m \left(S_{m-10}\right) + \sum_{j=58}^{84} \beta_j \left(Y_{j-58}\right)_t + \epsilon_t \quad (8.2)$$

The primary purpose of including the growth model is to test the results of the base model. The base model and the growth model ask the same question: Does a state's tax policy have an impact on productivity? The only difference between the two models is how they ask the question. The growth model measures the change in productivity that results from the previous period's tax policy where the previous period is three years back. In contrast, the base model measures the level of productivity that results from the previous period's tax policy where the previous period is four years back.

The growth model elasticity results are summarized in table 8.5 for comparison with the base model. Results as beta estimates are summarized in table 8.6. The growth model regresses the change in logged productivity over the interval t_0 to t_{+3} on the change in control values over the interval t_{-3} to t_0 and on tax rates in t_0. This is a more stringent model then the base model which regresses logged productivity in t_3 on tax rates and controls in t_0. The result is that all the significance levels and most of the estimates drop significantly.

The income and property tax rates are still estimated to have a negative effect on productivity, however, the significance of the tax policy affect on productivity drops for the growth model compared to the base model.

The effect of taxes on sales is still considered small under the growth model, but is now estimated to have a negative albeit insignificant effect on productivity. The growth model contradicts the level model in its estimation of the capital gains tax effect. The level model estimated taxes on capital gains to have a negative and sometimes statistically significant effect on productivity depending on the lag used. The growth model estimates a positive effect although still insignificant.

Two tests are conducted on the joint effect of all four tax levies. The first test is a simple F-test to see whether all the tax coefficients were zero. The second tests whether the average state tax policy significantly effects state productivity. This second test is conducted by multiplying the average tax rate by the estimated coefficient for the growth model. Both versions of the growth model estimate the joint effect of taxes on productivity to be significant at the 10% level. The F-test always comes up significant at the 10% level as well.

A random effects version of the growth model includes taxes on corporate profits. The corporate tax is estimated to be very small and insignificant. The reason for this is that there is absolutely no variation in whether a state taxes corporate profits. Until there is more variation is state corporate tax law it will be difficult to pin down its effect on productivity using time series analysis.

8.4 Comparing theoretical and empirical model results

The property tax has by far the largest negative impact on productivity according to both the empirical models and all three theoretical model simulations. The two approaches also agree that taxes on consumption (sales and excise taxes) are the most benign. The level model actually shows a positive relationship between taxes on consumption and productivity, although this relationship is not significant, and not robust to other perturbations of the level model.

The two approaches differ in their rankings for taxes on income and capital gains. The base model estimates the income tax effect to be larger than that of capital gains, while the theoretical model simulations estimate the opposite.

While there are some differences in these estimates, two results are clear. At current tax rates, an increase in property taxes will have a much stronger negative impact on productivity than any other taxes on income and consumption. In contrast, taxes on consumption, in the form of sales or excise taxes, will have a much smaller and possibly insignificant impact on

Regression	**XI**	XII
State Effects	**Fixed**	Random
Units	**Elasticity**	Elasticity
Income	**-0.032**	-0.051
	(0.34)	(0.89)
Property	**-0.284**	-0.144
	(2.52)*	(2.40)*
Sales + Excise	**-0.032**	-0.051
	(0.53)	(0.87)
Capital Gains	**0.057**	0.056
	(1.05)	(1.13)
Corporate Binary		0.128
		(1.38)
Chg Education t-3 - t0	**0.001**	0.588
	(0.79)	(2.82)**
Chg Size of Work Force t-3 - t0	**0.000**	-0.039
	(1.56)	(0.61)
Chg Manufacturing Share GSP t-3 - t0	**0.000**	0.035
	(4.44)**	(5.01)**
Chg Population Density t-3 - t0	**0.000**	0.136
	(1.48)	(0.45)
Chg Union Density t-3 - t0	**0.001**	0.000
	(1.18)	(0.82)
Chg Real Energy Prices t-3 - t0	**0.000**	-0.004
	(0.20)	(2.80)**
Constant	**0.062**	0.01
	(3.53)**	(2.52)*
Year Dummies	**Yes**	Yes
Observations	**384**	384
R-squared	**0.3**	N/A
Avg Tax Effect	**-2.92%**	-0.61%
Joint Effect (F-Stat)	**3.42**	3.58
F-Test (F-Stat)	**1.99**	8.31

Table 8.5 **Growth model elasticities:** These five regressions model productivity and control groups as a growth rate over three years. Taxes are measured the same as in the base model. Estimates are given as elasticity in productivity from a 10% increase in each tax rate (say 5% to 5.5%). The corporate binary variable estimates the change in productivity that occurs when a state levies any taxes on corporate profits. The joint effect tests whether the average tax effect is significant. The F-test tests the null hypothesis that tax coefficients on income, property, sales plus excise, and capital gains are equal to zero. Results of both tests indicate significance at the 10% level in every regression.

Regression	XI	XII
State Effects	**Fixed**	Random
Units	**Beta**	Beta
Income	**-0.062**	-0.098
	(0.34)	(0.89)
Property	**-1.836**	-0.931
	(2.52)*	(2.40)*
Sales + Excise	**-0.127**	-0.199
	(0.53)	(0.87)
Capital Gains	**0.134**	0.132
	(1.05)	(1.13)
Corporate Binary		0.014
		(1.38)
Chg Education t-3 - t0	**0.149**	0.274
	(0.79)	(2.82)**
Chg Size of Work Force t-3 - t0	**-0.059**	-0.011
	(1.56)	(0.61)
Chg Manufacturing Share GSP t-3 - t0	**0.083**	0.080
	(4.44)**	(5.01)**
Chg Population Density t-3 - t0	**-0.017**	0.000
	(1.48)	(0.45)
Chg Union Density t-3 - t0	**-0.001**	0.000
	(1.18)	(0.82)
Chg Real Energy Prices t-3 - t0	**0.000**	0.003
	(0.20)	(2.80)**
Constant	**0.044**	0.033
	(3.53)**	(2.52)*
Year Dummies	Yes	Yes
Observations	**384**	384
R-squared	**0.3**	N/A
Avg Tax Effect	**-2.92%**	-0.61%
Joint Effect (F-Stat)	**3.42**	3.58
F-Test (F-Stat)	**1.99**	8.31

Table 8.6 **Growth model beta estimates:** These five regressions model productivity and control groups as a growth rate over three years. Taxes are measured the same as in the base model. Estimates are interpreted as a beta. The joint effect tests whether the average tax effect is significant. The F-test tests the null hypothesis that tax coefficients on income, property, sales plus excise, and capital gains are equal to zero. Results of both tests indicate significance at the 10% level in every regression.

productivity compared to other tax levies.

Table 8.7 summarizes the empirical and general equilibrium model estimates of each tax effect on productivity. The base model results are taken from table 8.2. The theoretical model estimate is from the simulation that uses average values of model parameters found in the state growth literature. Estimates are given as an elasticity in productivity for a 10% increase in each tax rate (say 5% to 5.5%).

