Do Taxes Distort Corporations' Investment Choices? Evidence from Industry-Level Data*

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Abstract

The U.S. corporate income tax system provides investment incentives that vary across asset types. Do corporations' investment choices respond to these differences and if so, by how much? I analyze the effect of corporate income taxes on the allocation of new capital investment in the U.S. economy by constructing an industry-level panel data from 1962 to 1997. My preferred-IV estimates of the asset substitution elasticities suggest a sizable interasset distortion effect of corporate income taxes. Substitutability is the strongest between machinery equipment and computing and electronic equipment. Compared to a revenue-neutral uniform tax scheme, differential corporate income taxes cause under-investment in computing and electronic equipment and over-investment in machinery and transportation equipment.

Keywords: User cost of capital, Investment choices, Efficiency cost, Corporate income taxation

JEL Classifications: H21, H25, H32, D24

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1 Introduction

Measuring the inter-asset distortion effect of the corporate income tax has received little attention despite the well-documented differences in the taxation of different capital assets. (see, for example, Auerbach (1983, 1996), Gravelle (1994), King and Fullerton (1984), and Mackie (2002).) While policy makers have made effort to impose more uniform corporate tax policies, no empirical study exists to quantify the extent to which corporate income taxes have altered the structure of business investment. This is rather unfortunate because, as pointed out in Feldstein (1982), capital consists of many types of equipment and structures. At any point in time there may be over-investment in one type and under-investment in another due to differential tax incentives. Asset substitution and the effect of tax incentives on the composition of new investment can be substantial and important for evaluating the efficiency and distributional effects of alternative tax policies.

This paper examines the effect of corporate income taxes on the allocation of new capital investment in the U.S. economy. The corporate tax code offers a wide range of tax instruments to encourage business investment. While a reduction in the statutory corporate tax rate applies uniformly to all investment types, the investment tax credit (ITC) and accelerated depreciation allowances are targeted tax incentives. The ITC, while no longer part of the U.S. tax code, allows a portion of the investment cost in new equipment and public utility property to be deducted from corporate tax liability. Accelerated depreciation provides a more generous deduction in present value compared to economic depreciation, generating different effective tax rates for assets with different economic life durations.[3] The overall effect of these tax incentives is therefore asset specific, depending on the characteristics of the physical asset and, to a lesser extent, the industry in which the asset is placed.

I begin my analysis by constructing a panel data of investment share, the user cost of capi-

[3]A particular method of accelerated depreciation, bonus depreciation, has been a common feature of recent tax bills to stimulate investment in equipment.

tal, and other control variables for 35 types of sub asset and four asset categories at the industry level from 1962 to 1997 in the United States. I calculate the Hall and Jorgenson (1967) user cost of capital (CoC), which summarizes the overall effect of the tax treatment and macroeconomic incentives on investment. The asset-level data allows me to analyze the elasticity of substitution among capital inputs within the Seemingly Unrelated Regression (SUR) framework. To obtain the causal effect of the user cost of capital despite its endogeneity due to tax-favored financing methods and capital structure, I instrument the cost of capital with industry-level financial variables that affect the overall debt level but are uncorrelated with the corporate income taxes. Based on the preferred-IV estimates, I gauge the impact of differential taxes on investment choices by calculating the own-CoC and cross-CoC elasticities of investment demand for each asset category. The cross-CoC elasticities capture responses of investment to tax incentives of other asset types. Therefore, a non-zero cross-CoC elasticity indicates the inter-asset distortionary effect of corporate taxes. Various robustness checks are performed to verify estimation efficiency gains from production constraints and to rule out the possibility of estimation bias from potential tax capitalization.

The empirical estimation results indicate that taxes distort corporations' investment choices. Investment in a particular asset responds to its own tax incentives and in addition, to the tax incentives of other asset types. The own-CoC elasticities of investment demand range from -0.57 for transportation equipment to -2.56 for machinery equipment. Investment in structures is less responsive to its own tax incentives due to a higher adjustment cost. Nevertheless the estimated own-CoC elasticity of -1.29 is still statistically significant. The cross-CoC elasticities demonstrate that corporate taxes distort the allocation of investment across asset classes. Substitutability is the strongest between machinery and computing and electronic equipment. To examine the efficiency costs that result from the tax-induced changes in investment choices, I perform a revenue-neutral experiment and simulate the investment path for each asset under an uniform corporate income tax. I find that differential corporate income taxes lead to under-investment in computing

and electronic equipment and over-investment in machinery and transportation equipment. Differential corporate taxes also distort investment in structures, for which there is under-investment before the passage of Tax Reform Act of 1986 and a slight over-investment afterwards.

Estimates of the asset substitution elasticities suggest a sizable inter-asset distortion effect of corporate income taxes. With a large asset substitution elasticity, changes in the relative tax treatment of different assets result in a significant change in the mix of investment, implying a relatively large efficiency cost. Ignoring this corporate tax distortion would overstate the efficiency gain from using tax instruments applicable to a particular type of investment. To approximate the lower bound of the inter-asset distortion of corporate taxes, I suggest an unitary substitution elasticity as a rule of thumb for major asset categories.[4] Given the magnitude of my substitution elasticity estimates, the marginal excess burden of the investment tax credit is at least 37 cents as found in Fullerton and Henderson (1989b), indicating that increase in the ITC is the least favorable corporate tax policy among the statutory corporate income tax rate, the investment tax credit rate, depreciation lifetimes, and declining balance rates for depreciation allowances from an efficiency standpoint. When taking the interasset distortion of corporate income taxes into consideration, the efficiency gain from lowering the dispersion in the user cost of capital by reducing the ITC or the depreciation rate is considerably larger than from increasing in the statutory corporate income tax rate.

The rest of this paper proceeds as follows. Section 2 reviews the related literature on investment and the corporate income tax. Section 3 gives an overview of incentives for business investment in the U.S. corporate tax system. Section 4 describes the data and Section 5 presents the regression methodology. Section 6 discusses the main results and Section 7 discusses various econometric issues. The last section concludes and points out some caveats of this paper. The Appendix provides a detailed description and construction of the variables.

[4]This is consistent with the Cobb-Douglas production function used in Auerbach (1981) and Gravelle (1981).

2 Literature Review

Although no previous work provides direct estimates of the effect of corporate taxes on the mix of investment among capital assets, a number of studies address differences in the marginal cost of investment due to corporate taxation. Differences in the marginal cost of investment at the asset level provide indirect evidence of the interasset distortion of corporate taxes. A few studies, including Auerbach (1983), King and Fullerton (1984), Gravelle (1994), Auerbach and Hassett (1991) and Mackie (2002), calculate the user cost of capital and the corresponding marginal effective tax rates for equipment and structures under various taxation schemes. All suggest that differential capital taxes generate variation in the user cost of capital by asset. In addition, changes in the relevant tax provisions alter the distribution (mean and standard deviation) of the cost of capital. Using a fixed after-tax corporate return and inflation rate, estimates in Auerbach and Jorgenson (1980) and Jorgenson and Sullivan (1981) suggest that accelerated depreciation and the investment tax credit drive differences in the effective corporate tax rates across investment types under the Economic Recovery Tax Act of 1981, which was especially favorable to equipment. Egger et al. (2009) recognize that as investment structure and financing opportunities differ across industries, an identical change in the statutory corporate tax rates or depreciation allowances will induce different changes in the user cost of capital at the industry and firm level. By computing the marginal effective tax rates for a large sample of firms, they demonstrate that industry- and firm-specific effects are important determinants of the variation in effective marginal tax rates.

Researchers have also used general equilibrium models to study the welfare costs of non-uniform capital income taxes with assumed values of asset substitution elasticities. For example, Auerbach (1983) and Gravelle (1994) find welfare costs of differential capital taxes in the range of 0.10 to 0.15 percent of GNP assuming Cobb-Douglass production technologies. Using a disaggregated general equilibrium model, Fullerton and Henderson (1989a) suggest that the pre-TRA86 tax scheme generates larger inter-asset distortions than inter-sectoral or inter-industry distortions,

provided that the asset substituion elasticity is above 0.4. Implicitly assuming a zero asset substitution elasticity, Auerbach (1989) finds that the welfare gains from a move toward uniform business taxation in TRA86 is the same order of magnitude as the welfare losses resulting from the reform's increase in overall tax rates. Mackie (1986) finds that the measured welfare cost of misallocated assets tends to be smaller when assets are aggregated. Specifically, the welfare cost from misallocation between aggregated equipment and aggregated structures is 60 percent less than the welfare cost associated with 30 disaggregated assets.

