The Neoclassical Theory of Firm Investment and Taxes: A Reassessment *

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Abstract

Drawing on decades of research in public and macroeconomics, this article offers a neoclassical synthesis of the effect of corporate taxation on firm investment and aggregate outcomes. The microeconometric literature has (often unwittingly) studied two distinct comparative statics of the firm's first order condition for capital. The first holds output fixed and identifies the capital-labor substitution elasticity (Eisner and Nadiri, 1968). The other holds fixed variables external to the firm (Coen, 1969). A consensus range for the Coen short-run relationship implies plausible values for parameters of the firm's revenue function, validating the neoclassical theory. The long-run, general equilibrium elasticity of capital instead involves a third comparative static, holding labor fixed. This elasticity depends on the parameters identified from the firm-level regressions, connecting the microeconometric evidence to macroeconomic questions. Using this framework, I quantitatively assess the effect of corporate taxation on aggregate capital, output, wages, and tax revenue, and compare to existing approaches including policy models.

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1 Introduction

The use of the tax code to promote investment has returned to the forefront of U.S. economic policy. This resurgence started with the accelerated expensing of equipment in the 2001 recession, and continued in 2017 with the first change to the corporate tax rate in 30 years along with full immediate expensing that became *de jure* permanent in 2025. Such large changes have spurred new empirical research into how corporate taxation affects firm investment, along with interest in aggregate outcomes including investment, output, wages, and tax revenue. These questions may become even more important if artificial intelligence continues the shift of income toward capital.

Empirical studies of how tax incentives affect capital formation stretch back to the seminal analysis in Jorgenson (1963) and Hall and Jorgenson (1967). Jorgenson (1963) conducts empirical analysis of aggregate investment based on a first order condition relating a firm's capital choice to the user cost of capital. Hall and Jorgenson (1967) measure the user cost inclusive of a detailed treatment of the corporate tax code and conduct counterfactual exercises for the effect of tax reforms on investment. Their analysis marked a major step forward from the *ad hoc* econometric practice at the time, and has guided the literature ever since. Yet, it also neglected important differences between a firm's constrained and unconstrained choice of capital, and between firm-level and macroeconomic effects of changes in the user cost. These omissions propagated through much of the subsequent 60 years of academic research and remain pervasive in policy analysis.

This article uses the neoclassical theory to bridge these differences and unify the microeconometric literature estimating the effect on firm-level investment with the macroeconomic analysis of tax reforms. Microeconometric studies provide causal evidence that corporate taxes matter, now using large-scale administrative data and quasi-experimental variation. I provide a reanalysis of both the modern and classic evidence and show how, properly interpreted, it also disciplines parameters such as the returns to scale in the firm's revenue function. Addressing aggregate questions requires macroeconomic theory to solve the "missing intercept" in microeconometric firm-level studies. I show how the revenue function parameters, estimable with firm-level variation, transparently inform macroeconomic counterfactual exercises involving aggregate investment, capital, output, wages, and tax revenue. While the particular topic is corporate taxation, this micro-to-macro methodology has broad application in many fields.

Before outlining the approach in detail, a brief summary of the existing state of practice stimulates appreciation for a reassessment. In an influential review, Hassett and Hubbard (2002, p.1321) conclude that the microeconometric evidence finds "elasticities of investment to the user cost of capital between -0.5 and -1.0." The value of -1 has been referred to as the "neoclassical benchmark" (Council of Economic Advisers, 2019, p. 59), as the Jorgenson (1963) first order condition implies an elasticity of capital with respect to the user cost of -1. Council of Economic Advisers (2019, 2025) use this value as the macroeconomic elasticity in their analysis of the 2017 Tax Cut and Jobs Act (TCJA). In contrast, I will contend that in general the appropriate benchmark for a firm's user cost elasticity is not -1, that a summary of the microeconometric evidence produces elasticities about five times larger than the Hassett and Hubbard (2002) range, and that the macroeconomic elasticity differs significantly from the firm-level elasticity.

Section 2 lays out the neoclassical theory of investment for an individual firm i. This firm uses capital K_i and labor L_i to produce output. It faces a weakly downward-sloping demand curve, but takes input prices as given. The steady state user cost $R_i = (\rho+\delta)P^K(1-\Gamma_i)/(1-\tau_i)$ consists of the before-tax discount rate and depreciation rate, $\rho + \delta$, multiplied by the relative price of capital P^K and the "tax term" $(1-\Gamma_i)/(1-\tau_i)$. Here τ_i is the firm's marginal tax rate, and Γ_i the effective subsidy to the cost of new investment, including from accelerated expensing. The firm's first order condition for capital equates the user cost to the marginal revenue product of capital.

A comparative static of the steady state capital first order condition with respect to the user cost gives a long-run elasticity. In taking this comparative static, the literature has variously held fixed either firm revenue, variables external to the firm (such as the wage), or the firm's labor input. Each exercise has a valid and useful interpretation, but keeping them distinct is a necessary and all-too-often overlooked condition for comparing across microeconometric studies and moving from firm-level to aggregate analysis.

The Jorgenson (1963) elasticity starts from a Cobb-Douglas function relating firm revenue Y_i to capital and labor, $Y_i = A_i K_i^{\alpha} L_i^{\beta}$. Using the resulting first order condition for capital, $R_i = \alpha Y_i/K_i$, the elasticity of capital to the user cost *holding revenue fixed* is $\partial \log K_i/\partial \log R_i|_{dY_i=0} = -1$, the so-called neoclassical benchmark. Eisner and Nadiri (1968) show more generally that the user cost elasticity holding revenue fixed recovers the elasticity of substitution between capital and labor (1 if Cobb-Douglas).

Coen (1969) critiqued Hall and Jorgenson (1967) for using this elasticity as the basis for counterfactual exercises when the user cost changes. The reasoning is simple — higher capital induced by a decrease in the user cost will also increase firm output and revenue, resulting in a "scale" effect that further increases capital and that the analysis of tax reforms in Hall and Jorgenson omits. Coen (1969) instead advocates a comparative static *holding fixed only variables exogenous to the firm*, such as the wage. Mathematically, this requires applying the chain rule to allow Y_i to adjust; in the Cobb-Douglas case, Section 2 derives the Coen long-run firm-level user cost elasticity $dk_i/dr_i = -1/(1-\gamma) < -1$, where $\gamma = \alpha/(1-\beta) \subseteq [0,1]$. Thus, the total neoclassical firm-level elasticity is not -1, but instead something (possibly much) larger in absolute value. Indeed, with constant returns to scale in the revenue function ($\alpha + \beta = 1$), the Coen elasticity diverges to $-\infty$, as an infinitesimal reduction in cost causes an infinitesimal but strictly positive profit that induces the firm to scale to infinity. The Coen elasticity generalizes with any homogenous production function, naturally with the elasticity of substitution between capital and labor also mattering.

The first two rows of Table 1 summarize the differences between the Eisner and Nadiri (1968) and Coen (1969) elasticities and give plausible ranges of values based on the empirical literature. In short, both have valid interpretations and map into structural parameters of the firm's revenue function, but, despite both using the terminology "user cost elasticity", they reflect distinct structural objects. Comparisons of magnitudes across these specifications, while prevalent in literature reviews and review essays, in fact make little sense.[1]

Bringing this theory to the empirical literature requires relating the long-run elasticities to the short-run investment responses typically estimated. With quadratic adjustment costs in capital, Summers (1981) and Hayashi (1982) obtain a third investment relationship, $I_{i,t}/K_{i,t} = \delta + (1/\phi)Q_{i,t}$, where $I_{i,t}$ denotes gross investment at date t, $Q_{i,t}$ is a transformation of Brainard-Tobin's q, and ϕ relates to the magnitude of adjustment costs. However, this equation involves

[1] As one example among many, Chirinko, Fazzari and Meyer (1999) directly compare their estimated user cost elasticity from regressing investment on the user cost while controlling for firm revenue to a user cost elasticity they infer from a regression in Cummins, Hassett and Hubbard (1994) that does not control for firm revenue. Dwenger (2014); Council of Economic Advisers (2019); Congressional Budget Office (2018*b*); Council of Economic Advisers (2025); Hartley, Hassett and Rauh (2025) all repeat some version of this transgression.