The estimated effect of taxes on productivity are much higher according to the theoretical model. This result is partially the result of the way the theoretical model handles government spending. In the "real world", governments use tax revenues to finance public goods that may create more value beyond their cost to finance. The empirical model does not control for government spending and therefore picks up the *net* effect of each tax levy in its estimation. The estimation is a net effect because it aggregates both the cost of levying each tax and the benefit of spending its receipts. The theoretical model assumes away the existence of public goods in order to calculate only the cost of government, and not the benefit. Largely for this reason, the estimated effect of a tax is usually much bigger when estimated by the theoretical model.

There is one significant difference between the tax levies used in the empirical models and the levies in the theoretical model. The empirical models examine taxes on income, property, sales plus excise, and capital gains while the theoretical model imposes taxes on wage income, wealth, consumption, capital income. These tax levies are roughly analogous. Property taxes are similar to taxes on wealth. Likewise, taxes on consumption are analogous to sales and excise taxes. However, income taxes are a composite of wage income and primarily short term capital income (or capital gains). Taxes on income have included different types of capital gains since 1977 (see Auten 1999). Income that falls under the category of capital gains is composed of "long-term" investments (more than a year) that sold after May 1997. To adjust for this difference, income is defined as a weighted average of capital income and wage income such that: Income = 84.7% Wage income + 15.3% Capital Income; The values come from a report by taxfoundation.org for the year 2005.

Method	Empirical	Theoretical
Model	**Base Regression**	**Avg Simulation**
Sales + Excise	0.08%	-0.55%
Income*	-0.25%	-0.25%
Property	-0.65%	-1.07%
Capital Gains	-0.13%	-1.64%

Table 8.7 **Comparing the empirical and theoretical models:** Estimates are given as an elasticity in productivity for a 10% increase in each tax rate (say 5% to 5.5%). * Income = 84.7% Wage income + 15.3% Capital Income; This calculation accommodates the definition of income which includes short-term capital gains.

8.5 Ranking state tax policies

How do states compare in terms of the productivity of their tax policies? Rankings of state tax policies, summarized in Table 8.8, are estimated using the base model. Rankings are constructed by multiplying the marginal effect of each tax, as estimated by the level model in 8.2, by each state's tax policy.

$$State\ i\ Total\ Tax\ Affect\ on\ Productivity = \beta_w \overline{\tau}_w^i + \beta_p \overline{\tau}_p^i + \beta_k \overline{\tau}_k^i + \beta_c \overline{\tau}_c^i \tag{8.3}$$

The usefulness of the rankings is demonstrated by its ability to explain about 10% of the variation in state productivity rankings. This correlation implies that 90% of the rest of the variation in state productivity rankings is left for every other possible factor of productivity, including capital accumulation, human capital, industrial composition, energy prices, population density, unionization, crime, health, climate, geography, etc. With so many factors, 10% being explained by tax policy alone is considerable.

A ranking of average state government size as a percent of GDP is also included. The most productive tax policies rely on taxes levied on sales, excise and capital gains. The top three most productive tax policies ranked using the level model are Nevada, Tennessee, and Washington with productivity rankings of 11th, 40th, and 10th respectively. The least productive tax policies are estimated to be those that rely heavily on taxes levied on property, income and corporate profits. Nebraska, Iowa and Vermont have the lowest estimated tax policy rankings with productivity rankings of 34th, 25th and 48th respectively. Rankings of states for specific years are summarized in table 8.9. Table 8.10 summarizes a new set of rankings calculated using the results of the growth model presented in equation 8.2. The correlation between the base model and growth model rankings is .73.

There is a fairly strong and negative relationship between state government size[3] and productivity. Just over 42% of the variation in state productivity can be explained by government size. Tests on the joint effect of tax rates on productivity from the empirical models suggest that the low productivity in a state is at least partially caused by the higher tax rates needed to fund a larger state government.

[3] State government size equals total state tax revenue over gross state product.

State	Base Rank	Gov. Size	Productivity
Nevada	1	33	11
Tennessee	2	25	40
Washington	3	11	10
Alabama	4	6	37
Florida	5	23	33
Louisiana	6	39	2
Kentucky	7	19	21
New Mexico	8	3	14
Maryland	9	2	19
Colorado	10	17	24
Missouri	11	34	28
Pennsylvania	12	41	18
New Hampshire	13	46	43
Oklahoma	14	10	26
Utah	15	5	30
Connecticut	16	48	15
Arizona	17	14	17
Delaware	18	43	7
Arkansas	19	27	42
Mississippi	20	9	45
Virginia	21	1	31
Texas	22	32	8
Massachusetts	23	47	27
South Dakota	24	15	44
Georgia	25	18	36
West Virginia	26	20	13
Indiana	27	44	16
Illinois	28	45	5
South Carolina	29	4	47
North Carolina	30	22	41
California	31	29	6
North Dakota	32	8	38
New Jersey	33	40	9
Wyoming	34	26	1
Ohio	35	42	12
Idaho	36	16	35
Michigan	37	35	3
Minnesota	38	37	22
Rhode Island	39	28	39
Oregon	40	24	20
Kansas	41	21	32
Montana	42	7	29
New York	43	38	4
Wisconsin	44	36	23
Maine	45	13	46
Vermont	46	30	48
Iowa	47	31	25
Nebraska	48	12	34

Table 8.8 **Average state tax policy rankings:** These rankings are based on a state's average tax policy from 1977 to 2004. State tax policy rankings explain 10% of the variation in the productivity ranking. Over 42% of the variation in productivity ranking is explained by the ranking based on state government size relative to state GDP.

Base Rank	**2004**	**2000**	**1990**	**1980**	**1977**
Nevada	4	3	1	1	1
Tennessee	2	2	2	4	4
Washington	1	5	4	3	2
Alabama	3	1	3	6	7
Florida	13	7	5	2	3
Louisiana	5	4	7	5	5
Kentucky	8	18	8	7	8
New Mexico	7	9	16	28	26
Maryland	15	11	9	16	22
Colorado	10	15	21	8	14
Missouri	19	22	14	13	16
Pennsylvania	17	17	13	21	15
New Hampshire	34	12	10	15	10
Oklahoma	16	14	26	22	21
Utah	12	30	32	14	9
Connecticut	38	8	6	11	17
Arizona	21	21	30	10	12
Delaware	6	6	11	40	47
Arkansas	9	16	15	31	33
Mississippi	20	27	29	17	13
Virginia	22	19	28	24	18
Texas	41	33	22	9	6
Massachusetts	18	10	12	44	43
South Dakota	14	34	33	26	24
Georgia	29	24	20	18	28
West Virginia	11	20	23	32	31
Indiana	23	37	18	12	20
Illinois	26	32	25	19	27
South Carolina	31	28	31	30	25
North Carolina	27	23	24	34	29
California	25	13	19	36	42
North Dakota	33	35	34	20	23
New Jersey	43	31	17	29	30
Wyoming	28	29	38	23	11
Ohio	35	36	37	25	19
Idaho	36	39	35	27	32
Michigan	24	38	44	37	36
Minnesota	32	40	43	35	34
Rhode Island	47	26	27	43	40
Oregon	30	41	45	41	39
Kansas	46	42	41	33	35
Montana	37	46	47	38	37
New York	40	25	40	48	48
Wisconsin	39	45	42	47	44
Maine	48	44	39	42	41
Vermont	45	43	36	46	45
Iowa	42	47	46	39	38
Nebraska	44	48	48	45	46

Table 8.9 **Base model rankings for specific years:** State tax policies have changed some over time which is why their rankings are not always the same.