The impact of corporate taxation on investment decisions has been an active area of research. This literature is relevant because it studies the distortionary effect of corporate taxes between consumption and savings. In contrast with a small user-cost elasticity found in early studies, results of recent work including Cummins et al. (1994, 1996), Caballero et al. (1995), Goolsbee (2000), Ramirez Verdugo (2005) Schaller (2006) and Dwenger (2010) imply that the elasticity of aggregate investment with respect to the user cost of capital is approximately -1.[5] In particular, Schaller (2006) uses a cointegrating relationship between aggregate investment in equipment and the user cost of capital and finds a long-run user-cost elasticity of -1.6 for investment in equipment in Canada. When applied to the total capital stock, the estimate of the user-cost elasticity is not statistically different from zero, suggesting that aggregation over types of capital might have disguised the role of user cost.

While the importance of capital heterogeneity to firms' investment decisions has largely been ignored in the taxation and investment literature, the productivity literature has presented considerable evidence that firms substitute among heterogenous inputs in response to price differences. Berndt and Wood (1975) use a three-input translog production function and find that equipment and structures are closer substitutes than for labor. Most subsequent studies derive a set of input-share functions based on the translog cost function and directly estimate the share functions as

[5] For an overview of the evolvement in the investment and user cost elasticity literature, see Chirinko (1993) and Hassett and Hubbard (2002).

a system of seemingly unrelated equations (SURs). A small selection of these important studies include Berndt and Wood (1979), Fuss (1977), Pindyck (1979), Jones (1995), Morrison (2000), Urga and Walters (2003), and Serletis et al. (2010). Most focus on energy demand and interfuel substitution. Regarding factor substitutability of heterogeneous capital inputs, Berndt and Christensen (1973) is the only empirical study that explicitly incorporates differential capital taxes in the price of capital services.

3 Investment Incentives in the U.S. Corporate Tax System

3.1 Overview of the Major Tax Incentives

The corporate tax code offers a range of investment subsidies designed to encourage investment in new capital including statutory corporate tax rates, depreciation allowances and investment tax credits.

Depreciation applies to an asset with an estimated life expectancy longer than the taxable year. The U.S. tax code specifies depreciation deductions as a function of the asset's cost basis, the recovery period (or useful tax life), and the depreciation method. The recovery period specifies the number of years over which depreciation deductions can be claimed and differs substantially across investments. The depreciation method specifies the annual amount of deduction and is usually related to the durability of the asset.

Depreciation affects firms' investment decision by allowing a portion of the investment costs to be deducted from corporate revenue. Tax depreciation is neutral to investment decisions if it equals the economic depreciation. The tax code can postpone taxes on the gross stream of return by allowing a shorter useful life compared to the asset's economic life, i.e. creating an accelerated rate of deduction relative to the economic depreciation. Firms therefore retain more after-tax income early in the depreciation cycle. Accelerated depreciation creates an investment subsidy by allowing

for more depreciation towards the beginning of the asset life.

A depreciation deduction has been a part of the U.S. income tax since 1909. Accelerated depreciation was first introduced in the The Internal Revenue Code of 1954 to provide a permanent investment incentive.[6, 7] Depreciation allowances were further liberalized in subsequent decades through shortened tax lives and higher deduction rates. Major revisions in the depreciation method include the Accelerated Depreciation Range system (ADR) in the Revenue Act of 1971, which allowed the actual tax life to be 20% more or less than the prescribed tax life; the Accelerated Cost Recovery System (ACRS) in the Economic Recovery Tax Act of 1981, which established property class lives and shorter recovery periods; the Modified Accelerated Cost Recovery System (MACRS) in the Tax Reform Act of 1986, which expanded the number of property classes and introduced a half-year convention to simplify the first and final years of a property's recovery life. In general, the depreciation scheme in the U.S. subsidizes investment by providing short tax lives and accelerated rate of cost deduction compared to the natural depreciation rate.

The investment tax credit (ITC) is a more explicit and direct subsidy to investment. An ITC is a reduction in the corporate tax liability determined as a percentage of the purchase price of an asset. It offers immediate proportional relief of tax liability within the same year when an asset is purchased. Consequently, unlike depreciation deductions, the effect of the ITC is independent of the current discount rate or inflation rate.

Introduced in 1962. the statutory rate for the ITC was 7 percent for spending on business capital equipment with tax lives longer than three years and for special-purpose structures. Public

[6] The new Code explicityly authorized the use of the double-declining balance (DDB), sum-of-the-years digits (SOY) method of computing depreciation deductions, and any other method that does not result in larger depreciation deduction during the first two-thirds of the life that exceeded amounts allowed under DDB.

[7] The primary motive behind the introduction of the accelerated methods in 1954 was documented in the Senate Finance Committee:

"More liberal depreciation allowances are anticipated to have far-reaching economic effects. The incentives resulting from the changes are well timed to help maintain the present high level of investment in plant and equipment... The faster tax write-off would increase available working capital and materially aid growing businesses in the financing of their expansion. For all segments of the American economy, liberalized depreciation policies should assist modernization and expansion of industrial capacity, with resulting economic growth, increased production, and a higher standard of living."

utility property (equipment and structures) also received a credit at 3 percent. The ITC was temporarily suspended twice between 1966 and 1969 in order to reduce inflation and wide fluctuation in investment.[8] It was later reinstated to seven percent in 1971. The maximum rate of the ITC was increased to 10 percent in 1975, but was eliminated by the Tax Reform Act of 1986 (TRA86) to provide more neutral taxation on assets and to compensate for the revenue loss from corporate tax rate cuts.

There is an interaction effect between the ITC and depreciation allowances. By increasing the cash flow available for investment, the ITC can reduce the net cost of acquiring depreciable assets. On the other hand, the statutory impact of the ITC increases with the tax life of an asset.[9] For the purpose of my study, frequent changes in depreciation allowances and the ITC provisions provide rich variation in the tax variables over time, and the differential tax treatment at the asset level generates variation among asset classes.

3.2 Evolution of the User Cost of Capital

Traditionally, the effects of tax policy on investment demand are summarized by the user cost of capital. A firm sets its investment level so that the marginal benefit of an additional dollar's investment equals the marginal cost–the user cost of capital. Conceptually, the user cost of investment is the minimum return a firm needs on the next dollar's investment to cover depreciation, taxes, and the opportunity cost of investment. The price of renting a unit of capital for one period is the product of the cost of capital and the relative price of capital good:

$$C = CoC \times \frac{P^i}{P^k},$$

[8]"Eliminating the credit would help reduce inflation and help keep the rate of change in investment on a more steady path" [U.S. Congress, House, Committee on Ways and Means, 1969, p. 178].

[9]For example, under the 1962 legislation, eligible property with a tax life of 4 to 6 years received one-third of the ITC, and eligible property with a tax life of 6 to 8 years received two-thirds of the ITC. The full credit was given for eligible property with a tax life of 8 or more years.

where P^i is the price deflator for the investment good and P^k is industry output price. I compute the cost of capital (CoC) as

$$CoC = \frac{(r - \pi + \delta)(1 - ITC - \tau z)}{(1 - \tau)}, \quad (1)$$

where r is the nominal discount rate, π is the inflation rate, δ is the rate of economic depreciation, ITC is the investment tax credit rate, τ is the statutory corporate tax rate, and z is the present value of depreciation allowance on a dollar of new capital.

In Equation (1), $r - \pi$ reflects the real cost of funds, a weighted average of the costs of debt and equity. Consequently, the particular value of z reflects the discount rate, the lifetime for the asset, and the depreciation schedule D. The term $(1 - ITC - \tau z)/(1 - \tau)$ summarizes the intended impact of corporate taxes on investment. A taxation system for which $(1 - ITC - \tau z)/(1 - \tau)$ equals one generates the same rate of return for investment in alternative assets and is therefore asset neutral.

