STATE INVESTMENT TAX INCENTIVES: A ZERO-SUM GAME?

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Abstract

Though the U.S. federal investment tax credit (ITC) was permanently repealed in 1986, state-level ITCs have proliferated over the last few decades. Are these tax incentives effective in increasing investment within the state? How much of this increase is due to investment drawn away from other states? Based on a panel dataset for all 50 states, we find a significant channel for state tax incentives on own-state economic activity and document the importance of interstate capital flows. Whether state investment incentives are a zero-sum game is less certain and depends on the definition of the set of competitive states.

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Keywords: state tax incentives, interstate tax competition, business taxes.

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State Investment Tax Incentives: A Zero-Sum Game?

Table of Contents

State Investment Tax Incentives: A Zero-Sum Game?

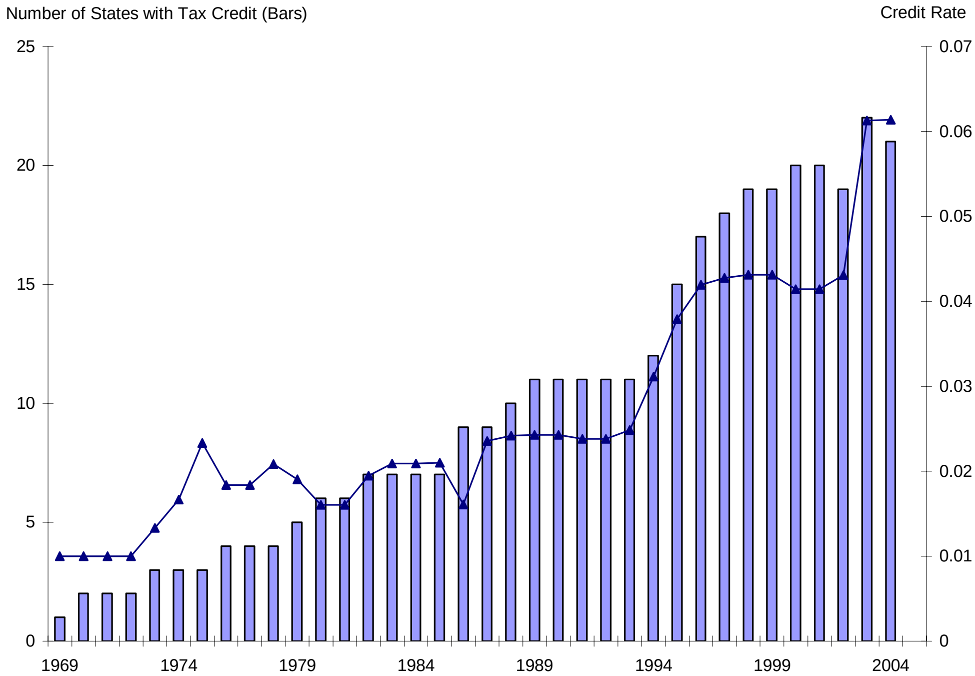
I. Introduction

Though the U.S. federal investment tax credit (ITC) was permanently repealed in 1986, ITC's at the state level and other state investment tax incentives have proliferated over the past two decades. As shown in Figure 1, 40% of states now offer a general, state-wide tax credit on investment in machinery and buildings, and the average rate of this credit exceeds 6 percentage points in 2004. The abundance of state investment tax incentives raises an important empirical question -- are these tax incentives effective in increasing investment and economic activity within the state? Academic research is far from a consensus on this point. Fisher and Peters 1998, pp. 12-13) state that "[I]n the case of the first argument [economic development incentives probably can influence firm location and expansion decisions…], the literature is massive but still inconclusive;…" In his survey paper, Wasylenko (1997, p. 38) concludes that elasticities of various forms of economic activity to tax policy "are not very reliable and change depending on which variables are included in the estimation equation or which time period is analyzed." By contrast, an overview of papers (including Wasylenko's study) presented at a conference focusing on the effectiveness of state and local taxes reports that there was general agreement that state and local policies affect economic activity within their borders, though the effects "are generally modest" (Bradbury, Kodrzycki, and Tannenwald, 1997, p. 1). A similar conclusion is reached in the encyclopedia entry by Bogart and Anderson (2005) concerning the effects of state policies on firm location. Perhaps the title of the report by McGuire (2003) sums up the current state of the scholarly empirical literature -- "Do Taxes Matter? Yes, No, Maybe So."

To the extent these incentives are effective in raising investment within the state, a second question arises from a national perspective -- how much of this increase is due to investment being drawn away from other states? As noted by Stark and Wilson (2006), surprisingly few empirical studies have addressed this question. Understanding the source of the increase in capital formation (or other economic activities) is important for assessing whether the increase merely reflects a zero-sum game among states and for informing discussions about the constitutionality of certain state tax incentives in light of the U.S. Constitution's Commerce Clause.[1]

[1] Regarding the Commerce Clause, see the papers in the special section of the *Georgetown Journal of Law & Public Policy* (2006) and the session on "Are State Business Tax Incentive Good Public Policy?" in the *National Tax Association Proceedings 2006.*

Figure 1. State Investment Tax Credits:
Number of States with a Credit (left vertical axis) and
Average Credit Rate (right vertical axis)
1969 to 2004



Notes: Counted investment tax credits (ITCs) include only general, statewide ITCs. Excluded are ITCs targetted at specific geographic zones ("Enterprise" zones) or at specific industries.
Data Source: Authors' calculations based on state corporate tax forms.

These two questions are addressed in this paper with a comprehensive panel dataset covering all 50 states for 20+ years (depending on the series). This dataset allows us to construct variables tied tightly to theory and to utilize a variety of powerful econometric techniques. Panel data have the decided advantages of allowing us to control for factors such as infrastructure and location that are fixed or change slowly over time and for aggregate effects such as the business cycle. The relative scarcity of empirical research on interstate capital mobility and tax competition may be traceable in good part to the absence of comprehensive data. Section 2 describes the panel dataset that is drawn from a several sources, including the Annual Survey of Manufacturers, national data from the Bureau of Economic Analysis, and a variety of sources of information on state tax rates. Details concerning construction and sources are provided in the Data Appendix.

We then develop and estimate three models in the subsequent three sections. Section 3 contains a Capital Demand Model motivated by a standard first-order condition relating the capital stock to output and the user cost of capital. We specify the latter as the ratio of a states own user cost of capital relative to the user cost of capital for a competitive set of states. The user cost of capital is based on the Hall-Jorgenson concept that relies on the equivalence between renting and owning a durable asset. Based on this insight, durable capital can be assigned a rental price that easily incorporates a variety of tax parameters and can be analyzed with the traditional tools of price theory. We find that a state's capital intensity decreases with the user cost prevailing in the state but increases with the user cost available in competitive states, thus documenting the importance of interstate capital flows that is a necessary element for meaningful tax competition. Whether state investment incentives are a zero-sum game among the states is less certain and depends on the definition of the set of competitive states.

Sections 4 and 5 estimate two models explaining the location of manufacturing establishments at the county level. The first model, which follows the spatial regression discontinuity design of Holmes (1998), posits that manufacturing activity varies smoothly across space and then utilizes the information generated by spatial breaks ("discontinuities") in tax policy at state borders. We apply Holmes' Spatial Discontinuity Model to assess the effects of a particular tax policy, relatively higher user costs. The evidence provides weak support for the role of state tax policy but is sensitive to the year in which the analysis is undertaken. Our second model, which we call the Twin-Counties Model, takes advantage of the panel structure of our data and exploits the "natural experiment" afforded by pairs of counties that are in the same geographic area but are separated by a state border. Comparing the differential outcomes of county pairs with common geographic conditions but differing state policies is akin to the twin studies employed frequently in labor economics and medical research, which analyze the differential outcomes of identical twins with common genetic conditions but different environmental conditions. The Twin-Counties Model uncovers a strong effect of user costs prevailing at the state level on the location of establishments at the county level. Moreover, consistent with significant interstate capital flows, we document that this effect increases monotonically as the distance between paired-counties decreases.

Section 6 concludes and draws some policy implications.

2. The Panel Dataset

The state data constructed and used in this paper measure economic activity in the manufacturing sector for all 50 states. This data set may be thought of as a state-level analog to other widely used data sets, such as the industry-level NBER Productivity Database or Dale Jorgenson's "KLEM" database or the country-level Penn World Tables. This section provides a cursory overview of the construction of the five key series used in this paper: two quantity variables (output (Y) and the capital stock (K)), their tax-adjusted prices (P^Y and P^K, respectively), and a fifth series for the number of establishments (NE). The quantity series are available from 1982 to 2004; the price series from 1963 to 2004; and the NE series from 1977 to 2004. Substantially more detail can be found in the appendix.

The primary raw source data for the nominal output (Y$), nominal investment (I$), and NE series is the Annual Survey of Manufacturers (ASM) conducted by the U.S. Census Bureau. Since these series all come from a single, representative-survey-based source, they are of fairly high quality. The ASM data are collected from a large, representative sample of manufacturing establishments with one or more paid employees. The 2004 ASM (Appendix B, p. B-1) defines the manufacturing sector as follows,

> The Manufacturing sector comprises establishments engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products. ….. Establishments in the manufacturing sector are often described as plants, factories, or mills and characteristically use power-driven machines and materials-handling equipment. However, establishments that transform materials or substances into new products by hand or in the worker's home and those engaged in selling to the general public products made on the same premises from which they are sold, such as bakeries, candy stores, and custom tailors, may also be included in this sector.

The ASM manufacturing sector corresponds to NAICS sectors 31 to 33.

The Y series equals Y$ deflated by a manufacturing output price index.

Capital stock data useful in economic analyses are not obtainable from raw sources but must be constructed from various series. The K series is computed according to a perpetual inventory formula based on real investment data (I) and depreciation rates. The I series equals I$ deflated by a price index for investment.

The P^K series is based on the concept introduced by Jorgenson (1963) and developed and expanded by, among others, Gravelle (1994), Hall and Jorgenson (1971), Jorgenson and Yun (2001), and King and Fullerton (1984). This series is defined as the product of three objects reflecting tax credits and deductions ($TAX_{s,t}$), the purchase price of the capital good ($PRICE_{s,t}$), and the opportunity costs of holding depreciating capital ($OPPCOST_{s,t}$),

$$P^{K}_{s,t} = TAX_{s,t} * PRICE_{s,t} * OPPCOST_{s,t}, \tag{1a}$$

$$\begin{aligned} TAX_{s,t} = {} & 1 - ITC^{L,S}_{s,t} - ITC^{L,F}_{t} - (\tau^{E,S}_{s,t} + \tau^{E,F}_{s,t}) TD_{s,t} \\ & + \left(1 - (\tau^{E,S}_{s,t} + \tau^{E,F}_{s,t})\right) PT_{s,t} \end{aligned} \tag{1b}$$

$$PRICE_{s,t} = P^{I}_{mfg,t}, \tag{1c}$$

$$OPPCOST_{s,t} = \rho_t + \delta_{mfg,t}, \tag{1d}$$

where $ITC^{L,S}_{s,t}$ and $ITC^{L,F}_{t}$ are the legislated investment tax credit rates at the state and federal levels, respectively, $\tau^{E,S}_{s,t}$ and $\tau^{E,F}_{t}$ are the effective corporate income tax rates at the state and federal levels, respectively, $TD_{s,t}$ is the present value of tax depreciation allowances at the federal level, $PT_{s,t}$ is the present value of property tax payments at the state level, $P^{I}_{mfg,t}$ is the price deflator for investment in the manufacturing sector, ρ_t is the financial cost of capital, and $\delta_{mfg,t}$ is the economic depreciation rate in the manufacturing sector. The $P^{K}_{s,t}$ series and its eight components are stated at annual rates and in continuous time.

The user cost of capital concept is a relative price and is defined as follows,

$$UC_{s,t} = P^{K}_{s,t} / P^{Y}_{s,t}, \tag{2}$$

where $P^{Y}_{s,t} = P^{BT,Y}_{mfg,t}\left[1 - \left(\tau^{E,S}_{s,t} + \tau^{E,F}_{s,t}\right)\right]$ is the price of output adjusted for corporate income taxes and $P^{BT,Y}_{mfg,t}$ is the price of output before taxes.

Summary statistics for the variables entering the estimating equations are provided in Table 1.