Growth Rank	**2004**	**2000**	**1990**	**1980**	**1977**
Alabama	1	4	3	1	1
New Mexico	3	3	1	12	12
Louisiana	5	5	12	9	3
California	4	1	4	11	27
Nevada	26	15	5	2	2
Arkansas	8	10	8	8	4
North Carolina	13	11	7	4	6
Kentucky	7	9	14	16	11
Delaware	2	2	2	33	32
Tennessee	14	14	11	6	10
Oklahoma	6	6	13	14	17
Washington	15	19	17	5	8
Utah	9	20	21	13	14
Maryland	16	8	19	25	22
West Virginia	10	13	9	23	23
Massachusetts	18	7	10	38	34
Virginia	21	16	18	17	16
Missouri	19	17	15	28	26
Connecticut	36	12	6	18	13
Arizona	23	22	26	22	18
Colorado	12	36	30	20	19
Mississippi	24	26	27	10	9
Georgia	25	24	22	26	20
Florida	35	27	28	7	5
South Carolina	30	30	20	15	15
Idaho	20	35	23	29	24
Pennsylvania	27	25	25	21	25
Ohio	22	32	31	27	30
Oregon	11	28	40	34	37
Minnesota	17	29	35	35	36
Rhode Island	38	23	16	40	39
Illinois	31	37	38	32	28
New Jersey	41	21	24	36	40
Indiana	29	42	36	31	33
Wisconsin	43	47	43	3	7
New York	37	18	29	46	47
North Dakota	34	40	37	24	29
New Hampshire	47	33	34	30	31
Texas	48	45	39	19	21
Maine	46	34	33	41	38
Vermont	44	31	32	43	46
Michigan	28	39	44	47	43
Kansas	42	38	41	42	42
South Dakota	39	48	42	37	41
Iowa	32	44	45	45	45
Montana	33	46	48	44	44
Wyoming	45	41	46	39	35
Nebraska	40	43	47	48	48

Table 8.10 **Growth model rankings for specific years:** This ranking is calculated using the growth model presented in equation 8.2. The correlation between the base model and growth model rankings is .73.

CHAPTER 9. Policy Recommendation

This thesis can be used by state legislators to construct tax policies that provide more funds for public services with less cost to productivity. Results from this thesis must, however, be coupled with an equally rigorous attempt to quantify the value of each public service under consideration. The primary result of this entire thesis is that state spending and government size are negatively correlated with wage rates after controlling for a plethora of state characteristics. This result makes a strong argument for reducing state level taxes on income, property, capital gains, and corporate profits. The value of the public services financed by these four tax levies are not generally useful enough to be worth their cost to the state's economic health, measured by productivity.[1] Taxes on consumption do seem to be worth their initial costs, but only just barely.

This chapter summarizes the results of this thesis and puts forth a method for constructing an efficient tax policy in the context of the dynamic general equilibrium model constructed in chapter 2. Much emphasis is placed on testing the effects of a tax policy using multiple measures of economic health and social well-being. This thesis relied mostly on the metric productivity, but using others measures in concert with productivity will help to give a fuller picture of how each tax contributes to the cost of government.

[1] The cost of government at the state level consists of market distortions that create dead weight losses, loss of business from tax competition, black markets, and additional administration.

9.1 Summary of results

Theoretical model results

Many assumptions are required in order to solve a theoretical model such as the one developed in chapter 2.[2] The elasticities estimated using the theoretical model are not going to be as accurate as those made by the empirical model developed in chapter 6. The purpose of the theoretical model is to give a causal argument for why taxes might negatively affect a variety of measures for economic health and social well-being. The empirical model is better equipped to quantify the negative effects of a state's tax policy.

The dynamic general equilibrium model, constructed in chapter 2, is used to quantify and compare the market distortions caused by taxes on income,[3] wealth (property), consumption (sales), and capital income (capital gains). The model economy takes the form of a single state containing a representative household and firm. A dynamic general equilibrium framework is used to solve for five endogenous variables including the wage rate, consumption, labor, rental rate, and accumulated capital. This model imposes taxes exogenously. There is no government in this model actively choosing a tax policy. Elasticities are calculated showing how a 10% increase in each tax (say from 5% to 5.5%) affects productivity, gross domestic product (GDP), and household welfare.

Taxes on capital income and wealth are always ranked as being more disruptive than taxes on income or consumption. For instance, the elasticity of productivity using the set of "Average" parameter values finds that a 10% increase in taxes on capital income (say from 5% to 5.5% will cause productivity to fall by -1.65%. This estimate, summarized in table 4.1 is greater than the estimated drop in productivity from the same increase in taxes on consumption, a drop of only -0.55%. All other measures of economic health and social well-being find taxes on capital gains to be more costly than taxes on wealth. Differences in estimates from one metric to the next emphasize the importance of testing one's definition of economic health and social well-being. A ranking of which tax is most disruptive is not

[2]Public goods don't exist, markets work efficiently, the household desires only to consume and have leisure time, there is no income inequality because there is only one representative household...etc.

[3]Income taxes in the United States include short term capital gains in addition to wage income.

sensitive to the values given to model parameters within the range being considered.

Empirical model results

A panel data analysis of the contiguous United States from 1977 - 2004 is used to test the results of the theoretical model. An empirical model, called the base model, is constructed for this purpose.

The base model regresses the total level of productivity on lagged tax rates and lagged controls. Of the four tax levies, the property tax is estimated to have the greatest and most significant negative impact on productivity. In contract, taxes on consumption are found to have mild if any effects on productivity.

Two tests are conducted on the significance of the joint effect of taxes on productivity. The first is an F-test to find the probability that all tax coefficients are zero. The second tests the significance of the estimated effect of the average state's tax policy as given in equation 8.3. Both joint effects are significant at the 0.1% level according to the base model.

Rankings of state tax policies, as summarized in table 8.8, are estimated using the base model. Rankings are constructed by multiplying each tax coefficient by the state's tax rates. Tax policies are ranked based on the cumulative effect of the state's tax policy on productivity. The usefulness of the ranking is tested by comparing it to rankings of states by productivity. Over 10% of the variation in state productivity rankings can be explained by state tax policy rankings.

The most productive tax policies rely on taxes levied on sales, excise and capital gains. The top three most productive tax policies ranked using the base model are Nevada, Tennessee, and Washington with productivity rankings of 11th, 40th, and 10th respectively. The least productive tax policies are estimated to be those that rely heavily on taxes levied on property, income and corporate profits. Nebraska, Iowa and Vermont have the lowest estimated tax policy rankings with productivity rankings of 34th, 25th and 48th respectively.

There is a fairly strong and negative relationship between state government size and productivity. Just over 42% of the variation in state productivity can be explained by government size. Tests on the joint effect of tax rates on productivity from the empirical models suggest that the low productivity in a state is at least partially caused by the higher tax rates needed to fund a larger state government.

9.2 A method for developing the most efficient tax policy

This section outlines a method for constructing the most efficient tax policy. This method ensures that all tax levies in the tax policy are set to minimize cost for a justified level of revenue.

