State Business Taxes and Investment: State-by-State Simulations*

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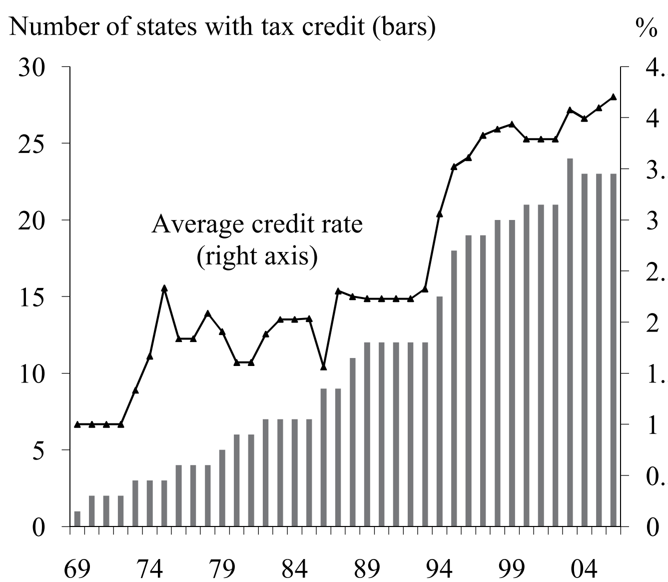
This article develops a framework for simulating the effects of state business taxes on state investment and output. Our simulations provide the predicted increase in investment—both in equipment and structures (E&S) and in research and development (R&D)—and the predicted increase in output for a given state resulting from a specified change in one of its three tax policies—the E&S investment tax credit, the R&D tax credit, or the corporate income tax. The simulations depend on a set of formulas linking economic parameters and state data to investment and output, all of which are reported in this article. We report results, based on our preferred set of parameters, for each of the 48 contiguous states. We also discuss alternative parameter values and explore the resulting sensitivity of predicted changes in state investment and output. Finally, we describe a simple web tool that we have made available online (www.frbsf.org/csip/taxapp.php) that allows users to insert their own preferred parameter values and simulate the economic effects for the state and tax policy of their choosing.

1. Introduction

Business tax incentives have become a powerful weapon in states' fiscal arsenals in recent years. Tax incentives have been used both for countering recessions in the short run and fostering sustainable economic growth in the long run. For example, California's initial budget for fiscal year 2009 passed in February 2009 expanded business tax incentives by $1 billion, even while the state cut spending by $20 billion and hiked personal taxes and fees.[1]

State tax policy has become much more business-friendly in recent years. The first broad, statewide tax credit for investment in equipment and structures (E&S) was enacted in 1969 by New York. By 2006, 23 states offered similar credits and the average credit rate among those states had grown to over four percentage points (see Figure 1). Similarly, state tax credits for investment in research and development (R&D) have become increasingly common and generous since the first such state credit was enacted in 1982 by Minnesota. By

Figure 1
State Investment Tax Credits for Equipment and Structures (E&S), 1969 to 2006



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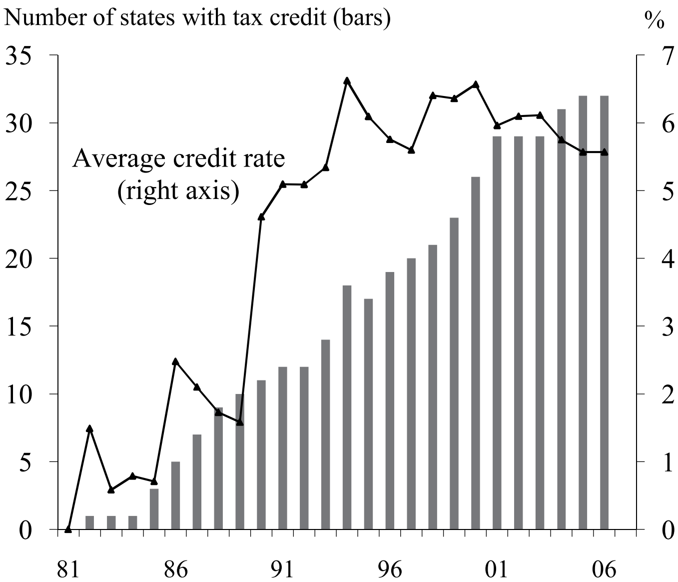
1. These tax incentives were later rescinded because continued deterioration in state receipts and the failure of certain ballot initiatives led to a further imbalance in the budget.

FIGURE 2
STATE RESEARCH AND DEVELOPMENT (R&D) TAX CREDITS IN THE UNITED STATES, 1981 TO 2006



2006, 32 states had an R&D tax credit, and the average rate among those states was 5.5 percentage points (see Figure 2). The proliferation of tax credits in subsequent years, combined with aggressive tax planning vis-à-vis apportionment formulas and passive investment companies, has led to a general decrease in average corporate tax collections over the past 25 years.[2] In response to recently slumping economies, states have accelerated their use of business tax incentives (Silver-Greenberg 2009). Whether such incentives are good public policy is a matter of great debate and controversy. Nonetheless, it is clear that states' reliance on such incentives have increased tremendously over the past few decades.

What impacts should state policymakers expect from granting investment tax incentives? This article offers a partial answer to this question and contributes to the quantitative evaluation of state business taxes. We present a framework that translates a given change in state business tax policy into changes in E&S investment, R&D investment, and overall state economic output. The links among tax policies, investment, and output depend on a set of channels determined by economic theory and a set of parameters whose values are drawn from empirical research. Some of these parameters depend on extant tax policy at the state level, and we provide the information needed for the computations. Other parameters represent structural characteristics of the economy. We rely on prior studies to determine our preferred parameter values, though we also consider the sensitivity of our results to alternative values of these parameters.

Our article proceeds as follows. Section 2 introduces the framework for simulating the impact of state business taxes. The user cost of capital is a fundamental concept linking legislated tax policies to economic incentives. The mobility of capital across states presents a particular challenge for analyzing state tax policy, because the incentive effects of the resulting tax competition must be quantified. A change in incentives affects investment and production through three sets of channels: direct and indirect (reflecting capital mobility and tax competition) user cost channels, substitution and scale channels, and direct production and multiplier channels. All of the relevant economic parameters are discussed. Section 3 reviews the literature and provides some perspective on reasonable ranges for the structural parameters. Section 4 presents state-by-state simulation results for all 48 contiguous states. We illustrate exactly how these results are obtained by walking through the process for one particular state, California. Last, we describe a simple web tool that we have made available online that allows users to insert their own preferred parameter values and simulate the economic effects for the state and tax policy of their choosing. Section 5 summarizes and discusses other state tax policies.

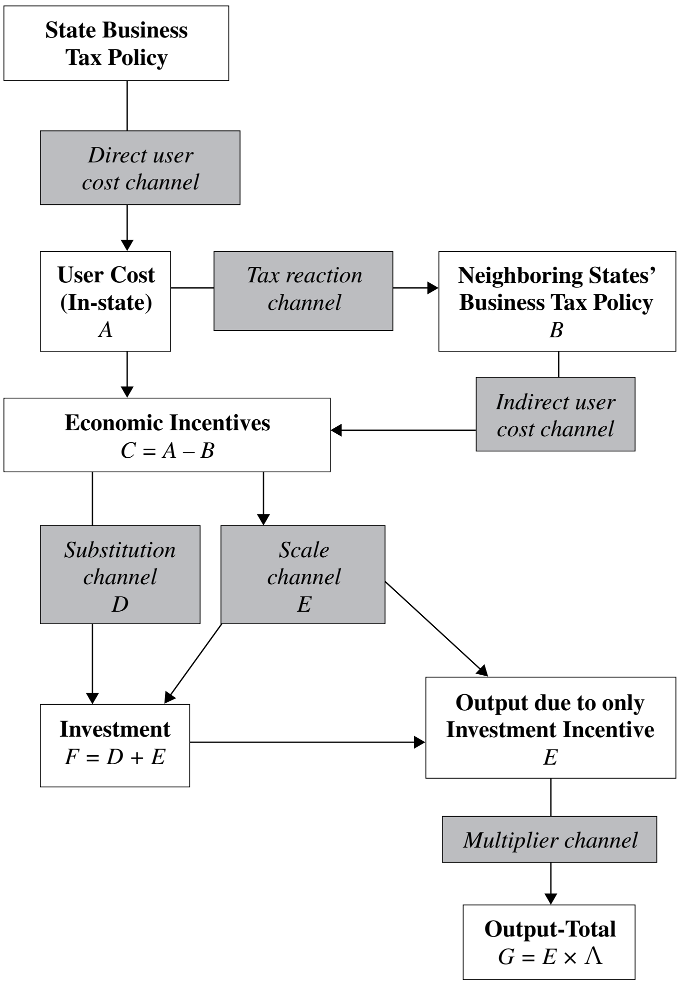
2. A Framework for Simulating the Impact of State Business Taxes

This section develops a framework that links legislated changes in a state's business taxes to resulting changes in the state's stock of equipment and structures capital, its stock of research and development capital, and output.[3] Our framework is depicted in Figure 3. A change in a given tax policy (e.g., a decrease in the corporate income tax rate) affects economic incentives embedded in the user cost of capital (explained later) that, in turn, affect investment and output. These economic variables—the user cost, investment, and output—are linked together by a series of channels that depend on theoretical relations and assumed parameters. (The channels and parameters are summarized in Table 1.) The structural parameter values underlying the simulations are not restricted in our framework, and any values can be inserted in the online applet that accompanies this study. We rely on the literature discussed in Section 3 for guidance on

2. See Wilson (2006) and Gupta et al. (2009) for further discussion of state corporate tax collections and the reason for the decline in recent years.