Table 1: Summary Statistics

	Mean	Median	Standard Deviation
	(1)	(2)	(3)
ky_t	-.2242475	-.2745625	.349972
uc-own$_t$	-1.397476	-1.402759	.0613904
UC-own$_t$	.2476925	.2459175	.015543
uc-comp$_t$ {border}	-1.395391	-1.397862	.0521876
UC-comp$_t$ {border}	.2480744	.2471248	.0130181
uc-comp$_t$ {5}	-1.384204	-1.394071	.065186
UC-comp$_t$ {5}	.2510698	.2480634	.0170703
uc-comp$_t$ {10}	-1.383383	-1.390204	.0553564
UC-comp$_t$ {10}	.2511203	.2490244	.0143214
uc-comp$_t$ {all}	-1.383511	-1.38322	.043599
UC-comp$_t$ {all}	.2509382	.2507698	.0111752

Notes to Table 1:
Variables are defined in the tables below. The standard deviations are computed with state or county fixed effects removed by subtracting time-series means. The words in brackets indicate whether the competitive set of states is defined by the bordering states, the five closest states, or the ten closest states to state s, or over all states other than state s.

3. Capital Demand Model

The first of the three models used to assess the own-state and competitive-states effects of state tax incentives is motivated by the first-order condition for optimal capital demand. This condition is at the core of the vast majority of econometric equations of capital formation (Chirinko, 1993). Sub-section 1 contains a derivation of the estimating equation containing the relative user cost of capital; that is, the own-state user cost relative to the competitive-states user cost. Sub-section 2 explores the sensitivity of results to state and time fixed effects and to lags of the relative user cost. For these results, the competitive set of states is defined as those bordering the state in question. The overall user cost for the competitive set of states is a weighted-average of the individual user costs in those states, where the weights are inversely related to the distance between the state in question and the individual competitive states. Sub-section 3 provides additional evidence when the competitive set of states is expanded to the 5 closest, 10 closest, or all other states, again weighted by inverse distance from the state in question. Sub-section 4 replaces the relative user cost by separate user costs for the own-state and competitive-states, and we can thus assess whether state tax incentives are a zero-sum game.

3.1. Estimating Equation

We begin by assuming that production for state s at time t is characterized by the following Constant Elasticity of Substitution (CES) technology,

$$\begin{aligned} Y_{s,t} &= Y[K_{s,t}, L_{s,t}, A_{s,t}, B^K_{s,t}, B^L_{s,t}] \\ &= A_{s,t} \left\{ \phi (B^K_{s,t} K_{s,t})^{[(\sigma-1)/\sigma]} + (1-\phi)(B^L_{s,t} L_{s,t})^{[(\sigma-1)/\sigma]} \right\}^{[\sigma/(\sigma-1)]}, \end{aligned} \tag{3}$$

where $Y_{s,t}$ is real output, $K_{s,t}$ is the real capital stock, $L_{s,t}$ is the level of labor input, ϕ is the capital distribution parameter, and σ is the elasticity of substitution between labor and capital. Technical progress is both neutral ($A_{s,t}$), and biased for capital and labor ($B^K_{s,t}$ and $B^L_{s,t}$, respectively). Equation (3) is homogeneous of degree one in $K_{s,t}$ and $L_{s,t}$.

Constrained by the CES production function, a profit-maximizing firm chooses capital so that its marginal product equals the user cost of capital (defined above in equations (1) and (2)). Differentiating equation (3) with respect to capital and rearranging terms, we obtain the following factor demand equation for capital,

$$K_{s,t} / Y_{s,t} = \phi^{\sigma} \; UC_{s,t}^{\;-\sigma} \; E_{s,t}, \tag{4a}$$

$$E_{s,t} \equiv A^{[\sigma-1]\sigma}_{s,t} \; B^{[\sigma-1]\sigma}_{s,t}, \tag{4b}$$

where the error term, $E_{s,t}$, captures the effects of technical change. We assume that $E_{s,t}$ follows a two-way error component specification,

$$E_{s,t} = \exp[e_s + e_t + e_{s,t}], \tag{5}$$

where state and aggregate fixed effects are captured by e_s and e_t, respectively, and the remaining time-varying, state-specific error, $e_{s,t}$, may have a non-zero mean. We augment the first-order condition in two ways. To allow for interstate capital flows, we replace the user cost by a relative user cost defined as the logarithm of the own-state user cost less the logarithm of the competitive-states user cost. Moreover, lagged values of the relative user cost variable are included to capture dynamic responses to tax stimuli. Taking logs of the first-order condition and augmenting the linear specification with lags of the relative user cost, we obtain the following estimating equation,

$$ky_{s,t} = \zeta + \alpha_0 \, ruc_{s,t} + \alpha_1 \, ruc_{s,t-1} + \alpha_2 \, ruc_{s,t-2} + e_s + e_t + e_{s,t}, \tag{6a}$$

$$ky_{s,t} = Ln[K_{s,t} / Y_{s,t}], \tag{6b}$$

$$\zeta = \sigma \, Ln[\phi], \tag{6c}$$

$$ruc_{s,t} = uc_{s,t}^{own} - uc_{s,t}^{comp}, \tag{6d}$$

$$uc_{s,t}^{own} = Ln[UC_{s,t}], \tag{6e}$$

$$uc_{s,t}^{comp} = Ln\left[\sum_{v} \varsigma_{s,v} \, UC_{v,t}\right] \quad , \tag{6f}$$

$$\varsigma_{s,v} \propto (\text{distance between centroids for states s and v})^{-1}, \tag{6g}$$

$$\sum_{v} \varsigma_{s,v} = 1, \tag{6h}$$

$$\Omega^{ruc} = \alpha_0 + \alpha_1 + \alpha_2, \tag{6i}$$

where the user cost for the competitive set of states ($uc_{s,t}^{comp}$) is defined in equation (6f) as the weighted-sum over the bordering states, the five closest states, or the ten closest states to state s, or over all states other than state s. The weights are the inverse of the distance between the population centroids for state s and that of the competitive state v, normalized to sum to unity. The impact of the user cost variables is assessed by Ω, which is the summation of the α's.

There are several noteworthy features of equations (6) for estimating the effects of relative state tax incentives. First, the specification is parsimonious and linear, and tax policy effects are captured by the coefficients on the current and lagged values of the relative user cost term. Second, the specification is robust to other factors that might affect production possibilities. For example, location and geographical features that affect productivity and are fixed through time are captured by the state fixed effect. Other state-specific factors that vary through time, such as infrastructure stocks and human capital, can enter as additional factors of production. Owing to the strong separability inherent in the CES function, these factors will not distort parameter estimates from equations (6) because their effects are absorbed by the output term appearing in the first-order condition. Third, equation (6a) highlights the importance of state and time fixed effects, an issue that will be important in the empirical results to which we now turn.

3.2. Initial Empirical Results

OLS estimates of equation (6a) are presented in Panels A-D of Table 2 for estimators that differ by the inclusion/exclusion of state and year fixed effects and by the number of lags. In this subsection, we discuss the results from Panel A where the competitive user cost is defined for bordering states. We begin in columns 1 to 4 with models containing only the current value of the relative user cost. In column 1 with neither state nor time fixed effects, the coefficient on $ruc_{s,t}$, which is equivalent to Ω^{ruc} in models with only one relative user cost variable, is positive and statistically insignificant. With the inclusion of state fixed effects in column 2, Ω^{ruc} is now negative but remains statistically insignificant. Column 3 includes time fixed effects but excludes state fixed effects; Ω^{ruc} has a difficult-to-rationalize positive coefficient. Column 4 includes both fixed effects, and Ω^{ruc} takes on an economically sensible and significant value of −.464 that is statistically different from zero. Comparing column 4 with both fixed effects to column 2 with only state fixed effects, we see that the inclusion of time fixed effects more than doubles the response of capital to its user cost, as Ω^{ruc} increases (in absolute value) from −.201 to −.464.

Table 2: Capital Demand Model. Equation (6a) with Various Lags
Dependent Variable: Logarithm of the Capital/Output Ratio

A. Competitive User Cost for Bordering States

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$ruc_{s,t}$	.449	-.201	.408	-.464	1.290	.372	1.415	.345	1.259	.346	1.385	.314
	(.219)	(.420)	(.188)	(.176)	(.773)	(.733)	(.684)	(.400)	(.783)	(.742)	(.682)	(.400)
$ruc_{s,t-1}$	-----	-----	-----	-----	-.876	-.647	-1.051	-.912	.342	-.094	.175	-.266
	-----	-----	-----	-----	(.780)	(.717)	(.701)	(.376)	(1.148)	(.994)	(1.061)	(.516)
$ruc_{s,t-2}$	-----	-----	-----	-----	-----	-----	-----	-----	-1.249	-.596	-1.256	-.697
	-----	-----	-----	-----	-----	-----	-----	-----	(.894)	(.771)	(.799)	(.358)
Ω	**.449**	**-.201**	**.408**	**-.464**	**.414**	**-.274**	**.365**	**-.567**	**.353**	**-.344**	**.304**	**-.649**
	(.219)	(.420)	(.188)	(.176)	(.223)	(.436)	(.193)	(.173)	(.229)	(.450)	(.201)	(.176)
State	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Time	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
R^2	.0047	.0003	.4094	.7636	.0054	.0010	.4104	.7650	.0067	.0015	.4117	.7657
N	1008	1008	1008	1008	1008	1008	1008	1008	1008	1008	1008	1008

Table 2: Capital Demand Model. Equation (6a) with Various Lags
(cont.) Dependent Variable: Logarithm of the Capital/Output Ratio

B. Competitive User Cost for the Closest Five States

	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)
$ruc_{s,t}$	.456	1.258	.298	-.067		1.047	1.413	.820	.521		1.026	1.410	.801	.492
	(.157)	(.323)	(.133)	(.161)		(.789)	(.669)	(.716)	(.395)		(.794)	(.668)	(.711)	(.395)
$ruc_{s,t-1}$	-----	-----	-----	-----		-.617	-.177	-.544	-.673		.290	-.123	.284	-.081
	-----	-----	-----	-----		(.834)	(.683)	(.754)	(.383)		(1.166)	(.879)	(1.090)	(.522)
$ruc_{s,t-2}$	-----	-----	-----	-----		-----	-----	-----	-----		-.928	-.058	-.850	-.652
	-----	-----	-----	-----		-----	-----	-----	-----		(.923)	(.703)	(.839)	(.383)
Ω	**.456**	**1.258**	**.298**	**-.067**		**.430**	**1.236**	**.275**	**-.152**		**.387**	**1.228**	**.235**	**-.241**
	(.157)	(.323)	(.133)	(.161)		(.167)	(.337)	(.141)	(.160)		(.180)	(.357)	(.152)	(.166)
State	No	Yes	No	Yes		No	Yes	No	Yes		No	Yes	No	Yes
Time	No	No	Yes	Yes		No	No	Yes	Yes		No	No	Yes	Yes
R^2	.0073	.0127	.3967	.7501		.0076	.0128	.3969	.7508		.0083	.0128	.3974	.7514
N	1050	1050	1050	1050		1050	1050	1050	1050		1050	1050	1050	1050

Table 2: Capital Demand Model. Equation (6a) with Various Lags
(cont.) Dependent Variable: Logarithm of the Capital/Output Ratio

C. Competitive User Cost for the Closest Ten States

	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)
$ruc_{s,t}$	.762	1.490	.525	-.361		1.776	1.809	1.390	.421		1.741	1.803	1.361	.387
	(.177)	(.348)	(.151)	(.184)		(.802)	(.692)	(.731)	(.434)		(.811)	(.693)	(.723)	(.433)
$ruc_{s,t-1}$	-----	-----	-----	-----		-1.058	-.362	-.901	-.891		.272	-.236	.215	-.271
	-----	-----	-----	-----		(.832)	(.703)	(.761)	(.414)		(1.181)	(.902)	(1.138)	(.553)
$ruc_{s,t-2}$	-----	-----	-----	-----		-----	-----	-----	-----		-1.358	-.136	-1.141	-.674
	-----	-----	-----	-----		-----	-----	-----	-----		(.918)	(.719)	(.873)	(.396)
Ω	**.762**	**1.490**	**.525**	**-.361**		**.719**	**1.448**	**.488**	**-.470**		**.655**	**1.430**	**.434**	**-.557**
	(.177)	(.348)	(.151)	(.184)		(.183)	(.364)	(.158)	(.181)		(.192)	(.384)	(.167)	(.186)
State	No	Yes	No	Yes		No	Yes	No	Yes		No	Yes	No	Yes
Time	No	No	Yes	Yes		No	No	Yes	Yes		No	No	Yes	Yes
R^2	.0157	.0151	.4010	.7509		.0166	.0152	.4016	.7520		.0179	.0153	.4025	.7526
N	1050	1050	1050	1050		1050	1050	1050	1050		1050	1050	1050	1050

Table 2: Capital Demand Model. Equation (6a) with Various Lags
(cont.) Dependent Variable: Logarithm of the Capital/Output Ratio