The most efficient tax policy satisfies two necessary conditions: All tax levies must generate the same amount of revenue per unit loss in economic health and social well-being. The last marginal increase in taxes must produce enough revenue that, when spent on public goods, completely offsets the cost of levying the additional taxes.

What this means is that an efficient tax policy maximizes revenue while minimizing costs to economic health and social well-being. A tax policy strategy based solely on revenue or cost will not be socially optimal except by pure coincidence. If a government focuses only on minimizing cost than a tax may not be effective at generating revenue. For example, suppose a tax T levied on product P causes consumers in the economy to avoid buying product P. In this case the tax is useless. The only effect of tax T was to prevent anyone from purchasing product P. Now consumers must settle for some product B, leaving the economy as a whole worse off. In addition, the government has generated no additional revenue to pay for public services, and the producers of product P are now out of a job.

A tax can still be inefficient, even if the cost of a tax is close to zero. Suppose that producers of product P in the example above could easily switch to producing product B. The effects of the tax T on economic growth would be negligible, making it appear to be the perfect tax levy; except for the fact that no one buys product B, making tax T completely useless. A similar example can be contrived for basing a tax policy strategy entirely on each tax levy's ability to generate revenue. A tax may be marginally better at generating revenue and at the same time be much more harmful to economic health and social well-being.

Defining efficiency

Efficiency is a metric used to precisely tax by accounting for both a tax's costs and benefits. The efficiency of a tax levy is defined here as the marginal rate at which the tax can collect receipts over the marginal loss in economic health and social well-being associated with the increase in taxes. Different definitions of economic health and social well-being will lead to some difference in the estimated efficiency of a tax levy. Welfare is the most typical definition used by economists and so it is used here.[4] Tax efficiency is thus defined more precisely as the marginal increase in tax receipts gained per unit loss in welfare.[5] In the limit, efficiency is defined as follows.

$$tax_i\, efficiency = (-1)\,\frac{\left(\frac{\partial G}{\partial \tau_i}\right)}{\left(\frac{\partial U}{\partial \tau_i}\right)} \tag{9.1}$$

Government revenues, G, is the sum of all tax revenues.

$$G = (\tau_w)\, wl + \tau_p k + \tau_s A\,(k)^{\theta}\,(l)^{1-\theta} + \tau_k r k$$

Household welfare, U, is a function of consumption and leisure.

$$U = \beta^t\,(c_t)^{\alpha}\,(1 - l_t)^{(1-\alpha)}$$

This measure of efficiency only makes intuitive sense when taxes positively affect government revenue and negatively affect welfare. A tax efficiency of 5 means that the change in government tax receipts is five times that of the util loss in household welfare, or more simply, five monetary units per util.[6]

This measurement is useful only when taxes actually hurt welfare. This is always the case

[4] A thorough construction of an optimal tax policy will use a variety of measures to proxy for economic health and social well-being in order to ensure against a bias in any one measure.

[5] The main idea behind the definition is that a tax's usefulness (or efficiency) should take into account both the tax levies benefits and costs.

[6] A different metric for measuring economic health, such as productivity, would use monetary units in the denominator. A metric without an easily interpretable unit could be measured in log terms, such as an index of multiple metrics.

in this theoretical model and generally the case in reality.[7] Taxes, by themselves, do nothing more than disrupt markets. It is the spending of tax receipts on public goods that cause greater welfare, not the levying of taxes.

Public goods are purposely not considered in this model. By not considering public goods, the effects of taxes are limited to their disruption on otherwise efficient markets. By levying taxes which have no other purpose but to distort markets, the effect on household welfare is always negative. A separate analysis of each potential public service under consideration is needed to properly estimate a tax's efficiency.

Tax revenues are given back to the consumer in a lump sum G.

$$G = (\tau_w)\, wl + \tau_p k + \tau_s A\,(k)^{\theta}\,(l)^{1-\theta} + \tau_k r k$$

The revenues obtained by each tax independent of all other tax levies are presented in figure 9.1. This figure gives the Laffer curve associated with each tax levy. A government cannot always increase tax rates and expect an increase in revenue. The intuition behind this result is simple. While a small tax may bring some loss in labor participation and output, the economy as a whole will still function allowing some positive level of government revenue. However, at higher tax rates the increase in the tax rate is not enough to compensate for the damage done to the economy from market distortions that create dead weight losses, loss of business from tax competition, black markets, and additional administration.

All tax levies produce a Laffer curves that only produce positive revenue at tax rates between 0% and 100% except taxes on wealth, represented. This is because the household still makes capital income from wealth each period before taxes are levied. As the property tax increases the equilibrium rental rate of return on capital increases as given by equation 2.7. The household's elasticity of intertemporal consumption substitution equals $1/(1-\alpha)$ so it is not linear.[8] The production function satisfies the Inada conditions so as the capital stock goes

[7]The exception is when a good or service has a negative externality that is not already accounted for in the price.

[8]For any $\alpha > 0$ it is an elastic case, with $\alpha = 1$ being the linear or infinitely elastic case. The steady state capital stock is decreasing in taxes on wealth.

to zero it's return approaches infinity. In short, as the tax rate on wealth approaches 100%, the returns from capital income get really big, offsetting the cost of having all the household's wealth taxed away. This result, although possibly of interest to academics, has no application to tax policy in the United States. The average property tax rate is is 1.55%. No property tax rate in the United States comes anywhere close to 10%, let alone 100%.

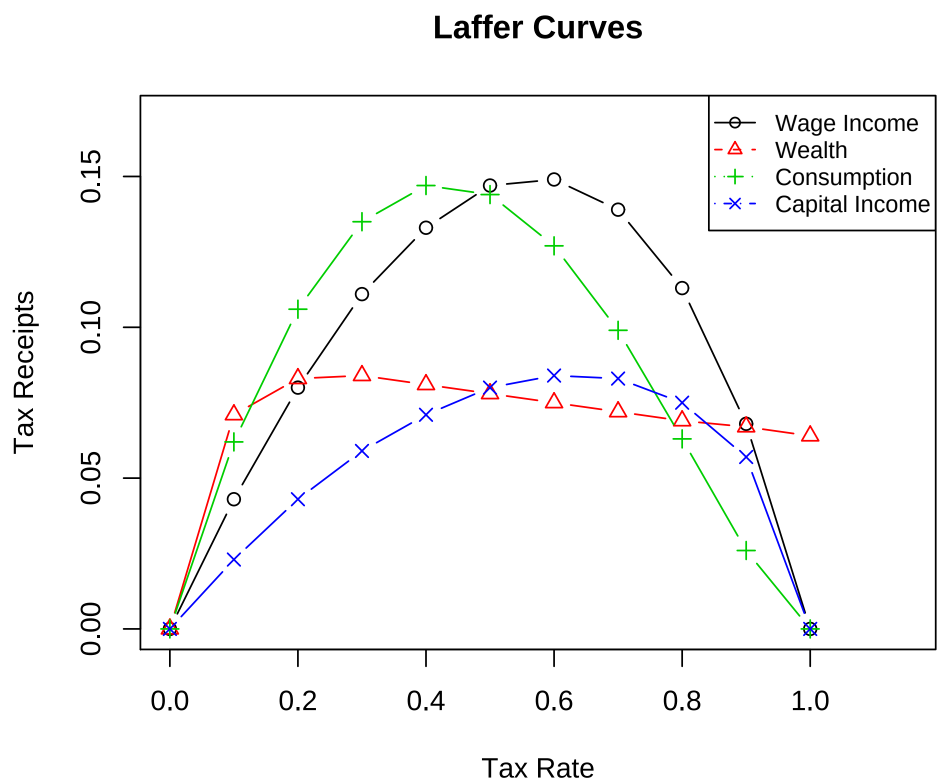

Figure 9.1 Supply side economists use Laffer curves to show how a decrease in a tax rate can actually increase tax revenues. Results from the dynamic general equilibrium model constructed in chapter 2 show this to be the case for all tax rates greater than 60%. Taxes on wealth can be set at 100% and still leave the household with an incentive to save. This is true only because the household can make some money by investing its wealth before it is taken away each period. This model ignores costs related to tax competition, black markets, and administration. If these additional costs were included in the model, these Laffer curves would dip down at even smaller tax rates.