3. Technically, the quantity of investment analyzed in this article is net investment, defined as the increase in the capital stock due to the stimulus less depreciation of the existing capital stock. Since we think of depreciation as largely exogenous to the tax policies under consideration, it is not considered explicitly in our analysis.

FIGURE 3
FRAMEWORK RELATING STATE BUSINESS TAX POLICY TO INVESTMENT AND OUTPUT



the range of appropriate parameter choices, and we show in Section 4, through simulations, the sensitivity of the economic effects of business tax policies with different parameter values.

Before proceeding to the specific channels, we note four characteristics of our framework. First, the framework for simulating the impacts of tax policies affecting E&S or R&D investment is the same, though the underlying parameter values will differ. The user cost framework applies equally to the tangible capital built up from past and present E&S investment and to intangible knowledge capital built up from past and present R&D investment. A state's user cost of R&D capital and its user cost of E&S capital will differ due to differences between R&D and E&S in the investment tax credit rate and tax depreciation allowances. Second, the simulations are based on a change relative to the status quo, which differs by state. Third, we restrict our attention to state business taxes and do not consider the additional and potentially important roles of state personal and sales taxes. Fourth, the simulations are most appropriate for economic environments where resources are fully utilized. With this long-run focus, which particularly affects the assumed value for the production multiplier, tax policies designed to stimulate investment in response to a temporary downturn in economic activity would need to be analyzed in a different framework. Our framework is more appropriate for long-run considerations and provides a "roadmap" from tax policy to its ultimate effects on investment and output through three sets of channels we will discuss. But first, we turn to the user cost of capital, the key variable for representing the economic incentives provided by legislated tax policies.

2.1. The User Cost of Capital

The user cost of capital is the fundamental concept for quantifying the effects of tax legislation on capital formation. This concept was introduced by Jorgenson (1963) and is based on the economic equivalence between renting and owning a piece of durable capital. In both cases, the user of that capital good can be thought of as making a periodic payment for capital services. The only difference is that renters of capital are making an explicit payment, whereas owners of capital are effectively renting the capital from themselves and hence making an implicit payment. With this insight, durable capital can be assigned a rental price or user cost that is easy to measure and can be readily analyzed with the standard tools of price theory. Furthermore, the economic impact of several tax policy instruments—investment credits, depreciation allowances, and income taxes—can also be quantified. The user cost provides an enormously convenient framework for translating the effects of legislated tax changes into numerical estimates useful in quantitative policy analysis.

The user cost of capital (UC) depends on several components—the opportunity cost of financial capital, the depreciation of physical capital, the relative price of investment goods, and taxes. The opportunity cost of financial capital, ρ, is the expected return from investing in financial markets, instead of spending the funds on equipment and structures or research and development, and can be specified in several ways that depend on auxiliary assumptions about corporate financing. One approach measures ρ in terms of the real cost of the marginal source of funds—retained earnings (internal equity), external debt, or external equity.[4] Under the

4. See Sinn (1991) for a taxonomy of different funding sources and the associated taxes and Auerbach (1983) for the relationship between taxes and corporate financial decisions. The real cost of funds is usually calculated by subtracting an estimate of the expected rate of inflation stated in terms of the producer price. To be consistent with the theoretical derivation of the user cost, the inflation correction should be stated in terms of the price of new investment.

Table 1
Glossary of Parameters and Variables

Parameter	Name	Description
		Panel A. Structural (non-state-varying) Parameters
α	Slope of the tax reaction function	The percent change in $UC^{\#}$ for a 1% change in UC (where the superscript # represents neighboring states considered as a singular unit). Range of values {–1.0, +1.0}. (equation 5)
σ	Elasticity of substitution between capital and other factors of production	The percent change in the capital stock with respect to a 1% change in UC, holding output and output price constant. Range of values for E&S {0.0, 1.5}; range of values for R&D {0.0, 3.0}. (equation 8)
ω^K	Factor share of capital	Capital's factor share. Range of values for E&S {0.25, 0.50}; range of values for R&D {0.0, 0.1}. (equation 8)
η	Price elasticity of demand for output	The percent change in output demand with respect to a 1 percent change in the price of output. Range of values {0.0, 10.0}. (equation 8)
Λ	Multiplier effect	
		Panel B. State-Specific Data Variables
Variable	Name	Description
UC	User cost of capital	equation (1)
P^I	Price of new investment goods	equation (1)
P^Y	Price of output	equation (1)
ρ	Opportunity cost of financial capital	equation (1), assumed to be 10 percent.
δ	Rate of economic depreciation	equation (1), estimated from depreciation in the manufacturing sector at the national level.
$ITCR^{R\&D}$	Investment tax credit for research and development	equation (2b)
$ITCR^{E\&S}$	Investment tax credit for equipment and structures	equation (2b)
$CITR$	Corporate income tax	equation (2b)
TDA	Tax depreciation allowances	equation (2b), set to 0.70 for all states. $TDA = 1$ for the user cost of research and development.
K	Capital stock	
Y	Output	
		Panel C. State-Specific Economic Variables (Channels)
Channel	Name	Description
A	Direct user cost channel	Parameter A: the percent change in UC for a one percentage point change in τ, where τ equals $ITCR^{E\&S}$, $ITCR^{R\&D}$, or $CITR$. See Table 2 for the values of $A_s^{ITCR(E\&S)}$, $A_s^{ITCR(R\&D)}$, and A_s^{CITR} that correspond to the $ITCR^{E\&S}$, $ITCR^{R\&D}$, and the $CITR$, respectively. Note that the s subscript reflects that the change in the UC with respect to the same change in τ varies by state. (equation 3)
B	Indirect user cost channel	The percent change in $UC^{\#}$ for a one percentage point change in τ and equals $\alpha \times A_s^{ITCR(E\&S)}$, $\alpha \times A_s^{ITCR(R\&D)}$, or $\alpha \times A_s^{CITR}$. (equation 6)
C	Net user cost channel	Direct user cost channel minus indirect user cost channel, $(1-\alpha) \times A_s^{\tau}$. (equation 7)
D	Substitution channel	The percent change in the capital stock with respect to a one percentage point change in τ, holding output constant, $D_s^{\tau} = (\sigma - \sigma \times \omega^k) C_s^{\tau}$.
E	Scale channel	The percent change in the capital stock with respect to a one percentage point change in τ, absent any capital-labor substitution, $E_s^{\tau} = \omega^k \times \eta \times C_s^{\tau}$. E_s^{τ} also gives the percent change in output due directly to the net change in economic incentives.
F	Net investment channel	The percent change in capital stock due to a one percentage point change in τ, $F_s^{\tau} = D_s^{\tau} + E_s^{\tau}$.
G	Multiplier channel	The percent change in total statewide output with respect to a one percentage point change in τ. Leads to the following amount of total output, $G_s^{\tau} = E_s^{\tau} \times \Lambda$.

trade-off theory of capital structure, financial policies equalize the costs of the marginal sources of funds (adjusted for risk and taxes), and thus ρ can be properly measured by either marginal cost. The "pecking order" model also relies on the marginal sources of funds but provides an alternative theory of capital structure that emphasizes asymmetric information in financial markets. In this model, there exists a hierarchy of costs, increasing from internal equity to debt to external equity, and thus our assumptions about the marginal source of funds matter. A third approach measures ρ as a weighted average of the real costs of debt and equity, where the weights represent the proportion of debt and equity in the capital structure. While the marginal funding used in any given year likely differs from the average capital structure reflected in these weights, it must ultimately correspond to the capital structure, and the weighted-average formulation is appropriate for a long-run analysis. The calculations presented in this article sidestep these corporate finance issues and are based on the assumption that $\rho = 10$ percent. This figure is somewhat higher than that used in some other studies but reflects the higher risk premium associated with the manufacturing firms analyzed here.