D. Competitive User Cost for All States

	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)
$ruc_{s,t}$	.978	1.888	.648	-.480		2.158	1.910	1.700	.180		2.102	1.916	1.655	.153
	(.218)	(.349)	(.188)	(.202)		(.830)	(.690)	(.761)	(.449)		(.842)	(.687)	(.750)	(.449)
$ruc_{s,t-1}$	-----	-----	-----	-----		-1.223	-.025	-1.089	-.755		.404	-.119	.232	-.303
	-----	-----	-----	-----		(.863)	(.686)	(.792)	(.417)		(1.220)	(.884)	(1.187)	(.545)
$ruc_{s,t-2}$	-----	-----	-----	-----		-----	-----	-----	-----		-1.640	.101	-1.332	-.488
	-----	-----	-----	-----		-----	-----	-----	-----		(.945)	(.697)	(.918)	(.383)
Ω	**.978**	**1.888**	**.648**	**-.480**		**.936**	**1.885**	**.611**	**-.575**		**.866**	**1.898**	**.555**	**-.638**
	(.218)	(.349)	(.188)	(.202)		(.225)	(.361)	(.195)	(.198)		(.233)	(.381)	(.204)	(.204)
State	No	Yes	No	Yes		No	Yes	No	Yes		No	Yes	No	Yes
Time	No	No	Yes	Yes		No	No	Yes	Yes		No	No	Yes	Yes
R^2	.0199	.0204	.4022	.7513		.0211	.0204	.4031	.7521		.0228	.0204	.4043	.7523
N	1050	1050	1050	1050		1050	1050	1050	1050		1050	1050	1050	1050

Notes to Table 2:
OLS estimates are based on panel data for 50 states (save Panel A, which excludes Alaska and Hawaii) for the period 1982 to 2004. Estimates are based on equation (6a); given the two lags, the effective sample is for the period 1984 to 2004. The dependent variable is the logarithm of the capital/output ratio for state s ($ky_{s,t}$). The independent variable is the relative user cost for state s ($ruc_{s,t}$) defined as the logarithm of the own-state user cost relative to the logarithm of the competitive-states user cost. The competitive set of states is defined over the bordering states (Panel A), the five closest states (Panel B), or the ten closest states (Panel C) to state s, or over all states other than state s (Panel D). The competitive user cost is a weighted-average of these state user costs, where the weights are the inverse of the distance between the population centroids for state s and that of a competitive state, normalized to sum to unity. See Section 3 and the Data Appendix for further details about data sources and construction. The models in columns (1), (5), and (9) contain no fixed effects (when state fixed effects are absent, a constant term is included); the models in columns (2), (4), (6), (8), (10), and (12) contain state fixed effects; the models in columns (3), (4), (7), (8), (11) and (12) contain time fixed effects. The Ω parameter is the summation of the immediately preceding point estimates on the $ruc_{s,t}$ variables. Standard errors are heteroscedastic consistent using the technique of White (1980); the standard error for Ω is the sum of the underlying variances and covariances raised to the one-half power. The R^2 measures the amount of explained variation within a state. N is the number of state/year observations.

These combinations of fixed effect estimations are repeated in columns 5 to 8 and 9 to 12 for models with one and two additional lags, respectively. In order to enhance comparability across models, the sample is identical for the zero, one, and two lag models. The pattern of Ω^{ruc}'s with respect to state and time fixed effects reported in the above paragraph is the same in these lag models. For the preferred models with both fixed effects, the Ω^{ruc}'s increase (in absolute value) with additional lags, rising from −.464 with zero lags to −.567 and −.649 with one and two additional lags, respectively. (Further lags had a negligible impact on Ω^{ruc}, and those results are not reported in Table 2.) These estimates imply a sizeable impact of state investment tax credits. In 2004, a 1 percentage point (100 basis point) increase in the own-state investment tax credit for the "average" state would lead to a .62%, .76%, or .87% increase in the capital stock, holding output and the competitive-state user cost constant.

In sum, these results reveal a substantial impact of individual state tax policies operating though the user cost on capital formation and highlight the importance of controlling for state and time fixed effects with panel data.

3.3. Additional Competitive States

The above results are based on the assumption that the competitive user cost was for states that border state s. Panels B through D in Table 2 expand the set of competing states by defining the competitive user cost for the five closest, ten closest, and all other states. The previously discussed results about the impact of fixed effects and the role of the user cost are largely confirmed in these models with additional competitive states. One notable exception, however, is that, when the competitive user cost is defined for the five closest states in Panel B, the coefficients of the relative user cost on capital formation remain negative (in the preferred model with both state and time effects) but are not statistically significant.

3.4. Zero-Sum Game?

The prior results suggest that a state's investment tax policy, relative to that of its neighboring states, strongly affects capital formation within the state. This sub-section examines the separate responses of own-state capital formation to own-state and competitive-states tax policies. The latter effect allows us to quantify the extent to which interstate capital flows impede own-state capital formation. We estimate the following more general model with own and competitive user costs entered separately,

$$\begin{aligned} ky_{s,t} &= \zeta + \beta_0\, uc_{s,t}^{own} + \beta_1\, uc_{s,t-1}^{own} + \beta_2\, uc_{s,t-2}^{own} \\ &\quad + \gamma_0\, uc_{s,t}^{comp} + \gamma_1\, uc_{s,t-1}^{comp} + \gamma_2\, uc_{s,t-2}^{comp} + e_s + e_t + e_{s,t} \end{aligned} \quad . \tag{7}$$

The β's and the γ's capture the own-state and competitive-states tax effects, respectively. Insofar as there is competition for scarce capital resources and competitive tax rates affect capital formation in state s, the sum of the γ's, as represented by $\Omega^{uc-comp}$, will be positive. Alternatively, if capital is provided perfectly elastically, then the γ's will equal zero. Note that equation (7) reduces to equation (6a) under the restriction $-\beta_j = \gamma_j \ \ \forall j$.

OLS estimates of equation (7), as well as equation (6a), are presented in Table 3 for models with current and two lags of the user cost variables and state and time fixed effects. As a benchmark, column 1 shows the results for the standard capital demand model containing only the own-state user cost (a special case of equation (7) where $\gamma_j = 0 \ \ \forall j$). Not surprisingly given the prior results, the sum of the coefficients on the distributed lag of $uc_{s,t}^{own}$ is negative and significant. Our contention, however, is that these results may suffer from an omitted variables bias due to the possible own-state effect of competitive states' user costs. Columns 2 and 3 are based on a competitive user cost defined for bordering states. Column 2 is simply replicated from equation (6a) presented in Table 2. Looking at column 3, the sum of the β's, as represented by Ω^{uc-own}, are larger (in absolute value) than the comparable sum from the constrained model in column 2. Moreover, $\Omega^{uc-comp}$ is positive and statistically significant. The sum of $\Omega^{uc-own} + \Omega^{uc-comp}$ equals -.144, which implies that, if both own-state and competitive-states user costs rise by 10%, the own-state's capital-output ratio will fall by 1.44%. However, it is important to note the sum of these coefficients is not statistically significantly different from zero.

The results for the other three measures of the set of competitive states are qualitatively similar, though differences exist. Here we examine to what extent own-state capital formation is affected by the competitive-state user cost. In all three cases, $\Omega^{uc-comp}$ is positive and in two cases statistically significant. These results suggest that state tax incentives have empirically important interstate effects.

We evaluate whether these interstate effects lead to a zero-sum game by the extent to which own-state and competitive-state user cost effects cancel in terms of the sum of $\Omega^{uc-own} + \Omega^{uc-comp}$. For the four sets of competitive-states listed in Table 3, these sums (with standard errors in parentheses) equal -.144 (.287) [discussed above], -.505 (.264), .231 (.324), and 1.634 (.575). Thus, for the bordering states and the ten closest states, the sums are statistically close to zero. However, the net effect is significantly negative for the five closest states and significantly positive for all states. We are thus unable to draw a firm conclusion as to whether state tax policies are a zero-sum game.

Table 3: Capital Demand Model: Equations (6a) and (7)
Dependent Variable: Logarithm of the Capital/Output Ratio

	All States	Bordering States		Closest Five States		Closest Ten States		All States	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$ruc_{s,t}$	-----	.314	-----	.491	-----	.387	-----	.153	-----
	-----	(.400)	-----	(.395)	-----	(.434)	-----	(.449)	-----
$ruc_{s,t-1}$	-----	-.266	-----	-.081	-----	-.271	-----	-.303	-----
	-----	(.516)	-----	(.522)	-----	(.553)	-----	(.545)	-----
$ruc_{s,t-2}$	-----	-.697	-----	-.652	-----	-.674	-----	-.487	-----
	-----	(.358)	-----	(.383)	-----	(.396)	-----	(.383)	-----
Ω^{ruc}	-----	**-.649**	**-----**	**-.241**	**-----**	**-.557**	**-----**	**-.638**	**-----**
	-----	(.176)	-----	(.166)	-----	(.186)	-----	(.204)	-----
$uc\text{-}own_{s,t}$	.037	-----	-.026	-----	.125	-----	.133	-----	.055
	(.450)	-----	(.446)	-----	(.444)	-----	(.438)	-----	(.440)
$uc\text{-}own_{s,t-1}$	-.265	-----	-.267	-----	-.264	-----	-.252	-----	-.260
	(.537)	-----	(.536)	-----	(.526)	-----	(.527)	-----	(.526)
$uc\text{-}own_{s,t-2}$	-.301	-----	-.412	-----	-.385	-----	-.438	-----	-.358
	(.375)	-----	(.372)	-----	(.373)	-----	(.377)	-----	(.374)
$\Omega^{uc\text{-}own}$	**-.529**	**-----**	**-.705**	**-----**	**-.523**	**-----**	**-.557**	**-----**	**-.563**
	(.209)	-----	(.205)	-----	(.214)	-----	(.211)	-----	(.210)
$uc\text{-}comp_{s,t}$	-----	-----	-1.356	-----	-1.217	-----	-2.486	-----	-6.918
	-----	-----	(.772)	-----	(.734)	-----	(1.159)	-----	(2.578)
$uc\text{-}comp_{s,t-1}$	-----	-----	.342	-----	-.586	-----	.459	-----	2.265
	-----	-----	(1.102)	-----	(1.148)	-----	(1.693)	-----	(3.812)
$uc\text{-}comp_{s,t-2}$	-----	-----	1.574	-----	1.821	-----	2.815	-----	6.849
	-----	-----	(.737)	-----	(.833)	-----	(1.176)	-----	(2.681)
$\Omega^{uc\text{-}comp}$	**-----**	**-----**	**.561**	**-----**	**.018**	**-----**	**.788**	**-----**	**2.196**
	-----	-----	(.251)	-----	(.218)	-----	(.297)	-----	(.562)
State	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	.7514	.7657	.7670	.7514	.7533	.7526	.7546	.7523	.7556
N	1050	1008	1008	1050	1050	1050	1050	1050	1050

Notes to Table 3:
OLS estimates are based on panel data for 50 states (save columns 2 and 3, which excludeAlaska and Hawaii) for the period 1982 to 2004. Estimates reported in columns (1), (3), (5), (7), and (9) are based on equation (7) and in columns (2), (4), (6), and (8) are based on equation (6a). Given the two lags, the effective sample is for the period 1984 to 2004. The dependent variable is the logarithm of the capital/output ratio for state s ($ky_{s,t}$). The independent variables in columns (2), (4), and (6) are the logarithm of the user cost for state s ($uc\text{-}own_{s,t}$) and the logarithm of the user cost for competitive states ($uc\text{-}comp_{s,t}$). The competitive set of states is defined over the bordering states (columns 2 and 3), the five closest states (columns 4 and 5), or the ten closest states (columns 6 and 7) to state s, or over all states other than state s (columns 1, 8, and 9). The competitive user cost is a weighted-average of these state user costs, where the weights are the inverse of the distance between the population centroids for state s and that of a competitive state, normalized to sum to unity. See Section 3 and the Data Appendix for further details about data sources and construction. All models contain fixed state and time effects. The Ω parameter is the summation of the three immediately preceding point estimates. Standard errors are heteroscedastic consistent using the technique of White (1980); the standard error for Ω is the sum of the underlying variances and covariances raised to the one-half power. The R^2 measures the amount of explained variation within a state. N is the number of state/year observations.

4. Spatial Discontinuity Model

A key problem confronting applied work on the impacts of government policy is separating policy effects, which are the primary object of our analysis, from the nonpolicy effects, which are undoubtedly quantitatively important but not of immediate interest. In the previous section, we relied on the first-order condition for capital demand to impose the required separation. This section addresses the key problem in an alternative way by exploiting the spatial discontinuity in tax policies that occurs at state borders. This strategy was pioneered by Holmes (1998) in his study of right-to-work laws and other “pro-business” policies on the location of manufacturing activity. We apply Holmes' model to the study of state tax polices in this section, and the evidence weakly supports the efficacy of state tax policy.