Table 1: Summary of Key Elasticities and Semi-Elasticities to User Cost Change

Outcome	Holds fixed	Horizon	Interpretation	Seminal reference	Plausible values
$\log K$	Revenue	Long-run	Elasticity of substitution between capital and labor	Eisner and Nadiri (1968)	$[-1, -0.3]$
$\log K$	Wage	Long-run	Firm-level elasticity to idiosyncratic user cost	Coen (1969)	$(-\infty, -1.6]$
I/K	Wage	Short-run	Firm-level semi-elasticity to idiosyncratic user cost	Coen (1969)	$[-0.75, -0.25]$
$\log K$	Labor	Long-run	Macroeconomic elasticity to aggregate user cost	Barro and Furman (2018)	$[-1.7, -0.6]$

Q, not the user cost. Section 2 therefore solves for the transition path following a permanent tax change, giving a useful relationship between the steady state Coen (1969) elasticity and the short-run semi-elasticity of I/K.

Section 3 revisits the empirical literature estimating firm or asset-level responses of investment or capital to idiosyncratic changes in taxes. A common takeaway across studies is that investment responds to tax incentives. Yet, the variety of empirical specifications, each involving seemingly minor differences in the dependent variable, controls, key regressor, or timing, complicates quantitative comparisons. An important contribution of this article is to organize this zoo by providing a set of simple propositions and lemmas that map each empirical specification into the Summers (1981) specification, the Coen (1969) user cost elasticity holding input costs fixed and allowing output to vary, hybrid specifications, the Eisner and Nadiri (1968) specification holding output fixed, or an asset-level specification.

With the benefit of this taxonomy and the recent studies using high quality administrative data, the quantitative conclusion changes. The plurality of estimates take the Coen approach. These translate into a short-run semi-elasticity of the investment-to-capital ratio to the user cost, $d\left[I_{i,t}/K_{i,t-1}\right]/d\log R_{i,t}$, in the range of -0.25 to -0.75, shown in the third row of Table 1. While this range echoes the Hassett and Hubbard (2002) range of -0.5 to -1, it concerns the *semi*-elasticity of $I_{i,t}/K_{i,t-1}$. Converting to a comparable investment elasticity requires dividing by I/K, yielding magnitudes for the short-run Coen elasticity at least five times larger than in Hassett and Hubbard.

The firm-level studies cannot directly inform what happens following a change to the aggregate user cost, because general equilibrium changes in the wage or in aggregate output that affect all firms equally are absorbed in the intercept term of a firm-level regression. This "missing intercept" problem has meant that applied microeconomic studies often stop short of rigorously connecting their results to macroeconomic questions, leaving macroeconomists to question the value of the microeconometric work. One rejoinder is that these studies provide the most (perhaps only) powerful causal evidence that corporate taxation matters for investment. A more ambitious response is to relate the microeconometric evidence to structural parameters, which then inform macroeconomic analysis. Of course, such an approach requires additional assumptions, already provided here by the neoclassical theory. From this perspective, firm-level tax variation complements other approaches to identifying revenue function parameters.

The next sections of the article carry out this program. The Summers (1981) and Eisner and Nadiri (1968) specifications map straightforwardly into the adjustment cost parameter and elasticity of substitution, respectively. The Coen (1969) specifications require additional assumptions to distinguish the importance of decreasing returns in the firm's revenue function from adjustment costs in accounting for the finite investment responses found in empirical work. Section 4 introduces calibration "trees" that start with values of the short-run Coen (1969) semi-elasticity and a calibrated labor share, "branch" for different values of the ratio of the short-to-long-run impulse response of investment and for the capital-labor substitution elasticity, and generate "leaves" with the implied revenue elasticity of capital α^* and adjustment cost parameter ϕ. For a plausible short-run semi-elasticity, the long-run firm-level user cost elasticity of capital is about -1.6 or below. The values of α^* imply total returns to scale in the revenue function of between 0.8 and 1. The reasonableness of the returns to scale and adjustment costs based on microeconometric user cost variation constitutes a victory for the neoclassical theory, especially in contrast to early estimates of the Summers (1981) specification that did not rely on tax variation.

Section 5 turns to macroeconomic questions. It makes two simplifying assumptions to resolve the "missing intercept" problem: (i) the economy consists of a large number of identical firms, and (ii) aggregate labor is fixed. With these assumptions, the long-run general equilibrium user cost elasticity involves a third variant of the comparative static of the first order condition for capital, *now holding labor fixed* (see the fourth row of Table 1), rather than output (as in Eisner and Nadiri (1968)) or the wage (as in Coen (1969)). With Cobb-Douglas and perfect competition in output markets, the general equilibrium elasticity of capital to the user cost becomes $d\log K/d\log R = -1 + (\partial \log Y/\partial \log K|_{dL=0}) \times d\log K/d\log R = -1/(1-\alpha)$. I refer to this object as the Barro and Furman (2018) elasticity, as these authors use it in their analysis of TCJA. With imperfect competition in output markets, the output elasticity of capital $\mathcal{M}\alpha$ replaces the revenue elasticity α. (The parameter $\mathcal{M} \geq 1$ equals the ratio of price to marginal cost for a monopolistically competitive firm.) Away from Cobb-Douglas, the formula again also involves the elasticity of substitution between capital and labor.

The calibration trees extend to plausible macroeconomic elasticities, with additional branches for the degree of imperfect competition. Under Cobb-Douglas, the general equilibrium elasticity ranges from -1.2 to -1.7. Compared to the firm-level elasticity, this range reflects substantial tightening and general equilibrium dampening due to the aggregate fixed factor of labor.

A lower capital-labor elasticity of substitution η reduces the general equilibrium elasticities of capital and output, as the fixed factor of labor generates faster decreasing returns to capital accumulation. Quantitatively, with constant returns to scale in the production function, the Barro and Furman (2018) elasticity becomes $-\eta/(1-\mathcal{M}\alpha^*)$ and hence scales with η. The values of α^* consistent with the short-run responses of investment imply returns to scale close enough to 1 that this formula roughly holds. Thus, both the Eisner and Nadiri (which identifies η) and Coen (which helps to identify α^*) firm-level specifications provide important inputs to the aggregate capital elasticity. The wage elasticity is much less sensitive to the value of η, as a lower elasticity of substitution implies less capital accumulation but faster wage growth per unit of capital. Indeed, Section 5 shows that in the constant returns limit the wage elasticity is independent of η.

These results characterize the general equilibrium elasticity of capital to a change in the user cost, $d\log K/d\log R$. The elasticity of aggregate capital to the tax term may be smaller if the non-tax component of the user cost changes. Such crowd-out could occur because an upward-sloping savings schedule causes higher interest rates ($\rho\uparrow$), or inelastic capital goods supply increases the price of investment ($P^K\uparrow$). Letting ζ denote the inverse elasticity of the non-tax component to capital, the overall elasticity of capital to the tax term equates capital demand $d\log K = (d\log K/d\log R) \times d\log R$ with capital supply $d\log K = \zeta^{-1} d[\log(\rho+\delta) + \log P^K]$.

Characterizing the response of tax revenue provides a final illustration of the neoclassical approach. Analogous to the large literature on labor income taxes (see e.g. Saez, Slemrod and Giertz, 2012), the revenue-maximizing corporate tax rate trades off mechanical and dynamic revenue responses and depends crucially on the elasticity of taxable corporate income to the net-of-tax rate (Swonder and Vergara, 2025). Yet, this analogy does not extend to treating this elasticity as a sufficient statistic estimable with only firm-level variation. Rather, the formula requires the general equilibrium elasticity, and recognition that this elasticity may vary with the tax rate. Using parameter values consistent with the firm-level investment evidence and the current U.S. tax system, I find a revenue-maximizing rate well above the current corporate rate.

Section 6 contrasts the micro-to-macro neoclassical approach to macroeconomic counterfactuals with two alternatives: time series analysis and models at policy institutions. Time series analysis directly estimates the responses of macroeconomic aggregates to changes in corporate taxation. However, the relatively small number of tax reforms yields imprecise estimates (Jentsch and Lunsford, 2019; Mertens and Ravn, 2019). From this paper's perspective, leading policy models, including those used by Council of Economic Advisers (2019, 2025); Congressional Research Service (2024); Congressional Budget Office (2018*b*), mix up aspects of the Coen (1969) and Eisner and Nadiri (1968) elasticities and the difference between firm-level and aggregate elasticities. For example, Council of Economic Advisers (2019, 2025) follow Hall and Jorgenson (1967) and apply an elasticity of -1 based on the Hassett and Hubbard (2002) range and an appeal to the neoclassical benchmark, but do not recognize the difference between the firm-level elasticity holding output fixed and the aggregate general equilibrium elasticity.[2]

The article concludes by summarizing promising directions for research that move beyond the neoclassical paradigm.