When the taxation system deviates from asset neutrality, it generates distortion in the choices of prospective investment. As pointed out in Auerbach (1983), the distortion can arise from various components of the user cost: (i) a discrepancy between the patterns of economic depreciation and those of depreciation allowances, which generates a specific cost of capital for each asset type; (ii) a lack of indexing nominal depreciation allowances for inflation, resulting in decline in the real value of depreciation allowances with inflation and an increase in the cost of capital; and (iii) the lack of investment tax credit on buildings. In particular, inflation discriminates against short-lived assets and consequently, the effect of inflation on the cost of capital depends on the value of economic depreciation rate for each asset. Therefore, the net effect of the tax incentives on the marginal investment in a particular asset depends on the interactions between the intended effect of tax policy, the industry capital structure (reflected by r), macroeconomic environment (reflected by π) and the asset characteristic (reflected by δ).

A related concept often used in the tax literature is the real social rate of return. This return, ρ, at which the gross future revenue from the potential investment has a zero net present value, can be expressed as the cost of capital net of depreciation:

$$\begin{aligned} \rho^c &= \frac{(r-\pi+\delta)(1-ITC-\tau z)}{(1-\tau)} - \delta \\ &= CoC - \delta. \end{aligned}$$

Consequently the marginal effective corporate tax rate is the difference between the before-tax return ρ^c and net-of-tax return $(r-\pi)$, divided by the before-tax return. Following the empirical investment literature, I use the traditional gross-of-depreciation user cost of capital to measure investment incentives.

Figure 1 summarizes the time-series movement of top statutory corporate tax rate, inflation rate, and the maximum investment tax credit rate from 1962 to 1997. The top statutory rate decreases over time.[10] The top statutory rate and the ITC rate have moved in the same or opposite directions depending on the objectives of the fiscal policy. Table 1 summarizes the unweighted mean and standard deviation of the user cost of capital, the net-of-depreciation cost of capital, the marginal effective tax rate, and the present value of tax depreciation per dollar by equipment and structures. The overall net-of-depreciation cost of capital and the marginal effective tax rate are lower for equipment, as well as the present value of tax depreciation per dollar. The negative effective tax rates for equipment during the 1970s and early 1980s are mainly due to the high ITC rate and accelerated depreciation. The TRA86 clearly narrows the gap between the effective tax rates on equipment and those on structures. The overall spread of effective tax rates has also decreased since the TRA86 came into effect. Nevertheless, there is still considerable variation in the user cost of capital and effective tax rates across asset types.

[10] The Korean War period is the only time when the statutory rate increased.

4 Data

4.1 Major Data Source

I construct a balanced panel of investment shares, user costs of capital and real prices at the asset and industry level with data from the Bureau of Economic Analysis (BEA), the Bureau of Labor Statistics (BLS), and various other sources. The BEA capital flow tables show new capital investment in equipment, software, and structures by industries that purchase or lease these capital goods and services in the U.S. economy. The Survey of Current Business publishes the capital flow table approximately every five years, and are available for 1963, 1967, 1972, 1977, 1982, 1992 and 1997. I match every commodity in the capital flow table to one of the standard 35 subasset categories defined in Hulten and Wykoff (1981). The BLS commodity database publishes the Producer Price Index (PPI) for each of these 35 sub assets over the sample period. Another major data source is the annual Compustat Industrial, Full coverage and Research files, which provide corporate financial data for the calculation of industry-level real interest rate.

4.2 Construction of Variables

I compute the investment share S_{ikt} as the share of investment in asset i relative to the annual gross investment in new equipment and structures in industry k, year t. Investment is measured in purchasers' price. Following Equation 1, I calculate the following inputs to estimate the user cost of capital CoC_{ikt}:

The nominal discount rate

The nominal corporate discount rate for industry k in year t (r_{kt}) is a weighted average of after-tax rates of return to debt and equity:

$$r_{kt} = \theta_{kt} \times i_t(1 - \tau_t) + (1 - \theta_{kt})e_t,$$

where θ_{kt} is the share financed by debt in industry k at year t (and $1 - \theta_{kt}$ is the share financed by equity), i_t is annual rate of return to debt measured by the nominal corporate AAA bond rates,[11] and e_t is the annual rate of return to equity imputed assuming a 4 percent premium following the standard approach.[12] I use every public traded company in operation during the sample period and compute industry averages by deleting observations without a complete record on the variables included in the analysis.

The tax term of the cost of capital

The tax term of the cost of capital for sub asset i in industry k at year t is $(1 - ITC_{it} - \tau_t z_{ikt})/(1 - \tau_t)$. Data on top statutory tax rate τ_t, investment tax credit rate ITC_{it}, tax life Y_{it} and depreciation method $D_{it}(s_{it})$ are collected from the Internal Revenue Services (IRS) corporate income tax laws. Let D_{it} denote the basic depreciation formula specifying the proportion of the purchase cost of an asset of age s_{it} to be deducted from income. The present value of the depreciation deduction per dollar on sub asset i in industry k at time t is:

$$z_{ikt} = \int_0^{Y_{it}} e^{-r_{kt} s_{it}} D_{it}(s_{it}) ds,$$

where Y_{it} is the tax life of asset i in year t and r_{kt} the nominal discount rate in industry k at year t. A detailed calculation of depreciation allowances is included in the Appendix.

The industry-level cost of capital

Finally, I collect the standard estimates of economic depreciation rates by asset type (δ_i) from Hulten and Wykoff (1981) to compute the industry-level user cost of capital.[13] The economic rates of depreciation are asset specific but time invariant. For each of the 35 sub assets in industry k at

[11] Sources: Board of Governors of the Federal Reserve System (http://www.federalreserve.gov/)

[12] For a recent application, see Gruber and Rauh (2007) on the effect of corporate tax rates on corporate taxable income.

[13] Hulten and Wykoff (1981) estimate economic depreciation rates for individual asset classes in the U.S. They compare their used market price approach to the BEA capital stock approach and find that both approaches produce very similar estimates of economic depreciation.

time t, I compute the user cost of capital as:

$$CoC_{ikt} = \frac{(r_{kt} - \pi_t + \delta_i)(1 - ITC_{it} - \tau_t z_{ikt})}{(1 - \tau_t)}$$

At each time period, the user cost of capital varies by asset type and industry due to the interaction between the industry-level interest rate and the asset-level tax incentives. The nominal interest rate r_{kt} depends on the capital structure of each industry. The present value of the depreciation allowances z_{ikt} also depends on the industry-specific nominal rate of discount r_{kt}, which further induces variation of the user cost at the asset–industry level.

For the price,variable, I use the PPI which measures the average change over time in the selling prices received by domestic producers for their output. The real price for sub asset i in year t (P_{it}) is the selling price of asset i received by domestic producers. The price index is normalized to 100 in 1982 relative to the price index of the final industry output (P_{kt}) and reflects the relative movement of the price series.

4.3 The Weighted Industry-Level Cost of Capital and Prices

I observe zero investment in some sub assets because almost no industry employs all of the 35 commodities in production. For example, three out of eight types of machinery equipment are designed for a particular industry (special purpose machinery): agriculture, construction, and mining machinery, industrial machinery, and commercial and service machinery. The other five types are common to all industries (general purpose machinery): metalworking, engine, turbine, and power transmission, office, computing, and accounting, electronic machinery, and other general purpose machinery. To overcome the missing value problem, I aggregate the 35 sub assets to four asset categories by nature of use: machinery equipment, computing and electronic equipment, transportation equipment, and nonresidential structures. This grouping strategy also accommodates variation in the assets' ITC and depreciation allowance.

The dependent variable in the regression analysis therefore becomes the share of investment in four asset categories. I construct the industry-level independent variables as the weighted average of sub asset-level variables, where the weight for each sub asset is the investment in the sub asset relative to total investment in its asset category. Weights for each asset category add to one. The weight for each sub asset therefore reflects its within-group importance but remains invariant to changes in investment across the four asset categories.

4.4 Summary Statistics

Table 2 presents summary statistics for all variables used in the regression analysis. The table shows the mean, standard deviation, quartiles and number of observations for investment share, cost of capital, and real price by asset category. Machinery equipment has the largest share of investment, followed by nonresidential structures. Slow economic depreciation explains the low level of the user cost of capital for structures compared to other asset categories.