Diminishing tax efficiencies

A comparison of each tax levy's efficiency is summarized in figure 9.2. The efficiency of each tax is calculated by holding all other tax rates at zero and by using model parameter values that reflect the economic environment of a state in the United States.

When interpreting figure 9.2, note that the efficiency of a tax is a function of all four tax rates. Although not shown in figure 9.2, the initial efficiency of the consumption tax drops from 4.25 to 3.57 once the wage income tax rate is increased to 10%. It isn't until the wage income tax rate reaches 40% that the efficiency of a tax on consumption becomes greater than that of a tax on wage income. What is shown in figure 9.2 is how the efficiency of any one tax diminishes with its own rate. For instance, the efficiency of the wage income tax drops from 10.61 to 1.72 when the wage income tax rate is raised from 0% to 40%. The values for tax efficiency are calculated using 10% intervals in the tax rate instead of the limit.[9]

When all tax rates are zero, the tax on wage income has the greatest efficiency. The efficiency of the wage income tax diminishes as the wage income tax rate increases. When the wage income tax rate reaches 60%, it becomes inefficient at generating additional revenue. All tax levies have points before 100% where they become completely inefficient. Taxes on wealth, consumption, and capital income lose all efficiency at roughly 30%, 40%, and 60% respectively.

[9]The derivatives of G and U with respect to each of the four tax rates contain more than 1024 characters, making it difficult to give precise calculations.

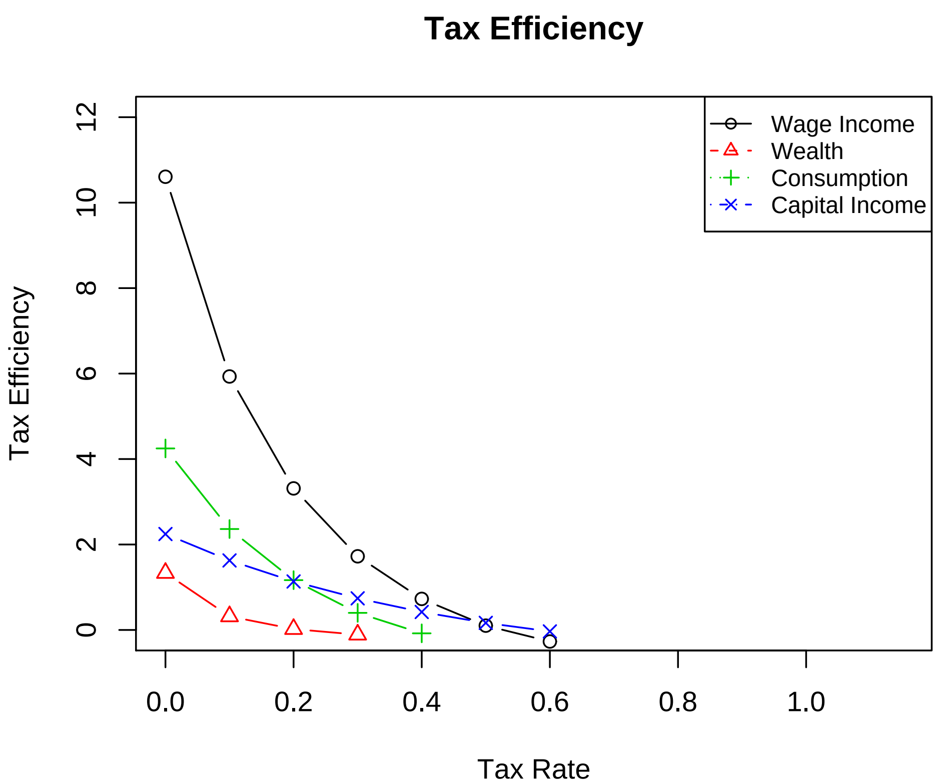

Figure 9.2 The efficiency of a tax is higher at lower tax rates. This is because Laffer curves are concave. The efficiency of each tax is constructed by holding all other tax rates at zero and using the "Average" set of model parameters.

Current tax efficiencies

The first thing to note from the estimates presented in table 9.1 is that all current tax levies are efficient at producing tax revenues. Tax efficiency is calculated by recording the effects of a 10% increase in each tax above historical averages where a 10% increase on a tax rate of 5% is 5.5% not 15%. The income tax is found to be the most efficient followed by taxes on consumption, capital income, and wealth.

Metric	**Tax Efficiency**			**Tax Receipts**			**Household Welfare**		
Parameter Set	**Low**	**Avg**	**High**	**Low**	**Avg**	**High**	**Low**	**Avg**	**High**
Income*	4.04	2.58	1.61	2.80%	2.02%	1.02%	-0.22%	-0.25%	-0.26%
Consumption	1.92	1.23	0.60	0.95%	0.67%	0.29%	-0.11%	-0.12%	-0.13%
Capital Income	0.42	0.22	**-0.16**	1.19%	0.68%	**-0.43%**	-0.62%	-0.69%	-0.73%
Wealth	0.44	0.23	**-0.16**	0.54%	0.45%	**-0.51%**	-0.27%	-0.44%	-0.85%

Table 9.1 **Current marginal tax effects on tax efficiency:** These results are calculated by substituting theoretical model parameters with average historical tax rates aggregating the federal, state, and local level. Each tax rate is increased by 10% in order to calculate its efficiency and elasticity where a 10% increase in a tax rate of 5% is 5.5% not 15%. * Income in the United States is composed of both wage income and short term capital gains. To adjust for this fact, all tax effects on income are defined as a weighted average of effects on capital income and wage income such that income = 84.7% wage income + 15.3% capital income; The weights come from a report by taxfoundation.org for the year 2005.

APPENDIX A. Additional Theoretical Model Simulations

A.1 Simulation of tax effects on endogenous variables

Simulations of the effects of taxes on model parameters are presented in figures A.1 through A.4 and table A.1. These effects assume values for models parameters mimicking that of the United States for the years 1977 - 2004. After consulting with other studies, model parameters A, θ, α, β, and δ are given the values 1, .35, .5, .935, and .08. These estimates are calculated using an average of the estimates cited in the literature discussed in the previous section.