2 Firm-level Theoretical Framework

This section derives key results starting from a firm-level production function. Section 2.1 provides the general setup and necessary conditions. Section 2.2 characterizes the steady state and defines the user cost and "tax term". Section 2.3 derives the Eisner and Nadiri (1968) revenue-fixed, Coen

[2]The critique of policy evaluation and counterfactuals echoes Lucas (1976), who also discussed Hall and Jorgenson (1967) in detail. My analysis differs from his however. Lucas (1976) focused on the interpretation of econometric evidence when tax policy is transitory. I instead assume throughout that firms expect current policy to continue and argue that even this simpler case has not properly integrated economic theory with econometric practice.

(1969) wage-fixed, and labor-fixed elasticities in full generality and previews the relationship among them. Section 2.4 specializes to the Cobb-Douglas production function as in Hall and Jorgenson (1967) and Coen (1969), while Section 2.5 uses the CES parametric form. Section 2.6 adds quadratic adjustment costs in capital and derives the Summers (1981) specification. Section 2.7 uses the quadratic adjustment cost environment to relate the cross steady state specifications to their short-run counterparts common in empirical work. Table 2 summarizes the notation.

Throughout this section, the analysis concerns a single firm that takes its input prices as given. This partial equilibrium perspective anticipates the firm, asset, or industry-level variation used in the studies reviewed in Section 3. Section 5 extends the results to general equilibrium and shows how the firm-level variation nonetheless disciplines aggregate elasticities.

2.1 General Setup

I set up the problem in continuous time. More substantively, I ignore uncertainty in order to arrive at the key relationships as neatly as possible.

Firm i produces output $X_{i,t}$ using capital $K_{i,t}$ and labor $L_{i,t}$:

$$X_{i,t} = \tilde{A}_{i,t}\tilde{F}\left(K_{i,t}, L_{i,t}\right), \tag{1}$$

where $\tilde{A}_{i,t}$ denotes exogenous Hicks-neutral technology and $\tilde{F}(.,.)$ is a twice differentiable, homogenous function. The firm faces a demand curve with exogenous shifter $\xi_{i,t}$ and price elasticity of demand $\mathcal{M}/(\mathcal{M}-1) > 1$:

$$X_{i,t} = \xi_{i,t}\left(P_{i,t}/P_t\right)^{-\mathcal{M}/(\mathcal{M}-1)} X_t, \tag{2}$$

where X_t and P_t denote aggregate output and the price of aggregate output, respectively, which the firm takes as given. Equations (1) and (2) imply a function for real revenue $Y_{i,t} \equiv P_{i,t}X_{i,t}/P_t$:

$$Y_{i,t} = A_{i,t}F\left(K_{i,t}, L_{i,t}\right), \tag{3}$$

$$\text{where: } F\left(K_{i,t}, L_{i,t}\right) = \tilde{F}\left(K_{i,t}, L_{i,t}\right)^{\frac{1}{\mathcal{M}}}, \tag{4}$$

$$\text{and: } A_{i,t} = \left(\xi_{i,t}X_t\right)^{\frac{\mathcal{M}-1}{\mathcal{M}}}\tilde{A}_{i,t}^{\frac{1}{\mathcal{M}}} \tag{5}$$

denotes an exogenous (to the firm) technology or demand shifter.[3] The revenue function (3) will

[3] That is, $Y_{i,t} = \left(\frac{P_{i,t}}{P_t}\right)X_{i,t} = \left(\xi_{i,t}^{-1}\frac{X_{i,t}}{X_t}\right)^{-\frac{\mathcal{M}-1}{\mathcal{M}}}X_{i,t} = \left(\xi_{i,t}X_t\right)^{\frac{\mathcal{M}-1}{\mathcal{M}}}X_{i,t}^{\frac{1}{\mathcal{M}}} = \left(\xi_{i,t}X_t\right)^{\frac{\mathcal{M}-1}{\mathcal{M}}}\tilde{A}_{i,t}^{\frac{1}{\mathcal{M}}}\tilde{F}\left(K_{i,t}, L_{i,t}\right)^{\frac{1}{\mathcal{M}}}$. I assume $F\left(K_{i,t}, L_{i,t}\right)$ is globally concave.

Table 2: Notation Summary

Symbol	Definition	Description	Eq.
$K_{i,t}$		Firm capital input	
$L_{i,t}$		Firm labor input	
$X_{i,t}$	$\tilde{A}_{i,t}\tilde{F}\left(K_{i,t},L_{i,t}\right)$	Firm output	(1)
$\mathcal{M}$		Equilibrium markup	
$A_{i,t}$	$\left(\xi_{i,t}X_t\right)^{\frac{\mathcal{M}-1}{\mathcal{M}}}\tilde{A}_{i,t}^{\frac{1}{\mathcal{M}}}$	Firm technology and demand	(5)
$Y_{i,t}$	$A_{i,t}F\left(K_{i,t},L_{i,t}\right),\ F\left(K_{i,t},L_{i,t}\right)=\tilde{F}\left(K_{i,t},L_{i,t}\right)^{\frac{1}{\mathcal{M}}}$	Firm revenue	(3)
$I_{i,t}$	$\dot{K}_{i,t}+\delta K_{i,t}$	Gross investment	(6)
$z_{i,t}$		Present value of depreciation allowances	(8)
$\tau_{i,t}$		Corporate tax rate	
$\Gamma_{i,t}$	$ITC_{i,t}+\tau_{i,t}z_{i,t}$	Effective subsidy to cost of new investment	(7)
ρ		Discount rate	
δ		Depreciation rate	
P_t^K		Relative price of new investment	
W_t		Common wage	
$\lambda_{i,t}$		Marginal value of unit of capital	(10)
R_i	$\left(\rho+\delta\right)P^K\left(\frac{1-\Gamma_i}{1-\tau_i}\right)$	Steady state user cost	(12)
$\Omega_{i,t}$	$\frac{1-\Gamma_{i,t}}{1-\tau_{i,t}}$	Tax term	(13)
α_i^*	R_iK_i/Y_i	Steady state capital share of revenue	(14)
β_i^*	WL_i/Y_i	Steady state labor share of revenue	(14)
ν	$\alpha_i^*+\beta_i^*$	Returns to scale in revenue function	(21)
α		Cobb Douglas elast. of revenue to capital	(23)
β		Cobb Douglas elast. of revenue to labor	(23)
γ	$\alpha/(1-\beta)$	Cobb Douglas elast. of revenue to capital allowing labor to adjust	(27)
η		Elast. of substitution between capital and labor	(30)
ϕ		Scalar in quadratic adjustment costs	(36)
$Q_{i,t}$	$\frac{\lambda_{i,t}-P_t^K\left(1-\Gamma_{i,t}\right)}{1-\tau_{i,t}}$	Transformation of Brainard-Tobin's q	(38)
$G_{i,t}\left(K_{i,t}\right)$	$\max_{L_{i,t}} A_{i,t}F\left(K_{i,t},L_{i,t}\right)-W_tL_{i,t}$	Revenue net of labor costs	(39)
χ_i	$\frac{\rho}{2}-\sqrt{\left(\frac{\rho}{2}\right)^2-\frac{G_i''(K_i)K_i}{\phi}}$	Stable eigenvalue	(42)
$b_1^{\text{Coen}k,r}$	dk_i/dr_i	Long-run firm-level Coen (1969) elast. of capital to user cost	
ζ	$d\left[\log\left(\rho+\delta\right)+p^K\right]/dk$	Inverse supply elast.	

This table summarizes key notation. In addition, lower case variables denote logs, variables or parameters with an i subscript pertain to the firm-level, and variables without an i pertain to the aggregate economy.

play the key role in firm-level elasticities, while the output function (1) will resurface in the analysis of general equilibrium.[4]

The firm hires labor on a spot market at a common real wage W_t. It owns its capital stock, a

[4]Equations (1) to (3) encode several assumptions that simplify expressions below but do not affect the substantive conclusions. Iso-elastic demand (2) plays no role in the firm-level results, which rely only on the general revenue function in equation (3). It will however facilitate transition to general equilibrium. Likewise, allowing for multiple types of capital or labor would not change the interpretion of firm-level empirical work. With an invariant intermediate inputs share of cost, equation (3) may be reinterpreted as the function giving revenue net of intermediate inputs, after concentrating these inputs out of the production function (see Appendix A.5). With fixed costs, K and L in equation (3) should be interpreted as the variable factors of production. The absence of uncertainty plays little role for the results concerning long-run elasticities.

fraction δdt of which depreciates each instant, giving the law of motion:

$$\dot{K}_{i,t} \equiv dK_{i,t}/dt = I_{i,t} - \delta K_{i,t}, \tag{6}$$

where $I_{i,t}$ denotes gross investment purchased at price P_t^K in units of real output. For example, the price P_t^K may result from a competitive capital goods sector that converts one unit of X_t into $1/P_t^K$ units of investment. Investment also requires payment of $\Phi(I_{i,t}, K_{i,t})$ dollars of installation costs. The firm discounts the future at a rate ρ that depends on the its (unmodeled) costs of debt and equity issuance.