The next component of the user cost of capital is economic depreciation. Economic depreciation (which differs from tax depreciation discussed later) can be viewed as a "nonrefundable security deposit," reflecting that only a fraction of the rented capital good will be returned at the end of the period because of depreciation. In the standard user cost formula, capital is assumed to depreciate geometrically at rate δ, and our simulations are based on a δ estimated from depreciation in the manufacturing sector at the national level.[5]

The third component of the user cost involves a relative price: the price of new investment goods (P^I) divided by the expected benefit from the output generated by the new unit of capital. For a profit-maximizing firm, the value of that incremental output is its selling price (P^Y). Apart from tax considerations, these three components—the opportunity cost, economic depreciation, and relative prices—lead to the following specification of the user cost,

$$UC = (\rho + \delta) \times (P^I/P^Y). \tag{1}$$

Taxes also affect the user cost of capital, and we consider the roles played by state investment tax credits and the corporate income tax on investment incentives. (For ease of exposition, we do not discuss in this section federal corporate tax policies—that is, the federal R&D tax credit rate, the federal corporate income tax rate, and federal tax depreciation allowances—but they are accounted for in our simulations.)

5. Even if capital depreciates according to some other pattern, long-run replacement requirements tend to a geometric pattern (Jorgenson 1974).

As shown in Figures 1 and 2, state policymakers have frequently sought to stimulate investment by offering tax credits on investment. An investment tax credit is a reduction in a corporation's income tax liability in proportion to the value of investment that the firm does in the state. That proportion is determined by the investment tax credit rate *(ITCR)*. Corporate profits are subject to a corporate income tax that enters the user cost in two ways. In its simplest form, the corporate income tax rate *(CITR)* lowers the pretax income a firm generates from production by a factor of $(1 - CITR)$ multiplied by the price of output appearing in the denominator of the user cost.

Complications arise with tax depreciation allowances that accrue over the useful life of the asset.[6] Since the pioneering work of Hall and Jorgenson (1971), these allowances have been modeled as a present value that depends on tax service lives, tax depreciation patterns, and discount rates. In general, these factors determining depreciation allowances do not vary by state because states normally piggyback on federal IRS depreciation rules. A recent exception is the federal government's temporary accelerated depreciation rules; not all states adjusted their depreciation rules to account for this temporary acceleration. Nonetheless, given that these temporary deviations between state and federal rules are rare, we assume the present value of tax depreciation allowances *(TDA)* is the same across states. The value of *TDA* used in this study is set, for all states, to 0.70 for equipment and structures, slightly lower than the average across asset types reported by Gravelle (1994) in order to make a rough adjustment for the basis reduction due to the investment tax credit. Because 100 percent of R&D investment may be expensed (that is, fully depreciated) in the first year, for all states and at the federal level, *TDA* for R&D is 1.0. Since the benefit of these allowances is to lower the amount of income subject to tax, *TDA* is multiplied by *CITR*. These three tax variables enter the user cost of capital in the following manner:

$$UC = (\rho + \delta) \times (P^I/P^Y) \times TAX \tag{2a}$$

6. There are two additional considerations that affect the *CITR* in the user cost formula. First, property taxes enter the user cost in a manner similar to tax depreciation allowances; both involve a stream of commitments that follow upon purchasing an asset. The present value of property taxes enters the user cost both as a direct cost and as a deduction against taxable income; hence the present value of property taxes would be multiplied by $(1 - CITR)$. Second, for determining corporate income tax liability in a given state, corporations that do business in multiple states must apportion their national income to each state using formulary apportionment. The apportionment formula is a weighted average of the company's sales, payroll, and property (E&S capital), but the weights vary by state. The capital weight can be thought of as a capital tax instrument with effects similar to the corporate income tax. We do not have sufficient information to analyze the effects of either the property tax or capital apportionment at the state level.

$$(2b) \qquad TAX = \frac{1 - ITCR - (CITR \times TDA)}{(1 - CITR)}.$$

Equation (2) captures in a succinct fashion the costs from tax and nontax factors that a profit-maximizing firm faces when evaluating the acquisition of the marginal piece of capital.[7]

There are three considerations to keep in mind in using equation (2) to assess tax policy. First, an important assumption underlying the above derivation of the user cost is that the firm has sufficient profits to pay taxes. Absent this condition, (nonrefundable) tax credits and deductions are not immediately useful, and the calculation of tax incentives becomes considerably more complicated.[8] Second, we assume that the firm does not face a corporate alternative minimum tax. Third, for firms whose cost of external finance exceeds that for internal funds, tax cuts provide two stimuli. Changing internal finance affects the behavior of financially constrained firms over and above the incentive represented by variations in the user cost. A higher investment tax credit, for example, may have standard incentive effects on the demand for capital but, for financially constrained firms, the resulting increase in cash flow raises capital formation further than if the firm did not face finance constraints. While these three factors may affect the quantitative impact of tax policy in the short run, they will have much less impact on the long-run calculations that are the focus of this article.

2.2. Investment Incentives via Direct and Indirect User Cost Channels

There are two channels through which changes in a state's tax policy may affect the state's user cost of capital and, in turn, investment and output. We illustrate these two channels by considering a tax policy change by the state of California. The first channel is the direct user cost channel whereby the change in one of California's tax variables discussed above implies a change in California's user cost. The second, which we call the indirect user cost channel, is more complex. Because capital (either E&S or R&D) in its pursuit of the highest net-of-tax return may well be mobile across states, investment in California can be affected by the user costs of capital in other "neighboring" states (which we discuss further in the literature review in Section 3). In addition, policymakers in the neighboring states may react to the California tax change, a phenomenon known as tax competition. Thus, the California tax change will not only have a direct effect on California's investment by changing California's user cost, but also an indirect effect on California investment by changing the user costs in neighboring states.

We first consider the percentage change in UC due to a one percentage point decrease in $CITR$ that leads to the following *direct user cost channel*. (Note that the equation is the same whether the UC refers to an E&S or R&D investment, though parameter values will differ.)

$$(3) \quad \frac{\partial UC/UC}{-\partial CITR} = \frac{-1.0}{(1 - CITR)} + \frac{(TDA)}{(1 - CITR) \times TAX} \equiv A_s^{CITR}.$$

A decrease in $CITR$ has two opposing effects. Of the two terms in the middle expression in equation (3), the first term captures a decline in UC because the lower $CITR$ raises the net-of-tax return from a unit of output. But the lower $CITR$ also implies that the value of tax deductions associated with TDA is worth less, thus raising UC. This latter effect is captured by the second term. In our data, A_s^{CITR} is always negative for the E&S user cost, but always positive for the R&D user cost. The magnitude of the decrease in UC depends on all tax variables discussed above. Since some of these tax variables vary by state, equation (3) is evaluated on a state-by-state basis. (We have added a subscript s to indicate that the effect varies by state.)

A one percentage point increase in the $ITCR$ creates an alternative *direct user cost channel* (stated as a percentage change),

$$(4) \qquad \frac{(\partial UC/UC)}{\partial ITCR} = \frac{-1}{(1 - CITR) \times TAX} \equiv A_s^{ITCR(E\&S)} \ \ (\text{or } A_s^{ITCR(R\&D)}).$$

The increase in $ITCR$ lowers UC. As with the change in $CITR$, equation (4) is evaluated on a state-by-state basis and differs for E&S and R&D user costs. We refer to the percentage change in the user costs for E&S and R&D by parameters $A_s^{ITCR(E\&S)}$ and $A_s^{ITCR(R\&D)}$, respectively.

As discussed earlier, the indirect user cost channel captures the effect that a change in a given state's tax policy may have on other states' tax policies (via tax competition) and, in turn, other states' user costs of capital. Recall that other states' user costs could negatively affect investment in a given state to the extent that investment is geographically mobile or "footloose." Letting a superscript # represent the neighboring states considered as a singular unit, we compute the following *tax reaction channel* relating the percentage change in $UC^{\#}$ to a given percentage change in UC,

7. For additional details about the construction of the user cost, see King and Fullerton (1984), Cordes, Ebel, and Gravelle (2005), and Chirinko and Wilson (2008, Appendix; 2009b).

8. See Auerbach and Poterba (1987), Mintz (1988), Altschuler and Auerbach (1990), and Devereux, Keen, and Schiantarelli (1994) for further discussion of tax incentives and tax-loss status. A few states have a refundable investment tax credit whereby a business in a tax-loss position can receive a direct payment from the state for the value of the credit.