The four simulations summarized in figures A.1 through A.4 hold all tax rates at zero except for the one tax rate of interest given on the x-axis. The value of all the model's endogenous variables including the wage, w, rental rate of capital, r, shadow price of consumption, λ, labor, l, consumption, c, and capital, k, are shown as the tax rate of interest increases from 0% to 100%. Table A.1 summarizes the direction of each tax effect on the model's endogenous variables in addition to the second derivative of each endogenous variable with respect to each tax rate.

Taxes always cause the household to work less and therefore consume less. The reason for this is that taxes decrease the returns the household receives from working. Wages are never increased by taxes. Every tax but the wage income tax decreases the wage rate paid to the household by the firm.[1] In addition to lowering the household's returns for working, taxes also decrease the purchasing power of the household. Taxes always increase the price of consumption. With higher prices and lower wages the household works less.

Taxes differ in the magnitude of their marginal effects on endogenous variables at different

[1]The wage rate is not affected by taxes on wages only because of the functional form of the production function.

tax rates. The wage income tax, τ_w, is noticeably easier on the economy in multiple ways. For one, the wage income tax has the smallest marginal effect on capital at low tax rates. The wage income tax, and the consumption tax, are independent of the cost of renting capital unlike taxes on wealth and capital income. The wage income tax effect on labor and consumption is concave, meaning that lower tax rates have smaller marginal effects than higher tax rates. For these reasons the wage income tax is more benign at low rates.

The wealth tax, τ_p, is a tax on the household's capital stock. This tax is roughly analogous to property taxes often levied by state and county governments in the United States. The wealth tax has the most detrimental marginal effects on the economy at low rates. By increasing the wealth tax rate to only 10%, total state capital drops by 57%; compare this drop to a 6% drop in capital caused by a similar increase in taxes on wage income. Wealth taxes also have the highest marginal effects on the wage rate. The wage rate drops by 24% when the wealth tax rate increases from 0% to 10%. The wage rate is unaffected by increases in the wage income tax. Taxes on capital income and consumption cause a drop in wages by 5.5% and 15% respectively from a similar increase in tax rates. Wealth taxes also have the strongest effect on consumption. By increasing the wealth tax rate from 0% to 10%, household consumption drops by 21%; compare this drop to a 6% drop in consumption caused by a similar increase in taxes on wage income. From the same increase in initial rates, taxes on consumption and capital income cause 10% and 5.5% drops in consumption respectively.

Taxes on wealth and capital income are fundamentally different from taxes on wage income and consumption because the former are applied directly to capital. The incentive for the household to work is not directly hurt by taxes on capital, but do cause the household to lower their savings rate. Conversely, taxes on wage income and consumption are taxes on the household's purchasing power and directly lower the household's incentive to work. This difference between the effects of taxes on capital and taxes affecting purchasing power are vividly apparent in figures A.1 through A.4. Although all taxes decrease labor, taxes on capital (wealth and capital income) have almost no effect compared to taxes on wage income and consumption.

Tax effects on the model's endogenous variables are useful in identifying how each tax levy is unique. However, the overall effect of each tax can be more accurately measured using a combinations of endogenous variables. In the next section, three proxies for economic health and social well-being are constructed from the models endogenous variables to better compare the four tax levies.

Figures A.1 through A.4 describe how each tax affects the model's endogenous variables. Taxes on the household's wage decrease output and supply of labor proportionally. For this reason, productivity (Y/l), remains constant. Wage income (w) is proportional to productivity. Thus, taxes on wage income do not affect the wage rate. This result is a product of the Cobb-Douglas production function. The tax on wealth is the most costly to the economy at the margin at smaller tax rates. Labor is less affected by taxes on property because the household is not punished directly for working. Taxes on consumption have a strong negative impact on capital accumulation, the wage rate, and consumption compared to taxes on wages. However, taxes on consumption are not as detrimental to the economy as taxes on property. Taxes on capital income diminish capital accumulation, but otherwise have relatively mild effects on the economy at smaller rates.

The shadow price is in terms of utility.[2] Labor is measured as portion of the household's time. The rental rate of capital and the wage rate are measured as the price of capital/labor relative to the price of consumption. Consumption is measured as the total value of consumption in the economy where the price of consumption equals one.

[2] How much will a unit of the good please the household at the margin given some level of consumption.

Variable	Rental Rate, r		Wage, w		Shadow Price, λ		Labor, l	
Derivative	FOD	SOD	FOD	SOD	FOD	SOD	FOD	SOD
Income Tax, τ_w	0	0	0	0	+	+	-	-
Property Tax, τ_p	+	0	-	+	+	-	-	+
Sales Tax, τ_s	0	0	-	+	+	+	-	-
Capital Gains, τ_k	+	+	-	-	+	+	-	+

Variable	Consumption, c		Capital, k		capital/labor	
Derivative	FOD	SOD	FOD	SOD	FOD	SOD
Income Tax, τ_w	-	-	-	-	0	0
Property Tax, τ_p	-	+	-	+	-	+
Sales Tax, τ_s	-	+	-	+	-	+
Capital Gains, τ_k	-	-	-	+	-	+

Table A.1 **Summary of tax effects on endogenous variables:** FOD stands for first order derivative of the endogenous variable with respect to the corresponding tax levy. SOD stands for second order derivative.