The corporate tax code affects the firm in three ways. First, a firm can deduct from its taxable income a fraction of past investment expenditure. Specifically, for a dollar of investment at date t, the firm can deduct a fraction $B_{i,t}$ immediately and the remainder according to a specified schedule, where $c_{i,t+h|t}$ denotes the fraction of the remainder deductible at horizon h. The fraction $B_{i,t}$ is referred to as "bonus depreciation" or "immediate expensing". Second, the firm may receive an additional investment tax credit $ITC_{i,t}$ for investment at date t. The i subscripts in the depreciation schedule and investment tax credit reflect the possibility that they vary by asset type or industry, and hence by firm i. Third, the corporate income tax $\tau_{i,t}$ applies to revenue net of deductible costs. The i subscript in the tax rate reflects the possibility of credits, deductions, or net operating losses that make the marginal tax rate vary across firms.

The firm's problem simplifies under the maintained assumption that it expects the marginal tax rate and expensing schedule to remain fixed from date t forward.[5] In that case, the present value of tax savings per dollar of investment at date t, denoted $\Gamma_{i,t}$, consists of the investment tax credit plus the tax rate multiplied by the present value of future depreciation allowances $z_{i,t}$:

$$\Gamma_{i,t} = ITC_{i,t} + \tau_{i,t} z_{i,t}, \tag{7}$$

$$\text{where: } z_{i,t} = B_{i,t} + (1 - B_{i,t}) \int_0^\infty e^{-\rho h} c_{i,t+h|t} dh. \tag{8}$$

[5]Given initial capital $K_{i,t}$ and investment history $\{I_{i,t+h}\}_{h=-\infty}^{0}$, the firm chooses sequences $\{K_{i,t+h}, I_{i,t+h}, L_{i,t+h}\}_{h=0}^{\infty}$ to maximize $\int_0^\infty e^{-\rho h} CF_{i,t+h} dh$, where cash flows are $CF_{i,t} = (1-\tau_{i,t}) \underbrace{((Y_{i,t} - W_t L_{i,t} - \Phi(I_{i,t}, K_{i,t}))}_{\text{Earnings}} + \tau_{i,t} \underbrace{\left(B_{i,t} P_t^K I_{i,t} + \int_0^\infty (1 - B_{i,t-h}) c_{i,t|t-h} P_{t-h}^K I_{i,t-h} dh \right)}_{\text{Depreciation allowances}} + \underbrace{ITC_{i,t} P_t^K I_{i,t}}_{\text{Tax credit}} - P_t^K I_{i,t}$.
With constant τ, this problem gives the same choices as equations (9a) to (9c). In reality the availability of some credits, deductions, and net operating losses depend on firm choices, and hence even with fixed policy the marginal tax rate may not be constant or strictly exogenous to the firm. See Chodorow-Reich et al. (2025, Appendix C.5) for analysis of the determinants of firm-level heterogeneity in the change in $\tau_{i,t}$ after TCJA.

Furthermore, while accumulated allowances from past investment affect the value of the firm, they do not affect the choice of future investment or capital. The optimal choices of capital and labor therefore arise under the maximization problem: $\max_{\{L_{i,t+h}, K_{i,t+h}, I_{i,t+h}\}}$

$$\int_0^\infty e^{-\rho h} \left((1-\tau_{i,t}) \left(A_{i,t+h} F\left(K_{i,t+h}, L_{i,t+h}\right) - W_{t+h} L_{i,t+h} - \Phi\left(I_{i,t+h}, K_{i,t+h}\right) \right) - \left(1-\Gamma_{i,t}\right) P^K_{t+h} I_{i,t+h} \right) dh,$$

subject to the law-of-motion (6) and initial capital $K_{i,t}$.

Let $\lambda_{i,t}$ denote the Lagrange multiplier associated with the constraint (6). Let $F_K\left(K_{i,t}, L_{i,t}\right) = \partial F\left(K_{i,t}, L_{i,t}\right)/\partial K_{i,t}$ and likewise for F_L, Φ_K, Φ_I. The necessary conditions are:

$$L_{i,t}: \qquad A_{i,t} F_L\left(K_{i,t}, L_{i,t}\right) = W_t, \tag{9a}$$

$$K_{i,t}: \qquad \frac{(1-\tau_{i,t})\left(A_{i,t} F_K\left(K_{i,t}, L_{i,t}\right) - \Phi_K\left(I_{i,t}, K_{i,t}\right)\right) - \delta\lambda_{i,t} + \dot{\lambda}_{i,t}}{\lambda_{i,t}} = \rho, \tag{9b}$$

$$I_{i,t}: \qquad (1-\tau_{i,t})\,\Phi_I\left(I_{i,t}, K_{i,t}\right) + \left(1-\Gamma_{i,t}\right) P^K_t = \lambda_{i,t}. \tag{9c}$$

Equation (9a) states that the firm will hire labor up to the point where the marginal revenue product equals the wage. Equation (9b) equates the firm's discount rate to the internal rate of return on the shadow value of capital, equal to the after-tax marginal revenue product, less the increment to adjustment costs, and plus the change in the shadow value net of depreciation. Equation (9c) states that the shadow value of capital $\lambda_{i,t}$ must equal the cost of investment, given by the sum of the marginal adjustment cost and the market price net of tax incentives.

Equation (9b) solved forward yields:

$$\lambda_{i,t} = \int_0^\infty e^{-(\rho+\delta)h} (1-\tau_{i,t}) \left(A_{i,t+h} F_K\left(K_{i,t+h}, L_{i,t+h}\right) - \Phi_K\left(I_{i,t+h}, K_{i,t+h}\right) \right) dh. \tag{10}$$

According to equation (10), the Lagrange multiplier $\lambda_{i,t}$ also equals the present discounted value of an additional unit of capital, where the composite discount rate $\rho+\delta$ accounts for both financial discounting and depreciation and the marginal value at horizon h consists of the after-tax marginal revenue product of capital net of marginal adjustment costs.

2.2 Steady State

While the setup so far required no assumptions on the process for technology $\tilde{A}_{i,t}$, it simplifies the exposition to assume the existence of a steady state with zero real growth or inflation. Let variables without t subscripts denote the steady state values. I assume no adjustment costs in steady state, $\Phi(I_i, K_i) = \Phi_I(I_i, K_i) = \Phi_K(I_i, K_i) = 0$. Equation (9c) then gives:

$$\lambda_i = (1 - \Gamma_i) P^K. \tag{11}$$

Substitute this condition into equation (9b) and rearrange slightly:

$$A_i F_K(K_i, L_i) = (\rho + \delta) P^K \left(\frac{1 - \Gamma_i}{1 - \tau_i}\right) \equiv R_i. \tag{12}$$

Equation (12) equates the steady state marginal revenue product of capital to the steady state user cost R_i.[6] The user cost has two terms. The component $(\rho + \delta) P^K$ comprises the opportunity cost and depreciation parts of the cost-of-capital, scaled by the replacement cost. The second component is the "tax term" and will be a key object throughout the analysis. Denote it by $\Omega_{i,t}$:

$$\Omega_{i,t} \equiv \frac{1 - \Gamma_{i,t}}{1 - \tau_{i,t}}. \tag{13}$$

The ratio $\Omega_{i,t}$ summarizes the taxation of capital, with a higher value indicating higher taxation.[7]

Using equation (12), the steady state choices of capital and labor also solve the static maximization problem:

$$\max_{K_i, L_i} A_i F(K_i, L_i) - W L_i - R_i K_i.$$

2.3 A Preview of Three Elasticities

Key results that follow involve taking comparative statics of K_i with respect to R_i using the capital first order condition (12), holding fixed firm revenue Y_i (as in Hall and Jorgenson (1967); Eisner and

[6] Away from steady state, one can still define a user cost $R_{i,t}$ equal to the marginal revenue product of capital: $R_{i,t} = (\rho + \delta)\left(\Phi_I(I_{i,t}, K_{i,t}) + \Omega_{i,t} P_t^K\right) - \frac{\dot{\lambda}_{i,t}}{1 - \tau_{i,t}} + \Phi_K(I_{i,t}, K_{i,t})$. However, unlike the steady state R_i, this object contains components not directly measurable in the data and varies endogenously with investment. This perspective takes the production function (3) as a technological constraint that holds at every date including outside of steady state. Chirinko (2008) instead views the production function itself as depending on whether the firm has its steady state quantity of capital.