(5) $$\frac{(\partial UC^{\#}/UC^{\#})}{(\partial UC/UC)} \equiv \alpha.$$

The actual change in investment incentives due to the one percentage point change in *CITR* or *ITCR* is the product of the implied change in *UC* determined by equations (3) or (4), respectively, and the change in $UC^{\#}$ determined by equation (5). This interaction leads to the following indirect user cost channel for *CITR*, $ITCR^{E\&S}$, and $ITCR^{R\&D}$,

(6a) $$\frac{(\partial UC^{\#}/UC^{\#})}{(\partial UC/UC)} \times \frac{(\partial UC/UC)}{\partial ITCR^{CIT}} = \alpha \times A_s^{CITR} \equiv B_s^{CITR}.$$

(6b) $$\frac{(\partial UC^{\#}/UC^{\#})}{(\partial UC/UC)} \times \frac{(\partial UC/UC)}{\partial ITCR^{E\&S}} = \alpha \times A_s^{ITCR(E\&S)} \equiv B_s^{ITCR(E\&S)},$$

(6c) $$\frac{(\partial UC^{\#}/UC^{\#})}{(\partial UC/UC)} \times \frac{(\partial UC/UC)}{\partial ITCR^{R\&D}} = \alpha \times A_s^{ITCR(R\&D)} \equiv B_s^{ITCR(R\&D)},$$

Equations (3) through (6) quantify the economic incentives for investment in a given state due to a change in tax policy. The net effect on economic incentives for a given tax instrument (τ) in state *s* is represented by C_s^{τ}, the difference between A_s^{τ} and B_s^{τ},

(7) $$C_s^{\tau} \equiv A_s^{\tau} - B_s^{\tau} = (1-\alpha)A_s^{\tau} \qquad \tau = \{CITR, ITCR^{E\&S}, ITCR^{R\&D}\},$$

Equation (7) represents how much (in percentage terms) the user cost in a given state changes relative to how much user costs in neighboring states change. Traditional neoclassical production theory implies that only the in-state user cost matters for economic incentives (that is, $\alpha = 0$). We diverge from the traditional theory and posit that this relative difference determines economic incentives.

2.3. Investment via Substitution and Scale Channels

The change in economic incentives represented by equation (7) is translated into changes in investment *I* through standard microeconomic substitution and scale channels.[9] A particularly convenient formula has been derived by Hicks (1932/1963) that quantifies these two channels in terms of a limited set of parameters describing the production function and market conditions faced by the firm. Hicks's formula is written as follows,

(8) $$\frac{(\partial I/I)}{-(\partial UC/UC)} = \sigma - \sigma \times \omega^K + \omega^K \times \eta,$$

where σ is the elasticity of substitution between capital and the other factors of production, ω^K is the factor share of capital (i.e., the portion of the value of output devoted to capital costs), and η is the price elasticity of demand for output.[10] Note that these parameters will vary by E&S and R&D capital, though our derivation here does not explicitly recognize these differences.

Equation (8) captures in a succinct manner the substitution and scale effects that link a change in the user cost to the change in investment. Suppose that the user cost has fallen because of a decrease in *CITR* or an increase in *ITCR*. The first term on the right side of equation (8), σ, represents a substitution effect holding output and its price constant. The larger σ is, the more that firms will substitute capital for labor (and other factors of production) for a given change in *UC*. The second term represents an additional substitution effect driven by the lower marginal cost of production. Under competitive conditions, the decline in marginal cost due to the lower user cost translates into a decline in the output price. The extent of this decline is determined by the relative importance of capital in production, as represented by ω^K. The decline in the output price raises the relative price of capital and lowers demand for capital (cf. equation 2); hence the negative sign in equation (8). The net substitution effect resulting from a specific tax policy change—a one percentage point reduction in *CITR* or a one percentage point increase in *ITCR*—is measured by $\sigma - \sigma \times \omega^K$ multiplied by the effect of the policy change *UC*. This substitution effect is represented by $D_s^{\tau} = (\sigma - \sigma \times \omega^K) \times C_s^{\tau}$.

The third term in equation (8), $\omega^K \times \eta$ represents the impact of a lower output price that allows the firm to slide down the product demand curve and increase output. Firms in markets where customers are very price-sensitive are able to reap greater benefits from being able to reduce the price of their output and hence will produce more. As with the substitution effect, the magnitude of this scale effect, E_s^{τ}, in response to a specific tax policy change, will be the product of the effect of a change in the user cost on investment, $\omega^K \times \eta$, multiplied by the effect of the policy change on the user cost, C_s^{τ}. This scale effect is represented by $E_s^{\tau} = \omega^K \times \eta \times C_s^{\tau}$.

9. In our long-run analysis, no difference exists between changes in investment and changes in the capital stock *(K)*. This equivalence holds because, in the long-run, investment is proportional to the capital stock, with proportionality factor equal to the sum of the depreciation and long-run growth rates. Hence the percentage change in investment equals the percentage change in the capital stock that, in turn, equals the percentage change in the user cost multiplied by parameters reflecting substitution and scale effects (cf. equation 8).

10. See Chirinko and Mallick (2009) for a derivation and further discussion of Hicks's formula.

Combining the direct and indirect user cost channels that affect investment incentives and the substitution and scale channels that affect investment, we can represent the impact of a one percentage point decrease in *CITR* or increase in *ITCR* by $F_s^\tau = D_s^\tau + E_s^\tau$.

2.4. Output via Scale and Multiplier Channels

State tax policy affects the amount of output produced by firms through scale and multiplier channels. The scale channel is the same as the one that affects investment in the preceding subsection whereby a reduction in the user cost of capital lowers the marginal cost of production that, in turn, lowers the price of and raises the demand for output. As stated above, the scale effect is represented by $E_s^\tau = \omega^K \times \eta \times C_s^\tau$.[11]

Many studies of tax and other government policies introduce a multiplier channel, arguing that the spending generated from the policy initiative will stimulate additional rounds of spending and production. We are not comfortable with multiplier analyses. For the long run we focus on in this article, the additional resources needed in the multiplier rounds of spending must be drawn away from other activities. Thus, while it is possible that the tax policy stimulates activity in one sector, this increase will be at the expense of other sectors. The net effect could be close to zero in the long run. There may be greater scope for multiplier analysis in the short run, but multiplier parameters are not usually based on models that allow for a temporary period of deficient demand and a gradual transition to a long run with reasonable steady-state properties. These caveats notwithstanding, we allow for the possibility of multiplier effects; specifically, we multiply the output from the direct production channel, E_s^τ, by Λ. The parameter Λ reflects assumptions about the size of the multiplier and varies from 0 to whatever number may be of interest. A value below 1.0 suggests negative within-state externalities from the direct production effect. For example, if the induced investment and increased production by firms that benefit from a tax change crowd out investment and production by other firms in the state, then Λ could be less than one. Total output arising from the tax policy is represented by $G_s^\tau = E_s^\tau \times \Lambda$.

11. It may seem odd that the scale channels for investment and output are equal. However, it should be kept in mind that the scale channel is stated as a percentage change. In the previous subsection, investment is raised by E_s^τ percent. When evaluating the response of output, both capital and other factors of production (e.g., labor) are raised by equal percentages of E_s^τ percent. In turn, the extra capital and labor are weighted by their respective factor shares. Since the factor shares sum to one, the effect on output is just the initial shock, E_s^τ percent.

3. A Brief Literature Review

This section offers a brief review of several papers and issues that are relevant for determining the values of the some of the key parameters and the economic variables introduced in Section 2. Note that channels B through G are transformations of these "primitive" economic variables and parameters and that channel A is determined by variables entering the user cost formula in equation (2). See Table 1 for a glossary providing the symbols, names, and descriptions of each of the parameters and variables used in this article.

It is worth commenting on five parameters that are central to the simulation results. First, the elasticity of substitution between capital and labor, $-\sigma$, plays a central role in determining the size of the substitution channel, and thus it is very important in assessing the quantitative impact of business tax policies. Given certain assumptions about the production function, $-\sigma$ turns out also to be the elasticity of the capital-output ratio with respect to a change in the user cost of capital *(UC)*. An increase in the user cost must have a nonpositive effect on capital demand, so $-\sigma \leq 0$. The larger σ is, the more responsive capital formation is to a given change in the user cost. Estimates in the literature have varied widely. The largest values tend to cluster around 1.0, a value consistent with a Cobb-Douglas production function. Other studies have reported much lower estimates. Chirinko (2008) reviews a large number of studies and concludes that the weight of the evidence suggests a value for σ ranging from 0.40 to 0.60.

Chirinko and Wilson (2008) estimate this parameter for a panel of states in a model with the user cost (current and lagged) and report that σ equals 0.71. When the user cost for neighboring states is included and the model estimated with a relative user cost variable, the value of σ equals 0.76.[12] In this article, we use this as our preferred estimate.

Second, the slope of the reaction function of the user costs in a given state (e.g., California) and its "neighboring" states governs how states might react to one another's policy changes. Practical considerations dictate that the user costs for the neighboring states be condensed into a single variable, and the standard procedure in the literature is to use spatial weights to aggregate all of California's neighboring states. The weights can be defined in several ways. In this study, we use weights based on geographic proximity—i.e., the inverse of the distance between the population centroids of California and all other 47 contiguous states.[13] Thus, all 47 states are

12. This value comes from Column 12 of Table 2 in Chirinko and Wilson (2008).

13. We use Census Bureau data on the latitude and longitude of states' population centroids and what is known as the "great circle distance formula," which accounts for the curvature of the earth, to calculate distances between states.