4.1. Estimating Equation

Holmes (1998) develops several different tests for identifying the effects of pro-business regulations. This section follows the development of the cross-section model presented in his equation (3) modified to the current situation,

$$MA_c = \text{nonpolicy}_c + \theta\ \text{policy}_c + e_c, \tag{8a}$$

$$\text{nonpolicy}_c = f_b[x_c] + g_b[x_c]\text{dist}_c, \tag{8b}$$

$$\text{nonpolicy}_c = \eta_{0,b} + \eta_{1,b}\, x_c + \eta_{2,b}\, x_c^2 + \eta_{3,b}\, \text{dist}_c, \tag{8c}$$

where c indexes counties (about 3000 in the 48 contiguous U.S. states) and b indexes the 109 state borders. Equation (8a) is a general decomposition between nonpolicy and policy influences on the manufacturing activity (MA_c) in county c. Our primary measure of MA_c is the five-year growth in the number of manufacturing establishments in the county; we also use the share of employment in manufacturing as an alternative measure of MA_c. Holmes proposes a unique method for modeling the nonpolicy influences on the establishment growth based on two geographic characteristics of county c -- dist_c, the minimum distance from the population centroid for county c to its closest state border, and x_c, the distance between an arbitrary fixed point (on this closest border) and the point along the border that minimizes the distance from the population centroid (Holmes refers to x_c as the "milemark"). The focus on state borders is critical to the analysis. "At state borders, the geographic determinants of the distribution of manufacturing ….. are approximately the same on both sides of the border" (Holmes, 1998, p. 671). Holmes' method depends on dist_c and the polynomial approximations in x_c given by $f_b[.]$ and $g_b[.]$ to map the geographic data of the counties into a Cartesian plane in order to isolate the geographic determinants of the distribution of manufacturing (see Holmes (1998, Sections II.B and 4) for further discussion).[2] The polynomial approximations are presented in equation (8c). Note that these approximations are only valid for a given year, and hence the model must be estimated as a cross-section. With panel data, the η's in the following equation must be reestimated for each year,

$$MA_{c,t} = \eta_{0bt} + \eta_{1bt}\, x_c + \eta_{2bt}\, x_c^2 + \eta_{3bt}\, \text{dist}_c + \theta_t\, \text{policy}_{c,t} + e_{c,t}. \tag{9}$$

If tax effects captured by the user cost are important for manufacturing activity, the coefficient on the policy variable, θ_t, will be negative.

4.2. Empirical Results

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[2] We gratefully acknowledge Thomas Holmes for making the data on x_c and dist_c available on his website.

Equation (9) is estimated with two measures of policy and our primary measure of manufacturing activity, the five-year growth in the number of manufacturing establishments in the county (i.e., between period t and t-5). Both policy variables reflect the user costs for the states in which counties c' and c" are located ($ruc_{c,t}$). The first policy variable is closest to that used by Holmes, and defines an "anti-business" variable as an indicator variable in terms of the ratio of user costs lagged five years,

$$\text{policy}_{c,t} = \text{anti-business}_{c,t}\,, \tag{10a}$$

$$\begin{aligned} \text{anti-business}_{c,t} &= 1 \ \text{ if } \ \text{ruc}_{c,t-5} \geq 1 \\ &= 0 \ \text{ if } \ \text{ruc}_{c,t-5} < 1 \end{aligned}\;. \tag{10b}$$

The coefficients on anti-business from estimating model (9), separately for each year from 1982 to 2004, are presented in Figure 2. For most years other than 1991 to 1993, the θ coefficient is positive and statistically indistinguishable from zero. However, for these three years, the coefficient is negative and statistically significant.

The second policy variable replaces the anti-business indicator variable by the continuous relative user costs variable, $ruc_{c,t-5}$, and the results are presented in Figure 3.

Figure 2. Coefficients on ANTIBUSINESS$_{t-5}$, by year
Dependent Variable: 5-year symmetric growth in establishment count
Dashed lines represent 95% C.I.

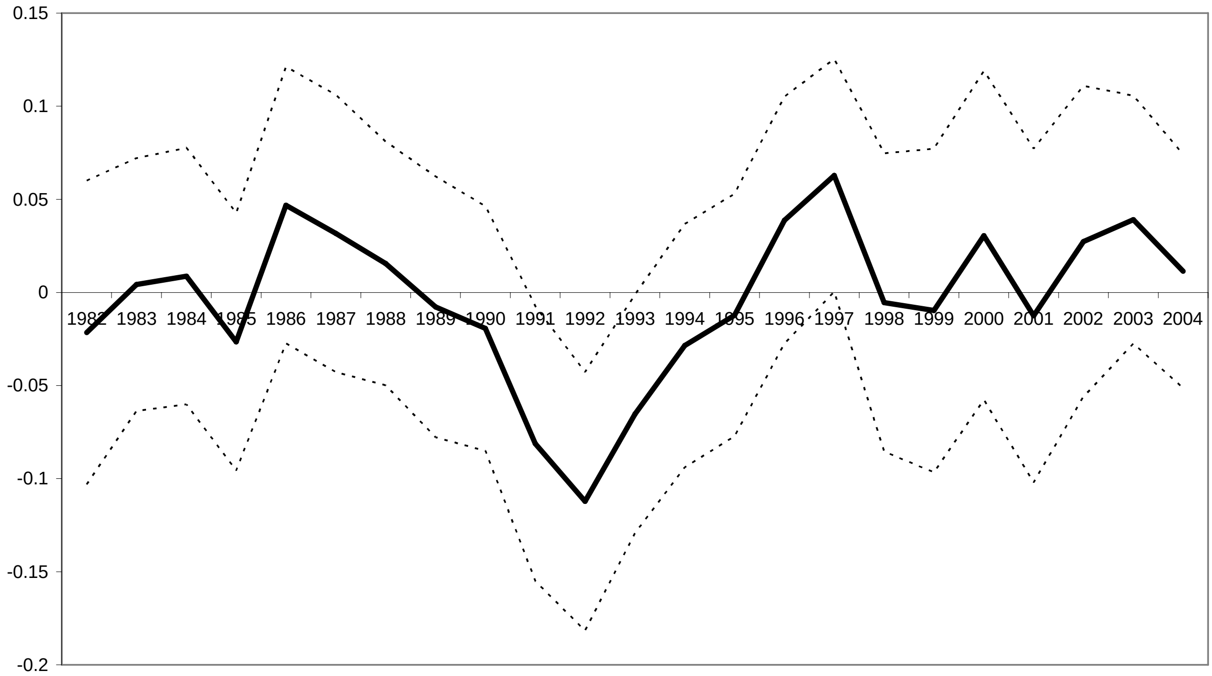
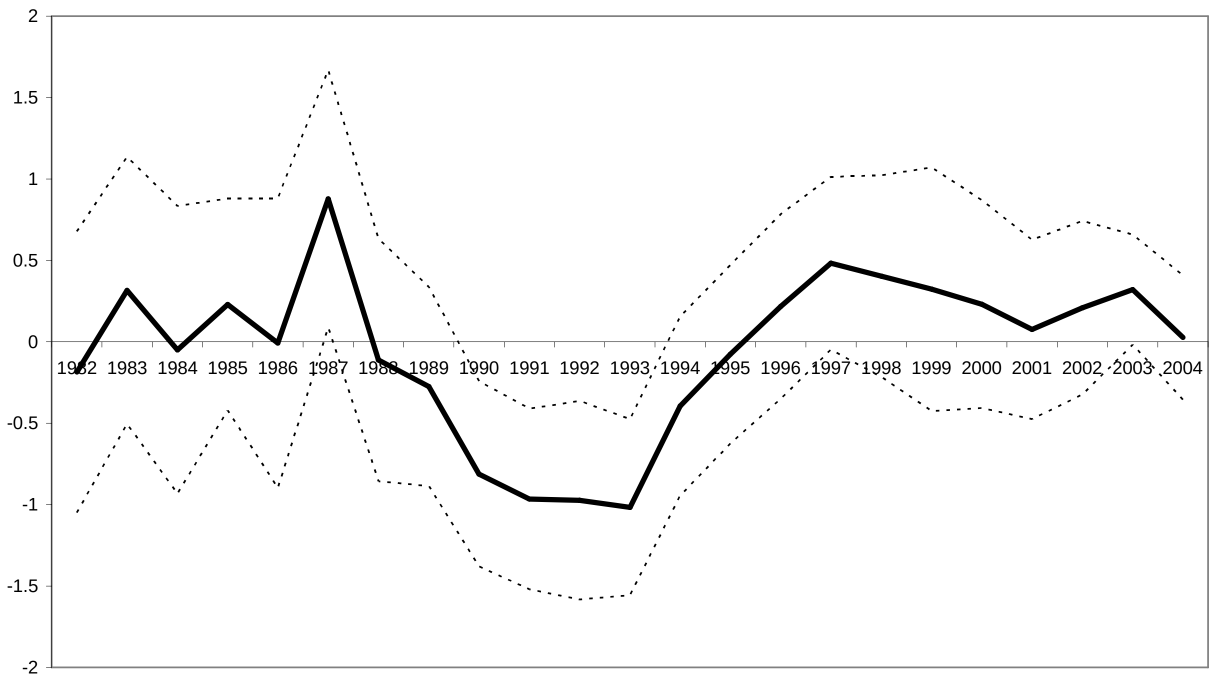


Figure 3. Coefficients on ln(RUC_{t-5}), by year
Dependent Variable: 5-year symmetric growth in establishment count
Dashed lines represent 95% C.I.



Similar to the results from model (9), the coefficient on the relative user cost generally is insignificantly different from zero, but is negative and significant in four years, 1990 to 1993.[3]

These estimates may be biased by the possible endogeneity of the user cost variable. In principle, endogeneity might arise because productivity or other shocks to employment growth equation are correlated with changes in the non-tax components of the user cost. This effect may largely cancel in our relative user cost variable, so we doubt that this channel seriously biases our estimates. An operative channel might exist if shocks affect state tax variables. This endogenous policy channel, coupled with the general possibility of measurement error, might lead to biased estimates. To investigate the potential bias, we reestimate the equation with policy measured by a continuous variables $ruc_{s,t-5}$ (i.e., the

[3] The share of employment in manufacturing was used by Holmes as a second measure of manufacturing activity. We prefer the growth rate measure for two reasons: (1) state investment tax incentives benefit all industries, not just manufacturing, and hence may have little impact on manufacturing's share of employment, and (2) it will be robust to time invariant policy effects occurring at the county level. Nonetheless, we reestimate equation (9) with employment share as the dependent variable and the continuous policy measure as the independent variable. The OLS estimates of θ are positive in all but two years and about one-half of the yearly coefficients are statistically significant.

results presented in Figure 3) using $ruc_{c,t-6}$, $ruc_{c,t-7}$, and $ruc_{c,t-8}$, as instruments. The IV point estimates and standard errors are very similar to those displayed in Figure 3. The IV point estimates continue to be statistically far from zero for the period 1990 to 1993. Endogeneity does not affect our overall conclusions.[4]

In sum, these results with the Spatial Discontinuity Model provide weak support for the role of state tax policy but also indicate that the evidence is sensitive to the year in which the analysis is undertaken. A series of cross-sectional data or panel data prove useful in avoiding this sensitivity.

5. Twin-Counties Model

In this section, we develop a novel alternative estimation framework in the spirit of Holmes that takes advantage of the panel structure of our dataset. This new model exploits the "natural experiment" afforded by pairs of counties in the same geographic area but separated by a state border. Thus, as in the Spatial Discontinuity Model, these counties are affected by similar nonpolicy factors but dissimilar tax policies. Comparing differential outcomes of pairs of counties with common geographic conditions but different state policies is akin to the twin studies employed frequently in labor economics and medical research, which analyze the differential outcomes of identical twins with common genetic but different environmental conditions (e.g., Ashenfelter and Krueger, 1994). The Twin-Counties Model uncovers a strong effect of state-level user costs on the location of establishments at the county level.