[7] The first order conditions (9a) to (9c) do not incorporate deductibility of interest payments. Interest deductibility matters if the firm's debt choice depends on the capital stock or the discount rate depends on the tax shield. For example, with a fixed leverage ratio ψ such that the value of the flow interest deduction is $\tau_i \rho \psi K_i$, the user cost would also subtract $\tau_i/(1 - \tau_i)\rho\psi$. The combination of low tax rates, low interest rates, and modest leverage make interest deductibility less important to capital choice today than historically: Gravelle and Keightley (2025) obtain an average user cost for corporate equipment of 0.184 inclusive of interest deductibility and 0.189 without it (my calculations based on their model and parameters). Nonetheless, interest deductibility can still non-trivially affect the magnitude of the change in the user cost when τ changes, because τ directly affects the value of the interest deduction. It matters much less for changes in the user cost due to changes in z. See Goodman, Isen and Richmond (2025) for an empirical analysis that finds a small effect of interest deductibility on capital.

Nadiri (1968)), the aggregate wage W (as in Coen (1969)), or, when moving to general equilibrium in Section 5, labor L_i. This sub-section previews these elasticities and the relationship among them in terms of general properties of the revenue function. Sections 2.4 and 2.5 provide additional economic insight by specializing to the Cobb-Douglas and CES functional forms, respectively.

Notation. Define the capital and labor shares of revenue using the first order conditions (9a) and (12):

$$\alpha_i^* \equiv \frac{R_i K_i}{Y_i} = \frac{F_K(K_i, L_i) K_i}{F(K_i, L_i)}, \quad \beta_i^* \equiv \frac{W L_i}{Y_i} = \frac{F_L(K_i, L_i) L_i}{F(K_i, L_i)}. \tag{14}$$

Also define the following curvature properties of $F(.,.)$:

$$\omega_{KK} \equiv \frac{F_{KK}(K_i, L_i) K_i}{F_K(K_i, L_i)}, \tag{15a}$$

$$\omega_{LL} \equiv \frac{F_{LL}(K_i, L_i) L_i}{F_L(K_i, L_i)}, \tag{15b}$$

$$\omega_{KL} \equiv \frac{F_{KL}(K_i, L_i) L_i}{F_K(K_i, L_i)}, \tag{15c}$$

$$\omega_{LK} \equiv \frac{F_{KL}(K_i, L_i) K_i}{F_L(K_i, L_i)} = \omega_{KL} \frac{\alpha_i^*}{\beta_i^*}. \tag{15d}$$

Let a lower case letter denotes the log of the upper case letter.

The three elasticities all start from linearizing the capital first order condition (12):

$$dr_i = \omega_{KK} dk_i + \omega_{KL} d\ell_i + da_i, \tag{16}$$

and the revenue function (3) (substituting using equation (14)):

$$dy_i = \frac{dF(K_i, L_i)}{F(K_i, L_i)} + da_i = \alpha_i^* dk_i + \beta_i^* d\ell_i + da_i. \tag{17}$$

Revenue fixed (Eisner and Nadiri, 1968). Holding revenue and A_i fixed, $\partial \ell_i / \partial k_i|_{dy_i=0} = -\alpha_i^*/\beta_i^*$ (see equation (17)). Then using equations (15d) and (16):

$$\frac{\partial k_i}{\partial r_i}|_{dy_i=0} = \left(\omega_{KK} + \omega_{KL} \frac{\partial \ell_i}{\partial k_i}|_{dy_i=0}\right)^{-1} = (\omega_{KK} - \omega_{LK})^{-1}. \tag{18}$$

Wage fixed (Coen, 1969). Holding the wage and A_i fixed, the first order condition for labor (9a) gives $d\ell_i/dk_i = -\omega_{LL}^{-1}\omega_{LK}$. Then using equation (16):

$$\frac{dk_i}{dr_i} = \left(\omega_{KK} + \omega_{KL} \frac{d\ell_i}{dk_i}\right)^{-1} = \left(\omega_{KK} - \omega_{LL}^{-1} \omega_{KL} \omega_{LK}\right)^{-1}. \tag{19}$$

Labor fixed (Barro and Furman, 2018). Holding labor fixed and allowing A_i to change in response to a common change to r that affects all firms (see equation (5)):

$$\frac{dk_i}{dr} = \left(\omega_{KK} + \frac{\partial a_i}{\partial x}\frac{\partial x}{\partial k}|_{d\ell=0}\right)^{-1}. \tag{20}$$

The term $\partial a_i/\partial x \times \partial x/\partial k|_{d\ell=0}$ involves general equilibrium adjustments detailed in Section 5.

The revenue-fixed, wage-fixed, and labor-fixed elasticities thus all depend on the curvature properties of the revenue function. Further assume a homogenous revenue function of degree $\nu \leq 1$ (i.e. $F(cK_i, cL_i) = c^{\nu} F(K_i, L_i)$, $F_K(K_i, L_i) K_i + F_L(K_i, L_i) L_i = \nu F(K_i, L_i)$), such that:

$$\nu = \alpha_i^* + \beta_i^*, \tag{21}$$

and Euler's formula gives (differentiate the second expression in the prior parentheses):

$$\omega_{KK} + \omega_{KL} = \omega_{LL} + \omega_{LK} = \nu - 1. \tag{22}$$

Using equations (15d) and (18) to (22), the firm-level Eisner and Nadiri and Coen elasticities, $\partial k_i/\partial r_i|_{dy_i=0}$ and dk_i/dr_i, together with a value for the labor share β^*, identify ω_{KK}, and hence also the aggregate elasticity dk_i/dr up to the general equilibrium term.

2.4 Cobb-Douglas Across Steady States

The system (9a) to (9c) and exposition of the three elasticities simplify considerably with a Cobb-Douglas production function. Thus, specialize the general revenue function (3) to:

$$Y_{i,t} = A_{i,t} K_{i,t}^{\alpha} L_{i,t}^{\beta}, \ \alpha > 0, \beta > 0, \alpha + \beta \leq 1. \tag{23}$$

Using $A_i F_K(K_i, L_i) = \alpha Y_i / K_i$ in equation (12) gives the Hall and Jorgenson (1967) relationship:

$$K_i = \frac{\alpha Y_i}{R_i}. \tag{24}$$

Intuitively, under Cobb-Douglas the factor shares of income are constant at $\alpha_i^* = \alpha, \beta_i^* = \beta$, and with no adjustment costs the cost-of-capital is the user cost $(\rho + \delta)\Omega_i P^K$. The Hall and Jorgenson (1967) user cost elasticity associated with equation (24) is:

$$\frac{\partial k_i}{\partial r_i}|_{dy_i=0} = -1. \tag{25}$$

Notably, while this user cost elasticity holds Y_i fixed, in equation (24) Y_i is an endogenous object.

The Coen (1969) elasticity relates K_i to idiosyncratic changes to R_i, holding fixed only variables exogenous to the firm. Under Cobb-Douglas the first order condition for labor (9a) takes the form:

$$L_{i,t} = \frac{\beta Y_{i,t}}{W_t} = \frac{\beta A_{i,t} K_{i,t}^{\alpha} L_{i,t}^{\beta}}{W_t} = \left(\frac{\beta A_{i,t} K_{i,t}^{\alpha}}{W_t}\right)^{\frac{1}{1-\beta}}. \tag{26}$$

Substitute equation (26) into the Cobb-Douglas production function (23) to find:

$$Y_{i,t} = A_{i,t} K_{i,t}^{\alpha} L_{i,t}^{\beta} = A_{i,t} K_{i,t}^{\alpha} \left(\frac{\beta A_{i,t} K_{i,t}^{\alpha}}{W_t}\right)^{\frac{\beta}{1-\beta}} = \mathcal{A}_{i,t} K_{i,t}^{\gamma}, \tag{27}$$

$$\text{where: } \mathcal{A}_{i,t} \equiv \left(\beta^{\beta} A_{i,t} W_t^{-\beta}\right)^{\frac{1}{1-\beta}}, \ \gamma \equiv \frac{\alpha}{1-\beta} \subseteq [0,1].$$