California's neighbors, with Nevada receiving a large weight and New York a very small weight. Alternative weighting schemes used in the literature include population weights (which would give New York a much larger impact on California), bordering states (which would give New York a zero weight for California), and commodity trade flows (based on the shipments of goods from and to California from a given state, a procedure which would give New York a weight between the values from the two other weighting schemes).

Given a definition of neighboring states, the slope of the reaction function for business taxes has been estimated in many studies, all but one of which find that the slope is positive.[14] As one example of this class of studies, Devereux, Lockwood, and Redoano (2008) find a value of α equal to 0.70 for the slope of the reaction function among countries in the European Union in terms of their corporate income tax rate. By contrast, Chirinko and Wilson (2009a) look at U.S. states and find that, when time lags and aggregate time effects are properly accounted for, the slope of the reaction function is negative. Their preferred estimates of α are –0.59 for $ITCR^{E\&S}$ and –0.08 for *CITR*, which we use in our benchmark simulation for this article. While the negative signs are surprising given the extant literature, they are fully consistent with a theoretical model in which the marginal preference of the representative voter for private goods relative to public goods with respect to an increase in income is positive. Thus, the α parameter can range widely, though considerations of stability require that the absolute value of the slope be less than one. We are unaware of any studies estimating the slope of the reaction function for the R&D investment tax credit. In our simulations, we will assume that the slope for the R&D credit is the same as that for the E&S credit.

A third important parameter in our framework is the price elasticity of demand for output, $-\eta$. This parameter plays a large role in macroeconomics, both in calibrating dynamic stochastic general equilibrium models and in assessing the role of market power on economic fluctuations. Econometric estimates of η (or other parameters from which η can be deduced) based on industry data have ranged widely from 1.04 (Chang, Hornstein, and Sarte 2009) to 4.68 (Chirinko and Fazzari 1994). The η parameter can also be inferred from industry accounting data on sales and costs. These estimates range from 2.59 (Chirinko and Fazzari 1994) to 3.45 (Domowitz, Hubbard, and Petersen 1987). These latter estimates are based on average costs that more closely measure long-run costs and long-run behavior than the econometric estimates. We use 3.0 as our benchmark value of η.

The parameter Λ reflects the additional rounds of spending and production that may follow from the output that is directly related to the tax policy. We noted our reservations about this parameter in subsection 2.4. Our simulation results below assume neither a positive nor a negative multiplier effect; hence, $\Lambda = 1$.

Last, capital's factor share in production, ω^K, is a parameter that can be measured directly from the data. This parameter plays a critical role in determining the magnitude of both substitution and scale effects. Given that compensation data are usually more readily available than data on payments to capital, this variable can be estimated as one minus labor's factor share. Estimates range from 0.25 to 0.50 for all capital, including E&S and R&D. We use $\omega^{E\&S} = 0.30$ and $\omega^{R\&D} = 0.05$ as baseline values in our model simulations.

4. Simulation Results: Predicted Responses of Investment and Output to Tax Policy Changes

This section contains a variety of simulation results by state, based on the framework described in Section 2 for hypothetical changes in three tax policies—*CITR*, $ITCR^{E\&S}$, and $ITCR^{R\&D}$. Subsection 4.1 presents the responses of investment and output to these tax policies based on our preferred structural parameters. As the discussion in Section 3 indicated, however, there is uncertainty over the precise values of these structural parameters, and subsection 4.2 documents the sensitivity of the results to alternative parameter values. To allow users flexibility, we have developed an online applet discussed in subsection 4.3 that permits users to choose their preferred parameter values.

4.1. Preferred Parameters

Results for our preferred parameters are shown in Tables 2 through 4. The first two columns of Table 2 contain the percentage changes in the user cost of capital due to a one percentage point decrease in *CITR* (column 1) and a one percentage point increase in $ITCR^{E\&S}$ (column 2). These computations are based on equations (3) and (4), respectively. The user cost differs for E&S and R&D capital by the value of the investment tax credit for either type of capital. Columns 3 and 4 present comparable calculations for R&D capital, specifically the percentage changes in the user cost of capital due to a one percentage point decrease in *CITR* (column 3) and a one percentage point increase in $ITCR^{R\&D}$ (column 4). The entries in Table 2 reflect both the direct and indirect user cost channels linking tax policy to economic incentives.

14. See Heyndels and Vuchelen (1998), Brueckner and Savaadra (2001), Hayashi and Boadway (2001), Altschuler and Goodspeed (2002), Revelli (2002), Devereux, Lockwood, and Redoano (2008), and Overesch and Rincke (2009). Brueckner (2006) surveys the literature estimating tax reaction functions.

At least four observations can be made about the results in Table 2. First, there is a great deal of variation in the response of user cost to different tax instruments. A one percentage point increase in $ITCR^{E\&S}$ or $ITCR^{R\&D}$ has a much larger effect on UC than a one percentage point decrease in *CITR*. Second, for a given tax instrument, there is much less variation across states. For example, the unweighted average change in the E&S user cost due to a one percentage point decrease in *CITR* is −0.66 percent, and the comparable entries in column 1 cluster rather closely around this average. Third, the decrease in *CITR* has radically different effects on economic incentives, decreasing the E&S user cost (column 1) but increasing the R&D user cost (column 3). This difference in *CITR*'s effect on E&S versus R&D is traceable to different values of *TDA*. E&S capital is depreciated over several years. Given the time value of money, $TDA^{E\&S}$ is less than 1.0; our simulations are based on a value of 0.70. By contrast, R&D capital is expensed, and hence $TDA^{R\&D}$ equals 1.0. When equation (4) is evaluated with this relatively higher value of *TDA*, the second term dominates, and the derivative is positive. Intuitively, the drop in *CITR* removes one of the primary tax advantages of R&D investment vis-à-vis E&S investment, thereby lowering incentives to invest in R&D and raising incentives to invest in E&S. Fourth, the increase in the $UC^{R\&D}$ is larger for those states with R&D investment tax credits (cf. equation (4) where the ($1/TAX$) term will be larger the larger is $ITCR^{R\&D}$). For example, California has one of the largest effective R&D credit rates with its $ITCR^{R\&D}$ equal to 13.7 percent and the second largest increase in $UC^{R\&D}$. The positive entries in column 3 indicate that a decrease in *CITR* actually increases the user cost qua price of R&D investment, thus increasing incentives for firms to substitute away from relatively costly R&D capital towards E&S capital, labor, and other factors of production.

Columns 1 and 2 of Table 3 show the predicted increases in E&S investment in response to the hypothetical tax policy changes mentioned earlier. The patterns are driven by the effects of the tax policy changes on user costs (Table 2) multiplied by parameters reflecting substitution and scale effects. For example, according to Table 2, a one percentage point decrease in *CITR* lowers California's user cost by –0.71 percent. This decrease is multiplied by 1.54, equal to our preferred values of the parameters entering the right side of equation (8). This multiplicative factor links each of the state entries in Table 2 to the corresponding state entries in Table 3. Columns 3 and 4 show the predicted change in R&D investment in response to a decrease in *CITR* and an increase in $ITCR^{R\&D}$. As indicated in the discussion of Table 2, the former effect is negative and the latter is positive.

Table 4 presents the predicted changes in state output in response to each of the three hypothetical tax policy changes.