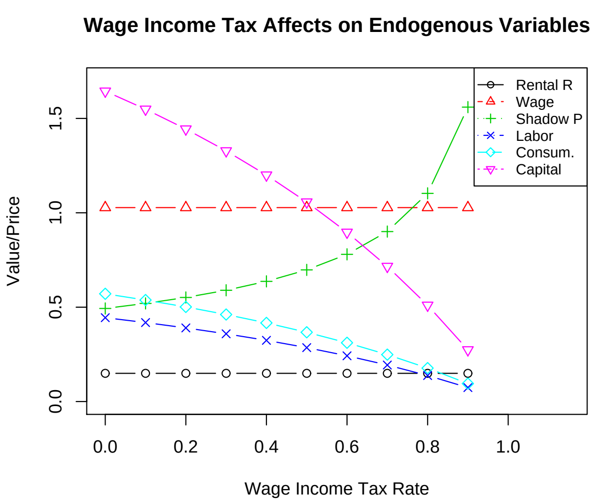

Figure A.1

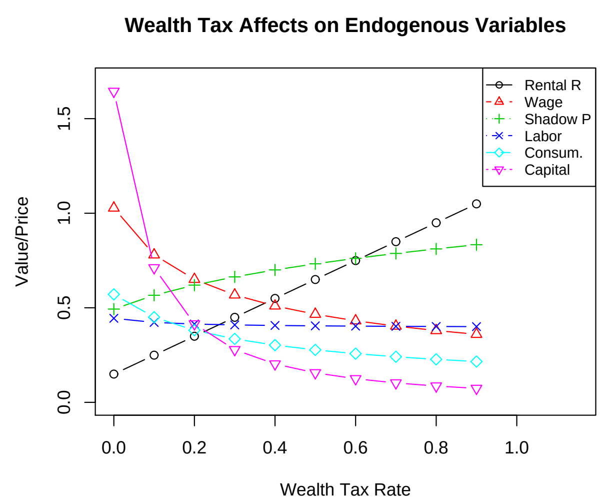

Figure A.2

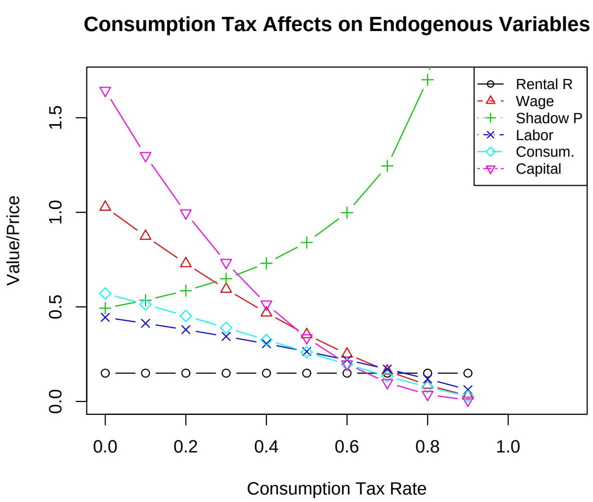

Figure A.3

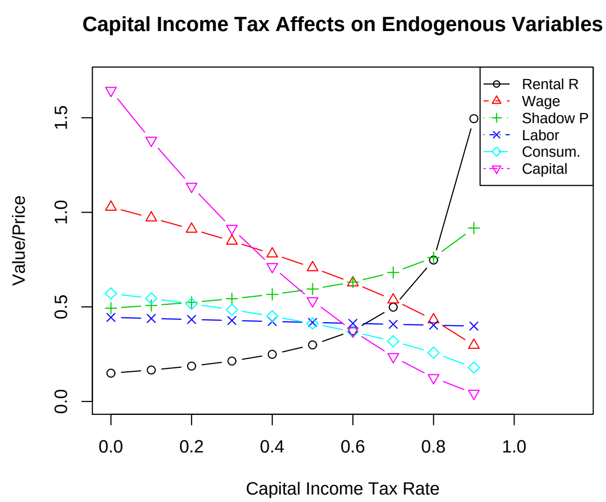

Figure A.4

A.2 Simulation of tax effects on proxies for economic health and social well-being

Three measures of well-being are calculated in chapter 3 from variables in this model including gross domestic product (GDP), productivity, and household welfare. Figures A.5 through A.4 give a visual summary of how each measure of well-being changes when model parameters A, θ, α, β, and δ are given the values 1, .35, .5, .935, and .08 respectively. All tax rates are given values of zero except for the one tax rate of interest given on the x-axis. Table A.2 summarizes the direction of each tax effect on the model's measures for well-being in addition to the second order derivative of the measure with respect to the corresponding tax levy.

Without the existence of a public good, or inefficient markets, it should come as no surprise that all taxes are bad for all three measures of economic health and social well-being. All tax levies hurt household welfare by distorting otherwise efficient markets.

This analysis is not meant to argue that all taxes should be removed from an economy. Like any good experiment, all variables except the one of interest are controlled for in this model. Only the distortionary effects of taxes are of interest here. In order to isolate these distortionary effects, the positive effects of government spending are removed from the model. The goal of this exercise is to compare the magnitudes of tax effects on measures for economic health and social well-being, and give a clearer picture of how "cheap" each of the four tax rates is.

One strong result from the simulations summarized in figures A.5 through A.4, is that taxes on wage income are initially cheaper than all other tax levies. An increase in the wage income tax rate from 0% to 10% has no noticeable effect on any one of the three measures of well-being. All other tax levies have significant negative effects on all three measures of economic health and social well-being.

Taxes on wealth have greater marginal effects on productivity, GDP and household welfare than any other tax levy. A tax on wealth is also unique in that its effects on all measures for well-being are convex, meaning that the magnitude of its marginal effects are greatest at lower tax rates.

A tax on consumption has relatively small initial effects on GDP and household welfare, but big noticeable effects on productivity. The consumption tax effect on consumption is concave when the consumption tax rate is less than 80%.

Taxes on capital income are almost as harmless as taxes on wage income at tax rates of less than 10%. However, because the relationships between the capital income tax and the three measures for well-being are concave, the negative marginal effects from the capital income tax increase as the tax rate increases.

The purpose of a tax is to produce tax receipts for public goods as cheaply as possible. Up to this point, tax levies have only been compared in terms of their cost. However, a true comparison of tax levies requires an estimation of the cost and benefit of a tax. For the best comparison of taxes, the revenues gained from the tax levy must be weighed against the effects of the tax on household welfare.

Figures A.5 through A.4 describe how each tax affects different measures of economic health and social well-being. Taxes on the household's wage decrease output and supply of labor proportionally. For this reason, productivity (Y/l), remains constant. Wage income (w) is proportional to productivity. Thus, taxes on wage income do not affect the wage rate. Again, this result is not robust to alternative forms of the production function. Other welfare measures are diminished by taxes on wages but only by small amounts. GDP is calculated by adding output and tax receipts. All welfare measures are considerably reduced when taxes on wealth are imposed. Taxes on consumption have adverse effects on the economy. Taxes on consumption are, however, less adverse than taxes on wealth. Taxes on capital income have relatively benign effects on all three measures of economic health and social well-being.

Variable	Productivity, w		Welfare, U		GDP, Y		Tax Receipts, G	
Derivative	FOD	SOD	FOD	SOD	FOD	SOD	FOD	SOD
Income Tax, τ_w	0	0	-	-	-	-	+,-	-
Property Tax, τ_p	-	+	-	+	-	+	+,-	-
Sales Tax, τ_s	-	+	-	-	-	-,+	+,-	-
Capital Gains, τ_k	-	-	-	-	-	-	+,-	-

Table A.2 **Summary of tax effects on economic health and social well-being:** FOD stands for first order derivative of the endogenous variable with respect to the corresponding tax levy. SOD stands for second order derivative.