5.1. Estimating Equation

The essential piece of information generated by bordering counties is that the non-policy effects are identical at the border. Holmes measures these non-policy effects through polynomial approximations of geographic characteristics. In our framework, we continue to rely on the information generated at the border but develop a different model to identify policy effects. Consider the following general decomposition for the number of manufacturing establishments in a pair of neighboring counties that are in different states,

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[4] Instrumental variables estimation is not feasible in the capital demand model because, since state fixed effects are removed by mean-differencing, lagged regressors are precluded as valid instruments.

$$ne_{c',t} = \alpha_{c'} + \beta_t + nonpolicy_{c',t} + \theta\, policy_{c',t} + e_{c',t}\,, \tag{11a}$$

$$ne_{c'',t} = \alpha_{c''} + \beta_t + nonpolicy_{c''.t} + \theta\, policy_{c'',t} + e_{c'',t}\,, \tag{11b}$$

where $ne_{c,t}$ (c=c',c") is the logarithm of the number of establishments, α_c is a county fixed effect (that can incorporate distance from the population centroid to the border, position along the closest state border, latitude, longitude, climate, etc.), β_t is a time fixed effect impacting both counties equally, $nonpolicy_{c,t}$ represents one or more nonpolicy variables, $policy_{c,t}$ can represent one or more policy variables but it should be equated to the user cost for the development of this particular model, $e_{c,t}$ is an error term, and θ is the parameter of interest. The key identifying assumption of the model is that, around a state border, counties c' and c" are "twins" and hence $nonpolicy_{c',t} = nonpolicy_{c'',t}$. We exploit this relation by taking cross-county differences of a pair of twin-counties (labeled p),

$$\nabla ne_{p,t} = \alpha_p + \theta \nabla policy_{p,t} + e_{p,t}\,, \tag{12a}$$

$$\nabla ne_{p,t} \equiv ne_{c',t} - ne_{c'',t}\,, \tag{12b}$$

$$\nabla policy_{p,t} \equiv uc_{c',t} - uc_{c'',t} \equiv ruc_{p,t}\,, \tag{12c}$$

where the county fixed effects have been absorbed into α_p, the β_t's cancel by construction, and the nonpolicy variables cancel by the twins assumption. The policy variable that enters equation (12a) is a relative user cost ($ruc_{p,t}$), where the relative relation is drawn across a pair of twin-counties. If state tax investment incentives are effective, we would expect θ to be negative and statistically significant.

The Twin-Counties Model permits an additional test of tax efficacy and tax competition. We would expect policy to be more effective the closer are the paired counties, where closesness is measured by the distance between the population centroids for twin counties, c' and c", forming a pair. Establishments in close counties (separated by a border) may be more likely to respond to differential tax incentives by moving operations across the state line than establishments that are far apart. We would thus expect θ to decrease (in absolute value) as equation (12a) is estimated for counties further away from the border. This monotonicity hypothesis is evaluated with the following modified version of equation (12a),

$$\nabla^d ne_{p,t} = \alpha_p + \theta^d\, \nabla^d policy_{p,t} + e_{p,t}\,, \tag{13}$$

where the superscript *d* denotes the distance between the population centroid for the initial county (c’) in a twin-county pair and the border. Identifying θ^d for a particular, exact value of *d* is impossible since each county’s *d* is unique; rather, we consider in each regression a 40-mile sample range, or window, of *d*’s. We test whether the policy effect decreases with d by repeatedly estimating equation (13) for windows further and further away from zero. (This approach is similar to analyses with rolling samples frequently used in time series econometric studies.) Hereafter, we will use *d* to refer to the midpoint of a 40-mile sample window.

5.2. Empirical Results

To estimate equations (12) or (13), we must have an algorithm for establishing a pair of twin-counties. We proceed to identify twin-counties in the following four steps. First, we form the set of all pairs of counties. For C total counties in the United States, there will be ((C-1)*C) / 2 pairs of counties, where the subtraction of 1 adjusts for the impossibility of a county being a twin to itself and the division by 2 adjusts for redundant pair (where a redundant pair is defined as c’ pairing with c” and c” pairing with c’). In the United States, there are approximately 3,000 counties and hence about 4.5 million pairs. Second, we restrict this set to those pairs that are in bordering states. Note that a given county, c’, will be paired with several counties because, on average, a state has four borders. Third, for a given c’, there are several pairs in a given bordering state; we choose that county in a bordering state, c”, that is closest to c’, where closeness is measured by geographic distance -- determined by latitude and longitude data (provided by U.S. Census Bureau) using the Great Circle distance formula -- between the population centroids for c’ and c”. This step yields approximately 12,000 pairs, which we refer to as twin-counties.

As an example of the above procedure, consider Modoc county, which is in the Northeast corner of California. California borders three states, Oregon, Nevada, and Arizona. Our algorithm finds the Oregon county whose population centroid is closest to Modoc's population centroid and identifies this as the twin for the Modoc-Oregon (county-border) pair. The process is then repeated for finding the closest county to Modoc in Nevada and identifying this as the twin for the Modoc-Nevada (county-border) pair, and, lastly, for finding the closest county to Modoc in Arizona and identifying this as the twin for the Modoc-Arizona (county-border) pair. The resulting dataset thus contains three twin-counties for which Modoc is the initial county (i.e., c’). Since Modoc itself is close to state borders (its population centroid is 31 miles from the Oregon border, 35 miles from the Nevada border, and 558 miles from the Arizona border), this algorithm may also generate observations in which Modoc is identified as the second county (i.e., c") and one of Modoc's twins is the initial county (c'). These redundant observations are excluded.

Estimation of equation (12) proceeds with this twin-county dataset with one additional restriction. The twin-counties defined in the three-step procedure may nonetheless be very far from the border. We restrict the twin-counties used in estimation to those for whom c' and c" are within 40 miles of the border.[5] (To return to our example of Modoc county, this restriction would eliminate the Modoc-Arizona observation.) Tighter restrictions yield relatively small samples and imprecise estimates; looser restrictions lead to larger samples but ones containing pairs that may not satisfy the key identifying assumption for nonpolicy effects. This "40 mile border restriction," coupled with the three-step algorithm, yields 1,883 twin-counties. The resulting OLS estimated value of θ is -.058 with a standard error of .021.[6] Instrumental variable estimation of the Twin-Counties Model (with the first and second lags of the policy variable as instruments) yields very similar results; the estimated value of θ is -.064 with a standard error of .026. Thus, we find that the number of manufacturing establishments in a county relative to its twin falls with the relative state-level user cost.

To assess the monotonicity hypothesis (i.e., whether the relative user cost effect decreases (in absolute value) as counties get further from the border), we estimate equation (13) repeatedly for varying samples defined by the distance between the population centroid for the initial county (c') in a twin-county pair and the border. The first regression restricts twin-counties to those where the initial county is within 40 miles of the border; we refer to this dataset by its midpoint of $d = 20$. The next restricts pairs to those where first county is between 1 and 41 miles from the border; then 2 to 42, 3 to 43, …, up to 60 to 100. In other words, we repeatedly consider 40-mile sample windows in which the midpoint of distance-to-border for the first county increases from 20 miles to 80 miles.

Estimates of θ^d are shown in Figure 4. The elasticity decreases (in absolute value) rapidly with *d*. As we consider counties further and further away from the border, the effect of tax policy differentials evaporates. In particular, we find that θ^d hits zero at a distance midpoint of 32 miles and then stays around zero with further increases in *d*. A caveat with

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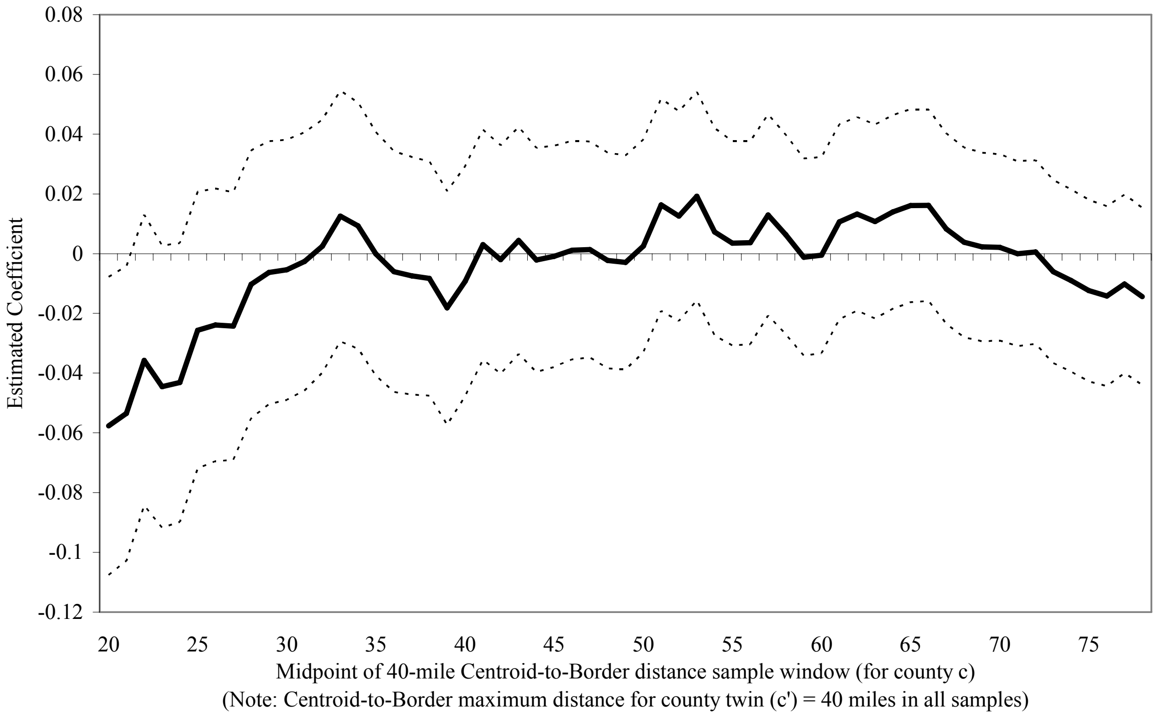
[5] As noted in Section 4, data on minimum distance between county population centroids and state borders comes from Holmes (1998) and is available on Holmes' website.

[6] The standard errors are adjusted for clustering induced by the appearance of c' in several datapoints.

these results is that the 95% confidence intervals are relatively wide and only the first few θ^{d}'s are significantly different from zero. Notwithstanding this issue, the movement of the θ^{d}'s toward zero can be explained by relocation or information costs increasing with distance. These frictions make it more difficult for firms in distant counties to take advantage of alternative tax regimes across the border and hence dominate the incentives offered by tax policy differentials.

Figure 4. Coefficients (OLS) on the policy variable by sample window
Dependent Variable: Cross-county difference in manufacturing employment
(Dashed lines represent 95% C.I.)



6. Summary And Conclusions

This paper is based on one fact, two questions, and three models. The one fact is the dramatic increase in state investment incentives. As documented in Figure 1, investment tax credits have become increasingly large and increasingly common among states. In 2004, the average rate of the investment tax credit (for adopting states) is greater than 6%.

This increased usage and size of state investment credits leads to two questions: Are these tax incentives effective in stimulating investment within the state? How much of this increase is due to investment drawn away from other states?

Based on a newly constructed panel dataset for all 50 states with over 20 years of data, we estimate three models to provide quantitative answers to these questions. The Capital Demand Model is motivated by the first-order condition for a profit-maximizing firm and relates the capital/output ratio to the relative user cost of capital defined as the own-state user cost less the competitive-states user cost. Controlling for fixed time and state effects proves important in obtaining economically and statistically significant user cost responses. The other two models relate the relative user cost to the location of manufacturing establishments at the county level. The Spatial Discontinuity Model utilizes the information generated by spatial breaks ("discontinuities") in tax policy at state borders. The Twin-Counties Model takes advantage of the panel structure of our data and exploits the "natural experiment" afforded by pairs of counties that are in the same geographic area but are separated by a state border.

Taken together, the estimates from these three models provide affirmative answers to the above two questions. We find that own-state economic activity is positively affected by own-state tax incentives and is negatively affected by competitive-state tax incentives. Interstate capital flows, which are a necessary element for meaningful tax competition, appear to be quantitatively important. Whether state investment incentives are a zero-sum game among the states is less certain and depends on the definition of the set of competitive states.

Future research needs to focus on obtaining a better understanding of the channels through which interstate tax competition might operate. The results presented in this study provide important evidence on the quantitative importance of competitive-states user cost and the sensitivity of interstate capital flows. But further work is needed in developing models with additional structure that can be estimated and that allow for a better understanding of tax competition among states and the attending welfare consequences.

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Data Appendix

This appendix describes the construction of and data sources for the data used in this study. Four series describe output ($Y_{s,t}$) and capital ($K_{s,t}$), as well as their tax-adjusted prices, $P^Y_{s,t}$ and $P^K_{s,t}$, respectively. The series are for the 50 states (indexed by subscript s) for the period 1963 to 2004 (indexed by subscript t), unless otherwise noted.[7] Each of the four series is described in a separate section. Section 5 describes the data sources for a series on the number of manufacturing establishments ($NE_{s,t}$). The general organizing principle for each section is to first define the series mentioned above and then discuss the components for each series. For each component, general issues concerning the construction of the series (if pertinent) and then data sources are discussed. Section 6 contains a Legend describing abbreviations and sources.