5 Methodology and Regression Framework

I estimate the effect of the corporate income tax on capital allocation using a translog specification, modeling the cost minimization as a two-stage process. Pioneered by Berndt and Wood (1975), Fuss (1977), and Pindyck (1979), the translog specification is the most common functional form in the productivity literature. In the first stage, the representative firm chooses the optimal levels of capital and labor to minimize the production cost. Given the total investment level is fixed, it chooses the optimal mix of capital assets to minimize the capital cost in the second stage. I focus on the second-stage minimization process because I am mainly interested in the interasset

allocation of capital. The second-stage cost function is:

$$\begin{aligned}\ln C &= \alpha_0 + \alpha_Q \ln Q + \sum_i \alpha_i \ln P_i + \frac{1}{2}\gamma_{QQ}(\ln Q)^2 + \sum_i \gamma_{Qi} \ln Q \ln P_i \\ &+ \frac{1}{2}\sum_i \sum_j \beta_{ij} \ln P_i \ln P_j + \beta_T Time + \frac{1}{2}\beta_T Time^2 \\ &+ \beta_{TQ} Time \ln Q + \sum_{i=1}^{n} \beta_{Ti} Time \ln P_i + \beta_I Industry + \frac{1}{2}\beta_I Industry^2 \\ &+ \beta_{IQ} Industry \ln Q + \sum_{i=1}^{n} \beta_{Ii} Industry \ln P_i + \varepsilon,\end{aligned} \tag{2}$$

where P_i is the after-tax price of input i, Q is the industry-level output, and $Time$ and $Industry$ are sets of time and industry dummies. The β_{ij}s are parameters to be estimated and ε is the stochastic error term. By Shepherd's Lemma, the set of cost-minimizing share equations are derived from differentiating the cost function (2) with respect to the log of the price of input i:

$$\begin{aligned}S_i &= \frac{\partial \ln C}{\partial \ln P_i} = (X_i P_i)/C \\ &= \alpha_i + \gamma_{Qi} \ln Q + \sum_j \beta_{ij} \ln P_j + \beta_{Ti} Time + \beta_{Ii} Industry, \; i = 1, ..., 4.\end{aligned}$$

where S_i is the cost share of input i. By definition, all the cost shares sum to one, and the cost function is homogeneous of degree one in price. The following properties hold for well-behaved investment share equations:

$$\begin{aligned}\sum_i \alpha_i &= 1, \\ \sum_i \gamma_{Qi} &= 0,\end{aligned} \tag{3}$$

and

$$\sum_j \beta_{ij} = \sum_i \beta_{ij} = 0. \tag{4}$$

The twice differentiability of the production frontier indicates that the cross-price derivatives of two capital inputs are identical when the aggregate investment is kept constant, i.e. $\beta_{ij} = \beta_{ji}$ for all input i and j. In addition, the homotheticity of the cost function restricts $\gamma_{Qi} = 0$ for all i.

The set of linear restrictions (3)-(4) implies a singular variance matrix in the SUR system, requiring one investment category to be dropped for analysis. Therefore I drop the share equation of transportation equipment and divide the price of every other asset by the price of transportation equipment. The choice of transportation equipment is rather arbitrary and the final estimation results are invariant to which share equation is dropped. The resulting investment share equations consist a non-singular system to be estimated using SUR. This allows for correlated disturbance to all investment types. The disturbance term ε captures unobserved factors that are common to all capital assets in an industry, such as the perceived general health of the economy, as well as idiosyncratic factors associated with the particular asset or industry.

6 Main Specification and Results

6.1 SUR Specifications: COC and Price Covariates

A profit-maximizing firm responds to the effective service price of capital input, which is the product of the before-tax market price and the user cost of capital. To capture the potentially different incentive effects of these two prices, I include the individual asset price and the user cost of capital in separate logarithms. This specification disentangles variation in the user cost from variation in the price, allowing a direct examination of the tax effect on investment. The basic SUR specification for the investment share of asset i in industry k (s_{ik}) at time t is

$$S_{ikt} = \alpha_i + \sum_j \beta_{ij} \ln(\frac{CoC_{ikt}}{CoC_{trans,kt}}) + \sum_j \gamma_{ij} \ln(\frac{P_{ikt}}{P_{trans,kt}}) + \eta_k + \gamma_t + \varepsilon_{ikt}, \quad (5)$$

with the symmetry restrictions

$$\beta_{ij} = \beta_{ji} \text{ and } \gamma_{ij} = \gamma_{ji} \text{ for all } i \neq j.$$

Table 3 summarizes the estimation results from pooled regressions (Column 1 and 4), time fixed-effect regressions (Column 2 and 5) and two-way fixed-effect regressions (Column 3 and 6). Compared to Column1-3, specifications in Column 4-6 include real asset prices as additional controls. The Breusch-Pagan Lagrange multiplier test for error independence in the full specification (Column 6) is 55.87 (with a $p-$value$= 0.00$) and has a $\chi^2(3)$ distribution. The null hypothesis of no contemporaneous correlation among cross-equation residuals is strongly rejected, suggesting that different investment categories are likely to subject to similar underlying determinants. The SUR method as in equation 5 is thus more efficient. (See Greene (2005) and Zellner (1962))

The parameter estimates themselves have little economic meaning. Nevertheless, I can draw two implications from the different estimation results in Table 3. First, it is important to control for unobserved industry heterogeneity. Choices of capital inputs are likely to be determined by unobserved industry-specific factors. For example, high-tech industries may use a disproportionately large share of computers and electronic equipment. Durable-good industries may rely more heavily on traditional machinery equipment. If the unobserved industry heterogeneity is correlated with the user cost of capital, estimates of the substitution elasticities would be biased and inconsistent. Comparing the results in Column 4 and 6 (or Column 1 and 3) in Table 3, inclusion of industry fixed effects corrects the signs of the CoC coefficient estimates.

Second, the magnitude of the CoC coefficients are slightly increased once price variables are included in the regression, although the changes are not statistically significant. Compared to Column 1-3, the specifications in Column 4-6 include price variables as additional controls. Consequently, the CoC estimates in Column 6 are slightly larger, indicating a negative correlation between the user cost of capital and the market price. This negative correlation suggests a test for

tax capitalization as a robustness check. The additional price variables also improve the estimation precision of the regression results.

6.2 Instrumental Variables Specifications

The instrumental variable (IV) approach makes the estimation robust to endogeneity in the user cost of capital. A main component of the user cost, the real interest rate, may be endogenous for two reasons. First, there exists potential reverse causality between the interest rate and investment level. An investment shock may increase the investment demand, putting upward pressure on the real interest rate. This problem is less of a concern, however, when investment is measured as a relative share instead of level. Second, the interest rate depends on the debt and equity shares, but the capital structure itself is influenced by the corporate tax. Interest payment is deductible from the corporate taxable income, but the cost of equity capital is not. Consequently, debt-financed investment faces a lower effective tax rate, which encourages the use of debt finance. [14] Given that differential tax treatment influences leverage decisions, the real interest rate is also likely to be endogenous.

I instrument the user cost of capital using financial variables that affect the overall leverage level but are uncorrelated with the preferential tax treatment of debt. Following the corporate finance literature, I use industry size, expected future return, earning volatility and industry growth rate as instruments. Definitions and descriptions of the instruments are included in the Appendix.

Table 4 presents the second-stage results of the IV specifications using two different sets of instruments. Both specifications include industry-time fixed effects. Instruments in Column 1 include the set of financial variables and the exogenous components of the user cost including the contemporaneous investment tax credit and economic depreciation rate. Instruments in Column 2 include the first lag of the user cost, which reduces the number of observation to 136. Most Column

[14] See, for example, Modigliani and Miller (1963), DeAngelo and Masulis (1980), and the survey by Graham (2003).

2 coefficients are estimated without precision, indicating a potential weak instrument problem. The weak instrument problem is confirmed by the F-statistics for excluded instruments, none of which pass the threshold of 10 suggested by Staiger and Stock (1997) for the case of three endogenous regressors. This is not surprising because there is a five-year lag between the user cost of capital and its first lag and the correlation between them can be weak. Therefore, my preferred IV estimates are those in Column 1.