Importantly, $\mathcal{A}_{i,t}$ contains only variables exogenous to the firm. The Coen (1969) user cost elasticity follows from applying the chain rule using equation (27) to equation (24):

$$\frac{dk_i}{dr_i} = -1 + \frac{\partial y_i}{\partial k_i} \times \frac{dk_i}{dr_i} = -\frac{1}{1-\gamma} \leq -1. \tag{28}$$

This elasticity captures the full firm-level response of capital to an idiosyncratic change in the firm's user cost, taking the wage W_t and aggregate output X_t (which appears in $A_{i,t}$) as exogenous. (Changes to these variables in response to a common change in the user cost enter in the intercept of a firm-level Coen (1969) specification, giving rise to the "missing intercept" addressed in Section 5.) Since in the steady state $I_i = \delta K_i$, equation (28) also gives the long-run investment Coen elasticity:

$$\frac{d \log I_i}{dr_i} = \frac{dk_i}{dr_i} = -\frac{1}{1-\gamma} \leq -1. \tag{29}$$

The feature that the Coen (1969) firm-level elasticity with Cobb Douglas is always weakly less than -1 clearly distinguishes it from the Hall and Jorgenson (1967) "neoclassical benchmark". The inequality is strict as long as $\alpha > 0$ and typically quite binding; for a plausible calibration of $\alpha = 0.25$ and $\beta = 0.65$, $\gamma = 5/7$ and $dk_i/dr_i = -3.5$.

It is instructive to arrive at equation (28) by instead starting from equation (24) and iterating in a "cobweb" adjustment process. Suppose a firm starts with capital $K_{i,-1}$ and revenue $Y_{i,-1}$ satisfying equations (24) and (27), implying $K_{i,-1} = (\alpha \mathcal{A}_{i,-1}/R_i)^{1/(1-\gamma)}$. At date 0, the log user cost r_i changes by dr_i. To ease exposition, temporarily let $\mathcal{A}_{i,t} = 1 \ \forall t$. If the firm myopically treats equation (24) as a static updating rule and changes its capital stock only periodically at dates $t = 0, 1, 2, \ldots$, its capital and revenue will evolve over time as:

Horizon	$dk_{i,t}$	$dy_{i,t}$
0	$-dr_i$	$\gamma dk_{i,0}$
1	$-dr_i + dy_{i,0} = -dr_i(1+\gamma)$	$\gamma dk_{i,1}$
2	$-dr_i + dy_{i,1} = -dr_i(1+\gamma+\gamma^2)$	$\gamma dk_{i,2}$
$\vdots$		
$t>0$	$-dr_i \sum_{h=0}^{t} \gamma^h$	$\gamma dk_{i,t}$

The cobweb adjustment process sheds additional light on the Coen (1969) critique of Hall and Jorgenson (1967). Hall and Jorgenson analyzed tax reforms by applying only step 0 of the iterative process, yielding the elasticity -1. Coen correctly noted that iterating fully would yield the elasticity $-\lim_{t\to\infty}\sum_{h=0}^{t}\gamma^h = -1/(1-\gamma)$. Hall and Jorgenson (1969, p.369) replied that with constant returns to scale in the revenue function, $\alpha+\beta=\nu=1$, the parameter γ equals 1 and the full firm-level elasticity becomes infinite, implying "serious shortcomings" of the Coen approach. The infinite elasticity obtains because with constant returns to scale in the revenue function and price-taking in factor markets, an infinitesimal reduction in cost causes an infinitesimal but strictly positive profit that induces the firm to scale to infinity. An alternative perspective is therefore that the coexistence of firms facing different user costs indicates less than unitary returns to scale at the firm level. Furthermore, and as discussed in detail in Section 5, this issue disappears for aggregate analysis since aggregate labor is not infinitely elastic.

2.5 Constant Elasticity of Substitution (CES) Across Steady States

The CES functional form offers additional generality. In fact, because the Hall and Jorgenson (1967) and Coen (1969) elasticities apply locally around the steady state, restricting to a CES function entails no loss of generality relative to the general homogenous function in Section 2.3 (see Appendix A.1). Thus, now define the revenue function $F(K_{i,t}, L_{i,t})$ in equation (3) as:

$$F(K_{i,t}, L_{i,t}) = \left(\left(\frac{\alpha}{\alpha+\beta}\right) K_{i,t}^{1-1/\eta} + \left(\frac{\beta}{\alpha+\beta}\right) L_{i,t}^{1-1/\eta}\right)^{\frac{(\alpha+\beta)\eta}{\eta-1}}, \ \alpha>0, \beta>0, \eta>0, \alpha+\beta\leq 1. \tag{30}$$

Immediately, $\alpha+\beta=\nu$ determines the returns to scale. The parameter η is the elasticity of substitution between capital and labor. Using $\frac{\eta\nu}{\eta-1} - 1 = \frac{\eta\nu}{\eta-1}\left(1+\frac{1-\eta}{\eta\nu}\right)$, the derivatives of this function are:

$$F_K\left(K_{i,t}, L_{i,t}\right) = \alpha F\left(K_{i,t}, L_{i,t}\right)^{1+\frac{1-\eta}{\eta\nu}} K_{i,t}^{-\frac{1}{\eta}}, \tag{31a}$$

$$F_L\left(K_{i,t}, L_{i,t}\right) = \beta F\left(K_{i,t}, L_{i,t}\right)^{1+\frac{1-\eta}{\eta\nu}} L_{i,t}^{-\frac{1}{\eta}}. \tag{31b}$$

Substitute equation (31a) into equation (12) relating the marginal revenue product of capital to the user cost to obtain (see e.g. Eisner and Nadiri, 1968):

$$A_i\alpha\left(Y_i/A_i\right)^{1+\frac{1-\eta}{\eta\nu}} K_i^{-\frac{1}{\eta}} = R_i. \tag{32}$$

The Eisner and Nadiri (1968) elasticity holding revenue fixed generalizes Hall and Jorgenson (1967) by applying to equation (32):

$$\frac{\partial k_i}{\partial r_i}|_{dy_i=0} = -\eta. \tag{33}$$

Equation (33) shows that the Eisner and Nadiri elasticity identifies η.

Next solve for the Coen (1969) specification holding the wage and A fixed. Take logs and implicitly differentiate equation (32) with respect to r_i and rearrange:

$$\frac{dk_i}{dr_i} = -\left(\frac{1}{\eta} - \left(1 + \frac{1-\eta}{\eta\nu}\right)\frac{dy_i}{dk_i}\right)^{-1}. \tag{34}$$

Substitute equation (31b) into equation (9a) with the wage held fixed, take logs and differentiate to obtain dy_i/dk_i (see equation (A.6)), and substitute this expression into equation (34) to find the generalized Coen elasticity (see equation (A.7)):

$$\frac{dk_i}{dr_i} = -\left(\frac{1-\beta_i^*\left(\eta + \frac{1-\eta}{\nu}\right)}{1-\nu}\right). \tag{35}$$

With $\eta = 1$, equation (35) simplifies to $-(1-\beta)/(1-\nu) = -1/(1-\gamma)$, as in equation (28). Away from $\eta = 1$, the degree of returns to scale in the revenue function, ν, governs how much equation (35) differs from equation (28). As $\nu \to 1$, the Coen elasticity again diverges to $-\infty$.

2.6 Adjustment Costs

Summers (1981) and Hayashi (1982) analyze quadratic adjustment costs in capital of the form:

$$\Phi\left(I_{i,t}, K_{i,t}\right) = \frac{\phi}{2}\left(\frac{I_{i,t}}{K_{i,t}} - \delta\right)^2 K_{i,t}, \tag{36}$$

$$\text{with: } \Phi_I\left(I_{i,t}, K_{i,t}\right) = \phi\left(I_{i,t}/K_{i,t} - \delta\right),$$

$$\Phi_K\left(I_{i,t}, K_{i,t}\right) = \Phi\left(I_{i,t}, K_{i,t}\right)/K_{i,t} - \left(I_{i,t}/K_{i,t}\right)\Phi_I\left(I_{i,t}, K_{i,t}\right).$$

The subsequent literature has emphasized more complicated adjustment costs, including over investment rather than capital (Christiano, Eichenbaum and Evans, 2005) or fixed or irreversible costs of adjustment with uncertainty (Abel and Eberly, 1994, 1996; Caballero and Engel, 1999; Caballero, 1999; Cooper and Haltiwanger, 2006; Winberry, 2021). I return below to what hinges on this choice.