The state data described in this paper measure economic activity in the manufacturing sector. The primary raw source data for the state-level totals of output, investment, labor and establishments counts is the Annual Survey of Manufacturers (ASM) conducted by the U.S. Census Bureau. State-level totals (which the Census Bureau refers to as "AS-3" data) are reported in the yearly volumes of the ASM publication. From 1994 onward, these data also can be found in the yearly ASM Geographic Area Statistics (ASM-GAS) publications. Hereafter, we will refer to the ASM data on state-level totals for all years as the ASM-GAS data. The ASM data are collected from a large, representative sample of manufacturing establishments with one or more paid employees. The 2004 ASM (Appendix B, p. B-1) defines the manufacturing sector as follows,

> "The Manufacturing sector comprises establishments engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products. The assembling of component parts of manufactured products is considered manufacturing, except in cases where the activity is appropriately classified in Sector 23, Construction. Establishments in the manufacturing sector are often described as plants, factories, or mills and characteristically use power-driven machines and materials-handling equipment. However, establishments that transform materials or substances into new products by hand or in the worker's home and those engaged in selling to the general public products made on the same premises from which they are sold, such as bakeries, candy stores, and custom tailors, may also be included in this sector. Manufacturing establishments may process materials or may contract with other establishments to process their materials for them. Both types of establishments are included in manufacturing."

[7] The most notable exception is that the Annual Survey of Manufacturers was not conducted from 1979 to 1981.

The ASM manufacturing sector corresponds to NAICS sectors 31 to 33.

1. OUTPUT -- $Y_{s,t}$

Output is measured by real value added, and it is defined as nominal value added divided by a price deflator,

$$Y_{s,t} = Y\$_{s,t} \,/\, P^{BT,Y}_{mfg,t},$$

where $Y\$_{s,t}$ is nominal value added output and $P^{BT,Y}_{mfg,t}$ is the price index for manufacturing output net of sales and excise taxes but before corporate income tax adjustments. Since the $P^{BT,Y}_{mfg,t}$ series is based on producer price indices, it measures average prices received by domestic producers (PPI). Our database presents $Y_{s,t}$ in billions of constant 2000 dollars.

The $Y\$_{s,t}$ series is obtained from ASM GAS (e.g., in 2004, the data are published in Table 1, column F). Our database presents $Y\$_{s,t}$ in billions of dollars.

The $P^{BT,Y}_{mfg,t}$ series is obtained from INDUSTRY, the table labeled "Chain-Type Price Indexes for Value Added by Industry," Line 12. Our database presents $P^{BT,Y}_{mfg,t}$ as an index number with a base year value in 2000 of 1.0.

2. PRICE OF OUTPUT (TAX-ADJUSTED) -- $P^{Y}_{s,t}$

The price of output (tax-adjusted) is defined as the price index for manufacturing output adjusted by the effective corporate income tax rates at the state and federal levels,

$$P^{Y}_{s,t} = P^{BT,Y}_{mfg,t}\left(1-(\tau^{E,S}_{s,t}+\tau^{E,F}_{s,t})\right),$$

where $P^{BT,Y}_{mfg,t}$ is the price index for manufacturing output before tax adjustments (defined in Section 1), $\tau^{E,S}_{s,t}$ is the effective corporate income tax rate at the state level, and $\tau^{E,F}_{s,t}$ is the effective corporate income tax rate at the federal level. (As discussed below, the effective federal tax rate depends, in principle, on state tax parameters, and hence is subscripted by s.) The $P^{BT,Y}_{mfg,t}$ series was discussed in Section 1. Since $P^{BT,Y}_{mfg,t}$ is the price of output paid by purchasers (per Section 1), $P^{Y}_{s,t}$ is the price of output received by producers. Our database presents $P^{Y}_{s,t}$ as an index number with 2000 as the base year. The two tax components are discussed in the following subsections.

The Effective Corporate Income Tax Rate At The State Level -- $\tau^{E,S}_{s,t}$

The effective corporate income tax rate at the state level is lower than the legislated (or statutory) corporate income tax rate ($\tau^{L,S}_{t}$) due to the deductibility (in some states) against state taxable income of taxes paid to the federal government.[8] Some states allow full deductibility of federal corporate income taxes from state taxable income, Iowa and Missouri allow only 50% deductibility, and some states allow no deductibility at all. The deductibility provision in state tax codes is represented by $\upsilon_{s,t} = \{1.0, 0.5, 0.0\}$, and the provisional effective corporate income tax rate at the state level is as follows,

$$\tau^{\#,E,S}_{s,t} = \tau^{L,S}_{t}(1 - \tau^{\#,E,F}_{s,t}\upsilon_{s,t}).$$

The effect of federal income tax deducibility is represented by the provisional *effective* corporate income tax rate at the federal level (defined below). (This formulation has been validated by "brute force" computations of state and federal taxes paid based on state and federal legislated tax rates.)

The $\tau^{L,S}_{s,t}$ and $\upsilon_{s,t}$ series are obtained from several sources. For recent years, data are obtained primarily from various issues of BOTS and STH, as well as actual state tax forms. Data for earlier years are obtained from various issues of BOTS and SFFF. Additional information has been provided by TAXFDN. Many states have multiple legislated tax rates that increase stepwise with taxable income; we measure $\tau^{L,S}_{t}$ with the marginal legislated tax rate for the highest income bracket. Our database presents $\tau^{L,S}_{t}$ in percentage points (e.g., 0.05) as opposed to basis points (e.g., 5).

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8 Some states refer to their corporate income taxes as "franchise" or "excise" taxes.

The Effective Corporate Income Tax Rate At The Federal Level -- $\tau_{s,t}^{E,F}$

The effective corporate income tax rate at the federal level is lower than the legislated corporate income tax rate ($\tau_t^{L,F}$) due to the deductibility against federal taxable income of taxes paid to the state. The provisional effective corporate income tax rate at the federal level is as follows,

$$\tau_{s,t}^{\#,E,F} = \tau_t^{L,F}(1-\tau_{s,t}^{\#,E,S})$$

The effect of state income tax deducibility is represented by the *effective* corporate income tax rate at the state level. (This formulation has been validated by "brute force" computations of state and federal taxes paid based on state and federal legislated tax rates.) The $\tau_t^{L,F}$ series is obtained from GRAVELLE, Table 2.1. Our database presents $\tau_t^{L,F}$ in percentage points.

It has not generally been recognized that, owing to deductibility of taxes paid to another level of government, the effective corporate income tax rates at the state and federal levels are functionally related to each other. As shown in the above equations, these interrelationships yield two equations in two unknowns, and thus can be solved for the effective corporate income tax rates at the state and federal levels, respectively, as follows,

$$\tau_{s,t}^{E,S} = \tau_{s,t}^{L,S}\left[1-\upsilon_{s,t}\tau_t^{L,F}\right]\Big/\left[1-\upsilon_{s,t}\tau_{s,t}^{L,S}\tau_t^{L,F}\right],$$

$$\tau_{s,t}^{E,F} = \tau_t^{L,F}\left[1-\tau_{s,t}^{L,S}\right]\Big/\left[1-\upsilon_{s,t}\tau_{s,t}^{L,S}\tau_t^{L,F}\right].$$

The overall corporate income tax rate is the sum of $\tau_{s,t}^{E,S}$ and $\tau_{s,t}^{E,F}$. In the limiting case where federal corporate income taxes are not deductible against state taxable income ($\upsilon_{s,t} = 0$), this sum reduces to the more frequently used formula, $\tau_{s,t}^{L,S} + \tau_t^{L,F} - \tau_{s,t}^{L,S} * \tau_t^{L,F}$.

3. CAPITAL -- $K_{s,t}$

Capital input is measured by the real (constant-cost) replacement value of equipment (excluding software) and structures, and this series is constructed from the following perpetual inventory formula,

$$K_{s,t} = K_{s,\tau}(1-\delta_{mfg,t})^{t-\tau} + I_{s.t} \qquad t = \tau+1,...,T \ ,$$

where $K_{s,\tau}$ is the initial value of the real capital stock (where the index τ represents the initial period), $\delta_{mfg,t}$ is the rate of economic depreciation (hence $(1-\delta_{mfg,t})$ is the survival rate), and $I_{s,t}$ is real total capital expenditure. This definition departs in a small way from the one usually employed in capital stock construction by allowing the depreciation rate to vary over time. The capital stock is dated end-of-period (EOP). Our database presents $K_{s,t}$ in billions of constant 2000 dollars. Each component determining the capital stock is discussed in the following subsections.

The Initial Value Of The Capital Stock -- $K_{s,\tau}$

The $K_{s,\tau}$ series is measured by the book value of the capital stock adjusted for inflation,

$$K_{s,\tau} = K_{s,\tau}^{BV} * \left(K_{mfg,\tau}^{CoC} / K_{mfg,\tau}^{HC}\right),$$

where $K_{s,\tau}^{BV}$ is the book value (historical-cost) of the capital stock for state s, $K_{mfg,\tau}^{CoC}$ is the constant-cost value of the capital stock for the manufacturing sector, and $K_{mfg,\tau}^{HC}$ is the historical-cost value of the capital stock for the manufacturing sector. All capital stock series are EOP. Inflation drives a wedge between book value capital stocks (based on the original purchase cost of investment) and real capital stocks useful in economic analyses. The $\left(K_{mfg,\tau}^{CoC} / K_{mfg,\tau}^{HC}\right)$ ratio provides an approximate adjustment for the inflation wedge based on national manufacturing industry data. Our database presents $K_{s,\tau}$ in billions of constant 2000 dollars.

We compute initial values of the real capital stock EOP for $\tau = 1962$ and $\tau = 1981$. Note we "re-initialize" the capital stock in 1981 (as opposed to simply using the perpetual inventory formula starting with the 1962 initial stock estimate) for two reasons. First, the 1962 initial stock is estimated (as described below) rather than observed and so we do not want to rely too heavily on it. Second and more importantly, data on capital expenditures are missing for 1979 to 1981. Thus, the initial capital stock for 1981, based on book value data, likely is a better measure of the true capital stock in 1981 than a capital stock measure based in part on imputed investment data from 1979 to 1981.

A provisional estimate of $K_{s,1962}$, $K^{\#}_{s,1962}$, is estimated by solving backward using the perpetual inventory formula, beginning with the 1975 data on the book value of capital (adjusted for inflation), subtracting investment data from 1963 to 1975, and weighting these terms by survival rates,

$$K^{\#}_{s,1962} = K^{\#}_{s,1975}(1-\delta_{1975})^{-(1975-1962)} - \left(\sum_{j=0}^{(1975-1962-1)} (1-\delta)^{-(1975-1962-j)} I_{s,1975-j}\right)$$

$$K^{\#}_{s,1975} = K^{BV}_{s,1975} * \left(K^{CoC}_{mfg,1975} / K^{HC}_{mfg,1975}\right)$$

The first part of the first of the equations above starts with the 1975 book value of capital (adjusted for inflation) and adds back all of the 1962 capital stock that has depreciated since 1962. The second part then subtracts all of the investments made from 1963 to 1975, after adding back to each year's investment the portion that has depreciated from when the investment was made and 1962. In essence, this formula undoes all of the additions to and depreciation from the original capital stock of 1962 and subsequent investments from 1963 to 1975. Note we choose 1975 as the year from which to work backwards since it is the earliest year in which book value data are available from the ASM.

The final estimate of $K_{s,1962}$ is then obtained by rescaling the provisional state estimates by the national real capital stock total in 1962 from the BEA, $K^{CoC}_{mfg,1962}$. Specifically,

$$K_{s,1962} = K^{\#}_{s,1962} * \left(K^{CoC}_{mfg,1962} \Big/ \sum_{s=1}^{51} K^{\#}_{s,1962} \right).$$

A potential inconsistency exists in using the BEA data to rescale our provisional estimate based on ASM data. Software investment is included in the BEA data but excluded in the ASM data. During the early 1960's, the discrepancy introduced by software investment is tiny. In 1963, software investment was 1.3% of manufacturing investment (though software embedded or bundled in computers and other equipment is not reflected in this figure). The impact of software investment is likely less than this figure for two reasons. First, for the vintages of investment entering the 1962 capital stock, their share is likely to be even smaller than 1.3%. Second, software depreciates more rapidly than other capital. It would seem safe to conclude that that the discrepancy owing to the different treatment of software investment is less than 1% of the 1962 capital stock.