Most of the IV estimates in Column 1 are significant and have the expected sign. Compared to the basic regression results, IV estimates of the substitution elasticity are larger for the machinery equation. Before calculating demand elasticities, I perform a heteroskedasticity-robust regression-based overidentification test to check the exogeneity of the instruments (Wooldridge, 2008). The J statistic for each of the three investment share equations is distributed as $\chi^2(3)$, with value about 4.92 (with p-value$= 0.18$), 4.90 (with p-value$= 0.18$), and 2.23 (with p-value$= 0.53$), respectively. The overidentifying restrictions are not rejected at any reasonable significance level. Overall, the results from the basic estimation are robust to IV strategies.

6.3 Elasticities of Demand and Substitution

In this section I use the parameter estimates from the preferred IV specification in Table 4 to assess investment elasticities. I provide estimates for input demand elasticities to characterize investment response to tax incentives. The derived demand elasticity measures the relative change in demand for two capital inputs due to a relative change in their user cost of capital. For the translog cost function, elasticities of factor demand are calculated as:

$$\xi_{ij} = (\widehat{\beta}_{ij} + S_i S_j)/S_i, \text{ for all } i \neq j \tag{6}$$

$$\xi_{ii} = (\widehat{\beta}_{ii} + S_i^2 - S_i)/S_i, \text{ for all } i, \tag{7}$$

where S_i is the investment share in asset i and the $\widehat{\beta}$s are the price parameters from the estimated translog cost function (Berndt and Wood, 1979). These elasticities are derived under the assumption that the total capital investment is held constant. I compute variance of the price elasticities using the Delta method (Pindyck, 1979; **?**):

$$V(\xi_{ij}) = -(1/S_i)^2 \times V(\widehat{\beta}_{ij}), \text{ for all } i, j.$$

Evaluated at the mean cost shares, the estimated elasticities of demand are summarized in Table 6.

All the own-CoC elasticities are negative and significant at 1% significance level except for transportation equipment. Excluding transportation equipment, investment responses to tax incentives are ranked in the following declining order: machinery equipment (-2.56), computing and electronic equipment (-2.55), and nonresidential structures (-1.29). The own-CoC elasticities for investment in equipment categories are larger compared to the user-cost elasticity of -2.0 reported by Ramirez Verdugo (2005) and the long-run user-cost elasticity of -1.6 by Schaller (2006). This is not surprising because the SUR estimation method allows us to disentangle the direct incentive effect of corporate income taxes from the interasset distortion effect. These two forces tend to work in opposite directions for capital classes that are substitutes, yielding a smaller user-cost elasticity of aggregate investment on net.

Relative to investment in equipment, investment in structures is much less responsive to own tax incentives as would be expected with a higher adjustment cost. Previous studies often obtain small and insignificant estimates of the user-cost elasticity of investment in structures. One possible explanation could be that the elasticity estimate confounds the direct effect of tax incentive with the interasset substitution effect between investment in equipment and structures.

I find evidence that corporate taxes distort the allocation of investment across capital classes. Out of twelve cross-CoC elasticities, six are positive and significantly different from zero. Machinery is a substitute for investment in every other category. Substitutability is the strongest

between machinery and computing and electronic equipment. A 1 percent change in the user cost of computing and electronic equipment leads to a 1.09 percent change in investment in machinery. Conversely, a 1 percent change in the user cost of machinery increases investment in computing and electronic equipment by 2.57 percent. Investment in computing and electronic equipment is more sensitive to changes in the CoC of machinery equipment because the cross-CoC elasticity is inversely related to the investment share. A small investment share implies an inclination to switch out of this particular asset category and into the large-share categories.

Findings in the productivity literature echo the substitution pattern between the two asset groups. Dewan and Min (1997) find that information technology capital is a net substitute for the ordinary capital including equipment and structures in all sectors of the U.S. economy. Morrison (2000) finds that machinery capital and office and information technology equipment are substitutes in durable-good industries, although the substitutability is less clear for the nondurable-good industries. Nevertheless, the magnitudes of the above-cited elasticities are not directly comparable with my estimates because the price variables do not capture the effects of corporate income taxes. Consequently, substition elasticities in the productivity literature are silent on the inter-asset distortion of capital due to differential corporate taxes.

There is also substantial substitutability between machinery and structures, consistent with the early study of Berndt and Christensen (1973). The estimated elasticity of investment in machinery with respect to the CoC of structure is 0.83, with a 95% confidence interval between 0.34 and 1.32. The estimated elasticity of investment in structure with respect to the CoC of machinery is 1.25, with a 95% confidence interval between 0.52 and 1.98. I also observe some substitutability between machinery and transportation equipment. All the pairwise cross-CoC elasticities are smaller than the own-CoC elasticities, suggesting that the first-order tax incentive effect outweighs the corresponding interasset distortion effect.

To quantify the size of interasset distortions resulting from differential tax treatment, I impute the hypothetical distribution of investment under a neutral taxation scheme. Operationally, for each

year I assign all assets the user cost of capital computed with the average effective marginal tax rate in the manufacturing sector. I then use the SUR elasticity estimates to predict the investment shares corresponding to the equalized user cost. By assumption, the total investment level is held fixed. Therefore, the total corporate tax revenue is held constant and this is a revenue-neutral experiment. I plot the hypothetical investment shares against the actual investment shares in Figure 2.

Compared to a neutral tax scheme, on average differential corporate taxes induce overinvestment in machinery and transportation equipment and underinvestment in computing and electronic equipment. The largest discrepancy occurs for computing and electronic equipment. There is under investment in structures before the TRA86 due to favorable tax treatment of machinery equipment. Once the TRA86 decreases the tax price of structure relative to equipment, it stimulates investment in structures and I observe some over-investment in structures compared to the investment pattern under neutral taxation. A closer look at the difference by year suggests that the size of distortion for machinery equipment has noticeably decreased under the current tax system, while for other asset categories the size of distortion has slightly increased in recent years.

The magnitudes of the substitution elasticity estimates lends support to several studies of the welfare implication of differential corporate taxes (in particular, Fullerton and Henderson (1989a) and Fullerton and Henderson (1989b)). The substitution elasticity is a key parameter for computing the welfare loss generated by differential taxation or for calculating the marginal excess burden of various capital tax instruments. However, since no previous empirical estimates of substitution elasticity among disaggregate assets were available, these studies assumed an arbitrary value or a range of values for this parameter. For example, Fullerton and Henderson (1989a) conclude that the pre-TRA86 tax scheme generates larger interasset distortions compared to intersectoral or interindustry distortions provided that the asset substituion elasticity is above 0.4. My substitution elasticity estimates verify that these studies use a reasonable elasticity value so that the welfare implication of these studies is quantitatively sound.

7 Robustness Checks

7.1 Test of Coefficient Equality

In this section I test whether investment shares respond equally to changes in the pretax return and in the user cost of capital using a likelihood ratio test. I constrain coefficients of the user cost of capital and coefficients of the before-tax price to be equal by estimating the following model:

$$S_{ikt} = \alpha_i + \sum_j \beta_{ij} \ln\left(\frac{CoC_{ikt} \times P_{ikt}}{CoC_{trans,kt} \times P_{trans,kit}}\right) + \eta_k + \gamma_t + \varepsilon_{ikt}, \tag{8}$$

with restrictions $\beta_{ij} = \beta_{ji,}$ for all $i \neq j$.

Under the null hypothesis of equal coefficients of the user cost and before-tax price, equation (8) is nested with the unconstrained model (5). The resulting likelihood ratio is distributed as a χ^2 statistics with 6 degree of freedom. The large value of the likelihood ratio 36.31 suggests a rejection of the null. For estimations with robust standard errors, I use a direct joint test of the equality of the two sets of coefficients. Once again, the large value of the F_6 statistic 15.26 suggests that investment shares respond differently to changes in the pre-tax market price and the user cost of capital. Intuitively, the price variable is measured with considerable noise. The measurement error in the price variable biases the coefficients toward zero, which may explain the discrepancy in the two sets of coefficients.