The Summers (1981) equation follows from substituting the expression for $\Phi_I\left(I_{i,t}, K_{i,t}\right)$ into the investment necessary condition (9c):

$$\frac{I_{i,t}}{K_{i,t}} = \delta + \frac{1}{\phi} Q_{i,t}, \tag{37}$$

$$\text{where: } Q_{i,t} \equiv \frac{\lambda_{i,t} - P_t^K\left(1-\Gamma_{i,t}\right)}{1-\tau_{i,t}} = \frac{\lambda_{i,t}}{1-\tau_{i,t}} - P_t^K \Omega_{i,t}. \tag{38}$$

The recognition of the difference between the market value of an additional unit of capital, $\lambda_{i,t}$ (see equation (10)), and the tax-adjusted replacement cost, $P_t^K\left(1-\Gamma_{i,t}\right)$, as a determinant of investment dates to Brainard and Tobin (1968). The ratio of these values is referred to as Brainard-Tobin's q. The definition of Q in equation (38) is a transformation of this concept. Equation (A.9) extends equation (37) to the case with a general convex adjustment cost function.

2.7 Coen (1969) in the Short-run

The linearized dynamic transition path links the steady state firm-level results to short-run empirical specifications. To that end, define the mapping from capital to revenue net of labor costs:

$$G_{i,t}\left(K_{i,t}\right) \equiv \max_{L_{i,t}} A_{i,t} F\left(K_{i,t}, L_{i,t}\right) - W_t L_{i,t}, \tag{39}$$

where $G_{i,t}\left(K_{i,t}\right)$ has concentrated out labor using the first order condition (9a). Under Cobb-Douglas $G_{i,t}\left(K_{i,t}\right) = (1-\beta)\mathcal{A}_{i,t} K_{i,t}^{\gamma}$ (see equation (27)); more generally the i, t subscripts on the G function reflect the dependence on technology and the wage. Importantly, $G_{i,t}(.)$ inherits the concavity of $F(.,.)$, with in particular $G'_{i,t}\left(K_{i,t}\right) = A_{i,t} F_K\left(K_{i,t}, L_{i,t}\right)$ due to the envelope theorem.

Imposing quadratic adjustment costs, the system (9b) and (9c) takes the form:

$$\dot{\lambda}_{i,t} = (\rho+\delta)\lambda_{i,t} - \left(1-\tau_{i,t}\right)\left(G'_{i,t}\left(K_{i,t}\right) - \Phi_K\left(I_{i,t}, K_{i,t}\right)\right), \tag{40a}$$

$$\dot{K}_{i,t} = \frac{1}{\phi}\left(\frac{\lambda_{i,t} - \left(1-\Gamma_{i,t}\right)P_t^K}{1-\tau_{i,t}}\right) K_{i,t}. \tag{40b}$$

Consider a permanent tax change at date 0 that affects only firm i.[8] Using the approximation $k_{i,t} - k_i \approx (K_{i,t} - K_i)/K_i$, for an initial condition $k_{i,0}$, the linearized solution is (see Appendix A.4 for details):

$$\lambda_{i,t} - \lambda_i = \phi\,(1-\tau_i)\,(k_{i,0} - k_i)\,\chi e^{\chi_i t}, \tag{41a}$$

$$k_{i,t} - k_i = (k_{i,0} - k_i)\,e^{\chi_i t}, \tag{41b}$$

$$\text{where: } \chi_i \equiv \frac{\rho}{2} - \sqrt{\left(\frac{\rho}{2}\right)^2 - \frac{G_i''(K_i)\,K_i}{\phi}} < 0 \tag{42}$$

is the stable eigenvalue of the system.[9] Implicitly differentiate the capital first order condition $G'_{i,t}(K_{i,t}) = R_i$ with respect to R_i, giving $\frac{G''_i(K_i)K_i}{R} \times \frac{dk_i}{dr_i} = 1$, and substitute into equation (42):

$$\chi_i = \frac{\rho}{2} - \sqrt{\left(\frac{\rho}{2}\right)^2 - \left(\frac{dk_i}{dr_i}\right)^{-1}\frac{R_i}{\phi}} < 0, \tag{43}$$

where dk_i/dr_i is the Coen (1969) elasticity in (28) or (35).

I can now state the key short-run results. The derivative of $k_{i,t}$ with respect to r_i in equation (41b) gives the elasticity of capital along the transition path:

$$\frac{dk_{i,t}}{dr_i} = \left(1 - e^{\chi_i t}\right)\frac{dk_i}{dr_i}. \tag{44}$$

The response of log net investment $\dot{k}_{i,t}$ is given by the time derivative of equation (41b):

$$\dot{k}_{i,t} = \frac{\dot{K}_{i,t}}{K_{i,t}} = \frac{I_{i,t}}{K_{i,t}} - \delta = \chi_i\,(k_{i,0} - k_i)\,e^{\chi_i t}.$$

The semi-elasticity of $I_{i,t}/K_{i,t}$ to the user cost after t periods is therefore:

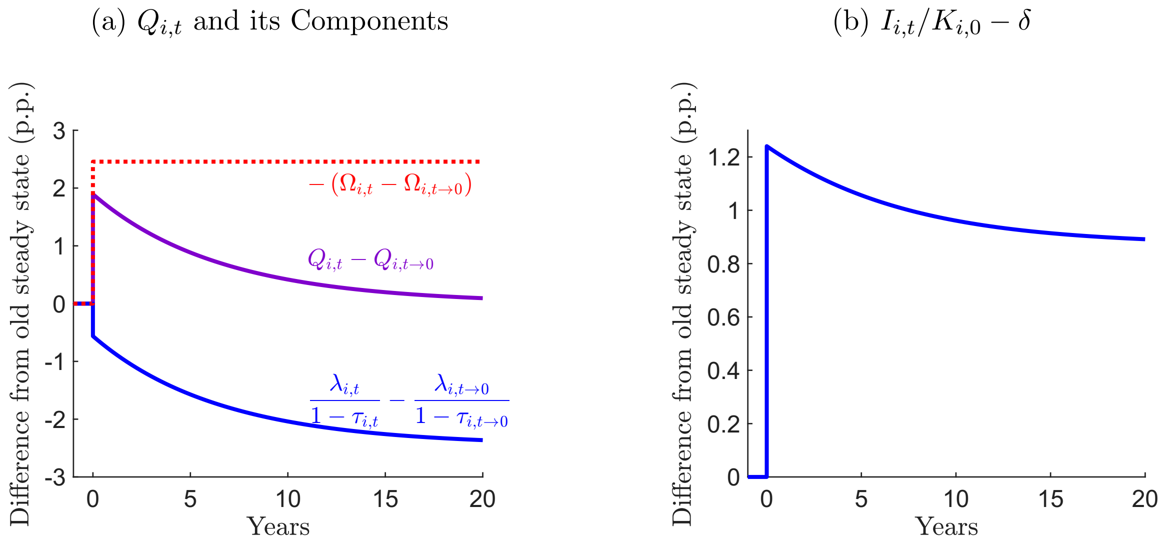
$$\frac{dI_{i,t}/K_{i,t}}{dr_i} = -\chi_i e^{\chi_i t}\frac{dk_i}{dr_i}. \tag{45}$$

In particular, the short-run semi-elasticity is $-\chi_i dk_i/dr_i$. This neat relationship illustrates why the summary of Coen elasticities in Section 3 focuses on the short-run semi-elasticity of I/K rather than the short-run elasticity of $\log I$ or k. More generally, one can always simply define

[8] A reform affecting all firms would involve changes in aggregate variables such as the wage. These changes would appear as additional forcing terms in equations (41a) and (41b) and contribute to the regression intercept in the Coen (1969) specifications reviewed in Section 3, as discussed further in Section 5.

[9] Auerbach (1989) first derives the partial adjustment form of the transition path as in equation (41b). The formula (43) differs slightly from Auerbach's due to my assumption that adjustment costs are fully immediately depreciable from income. Auerbach (1989) and Auerbach and Hassett (1992) also allow for transitory tax policy changes, in which case k_i depends on both current and future tax policy.

Figure 1: Impulse Response of Q and I/K



Notes: In Panel (a), the dotted red line shows the absolute value of the change in the tax term Ω, the solid blue line shows the response of the market value of installed capital $\lambda/(1-\tau)$, and the solid purple line shows the response of Q. Panel (b) shows the percentage point increase in the investment-capital ratio I/K.

$-\chi$ as the ratio of the short-run semi-elasticity to the long-run elasticity. With more complicated adjustment costs and idiosyncratic uncertainty, this ratio is not necessarily a closed form function of parameters, but it is estimable from the impulse response of $I_{i,t}/K_{i,0}$.