The $K^{BV}_{s,\tau}$ series is obtained from ASM (e.g., in 1975, the data are published in Table 4, row 5). Our database presents $K^{BV}_{s,\tau}$ in billions of dollars.

The $K^{CoC}_{mfg,\tau}$ series is the product of a quantity index and a base year value that converts the index into a real stock,

$$K^{CoC}_{mfg,\tau} = INDEXK^{CoC}_{mfg,\tau} * K^{CuC}_{mfg,t=2000},$$

where $INDEXK^{CoC}_{mfg,\tau}$ is the chain-type quantity index for the real capital stock and $K^{CuC}_{mfg,t=2000}$ is the base year value for the current-cost value of the capital stock for the manufacturing sector. Our database presents $K^{CoC}_{mfg,\tau}$ in millions of dollars. The $INDEXK^{CoC}_{mfg,\tau}$ is obtained from FIXED, Table 4.2, line 7, and this series is divided by 100. Our database presents $INDEXK^{CoC}_{mfg,\tau}$ as an index number with a base year value in 2000 of 1.0. The $K^{CuC}_{mfg,t=2000}$ datapoint is obtained from FIXED, Table 4.1, line 7. Our database presents $K^{CuC}_{mfg,t=2000}$ in millions of dollars.

The $K^{HC}_{mfg,\tau}$ series is obtained from FIXED, Table 4.3, line 7. Our database presents $K^{HC}_{mfg,\tau}$ in millions of dollars.

The Rate Of Economic Depreciation -- $\delta_{mfg,t}$

The $\delta_{mfg,t}$ series is measured by the flow of annual depreciation divided by the capital stock existing at the beginning of the year,

$$\delta_{mfg,t} = \frac{D^{CuC}_{mfg,t}}{K^{CuC}_{mfg,t-1}},$$

where $D^{CuC}_{mfg,t}$ is the current-cost flow of depreciation in manufacturing industries and $K^{CuC}_{mfg,t-1}$ is the current-cost capital stock in manufacturing industries. Our database presents $\delta_{mfg,t}$ in percentage points.

The $D^{CuC}_{mfg,t}$ series is obtained from FIXED, Table 4.4, line 7. Our database presents $D^{CuC}_{mfg,t}$ in millions of dollars.

The $K^{CuC}_{mfg,t-1}$ series is obtained from FIXED, Table 4.1, line 7. Our database presents $K^{CuC}_{mfg,t-1}$ in millions of dollars.

Real Total Capital Expenditure -- $I_{s,t}$

Real total capital expenditure is defined as nominal capital expenditures deflated by a price index,

$$I_{s,t} = \frac{I\$_{s,t}}{P^{I}_{mfg,t}},$$

$$I\$_{s,t} = I\$^{NEW}_{s,t} + I\$^{USED}_{s,t},$$

where $I\$_{s,t}$, $I\$^{NEW}_{s,t}$, and $I\$^{USED}_{s,t}$ are total, new, and used nominal capital expenditures, respectively, and $P^{I}_{mfg,t}$ is the price deflator for investment for the manufacturing sector. Our database presents $I_{s,t}$ in billions of constant 2000 dollars. The $I\$_{s,t}$ and $P^{I}_{mfg,t}$ series are discussed in the following subsections.

Total Nominal Capital Expenditure -- $I\$_{s,t}$

The $I\$_{s,t}$ series is obtained in three different ways each of which are based on the ASM-GAS and depend on disjoint time periods. (This mixture of direct and indirect estimates is forced upon us because of some anomalies in the ASM-GAS.) The series represents nominal expenditures on equipment (excluding software) and structures. Our database presents $I\$_{s,t}$ in billions of dollars.

For 1977, 1978, and 1982 to 2004, the series is obtained directly from ASM-GAS (e.g, in 2004, the data are published in Table 2, column I).

For 1963 to 1976, the ASM-GAS only publishes data for $I\$_{s,t}^{NEW}$. For these years, $I\$_{s,t}$ is derived based on a state's mean ratio of $I\$_{s,t}^{NEW}$ to $I\$_{s,t}$,

$$
\begin{aligned}
I\$_{s,t} = I\$_{s,t}^{NEW} * \mathrm{MEAN}_s \left\{ I\$_{s,v} / I\$_{s,v}^{NEW} \right\} & \\
t = 1963,...,1976 & \quad , \\
v = 1977,\ 1978,\ 1982,...,\ 2004. &
\end{aligned}
$$

where the $\mathrm{MEAN}_s\{.\}$ is computed separately for each state and over all available observations represented by the index v.

For 1979 to 1981, the ASM was not conducted, and hence no ASM-GAS source data are available for $I\$_{s,t}$, $I\$_{s,t}^{NEW}$, nor $Y_{s,t}$. The missing investment data for these three years are estimated with the following three-step procedure. First, we rely on the availability of alternative output data from BEA for these three years and the workhorse of investment theory, the accelerator model, to estimate the missing total capital expenditure data. Output is defined as real Gross State Product (GSP) for the manufacturing sector.[9] With these data and the available data for $I_{s,t}$, we estimate the following flexible accelerator model,

$$
\begin{aligned}
I_{s,t} / Y'_{s,t} = \alpha_s + \beta_{s,0}(\Delta Y'_{s,t} / Y'_{s,t-1}) + \beta_{s,1}(\Delta Y'_{s,t-1} / Y'_{s,t-2}) & \\
+ \beta_{s,2}(\Delta Y'_{s,t-2} / Y'_{s,t-3}) + \varepsilon_{s,t} & \quad , \\
t = 1977,\ 1978,\ 1982,\ ...,\ 2004 &
\end{aligned}
$$

where α_s is a state-specific constant capturing state fixed effects, the β_s's are state-specific slope parameters, $\varepsilon_{s,t}$ is an error term, and $Y'_{s,t}$ is real manufacturing GSP. The $Y'_{s,t}$ series is nominal manufacturing GSP divided by a price deflator. Nominal manufacturing GSP is

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[9] For all intents and purposes, Gross State Product is conceptually identical to Gross Domestic Product, though small differences exist in some minor categories.

obtained from the BEA's Regional Economic Accounts (REA) data. (In 1997, the data are reported on both SIC and NAICS bases; we use the SIC figures.) The deflator is $P^{BT,Y}_{mfg,t}$ discussed in Section 1.

Second, we use the estimated parameters (represented by ^ 's over the α and the β 's), data for $Y'_{s,t}$ and $P^{I}_{s,t}$, and a transformed version of the above equation to generate a provisional estimate of $I\$_{s,t}$ ($I\$^{\#}_{s,t}$) for the missing nominal capital expenditure observations,

$$I\$^{\#}_{s,t} = \left[\hat{\alpha}_s + \hat{\beta}_{s,0}(\Delta Y'_{s,t} / Y'_{s,t-1}) + \hat{\beta}_{s,1}(\Delta Y'_{s,t-1} / Y'_{s,t-2}) + \hat{\beta}_{s,2}(\Delta Y'_{s,t-2} / Y'_{s,t-3})\right] * Y'_{s,t} * P^{I}_{s,t} \quad .$$

$$t = 1979,\ 1980,\ 1981$$

Third, for each year (1979, 1980, 1981), we rescale states' nominal investment so that it equals the national total, $I\$^{ASM}_{mfg,t}$, which we estimate by applying the growth rate of the BEA's nominal private nonresidential fixed investment (net of software) for the manufacturing sector, $I\$_{mfg,t}$, to the previous year's value of national investment reported in the ASM. Specifically, we multiply each state's provisional estimate by the ratio of national manufacturing investment to the national sum of the provisional estimates,

$$I\$_{s,t} = I\$^{\#}_{s,t} * \left(I\$^{ASM}_{mfg,t} \Big/ \sum_{s=1}^{51} I\$^{\#}_{s,t} \right),$$

$$t = 1979, 1980, 1981$$

$$I\$^{ASM}_{mfg,1979} = \sum_{s=1}^{51} I\$_{s,1978} \left(\frac{I\$_{mfg,1979}}{I\$_{mfg,1978}} \right)$$

$$I\$^{ASM}_{mfg,1980} = I\$^{ASM}_{mfg,1979} \left(\frac{I\$_{mfg,1980}}{I\$_{mfg,1979}} \right) \quad .$$

$$I\$^{ASM}_{mfg,1981} = I\$^{ASM}_{mfg,1980} \left(\frac{I\$_{mfg,1981}}{I\$_{mfg,1980}} \right)$$

The $I\$_{mfg,t}$ series is obtained from FIXED, Table 4.7, line 7 less the sum of software investment over all manufacturing industries (NAICS sectors 31 to 33) from DETAILED, row 9.

The ASM-GAS data for $I\$_{s,t}$ need to be adjusted for additional missing values and an error. The additional missing values occur because the ASM-GAS did not report data for Minnesota for the years 1970 and 1971. We use the relation between BEA data for the manufacturing sector and state data for Minnesota on investment expenditures to impute the missing values with the following relation,

$$I\$_{s=minnesota,t} = MEAN\left\{\frac{I\$_{s=minnesota,v}}{I\$_{mfg,v}}\right\} * I\$_{mfg,t}$$

$$t = 1970,\ 1971$$

$$v = 1967,\ 1968,\ 1969,\ 1972,\ 1973,\ 1974$$

where $I\$_{mfg,t}$ is nominal capital expenditures on new and used capital by the manufacturing sectors defined above and the mean of the ratio is computed for three years before and after the missing values. The $I\$_{mfg,t}$ series was discussed previously in this subsection.

The error occurs for $I\$_{s=ohio,t=1996}$. In 1996, ASM-GAS shows a 400% jump in nominal total capital expenditures in Ohio from about \$8 billion in 1995 to \$40 billion in 1996 and then back down to \$9 billion in 1997. This enormous jump can be traced to the motor vehicles sector (\$35 billion), which suggests a huge capital investment – equal to 85% of the sector's national capital expenditures – for the building of an auto plant(s) in Ohio in 1996. We dismiss this number for three reasons. First, the magnitude of this investment is implausible. By comparison, DaimlerChrysler's jeep plant expansion in Toledo in 1998 was \$1.2 billion of total investment over several years. Second, correspondence with experts on the Ohio manufacturing sector (including one at the Ohio Department of Economic Development) could not confirm any massive capital expenditure programs in 1996. Third, the 1996 value for national total capital expenditures reported in the ASM-GAS is inconsistent with and about \$32 billion higher than a comparable figure reported in a separate ASM publication, Statistics for Industry Groups and Industries (ASM-SIGI). These two publications disagree on national capital expenditures only in 1996, suggesting an error is present. We thus conclude that $I\$_{s=ohio,t=1996} = \$40$ billion is erroneous.

We fill in the 1996 Ohio data point by simply taking national manufacturing capital expenditures from the alternative ASM publication, ASM-SIGI, and subtracting the sum of capital expenditures from all other states.

Price Deflator For Investment -- $P^{I}_{mfg,t}$

The price deflator for investment is constructed as an implicit deflator,

$$P^{I}_{mfg,t} = \frac{I\$_{mfg,t}}{I_{mfg,t}},$$

where $I\$_{mfg,t}$ and $I_{mfg,t}$ are nominal and real total capital expenditures, respectively, for the manufacturing sector. Our dataset presents $P^{I}_{mfg,t}$ as an index number with a base year value in 2000 of 1.0.

The $I\$_{mfg,t}$ series was discussed in the preceding subsection (Total Nominal Capital Expenditure).

The $I_{mfg,t}$ series is the product of a quantity index and a base year value that converts the index into real investment expenditures,

$$I_{mfg,t} = INDEXI_{mfg,t} * I\$_{mfg,t=2000},$$

where $INDEXI_{mfg,t}$ is the chain-type quantity index for real investment expenditures and $I\$_{mfg,t=2000}$ the base year value for current investment expenditures. Our database presents $I_{mfg,t}$ in billions of dollars. The $INDEXI_{mfg,t}$ is obtained from FIXED, Table 4.8, line 7, and this series is divided by 100. Our database presents $INDEXI_{mfg,t}$ as an index number with a base year value in 2000 of 1.0. The series containing the $I\$_{mfg,t=2000}$ datapoint was discussed in the preceding paragraph.