7.2 Tax Capitalization

Investment incentives may have a high revenue cost if they simultaneous increase investment demand and the prices of investment goods. This would be the case if the short-run supply of capital goods are fixed or highly inelastic. I use the disaggregated data on asset-specific investment good to address this issue. Specifically, I regress the price of investment good i in industry k at time t

(P_{ikt}) on the corresponding user cost of capital (CoC_{ikt}):

$$\ln P_{ikt} = \theta_i + \delta \ln CoC_{ikt} + \eta_k + \gamma_t + \varepsilon_{ikt},$$

with η_k and γ_t the usual industry and time fixed effects. The estimated CoC coefficient is -0.1258 with a p-value of 0.13, suggesting that the effect of the tax incentives on investment good price is statistically insignificant. I estimate the long-run effect of tax policy on capital-good prices. In the long run, capital goods are mobile in the international market. This result is consistent with Hassett and Hubbard (1998)'s finding that local investment tax credits have a negligible effect on prices paid for capital goods and tax incentives have negligible effect on capital-goods prices in the long run.

8 Conclusion

The empirical results in this paper demonstrate the important distortionary effect of corporate income taxes on capital allocation. There is significant variation in the tax treatment of corporate income from different capital assets. Exploiting the exogenous variation in the user cost of capital at the asset and industry level in the U.S. economy from 1962 to 1997, estimates of the asset substitution elasticity reveals a statistically significant and economically sizable inter-asset distortion of corporate income taxes.

This paper contributes to the existing literature that examines the welfare cost of alternative corporate taxation schemes as it quantifies the inter-asset distortion generated from differential corporate taxes. It is important to incorporate this dimension of distortion when evaluating the overall effect of corporate tax policy or proposal. For example, policy makers are considering fiscal instrument such as bonus depreciation of new equipment to stimulate business investment during economic downturns. Accounting for the inter-asset distortionary effects is important for

understanding the efficiency and welfare consequences of such policy proposals. In particular, my findings suggest that ignoring the inter-asset distortion of corporate taxes will lead to a downward biased estimate of the deadweight loss.

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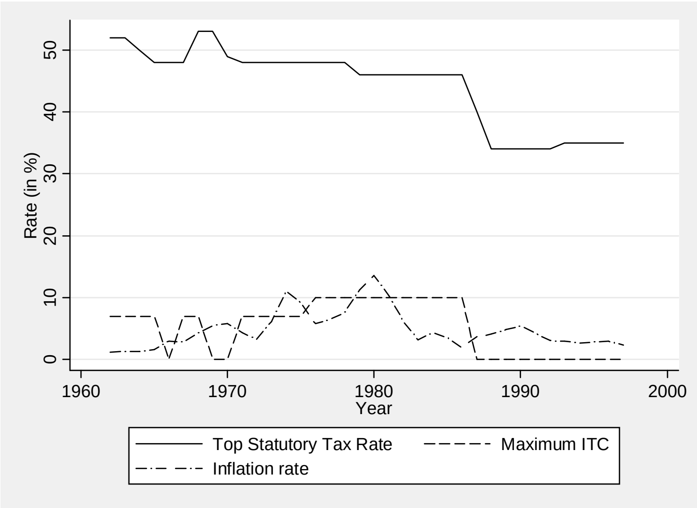
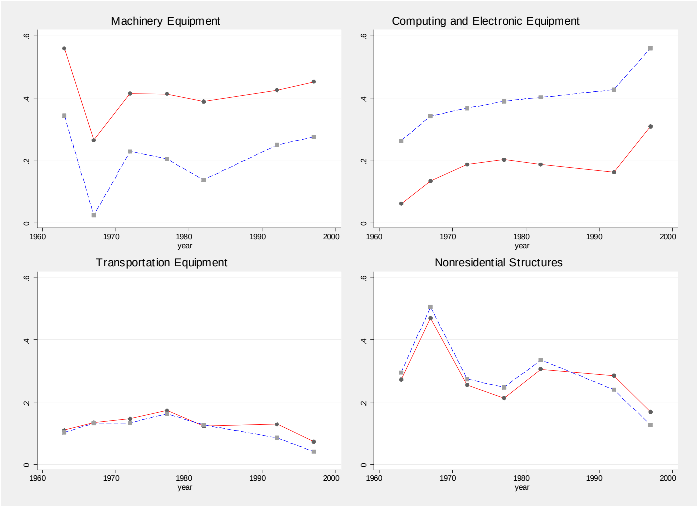
Figure 1: Top Statutory Corporate Tax Rate, Inflation Rate and Maximum ITC: 1962-1997



Note: Data on top statutory corporate tax rate are from the World Tax Database; data on inflation rate are from the Federal Reserve Bank-St. Louis; The ITC rates are summarized from various tax legislations during 1962-1997.

Figure 2: Fitted Investment Shares under Different Tax Regimes



Note: Fitted investment share under differential taxation in solid line. Fitted investment share under neutral taxation in dash line. Difference by year between investment share under these two tax schemes are summarized as follows:

Year	Machinery	Computing and Electronic Equipment	Transportation Equipment	Structures
1963	0.2158	-0.2005	0.0074	-0.0227
1967	0.2396	-0.2073	0.0027	-0.0349
1972	0.1859	-0.1802	0.0136	-0.0193
1977	0.2093	-0.1866	0.0113	-0.0340
1982	0.2497	-0.2155	-0.0046	-0.0296
1992	0.1769	-0.2647	0.0434	0.0444
1997	0.1774	-0.2512	0.0317	0.0412

Table 1: Mean and Standard Deviation of Selected Tax Parameters

Tax Parameters	1962-1967	1972-1977	1982	1992-1997
CoC: Equipment	23.39	21.11	18.39	24.38
	(7.83)	(7.27)	(6.78)	(8.72)
CoC: Structures	13.83	12.44	12.18	10.76
	(4.36)	(4.42)	(4.44)	(4.24)
CoC: Overall	19.43	17.42	15.51	18.36
	(8.12)	(7.55)	(6.59)	(9.80)
ρ: Equipment	8.42	6.23	4.59	9.74
	(4.20)	(3.70)	(3.14)	(3.84)
ρ: Structures	10.87	9.46	9.20	7.78
	(4.10)	(4.25)	(4.21)	(4.05)
ρ: Overall	9.44	7.61	6.73	8.87
	(4.33)	(4.26)	(4.33)	(4.05)
ETR: Equipment	29.32	-0.21	-44.04	27.65
	(13.01)	(25.47)	(35.47)	(10.44)
ETR: Structures	50.76	39.88	40.39	36.28
	(5.22)	(10.92)	(5.81)	(6.71)
ETR: Overall	38.56	16.86	-4.86	22.63
	(14.69)	(28.57)	(49.63)	(10.61)
z: Equipment	0.76	0.80	0.86	0.57
	(0.09)	(0.08)	(0.05)	(0.05)
z: Structures	0.33	0.46	0.43	0.38
	(0.05)	(0.14)	(0.05)	(0.09)
z: Overall	0.58	0.66	0.66	0.49
	(0.23)	(0.20)	(0.22)	(0.12)

Note: Unweighted mean and standard deviation of selected tax parameters for all industries. Standard deviation in parentheses. z is the present value of tax depreciation per dollar. All variables winsorized at the 1 and 99 percent of the empirical distribution.

Table 2: Summary Statistics, 1963-1997

	Mean	Std. Dev	25%	50%	75%	N
Machinery equipment						
Investment share	0.42	0.19	0.29	0.47	0.55	161
CoC (in %)	19.41	5.02	15.52	17.62	23.15	161
Real price index	96.23	10.73	88.84	97.61	103.31	161
Computing and Electronic equipment						
Investment share	0.18	0.13	0.08	0.15	0.24	161
CoC (in %)	28.12	6.65	22.75	26.63	32.08	161
Real price index	108.36	5.11	105.22	109.86	111.94	161
Transportation equipment						
Investment share	0.13	0.14	0.04	0.09	0.15	161
CoC (in %)	37.66	5.83	33.34	37.40	40.67	161
Real price index	82.58	18.26	69.92	82.39	101.23	161
Nonresidential structures						
Investment share	0.28	0.16	0.18	0.24	0.32	161
CoC (in %)	14.33	6.02	10.37	12.15	17.07	161
Real price index	95.49	17.68	85.50	94.99	103.31	161

Note: Summary statistics given for all industries in the manufacturing sector. Investment share are computed as the dollar investment in the specific asset class relative to the total industry new capital investment. CoC is the user cost of capital expressed in percentage. Real prices are expressed relative to 1982 price level, which equals 100 in 1982.