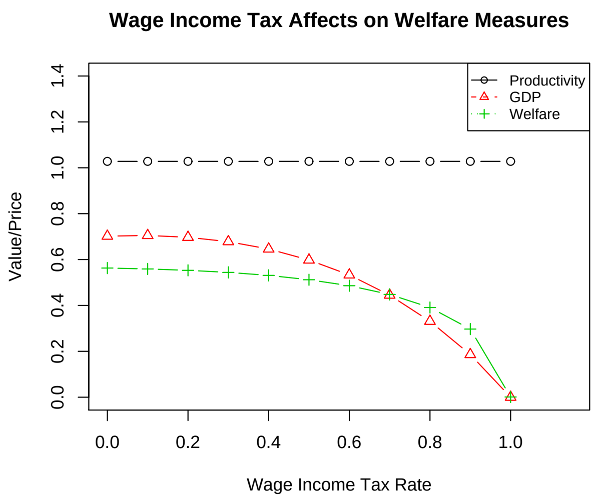

Figure A.5

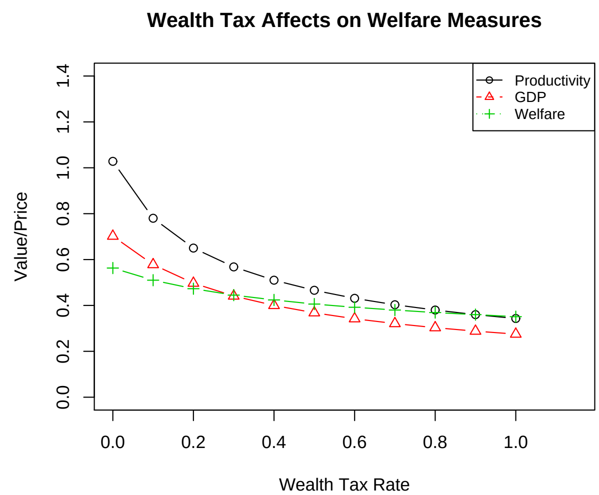

Figure A.6

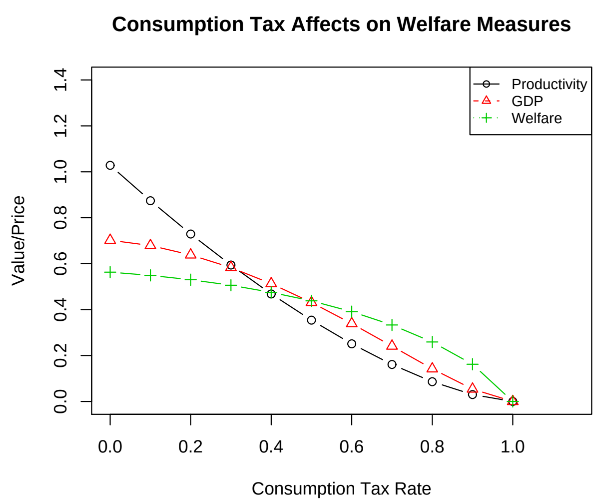

Figure A.7

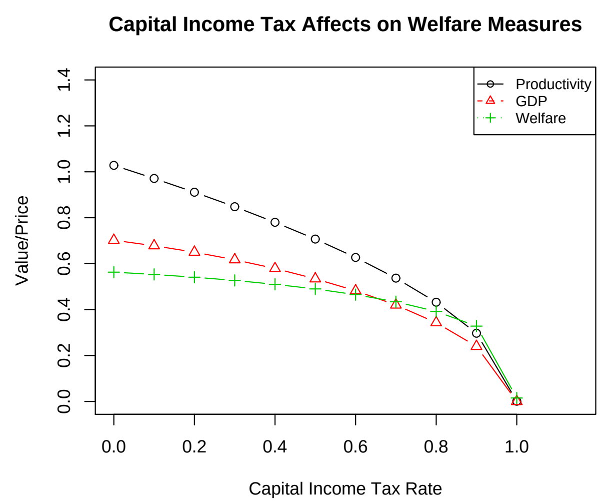

Figure A.8

APPENDIX B. The zero-tax-on-capital debate

A sizable portion of the literature on tax policy focuses on this debate. For this reason a summary is included to show the contrast of how this work's approach to the optimal tax policy question is different from "golden bullet" approach taken in this example.

Chamley (1986) formalized the argument for a zero-tax-on-capital using a closed economy, infinitely lived homogenous agents and exogenous growth rates. Chari (1999) extended Chamley's result, showing that it "holds when agents are heterogeneous rather than identical, the economy's growth rate is endogenous rather than exogenous, the economy is open rather than closed, and agents live in overlapping generations rather than forever. (With this last assumption, the result holds under stricter conditions than with the others)".[1] Judd (2002) argues that Chamley's results holds under imperfect competition as well since "the estimated gains are larger and the range of Pareto-improving policies is greater."

These studies by Chamley, Chari and Judd, taken together, provide a rigorous theoretical argument for taxing consumption instead of capital income. Their findings are given empirical credence by Altig (2001), who uses a dynamic life-cycle simulation model to compare the welfare effects of different tax reform policies. Altig also concludes that income taxes are too high and should be partially replaced with taxes on consumption. A recent empirical study by the Organization for Economic Cooperation and Development titled "Taxes and Economic Growth", supports Chamley's original claim still further. The study argues that "corporate taxes are the most harmful for growth, followed by personal income taxes, and then consumption taxes."

Opponents of the zero-tax-on-capital view include Aiyagari (1995) and Uhlig (1995) among

[1] Taken directly from Chari's (1999) abstract.

others. Both scholars use finitely lived agent models, such as the over-lapping generations, to show that the optimal tax on capital income can be positive in the long run. The fact that both major opponents use a similar model that is fundamentally different from Chari, Chamley, and Judd is not a mere coincidence. Only Chari (1999) uses a finite lived agent model to achieve Chamley's original result, and in this one exception, Chari recognizes that additional strict assumptions are necessary to ensure that the optimal tax on capital is still zero.[2]

Supporters of each tax policy are, for the most part, segregated by the style of model. Those who find any tax on capital to be a bad idea typically use general equilibrium (GE) models (Chari 1999, Chamley 1986). Their models assume that government tax receipts are paid back to consumers in a lump sum rebate and ignore income inequality. Judd argues that Chamley's result holds for inefficient markets but uses a persuasive argument rather then a rigorous macroeconomic model.[3] Proponents of the zero-tax-on-capital view use models that assume away all the problems in a real economy that lead to government intervention such as the value of public goods and externalities.

Opponents of Chamley's conclusion, including Koskela (2002) and Aiyagari (1995) typically use over-lapping generation (OLG) or Bewley-type models.[4] This alternative approach to analyzing the tax effect on the economy carries with it a new set of assumptions. Both Koskela and Aiyagari assume market inefficiency. Uhlig goes a step further and assumes that a household's willingness to work is unaffected by the income tax rate.[5] These new assumptions lead to new conclusions. One plausible role of government is to correct market inefficiencies. By assuming markets are inefficient, the need for a larger government increases. Larger governments require greater tax receipts and the need for higher tax rates. The benefits of taxing capital are enhanced by the need for additional government revenues to correct for market inefficiencies. By assuming household's willingness to work is unaffected by the tax rate the cost of taxes are

[2] Additional authors may have made this claim as well but we focused on more recent, published studies.

[3] Judd's paper "Capital-Income Taxation with Imperfection Competition" is a short, five page paper, that pulls conclusions from other papers to make his argument.

[4] Koskela uses a GE model but assumes markets are imperfectly competitive making markets inefficient. This is a typical characteristic of the over-lapping generations model.

[5] Uhlig assumes that supply of labor is inelastic to changes in income taxes, or anything else for that matter. This assumption is necessary in order to show that increasing the income tax rate increases growth. In this case capital gains are considered part of the household's income.

diminished.

Between these two extremes are those who find mixed results[6] and those who find taxes to have no significant effect at all[7]. Fourteen years later, Chamley (2000) questions his original thesis that capital income should not be taxed and finds that his previous conclusion “hinges critically on the assumptions of a long horizon and perfect markets for the inter-temporal allocation of resources”. In his reminiscent work he essentially reiterates the importance of model assumptions in generating model conclusions.

[6] Zodrow (2006), “Should Capital Income Be Subject to Consumption-based Taxation?”
Helms (1985), “The effect of state and local taxes on economic growth: A time series-cross section approach”
[7] Bauer (2006), “State growth empirics: the long-run determinants of state income growth”
Wasylenko (1985), “Jobs and Taxes: The Effect of Business Climate on States’ Employment Growth Rates”

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