Table 2
Effect of Selected Tax Policies on E&S or R&D User Costs of Capital, by State

State	Change in E&S user cost due to 1 percentage point change: drop in *CITR*	Change in E&S user cost due to 1 percentage point change: increase in $ITCR^{E\&S}$	Change in R&D user cost due to 1 percentage point change: drop in *CITR*	Change in R&D user cost due to 1 percentage point change: increase in $ITCR^{R\&D}$
Alabama	–0.59%	–2.35%	0.42%	–2.81%
Arizona	–0.69	–2.29	1.09	–2.73
Arkansas	–0.53	–2.63	0.45	–3.24
California	–0.71	–2.36	1.38	–2.85
Colorado	–0.66	–2.20	0.43	–2.60
Connecticut	–0.63	–2.45	0.77	–2.98
Delaware	–0.70	–2.37	0.52	–2.86
Florida	–0.67	–2.23	0.44	–2.65
Georgia	–0.56	–2.53	0.99	–3.08
Idaho	–0.66	–2.40	0.71	–2.90
Illinois	–0.68	–2.32	0.48	–2.78
Indiana	–0.70	–2.35	1.06	–2.83
Iowa	–0.65	–2.60	0.86	–3.20
Kansas	–0.68	–2.33	0.47	–2.80
Kentucky	–0.69	–2.29	0.45	–2.74
Louisiana	–0.67	–2.22	0.84	–2.64
Maine	–0.71	–2.36	0.49	–2.85
Maryland	–0.69	–2.29	0.50	–2.74
Massachusetts	–0.67	–2.49	1.09	–3.05
Michigan	–0.62	–2.13	0.40	–2.49
Minnesota	–0.72	–2.40	0.61	–2.91
Mississippi	–0.59	–2.37	0.43	–2.85
Missouri	–0.67	–2.22	0.46	–2.63
Montana	–0.68	–2.28	0.70	–2.72
Nebraska	–0.54	–2.69	0.47	–3.34
Nevada	–0.61	–2.04	0.38	–2.37
New Hampshire	–0.71	–2.38	0.48	–2.87
New Jersey	–0.71	–2.37	1.08	–2.86
New Mexico	–0.69	–2.31	0.46	–2.77
New York	–0.64	–2.44	0.46	–2.96
North Carolina	–0.61	–2.47	0.59	–3.00
North Dakota	–0.66	–2.20	0.61	–2.60
Ohio	–0.68	–2.41	0.50	–2.92
Oklahoma	–0.66	–2.28	0.44	–2.72
Oregon	–0.68	–2.27	0.69	–2.71
Pennsylvania	–0.72	–2.41	0.53	–2.92
Rhode Island	–0.65	–2.51	1.73	–3.07
South Carolina	–0.66	–2.21	0.67	–2.62
South Dakota	–0.61	–2.04	0.38	–2.37
Tennessee	–0.67	–2.30	0.45	–2.75
Texas	–0.66	–2.19	0.66	–2.60
Utah	–0.66	–2.21	0.72	–2.62
Vermont	–0.65	–2.58	0.53	–3.18
Virginia	–0.67	–2.25	0.44	–2.68
Washington	–0.61	–2.04	0.38	–2.37
West Virginia	–0.64	–2.55	0.63	–3.12
Wisconsin	–0.70	–2.32	0.70	–2.79
Wyoming	–0.61	–2.04	0.38	–2.37
Unweighted average	–0.66%	–2.33%	0.63%	–2.80%

TABLE 3
EFFECT OF TAX POLICIES ON CAPITAL STOCK BY STATE

	Change in E&S capital due to 1 percentage point change		Change in R&D capital due to 1 percentage point change	
State	drop in *CITR*	increase in $ITCR^{E\&S}$	drop in *CITR*	increase in $ITCR^{R\&D}$
Alabama	0.90%	5.34%	–1.16%	11.27%
Arizona	1.06	5.20	–2.96	10.97
Arkansas	0.81	5.98	–1.22	12.99
California	1.09	5.37	–3.76	11.42
Colorado	1.02	5.00	–1.16	10.43
Connecticut	0.97	5.58	–2.09	11.94
Delaware	1.08	5.39	–1.41	11.46
Florida	1.03	5.07	–1.19	10.63
Georgia	0.86	5.75	–2.69	12.36
Idaho	1.01	5.45	–1.94	11.61
Illinois	1.05	5.27	–1.30	11.14
Indiana	1.09	5.34	–2.88	11.34
Iowa	1.00	5.91	–2.33	12.85
Kansas	1.04	5.31	–1.29	11.24
Kentucky	1.06	5.20	–1.23	10.97
Louisiana	1.03	5.06	–2.29	10.59
Maine	1.09	5.38	–1.34	11.44
Maryland	1.06	5.20	–1.35	10.97
Massachusetts	1.04	5.67	–2.97	12.21
Michigan	0.96	4.83	–1.09	9.99
Minnesota	1.11	5.46	–1.67	11.66
Mississippi	0.92	5.40	–1.17	11.44
Missouri	1.03	5.05	–1.24	10.56
Montana	1.05	5.18	–1.90	10.91
Nebraska	0.83	6.13	–1.28	13.40
Nevada	0.94	4.63	–1.05	9.49
New Hampshire	1.10	5.41	–1.30	11.52
New Jersey	1.10	5.38	–2.93	11.46
New Mexico	1.07	5.26	–1.25	11.12
New York	0.98	5.55	–1.25	11.88
North Carolina	0.93	5.62	–1.62	12.04
North Dakota	1.02	5.00	–1.66	10.44
Ohio	1.04	5.49	–1.35	11.72
Oklahoma	1.02	5.19	–1.20	10.92
Oregon	1.05	5.17	–1.89	10.88
Pennsylvania	1.11	5.48	–1.45	11.71
Rhode Island	1.01	5.70	–4.70	12.29
South Carolina	1.02	5.03	–1.81	10.52
South Dakota	0.94	4.63	–1.05	9.49
Tennessee	1.03	5.23	–1.22	11.04
Texas	1.01	4.99	–1.79	10.41
Utah	1.02	5.03	–1.96	10.52
Vermont	0.99	5.87	–1.44	12.74
Virginia	1.04	5.11	–1.20	10.74
Washington	0.94	4.63	–1.05	9.49
West Virginia	0.98	5.79	–1.70	12.52
Wisconsin	1.07	5.28	–1.89	11.19
Wyoming	0.94	4.63	–1.05	9.49
Unweighted average	1.01%	5.30%	–1.72%	11.24%

TABLE 4
EFFECT OF TAX POLICIES ON OUTPUT BY STATE

	Increase in output due to 1 percentage point change		
State	drop in *CITR*	increase in $ITCR^{E\&S}$	increase in $ITCR^{R\&D}$
Alabama	0.50%	3.35%	0.67%
Arizona	0.49	3.27	0.65
Arkansas	0.44	3.76	0.77
California	0.46	3.37	0.68
Colorado	0.57	3.14	0.62
Connecticut	0.49	3.50	0.71
Delaware	0.60	3.39	0.68
Florida	0.58	3.19	0.63
Georgia	0.38	3.61	0.73
Idaho	0.52	3.42	0.69
Illinois	0.58	3.31	0.66
Indiana	0.51	3.35	0.67
Iowa	0.49	3.71	0.76
Kansas	0.58	3.34	0.67
Kentucky	0.59	3.27	0.65
Louisiana	0.51	3.18	0.63
Maine	0.61	3.38	0.68
Maryland	0.59	3.27	0.65
Massachusetts	0.48	3.56	0.73
Michigan	0.54	3.04	0.59
Minnesota	0.60	3.43	0.69
Mississippi	0.51	3.39	0.68
Missouri	0.57	3.17	0.63
Montana	0.55	3.26	0.65
Nebraska	0.45	3.85	0.80
Nevada	0.53	2.91	0.56
New Hampshire	0.61	3.40	0.68
New Jersey	0.51	3.38	0.68
New Mexico	0.60	3.30	0.66
New York	0.54	3.49	0.71
North Carolina	0.49	3.53	0.72
North Dakota	0.54	3.14	0.62
Ohio	0.58	3.45	0.70
Oklahoma	0.57	3.26	0.65
Oregon	0.55	3.25	0.65
Pennsylvania	0.61	3.44	0.70
Rhode Island	0.35	3.58	0.73
South Carolina	0.54	3.16	0.62
South Dakota	0.53	2.91	0.56
Tennessee	0.57	3.29	0.66
Texas	0.53	3.13	0.62
Utah	0.53	3.16	0.62
Vermont	0.54	3.69	0.76
Virginia	0.58	3.21	0.64
Washington	0.53	2.91	0.56
West Virginia	0.52	3.64	0.74
Wisconsin	0.56	3.32	0.66
Wyoming	0.53	2.91	0.56
Unweighted average	0.53%	3.33%	0.67%

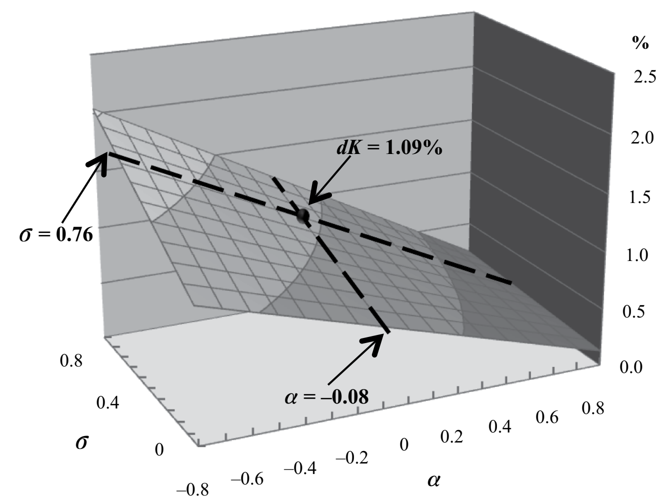
The predicted changes are based on the scale effect described in subsections 2.3 and 2.4. For changes in $ITCR^{E\&S}$ and $ITCR^{R\&D}$, the change in output equals the product of capital's income share (ω^K), the price elasticity of demand for output (η), and the percentage change in the user cost (Table 2, columns 2 and 4, respectively). For a change in *CITR*, the change in output is the sum of the change in output due to changes in $UC^{E\&S}$ ($\omega^{E\&S} \times \eta \times$ entry in Table 2, column 1) and $UC^{R\&D}$ ($\omega^{R\&D} \times \eta \times$ entry in Table 2, column 3). The increase in $ITCR^{E\&S}$ has a substantially larger impact on output than $ITCR^{R\&D}$ because R&D plays a much smaller role in production: R&D's average share of production costs in U.S. manufacturing is lower than E&S's share by a factor of six (i.e., $\omega^{E\&S} = 6 \times \omega^{R\&D}$). The predicted increase in output due to $ITCR^{E\&S}$ is also much larger than the predicted increase due to *CITR* because the latter has a relatively smaller impact on the user cost (Table 2, columns 1 and 3). It is possible that a multiplier effect could make the predicted increases reported in Table 4 smaller or larger, though, as discussed earlier, we suggest caution when inserting multiplier assumptions.