Table 3: Seemingly Unrelated Regressions: COC and Price

		(1)	(2)	(3)	(4)	(5)	(6)
Equation							
Machinery:	CoC_{mach}	-0.7501***	-1.0724***	-0.6167***	-0.7571***	-1.0693***	-0.6457***
		(0.1558)	(0.1746)	(0.2296)	(0.1549)	(0.1717)	(0.2254)
	CoC_{comp}	0.4165***	0.2772***	0.3353***	0.4204***	0.2755***	0.3532***
		(0.0930)	(0.0909)	(0.1157)	(0.0927)	(0.0896)	(0.1128)
	CoC_{struc}	0.0814	0.2792**	0.1014	0.0857	0.2797***	0.1161
		(0.0667)	(0.0915)	(0.1064)	(0.0671)	(0.0901)	(0.1051)
Computing:	CoC_{comp}	-0.2209***	-0.4184***	-0.3399***	-0.2173**	-0.4319***	-0.3613***
		(0.0854)	(0.0842)	(0.1040)	(0.0852)	(0.0837)	(0.1014)
	CoC_{struc}	-0.1466***	-0.0051	0.0462	-0.1542***	-0.0035	0.0505
		(0.0418)	(0.0506)	(0.0670)	(0.0420)	(0.0502)	(0.0659)
Structure:	CoC_{struc}	0.0887**	-0.0370	-0.0623	0.0897**	-0.0405	-0.0875
		(0.0503)	(0.0673)	(0.0996)	(0.0506)	(0.0666)	(0.0992)
Add. price variables:		No	No	No	Yes	Yes	Yes
Year fixed effects?		No	Yes	Yes	No	Yes	Yes
Industry fixed effects?		No	No	Yes	No	No	Yes
N		161	161	161	161	161	161
$R^2_{machinery}$		0.1529	0.3790	0.6591	0.1617	0.3979	0.6715
$R^2_{computing}$		0.0825	0.3712	0.6214	0.0917	0.3886	0.6424
$R^2_{structure}$		0.0512	0.2834	0.5369	0.0632	0.2997	0.5487

Note: Industry investment on new capital consists of investment in four broad asset classes: machinery equipment, computing and electronic equipment, transportation equipment, and nonresidential structures. Investment share equation for transportation equipment is omitted to satisfy the estimation constraints. Standard errors in parentheses. * significant at 0.10 level, ** significant at 0.05 level, *** significant at 0.01 level.

Table 4: SUR-IV Regression

		(1)	(2)
Equation			
Machinery:	CoC_{mach}	-0.8272***	-0.0856
		(0.2249)	(0.2072)
		(0.4028)	(0.3368)
	CoC_{comp}	0.3812***	0.2086*
		(0.1126)	(0.1100)
		(0.1509)	(0.1294)
	CoC_{struc}	0.2313**	-0.0664
		(0.1042)	(0.0906)
		(0.1744)	(0.1683)
Computing:	CoC_{comp}	-0.3054**	-0.3829***
		(0.1010)	(0.1107)
		(0.1555)	(0.1813)
	CoC_{struc}	0.0473	0.1437**
		(0.0654)	(0.0674)
		(0.1105)	(0.1152)
Structure	CoC_{struc}	-0.1591	-0.0640
		(0.0987)	(0.0889)
		(0.1443)	(0.1298)
IV included:		ind.size, exp. return earning volatility, growth rate δ_{it}, π_t,and ITC_{it}	$COC_{ik,t-1}$
Control variables included		$P_{mach}, P_{comp}, P_{struc}$	$P_{mach}, P_{comp}, P_{struc}$
Year/industry fixed effects?		Yes	Yes
N		161	136
$R^2_{machinery}$		0.6606	0.7738
$R^2_{computing}$		0.6314	0.6152
$R^2_{structure}$		0.5434	0.6601

Note: Standard errors in parentheses; Standard errors in the second parenthese in Column (3) are bootstrapped by 250 random draws with replacement. * significant at 0.10 level, ** significant at 0.05 level, *** significant at 0.01 level.

Table 5: Parameter Estimates: IV Specification

	Coefficient	Std. Error	95% C.I.	
$\beta_{mach,mach}$	-0.8272	(0.2249)	-1.2680	-0.3864
$\beta_{comp,comp}$	-0.3054	(0.1010)	-0.5034	-0.1073
$\beta_{trans,trans}$	0.0280	(0.1489)	-0.2639	0.3199
$\beta_{struc,struc}$	-0.1591	(0.0987)	-0.3525	0.0344
$\beta_{mach,comp}$	0.3812	(0.1126)	0.1605	0.6019
$\beta_{mach,trans}$	0.2147	(0.1482)	-0.0757	0.5051
$\beta_{mach,struc}$	0.2313	(0.1042)	0.0271	0.4355
$\beta_{comp,trans}$	-0.1231	(0.0919)	-0.3032	0.0570
$\beta_{comp,struc}$	0.0473	(0.0654)	-0.0808	0.1755
$\beta_{trans,struc}$	-0.1196	(0.0819)	-0.2801	0.0410

Note: Standard errors in parentheses; Parameter estimates related to transportation equipment are imputed using regression results from Table 4 Column 1.

Table 6: Demand Elasticities: IV Specification

	Machinery Equipment	Computing and Electronic Equipment	Transportation Equipment	Nonresidential Structures
		Average Investment Shares		
Actual Shares	0.4146	0.1799	0.1268	0.2786
Fitted Shares	0.4159	0.1766	0.1264	0.2811
		Price Elasticities of Demand		
Factor i	$\xi_{i,mach}$	$\xi_{i,comp}$	$\xi_{i,trans}$	$\xi_{i,struc}$
Machinery Equipment	-2.5632***	1.0897***	0.6410*	0.8325***
	(0.5386)	(0.2696)	(0.3548)	(0.2495)
Computing and Electronic Equipment	2.5715***	-2.5486***	-0.5689	0.5460
	(0.6363)	(0.5710)	(0.5192)	(0.3694)
Transportation Equipment	2.1102*	-0.7937	-0.6524	-0.6641
	(1.1681)	(0.7244)	(1.1741)	(0.5383)
Structures	1.2479***	0.3469	-0.3024	-1.2924***
	(0.3739)	(0.2346)	(0.2941)	(0.3543)

Note: Standard errors in parentheses; * significant at 0.10 level, ** significant at 0.05 level, *** significant at 0.01 level.

A Data Appendix

I use data from the Bureau of Economic Analysis (BEA), the Bureau of Labor Statistics (BLS), and various other sources to construct a panel of investment shares, user cost of capital and prices by asset type and industry.

A.1 User Cost of Capital

The nominal discount rate

The primary independent variable of interest is the user cost of capital. Following equation (1), I first calculate the nominal discount rate of the corporation for industry j in year t (r_{jt}) as a weighted average of after-tax rates of return to debt and equity:

$$r_{jt} = \theta_{jt} \times i_t(1 - \tau_t) + (1 - \theta_{jt})e_t,$$

where θ_{jt} is the share financed by debt (and $1 - \theta_{jt}$ is the share financed by equity), i_t is annual rate of return to debt measured by the nominal corporate AAA bond rates,[15] and e_t is the annual rate of return to equity imputed assuming a 4% premium following the standard approach in the user cost and effective tax rates literature. I collect the financial data on every public traded company that remains operating during the entire sample period from the annual Compustat industrial, full coverage and research files. I construct industry averages by deleting observations without a complete record on the variables included in the analysis. The nominal discount rate r_{jt} reflects the capital structure at the firm and hence industry level. As the weights are the respective annual shares of debt and equity in each industry, the nominal discount rate varies at the industry level at each time period. The real discount rate is $r_{jt} - \pi_t$, where π_t is the annual inflation rate at year t.[16]

Tax Term of the User Cost

The tax term of the user cost of capital for asset i in year t is $(1 - ITC_{it} - \tau_t z_{it})/(1 - \tau_t)$, for which I collect data on top statutory tax rate τ_t, investment tax credit rate ITC_{it}, tax life Y_{it} and depreciation method $D_{it}(s_{it})$ from IRS corporate income tax laws. The tax code specifies three methods of depreciation: straight-line, declining balance depreciation with a switch to straight line, and sum of the years' digits depreciation. Denote $D_{it}(s_{it})$ the basic depreciation formula which