4. PRICE OF CAPITAL (TAX-ADJUSTED) -- $\mathbf{P^K_{s,t}}$

The price of capital (tax-adjusted) is defined as the product of three objects reflecting tax credits and deductions ($TAX_{s,t}$), the purchase price of the capital good ($PRICE_{s,t}$), and the opportunity costs of holding depreciating capital ($OPPCOST_{s,t}$),

$$P^K_{s,t} = TAX_{s,t} * PRICE_{s,t} * OPPCOST_{s,t},$$

$$\begin{aligned} TAX_{s,t} = {} & 1 - ITC^{L,S}_{s,t} - ITC^{L,F}_{t} - (\tau^{E,S}_{s,t} + \tau^{E,F}_{s,t})TD_{s,t} \\ & + \left(1 - (\tau^{E,S}_{s,t} + \tau^{E,F}_{s,t})\right)PT_{s,t} \end{aligned},$$

$$PRICE_{s,t} = P^I_{mfg,t},$$

$$OPPCOST_{s,t} = \rho_t + \delta_{mfg,t},$$

where $ITC^{L,S}_{s,t}$ and $ITC^{L,F}_{t}$ are the legislated investment tax credit rates at the state and federal levels, respectively, $\tau^{E,S}_{s,t}$ and $\tau^{E,F}_{t}$ are the effective corporate income tax rates at the state and federal levels, respectively, $TD_{s,t}$ is the present value of tax depreciation allowances at the federal level, $PT_{s,t}$ is the present value of property tax payments at the state level, $P^I_{mfg,t}$ is the price deflator for investment in the manufacturing sector, $\rho_{s,t}$ is the financial cost of capital, and δ_t is the economic depreciation rate. The $P^K_{s,t}$ series and its eight components are stated at an annual rate and in continuous time. Four of the components have been discussed previously -- $\tau^{E,S}_{s,t}$, $\tau^{E,F}_{s,t}$, $P^I_{mfg,t}$, and $\delta_{mfg,t}$; the remaining four components are discussed in the following subsections. Note that the user cost of capital, which was introduced by JORGENSON in 1963 and extended by, among others, HALL-JORGENSON, GRAVELLE, JORGENSON-YUN, and KING-FULLERTON, equals $P^K_{s,t}$ divided by $P^Y_{s,t}$ (the latter discussed in Section 2).

The Legislated Investment Tax Credit, State -- $\mathbf{ITC^{L,S}_{s,t}}$

The state investment tax credit is a credit against state corporate income tax liabilities. In general, the effective amount of the investment tax credit is simply the legislated investment tax credit rate ($ITC^{L,S}_{s,t}$) multiplied by the value of capital expenditures put into place within the state in a tax year. The effective rate is lower than the legislated rate in a handful of states for two reasons. First, five states (Connecticut, Idaho, Maine, North Carolina, and Ohio) permit the state investment tax credit to be applied only to equipment. Since equipment investment is approximately 85% of ASM total national investment, we multiply $ITC^{L,S}_{s,t}$ by 0.85 for these five states. Second, several states require basis adjustments deducting the amount of the credit from the asset basis for depreciation purposes; this adjustment is considered in the subsection on the Present Value of Tax Depreciation Allowances.

The $ITC^{L,S}_{s,t}$ series is obtained directly from states' online corporate tax forms and instructions. For most states with an investment tax credit, both current and historical credit rates are provided in the current year instructions (since companies applying for a credit based on some past year's investment apply that year's credit rate rather than the current rate). In those few cases where some or all historical rates were missing from the online forms and instructions, the missing rates are obtained via direct communication with the state's department of taxation. In some states, the legislated investment tax credit rate varies by the level of capital expenditures; we use the legislated credit rate for the highest tier of capital expenditures. Our database presents $ITC^{L,S}_{s,t}$ in percentage points.

The Legislated Investment Tax Credit Rate, Federal -- $ITC^{L,F}_{t}$

The federal investment tax credit enters the price of capital in a manner similar to that of $ITC^{S,F}_{s,t}$ and is a credit against federal corporate income tax liabilities. In general, the effective amount of the investment tax credit is simply the legislated investment tax credit rate ($ITC^{L,F}_{t}$) multiplied by the value of capital expenditures put into place in a tax year. The effective credit rate is lower than the legislated credit rate because of basis adjustments specifying that the amount of the credit must be deducted from the asset basis for depreciation purposes; this adjustment is considered in the subsection on the Present Value of Tax Depreciation Allowances.

Legislated investment tax credit rates generally increase with asset lives (as determined by the tax authorities). Thus, the $ITC_t^{L,F}$ series is a weighted-average of the legislated investment tax credit rates by equipment+software asset type ($ITC_{a,t}^{L,F}$),

$$ITC_t^{L,F} = \sum_{a=1}^{22} \omega_{a,t}\ ITC_{a,t}^{L,F},$$

$$\omega_{a,t} = \frac{K_{a,t-1}^{CuC}}{\sum_{a=1}^{22} K_{a,t-1}^{CuC}},$$

where the weights are the ratio of the current-cost capital stock for asset *a* to the total over 22 nonresidential equipment assets. (Note that software assets, which are excluded from our measure of capital, are not included in the 22 nonresidential equipment assets used to compute the $\omega_{a,t}$ weights.) We thus assume that weights based on data for the nonresidential sector are appropriate for the manufacturing sector. Current-cost capital stocks are used in computing weights because the divisia-aggregated constant-cost capital stocks are not additive across components.

The $ITC_{a,t}^{L,F}$ series is obtained from GRAVELLE, Table B3. Our database presents $ITC_{a,t}^{L,F}$ in percentage points.

The $K_{a,t-1}^{CuC}$ series are obtained from FIXED, Table 2.1, lines 3 to 34. Our database presents $K_{a,t-1}^{CuC}$ in millions of dollars.

The Present Value of Tax Depreciation Allowances -- $TD_{s,t}$

Tax depreciation allowances accrue over the useful life of the asset. We have assumed that the value of $TD_{s,t}$ is 0.70 for all s and t.

The Present Value Of Property Tax Payments -- $PT_{s,t}$

The formula for the present value of property tax payments ($PT_{s,t}$) is conceptually similar to the one for the present value of tax depreciation allowances. Both involve a stream of commitments that follow upon purchasing an asset. In the case of property taxes, this stream involves tax payments beginning in period t and extending into the indefinite future based on the remaining value of the asset.

The $PT_{s,t}$ series is constructed according to the following formula stated in continuous time,

$$PT_{s,t} = \int_t^{\infty} e^{-(\rho_{s,t} + \delta_{mfg,t})(v-t)} \; ptr_{s,t} \; dv \, ,$$

where $\rho_{s,t}$ is the nominal discount rate equal to the financial cost of capital, $\delta_{mfg,t}$ is the rate of economic depreciation for the manufacturing sector, and $ptr_{s,t}$ is the effective property tax rate on business property, which varies across states and over time. Conceptually, the variable $ptr_{s,t}$ equals property taxes paid to the state and all its localities by businesses divided by the market value of business property. Thus, it is useful to express $ptr_{s,t}$ as,

$$ptr_{s,t} = \left(0.404 * PTREV_{s,t}\right) \Big/ \left[\left(K_{s,t} \big/ \sum_i K_{i,t}\right) * BUS\_ASSETS_t\right],$$

where $PTREV_{s,t}$ is property tax revenues of state and local governments within state *s*, and BUS_ASSETS_t is tangible assets owned by the nonfarm corporate business sector (from Table B.102 of the Federal Reserve Board of Governors' Flow of Funds data). Assets data is not available at the state-level; thus, as indicated in the above formula, national business assets are allocated to the states in proportion to the state's share of national capital stock.

We use the period t values of $\rho_{s,t}$ and $ptr_{s,t}$ in computing the period t present value of property tax payments, thus assuming static expectations for the discount and property tax rates used in this specific computation. We further assume that the assessed market value depreciates over time at rate $\delta_{mfg,t}$. The above equation can be integrated to obtain the following expression for the present value of property tax payments, which is similar to an annuity,

$$PT_{s,t} = ptr_{s,t} \;/\; (\rho_t + \delta_{mfg,t}) = ptr_{s,t} \;/\; OPPCOST_{s,t} \, .$$

The series for $PTREV_{s,t}$ is obtained from the Census of Governments (CG). CG provides data on PTREV for years 1961, 1966, 1971, 1976, 1981, 1986, 1991, 1996, and 2001; data for other years in the range 1961-2004 are filled in via linear interpolation (through 2000) or extrapolation (2002-2004). Our database presents $ptr_{s,t}$ in percentage points.

The Financial Cost Of Capital -- $\rho_{s,t}$

The financial cost of capital is the real discount rate applied to cash flows accruing over a long horizon and is assumed to be equal to 0.10 for all t.

5. NUMBER OF MANUFACTURING ESTABLISHMENTS -- $NE_{s,t}$

The number of manufacturing establishments is measured by the $NE_{s,t}$ series is obtained from County Business Patterns (CBP; e.g., for 2004, the data are published in row, NAICS=”31-----“, column “est”). The coverage of the CBP begins in 1977, but it has the advantage of being available continuously through 2004. In our database, $NE_{s,t}$ is presented in numbers of establishments.

6. LEGEND[10]

ASM: CENSUS, *Annual Survey of Manufactures, Complete Volume* (Various Years).

ASM-GAS: CENSUS, *Annual Survey of Manufacturers, Geographic AreaStatistics* (Various Years). Publications for the years 1994 to 2004 (except 1997 and 2002) are available online. These data are published on an establishment basis. The data are obtained from electronic or paper documents depending on the time period: 2004 (Census website); 2003 to 1972 (CD's purchased from Census); 1971 to 1963 (paper copies). URL: http://www.census.gov/mcd/asm-as3.html.

ASM-SIGI: CENSUS, *Annual Survey of Manufacturers, Statistics for Industry Groups and Industries* (1996). URL: http://www.census.gov/mcd/asm-as1.html.

[10] In describing the raw data, some of the text in this paper has been taken directly from government publications.

BEA: Bureau of Economic Analysis, U.S. Department of Commerce. URL: http://www.bea.gov.

BLS: Bureau of Labor Statistics, U.S. Department of Labor. URL: http://www.bls.gov.

BOP: Beginning-Of-Period t.

BOTS: The Council of State Governments, *The Book of the States* (The Council of State Governments : Lexington, Kentucky, Various Issues).

CCHTB: CCH Tax Briefing: *Corporate Income Tax and 'Bonus' Depreciation Special Report* (December 4, 2003). URL: http://tax.cchgroup.com/Tax-Briefings/2003-Corporate-Tax-Bonus-Depreciation.pdf.

CENSUS: Bureau of the Census, U.S. Department of Commerce. URL: http://www.census.gov.

CG: Census of Governments, Volume 2 (Various Years).

CM: CENSUS, *Census of Manufacturers* (Various Years). Publications for 1997 and 2002 are available online. URL for the 2002 edition: http://www.census.gov/prod/ec02/ec0231sg1t.pdf.

CPB: CENSUS, *County Business Patterns.* URL: http://www.census.gov/epcd/cbp/download/cbpdownload.html.

DETAILED: BEA, Detailed Fixed Assets Tables, Nonresidential Investment, Historical-Cost. URL: http://www.bea.gov/bea/dn/FA2004/Details/xls/detailnonres_inv1.xls

EOP: End-Of-Period t.

ERP: Council of Economic Advisers, *Economic Report of the President* (Washington: U.S. Government Printing Office, 2006).

FIXED: BEA, *Standard Fixed Asset Tables.* URL: http://www.bea.gov/bea/dn/FA2004/SelectTable.asp.

FOF: Board of Governors of the Federal Reserve System, *Flow of Funds Accounts of the United States* (Washington: Board of Governors of the Federal Reserve System, various issues). URL: http://www.federalreserve.gov/releases/Z1/Current/annuals/a1995-2005.pdf.

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KING-FULLERTON: King, Mervyn A., and Fullerton, Don (eds.), *The Taxation of Income from Capital* (Chicago: University of Chicago Press (for the NBER), 1984).

NIPA: BEA, *National Income and Product Accounts Tables*. URL: http://www.bea.gov/bea/dn/nipaweb/SelectTable.asp?Selected=N.

PPI: BLS, *BLS Handbook of Methods*, Chapter 14 Producer Prices. URL: http://www.bls.gov/opub/hom/pdf/homch14.pdf.

REA: BEA, *Regional Economic Accounts: Gross State Product*. URL: http://www.bea.gov/bea/regional/gsp/default.cfm?series=SIC.

SFFF: American Council on Intergovernmental Affairs, *Significant Features of Fiscal Federalism* (Washington, DC: American Council on Intergovernmental Affairs, Various Issues). URL (e.g., 1987): http://www.library.unt.edu/gpo/ACIR/SFFF/SFFF-1988-Vol-1.pdf.

STH: Commerce Clearing House, *State Tax Handbook* (Chicago: Commerce Clearing House, Various Issues).

TAXFDN: Tax Foundation web site. URL: http://www.taxfoundation.org.

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