4.2. Sensitivity to Alternative Parameter Values

The simulation results presented in the previous subsection are based on a set of parameters that we believe most accurately characterize relevant structural features of the economy. However, Section 3 highlights that other values of these parameters are also quite plausible. In order to assess the sensitivity of the simulation results to alternative values, we recompute our simulations for California and present the results in three-dimensional figures that plot a wide range of parameter values on two of the axes and the predicted increases in investment or output on the vertical axis. Seven figures are presented, and they parallel the seven columns of results presented in Tables 3 and 4.

Figures 4 to 7 report predicted increases in E&S and R&D investment for alternative values of the elasticity of substitution between capital and other factors of production (σ) and the slope of the tax reaction function (α). Our preferred parameter values are indicated with the dashed black lines in each figure, and their intersection, which indicates our predicted increase in investment given these preferred parameter values (and matches the values in Tables 3 and 4 for California), is shown as a circle. For example, Figure 4 shows the response of E&S investment to a decrease in *CITR*. Here, our preferred parameter values of σ = 0.76 and α = –0.08 yield a predicted increase in investment of 1.09 percent for a one percentage point decrease in *CITR*. Figure 4 allows σ to vary between 0.0 and 1.0 and α between –0.8 and +0.8. The variations in σ have a modest effect on the predicted increase in investment. Holding α fixed at −0.08, the predicted increases in investment rise to 1.22 percent when σ is at its upper bound of 1.0 and fall to 0.69 percent when σ is at its lower bound of 0.0. The latter result represents a situation where the substitution channel is completely inoperative, and the investment increase is solely from the scale channel. More dramatic changes occur with variations in α. The predicted increase in investment from a decrease in *CITR* falls with α. An upper bound value of 0.80 for α represents very competitive responses by neighboring states and severely diminishes the economic incentive and incremental investment from a tax policy change. As α varies from −0.8 to +0.8, the predicted increase in investment falls from 1.83 to 0.20 percent. Similar results presented in Figure 5 hold

FIGURE 4
PREDICTED INCREASE IN E&S INVESTMENT DUE TO 1 PERCENTAGE POINT DROP IN *CITR*
(for various values of tax competition slope (α) and relative user cost elasticity (σ))



Notes: Figures 4 through 10 are three-dimensional surface charts describing the sensitivity of the economic impact (investment or output) of a change in tax policy to variations in selected parameters. For example, in Figure 4, the height of the surface (z axis) indicates the percentage change in a state's investment (*dI/I* (= *dK/K*, per footnote 9)) resulting from a one percentage point reduction in the state's corporate income tax rate *(CITR)*, based on our simulations and data for 2006 for the state of California. The size of the impact, *dI/I*, depends on several variables and parameters. Figure 4 highlights the sensitivity of impact to two key economic parameters: the slope of the *CITR* interstate reaction function (α), which varies along the x axis, and the elasticity of the capital with respect to the relative user cost of capital (σ), which varies along the y axis. Note that the height of the three-dimensional surface shown in the figure varies by state, but the shape of the surface does not change. For instance, while *dI/I* = 1.09% is specific to California, the sensitivities of *dI/I* to α and σ is qualitatively the same for all states.

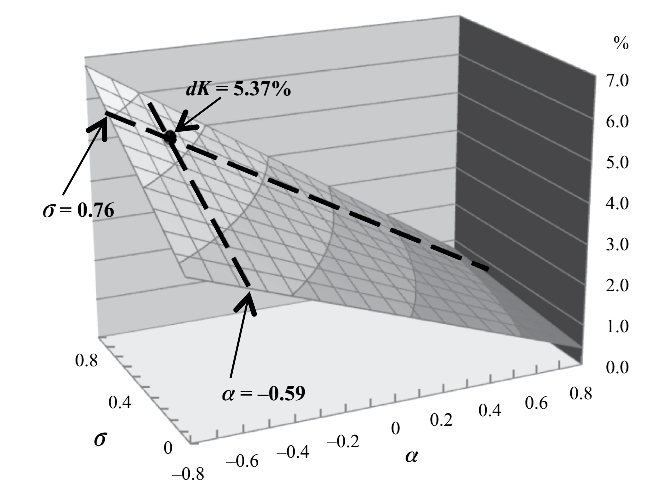
The dashed line at α = –0.08 indicates the *CITR* reaction function slope estimated in Chirinko and Wilson (2009a); the dashed line at σ = 0.76 indicates the relative user cost elasticity estimated in Chirinko and Wilson (2008). The point where these lines intersect, shown as a ball in the chart, therefore reflects our best estimate of exactly how much the capital stock in California would increase if the state were to reduce its corporate income tax rate by one percentage point.

for the predicted increase in investment from an increase in *ITCR*.

Figures 6 and 7 present comparable results for R&D investment. For these R&D figures, we vary σ over a wider range (0.0 to 3.0) than we did for the E&S figures. We do so because our preferred value of 2.5, based on the estimates found in Wilson (2009), are much larger than the range of values typically found for the E&S elasticity of substitution. The sensitivity of the simulation results to α remains. Variations in σ have a more dramatic effect than was evident in Figures 4 and 5, though this is primarily due to the wider range of values for σ in Figures 6 and 7. Owing to R&D's small share of capital income, the scale effect for R&D investment is very small. Thus, as σ approaches 0.0 and the substitution effect is eliminated, the predicted increase in investment also approaches 0.0.

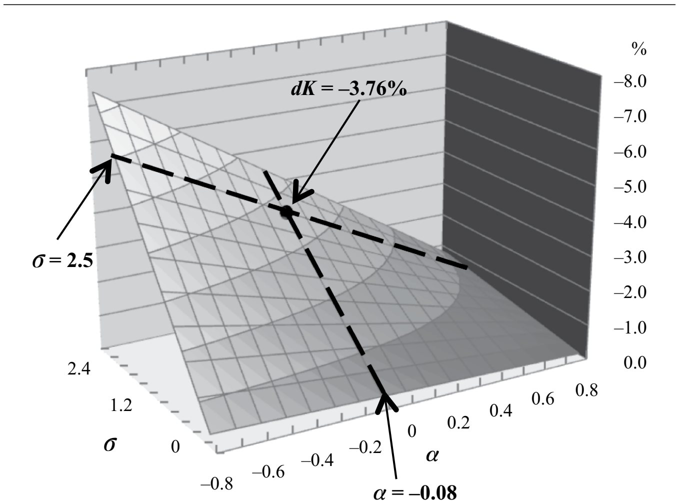
The sensitivity of the predicted increases in output are presented in Figures 8 to 10 for alternative values of α and the price elasticity of demand for output (η), the latter ranging from 0.0 to 5.0. As with the prior figures, the simulation results are very sensitive to α. For example, a one percentage point increase in $ITCR^{E\&S}$ results in a 3.37 percent increase in output for our benchmark parameters. This predicted increase (Figure 9) falls to 2.12 percent and 0.42 percent when α equals 0.00 and 0.80, respectively. Since the scale effect is proportionate to η, this parameter also has substantial influence on the predicted output resulting from changes in each of the three tax variables. In Figure 9, an increase in η from its benchmark value of 3.0 to its upper limit of 5.0 raises the predicted increase in output from 3.37 percent to 5.62 percent.