[15] data from the Federal Reserve at St. Louis

[16] Data on annual inflation are provided by the Bureau and Labor Statistics (BLS).

gives the proportion of the original cost of an asset of age s_{it} that may be deducted from income for tax purposes. The present value of the depreciation deduction on one dollar's investment on asset i in industry k at time t is:

$$z_{ikt} = \int_0^{Y_{it}} e^{-r_{kt}s_{it}} D_{it}(s_{it})ds,$$

where Y_{it} is the tax life of asset i specified by IRS in year t and r_{kt} the nominal discount rate in industry k at year t. Note that the present value of the depreciation allowance also depends on the nominal discount rate r_{kt}. Please refer to the Appendix for the detailed calculation of z . In particular, calculation of the tax term in 1963 receives special basis adjustment according to the Revenue Procedure 62-21. The basis in calculating tax depreciation for an asset is reduced by the value of the ITC the asset receives. This base reduction was repealed by Revenue Act of 1964. Consequently, the 1963 tax term of the user cost of capital for asset i is adjusted as $(1 - ITC_{i,1963} - (1 - ITC_{i,1963})\tau_{1963}z_{i,1963})/(1 - \tau_{1963})$. Both the depreciation formula and the tax life vary across asset types and years due to policy changes.

User Cost of Capital at Industry Level

To compute the industry-level user cost of capital, I collect the standard estimates of economic depreciation rates by asset type (δ_i) from **?**. The economics rates of depreciation are asset specific and time invariant. For each of the 35 asset categories in industry k at time t, I compute the user cost of capital as

$$coc_{ikt} = \frac{(r_{kt} - \pi_t + \delta_i)(1 - ITC_{it} - \tau_t z_{ikt})}{(1 - \tau_t)}.$$

At each time period, the user cost of capital varies by asset type and industry due to the interaction between the industry-level interest rate and the asset-level tax incentives. The nominal interest rate r_{kt} depends on the capital structure of each industry. The industry-specific financial cost of capital drives the variation of the user cost across industry. The present value of the depreciation allowances z_{ikt} also depends on the industry-specific nominal rate of discount r_{kt}, which further induces variation of the user cost at the asset–industry level.

A.2 Depreciation Allowances

1. *Straight-Line Depreciation*. This method allows a constant-dollar amount to be claimed annually over the tax life of an asset. Therefore, the annual deduction D as a function of life

length is:

$$D(s) = \frac{1}{Y}, \text{ for } 0 \leq s \leq Y$$

The present value of straight-line depreciation, z_{sl}, is obtained by discounting those depreciation amounts at the nominal discount rate, r, of the firm making the investment.

$$\begin{aligned} z &= \int_0^Y \frac{e^{-rs}}{Y} ds \\ &= \frac{1 - e^{-rY}}{rY}. \end{aligned}$$

2. *Sum of the Years' Digits Depreciation.* The deduction declines linearly over the lifetime for tax purposes:

$$D(s) = \frac{2(Y - s)}{Y^2}, \text{ for } 0 \leq s \leq Y$$

Depreciation in each year is the number of years of remaining life $(Y - s)$ divided by the sum of the years in the life $Y^2/2$. The present value of deduction is:

$$\begin{aligned} z &= \int_0^Y e^{-rs} \frac{2(Y - s)}{Y^2} ds \\ &= \frac{2}{rY} \left[1 - \frac{1}{rY}(1 - e^{-rY})\right]. \end{aligned}$$

3. *Declining-Balance Depreciation with a Switch to Straight-Line Depreciation.* The declining-balance method is actually a constant-percentage rate of depreciation, so the dollar amount of depreciation declines in each successive period. To allow taxpayers to fully recover investments when declining-balance depreciation is used, depreciation schedules switch to the straight-line method before the recovery period ends. The time chosen is the year in which straight-line depreciation on the remaining balance would give the same or a larger depreciation allowance. The deduction is

$$D(s) = \left\{ \begin{array}{c} \frac{b}{Y} e^{-(b/Y)s}, \text{ for } 0 \leq s \leq Y^* \\ \frac{1 - e^{-(b/Y)Y^*}}{Y - Y^*}, \text{for } Y^* \leq s \leq Y^* \\ 0, \text{ otherwise} \end{array} \right\}$$

The present value of depreciation deductions taken by the declining-balance method with a

switch to straight-line depreciation at point Y^* is given by

$$
\begin{aligned}
z &= \frac{b}{Y}\int_0^{Y^*} e^{-(r+b/Y)s}ds + \frac{1-e^{-(b/Y)Y^*}}{Y-Y^*}\int_{Y^*}^{Y} e^{-rs}ds \\
&= \frac{\beta}{\beta+r}\left[1-e^{-(\beta+r)Y^*}\right] + \frac{1-e^{-\beta Y^*}}{(Y-Y^*)r}\left[e^{-rY^*}-e^{-rY}\right]
\end{aligned}
$$

where β the rate of decline in value equals b/Y. For example, for a 200 percent declining balance over five years, $\beta = 2/5$. Y^* the optimal switching time is

$$
Y^* = Y(1-\frac{1}{b}).
$$

When the degree of acceleration is double the straight-line rate, the switching point is halfway through the recovery period, $Y/2$. When the degree of acceleration is 1.5, the switching point is one-third of the way through the recovery period, $Y/3$.

For the year 1962, my first attempt use the estimated average asset tax life as in Gravelle (1982). Measurement of tax lives for certain equipment investments presents some difficulties, particularly under the ADR system where lives for these assets are specified by using industry rather than by asset type. In these cases, Gravelle (1982) used data supplied by the Department of Treasury to estimate the average tax lives by industry. Average lives for each asset type are then weighted by the share of the asset held by each industry based on investment shares in the 1972 capital flow tables. Minimum ADR lives are assumed for all equipment except in some cases where choice of a longer life resulted in a larger investment credit and a greater combined value of depreciation and credits.

B Price

One limitation of the PPI series is that the BLS did not collect price for building until 1986. Using data during 1986-2002, I project backward the PPI for building from a log-linear equation

$$
\ln P_{mt} = \mu + X_{mt}\gamma + \phi_m + year_t + year_t^2 + \epsilon_{mt},
$$

where P_{mt} is the PPI for building at month m year t, X_{mt} includes earnings of construction workers and the PPI for steel at month m year t, ϕ_m is monthly dummy, $year_t$ is a year trend, and ϵ_{mt} is

white noise. The within-sample R^2 is 0.99.

Assuming that ϵ_{mt} is independent of the explanatory variables, the predicted PPI for building is of the form:

$$E(P_{mt}|X_{mt}, \phi_m, year_t) = \alpha_0 \exp(\mu + X_{mt}\gamma + \phi_m + year_t + year_t^2),$$

where α_0 is the expected value of $\exp(\epsilon_{mt})$. Following Wooldridge (2008, p. 211-218), I create $\lambda_{mt} = \exp(\widehat{\ln P_{mt}})$ and regress P_{mt} on λ_{mt} without intercept to obtain an estimated coefficient on α_0. The predicted price is $\widehat{\alpha}_0 \exp(\widehat{\ln P_{mt}})$. The within-sample correlation between the actual price and the predicted price is 0.9969. The out-of-sample predicted price for building is the annual average of monthly PPI in 1963, 1972, 1977 and 1982.

C Instrumental Variables

I use the total assets in the industry to measure size. Direct bankruptcy costs appear to constitute a larger proportion of a firm's value as that value decreases. Relatively large firms tend to be more diversified and less prone to bankruptcy, suggesting that large firms should be more highly leveraged.

I measure the expected future return as a weighted average of earnings from previous and current period. I assume that the realized values as (imperfect) proxies of the values expected when a firm makes the capital structure decision.[17] The earning volatility is measured by the standard deviation of five-year earnings previous to the current period. The corporate finance literature suggests an inverse relationship between uncertainty and the debt level. Finally, I calculate the growth rate as total capital expenditure over total asset value. Equity-controlled firms tend to invest suboptimally to expropriate wealth from the firm's bondholders. The cost associated with this agency relationship is likely to be higher for firms in growing industries, which have more flexibility in their choice of future investments.

[17]Two other measures of expected future return are constructed and the IV results are almost identical.