FIGURE 5
PREDICTED INCREASE IN E&S INVESTMENT
DUE TO 1 PERCENTAGE POINT INCREASE IN $ITCR^{E\&S}$
(for various values of tax competition slope (α)
and relative user cost elasticity (σ))



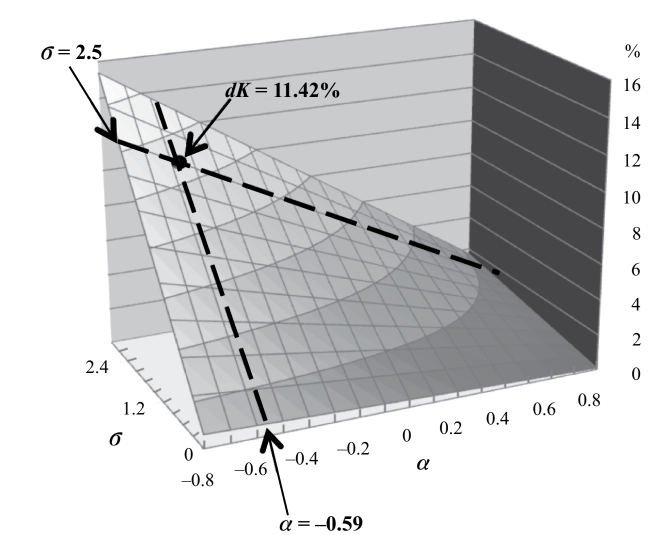
See notes to Figure 4.

FIGURE 6
PREDICTED DECREASE IN R&D INVESTMENT
DUE TO 1 PERCENTAGE POINT DROP IN *CITR*
(for various values of tax competition slope (α)
and relative user cost elasticity (σ))



See notes to Figure 4.

FIGURE 7
PREDICTED INCREASE IN R&D INVESTMENT
DUE TO 1 PERCENTAGE POINT INCREASE IN $ITCR^{R\&D}$
(for various values of tax competition slope (α)
and relative user cost elasticity (σ))



See notes to Figure 4.

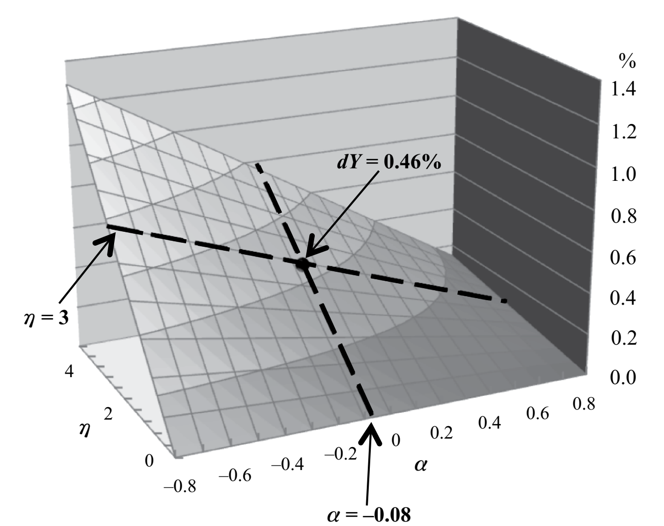
4.3. An Online Applet Allowing Users to Select Their Own Parameter Values

Figures 4 to 10 document the sensitivity of the simulations to the underlying parameter values. In order to allow users flexibility in tailoring the simulations to their own views on the appropriate parameter values best describing the firms operating in their states, we have created an applet that allows choices for the following parameters: σ, α, η, Λ, $\omega^{E\&S}$, and $\omega^{R\&D}$. The applet also allows users to choose the size of the increase or decrease in any one of the three tax policies. This could be quite valuable for policymakers or analysts debating the merits of a particular tax policy change under legislative consideration. Table 1 suggests what we believe is a plausible range of values, though any values can be employed in the user-directed simulations. The applet can be accessed at http://www.frbsf.org/csip/taxapp.php.

5. Summary

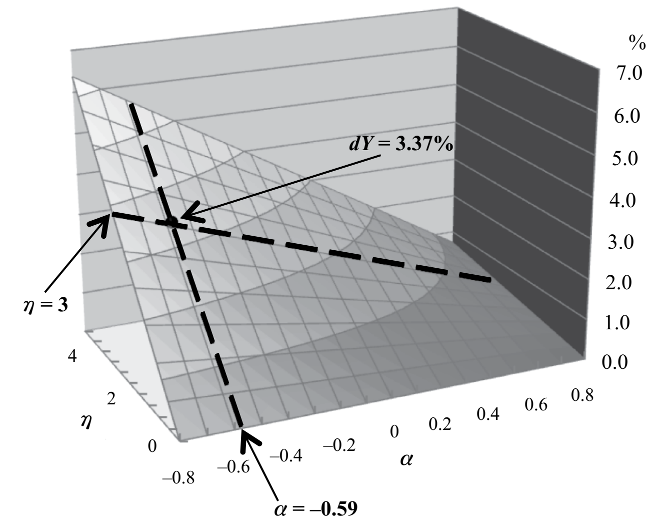
This article has developed a framework for quantifying the impacts of state business tax policies. We examine three tax instruments: the corporate income tax, the investment tax credit on equipment and structures, and the investment tax credit on research and development. The links among tax policies, investment, and output depend on a set of channels determined by economic theory and a set of parameters whose values are drawn from empirical research. We have provided illustrative calculations based on our preferred parameter values. Recognizing the differences that exist about the values of key parameters, we discuss how the predicted economic effects of these tax policy changes vary depending on the choice of these parameters. In addition, we have developed and made available online a simple web tool that al-

Figure 8
Predicted Increase in Output due to
1 Percentage Point Drop in *CITR*
(for various values of tax competition slope (α)
and elasticity of demand (η))



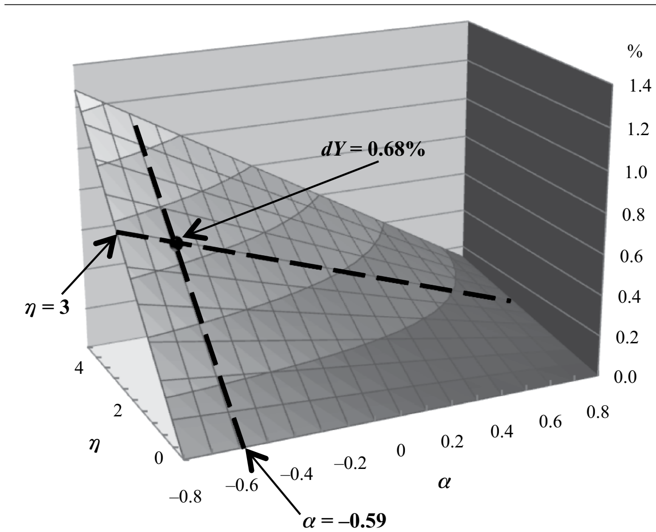
See notes to Figure 4.

Figure 9
Predicted Increase in Output due to
1 Percentage Point Increase in $ITCR^{E\&S}$
(for various values of tax competition slope (α)
and elasticity of demand (η))



See notes to Figure 4.

Figure 10
Predicted Increase in Output due to
1 Percentage Point Increase in $ITCR^{R\&D}$
(for various values of tax competition slope (α)
and elasticity of demand (η))



See notes to Figure 4.

lows users to insert their own preferred parameter values and simulate the economic effects for the state and tax policy of their choosing.

Three caveats should be kept in mind with our simulations. A comprehensive evaluation of a proposed tax policy requires several pieces of information. The simulation results presented in this article provide information on one important benefit. Additional information is required concerning the revenues that are decreased initially due to the tax incentives and increased eventually due to higher levels of economic activity. Moreover, second-round effects need to be considered. For example, generous investment incentives may require state governments to lower expenditures on government services or may induce firms to lower employment. That these effects are *second* does not necessarily imply that they are *secondary*. Nonetheless, our simulation results provide a valuable input to the complex process of policy evaluation.

A second caveat is that we have restricted ourselves to a limited number of fiscal options. Apart from the three state business taxes considered in this article, state policymakers have many other revenue options, such as sales taxes and user fees, as well as expenditure reductions. Job tax credits are an additional policy option that have been adopted by approximately half of states sometime during this decade. Given the sharp decrease in employment during the recent recession and the anemic pace at which jobs are recovering, job tax credits have received more attention as a policy tool. The framework developed in this article can be extended to consider the effects of job credits and other policies on employment.

Finally, since our simulations are at the state level, these results may not inform national policy. The calculations reported in this article only pertain to each state's investment and output from a change in its tax policy. Given the mobility of capital across and tax competition among states, a tax policy that looks highly desirable from the perspective of a single state may be much less desirable nationally. Increases in investment and output may be at the expense of other states. From a national perspective, state tax initiatives may well be a zero-sum game.[15] Simulating the impacts of a given state's policy on the behavior of other states and on national investment and output as a whole is beyond the scope of this article and our existing work, but it is a topic for future research.

15. In our analysis of equipment and structure capital formation, we could not reject the hypothesis that state business tax policy is a zero-sum game (Chirinko and Wilson 2008). Wilson (2009) finds a similar result for research and development.

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