The statement that a finite firm-level elasticity implies diminishing returns to scale in revenue does not carry over to the short-run elasticity. Take the Cobb-Douglas case for simplicity, in which $dk_i/dr_i = -1/(1-\gamma)$ (equation (28)). Apply L'Hopital's rule to $\chi_i/(1-\gamma)$ (see equation (45)):

$$\lim_{\gamma\to 1}\frac{dI_{i,0}/K_{i,0}}{dr_i} = \lim_{\gamma\to 1}\frac{\chi_i}{1-\gamma} = -\frac{R_i}{\rho\phi}. \tag{46}$$

In the knife edge case of constant returns to scale, the short-run semi-elasticity contains no information about the long-run elasticity.

Figure 1 plots the transition path of the components of $Q_{i,t}$ and $I_{i,t}/K_{i,0}$ in response to a change in $\Omega_{i,t}$ at date 0 due to more generous expensing. The top dotted line in Figure 1(a) shows the absolute value of the change in Ω, which in this example falls by 2.5p.p., roughly the difference between 0 and 100% expensing of equipment at the current marginal tax rate and depreciation schedule. The remainder of the calibration is illustrative but realistic: a Cobb-Douglas revenue function with $\alpha = 0.25, \beta = 0.65$, a depreciation rate $\delta = 0.1$, a discount rate $\rho = 0.06$, and adjustment cost parameter $\phi = 1.5$. The middle line shows that $Q_{i,t}$ jumps up at date 0, but by less than the reduction in $\Omega_{i,t}$. Arithmetically, $\lambda_{i,t}$ must then jump down, as shown in the bottom line. Figure 1(b) shows that investment jumps above the new long run steady state value and converges toward it from above (this qualitative pattern is not generic; with large enough ϕ, $\lambda_{i,t}$ can jump up and investment can converge to its long-run value from below). The log change in $\Omega_{i,t}$ (and hence also r) is -2.4% and $\gamma = 5/7$, implying a long-run increase in investment of $2.4\%/(1-\gamma) = 8.4\%$ (see equation (28)), or a level change of 0.84p.p. of initial capital given $\delta = 0.1$. Furthermore, $\chi_i \approx -0.15$, giving $I_{i,0}/K_{i,0} - \delta = -\chi_i \times 8.4\% = 1.24\%$ of K_0 (see equation (45)), equal to the date 0 value of the impulse response shown in Figure 1(b).

3 A Reanalysis of Empirical Findings

This section reviews empirical estimates of the effect of taxes on capital and investment across firms or asset types. A common takeaway is that investment responds to tax incentives. Yet, the variety of empirical specifications complicates quantitative comparisons. I organize them using the results derived in Section 2 into the Summers (1981) specification involving tax-adjusted Q (Section 3.1), the Coen (1969) specification allowing output to vary (Section 3.2), hybrid specifications (Section 3.3), the Eisner and Nadiri (1968) specification holding output fixed (Section 3.4), and asset-level specifications (Section 3.5). Section 4 relates the coefficients to structural parameters of the firm's revenue function. As the identifying variation involves idiosyncratic changes to the taxation of individual firms or asset types, the investment responses omit the effect of changes to aggregate factor prices or production that affect all firms. Section 5 addresses this "missing intercept" and shows how the parameters recovered in Section 4 inform aggregate elasticities.

The set of papers builds on Zwick and Mahon (2017, table B.8).[10] Appendix B contains additional details on individual studies and how I harmonize them. The research designs mostly share the approach of using changes in tax law that have heterogeneous effects across industries or firms. Hence, they rely on the units most exposed to the tax changes not also being differentially

[10] I restrict analysis to firm or asset-level studies relating investment to changes in corporate tax policy. Bond and Van Reenen (2007) review estimates of investment and production function-related parameters using other sources of variation or structural methods. To keep the analysis manageable, with one exception I also restrict to results using U.S. data. Recent articles using non-U.S. data include Maffini, Xing and Devereux (2019); Guceri and Albinowski (2021); Harju, Koivisto and Matikka (2022); Link et al. (2024); Lerche (2025). I also exclude articles such as Ohrn (2018) that link investment to corporate taxation but do not use an empirical specification that has a structural interpretation.

Table 3: Estimates of the Summers (1981) Specification

Article	Table (col.)	Estimating equation	Data	Variation	b_1 (s.e.)	Implied ϕ
Cummins, Hassett and Hubbard (1994)	3(2)	$I_{i,t}/K_{i,t-1} = b_0 + b_1 Q_{i,t}$	Compustat annual 1953-1988	Firm-level with year and firm FE and control for cash flow (het. SEs)	$b_1 =$ 0.019 (0.001)	52.6
Cummins, Hassett and Hubbard (1996)	7	$I_{i,t}/K_{i,t-1} = b_0 + b_1 Q_{i,t}$	Global Vantage USA 1987	Firm-level first-differences IV using $\Omega_{i,t}$ and lagged $I_{i,t}/K_{i,t-1}$ and cash flow (het. SEs)	$b_1 =$ 0.650 (0.077)	1.5
Desai and Goolsbee (2004)	7(2)	$I_{i,t}/K_{i,t-1} = b_0 + b_1 Q_{i,t}$	Compustat annual 1962-2003	Four-digit SIC with year and firm FE (cluster by firm) and control for cash flow	$b_1 =$ 0.0231 (0.0011)	43.3

exposed to other common shocks or having systematically different treatment effects. Tax changes specific to an individual firm or asset type also must not cause firm or asset-specific changes in input prices, as such changes would contribute to the regression residuals.[11] I do not critique the measurement of tax changes, but note here that papers differ in using statutory or effective tax rates and these differences can matter quantitatively.

3.1 Estimates of the Summers (1981) Specification

A seemingly straightforward specification at short horizons is the Summers (1981) equation:

$$I_{i,t}/K_{i,t-1} = b_0^{I/K,Q} + b_1^{I/K,Q} Q_{i,t}, \tag{47}$$

where $Q_{i,t}$ is defined in equation (38). Proposition 1 formalizes the interpretation of $b_1^{I/K,Q}$:

Proposition 1 *In the environment of Section 2.6 with quadratic adjustment costs in capital, $b_1^{I/K,Q} = 1/\phi$, where ϕ scales the adjustment cost in equation (36). With general convex adjustment costs in capital, $b_1^{I/K,Q}$ equals the average inverse of the convexity of the adjustment cost function.*

Proof. See equations (A.9) and (37). ■

Table 3 reviews empirical estimates. The implied adjustment costs in Cummins, Hassett and Hubbard (1994) and Desai and Goolsbee (2004) seem implausibly high; they suggest that a firm

[11] See House and Shapiro (2008) for a joint analysis of investment and its price in response to bonus depreciation. Because their setup assumes a temporary tax change, I do not include it below, acknowledging here that whether firms perceived bonus depreciation in 2001 as transitory or permanent matters to analyses of that episode. In general, better measurement of firms' expectations of the persistence of tax policy would be an important step forward in refining the user cost changes during particular episodes and hence in comparing across studies.

could pay more than \$1 of adjustment costs per dollar of new capital. An additional problem concerns the absence of a theoretical rationale for a regression residual in equation (47), suggesting the R^2 should be one (Romer, 2018). One interpretation of the results in Cummins, Hassett and Hubbard (1994) and Desai and Goolsbee (2004) (and earlier in Summers (1981) in the time series) is that they reveal a major failure of the neoclassical framework. This interpretation proved intellectually fruitful, spurring developments including irreversibility and fixed costs (Abel and Eberly, 1994; Caballero and Engel, 1999) and cash-flow sensitivity of investment (Fazzari, Hubbard and Petersen, 1988). An alternative interpretation indicts attenuation bias stemming from measurement error in the λ component of Q, which in practice is estimated by imposing constant returns to scale in the firm's revenue function and using data on the market value of publicly-traded equity. This interpretation spurred a search for more powerful tests of the neoclassical model based on tax variation, the focus of much of this section. Cummins, Hassett and Hubbard (1996) use tax variation as an excluded instrument in the Summers (1981) specification and find a much larger regression coefficient, implying a value of ϕ of 1.5.[12]

3.2 Estimates of the Coen (1969) Specification

This section reviews articles that estimate variants of the equation:

$$I_{i,t}/K_{i,t-1} = b_0^{\text{Coen}I(0)/K,r} + b_1^{\text{Coen}I(0)/K,r} \log \Omega_{i,t} + e_{i,t}. \tag{48}$$

Equation (48) relates the investment-capital ratio, $I_{i,t}/K_{i,t-1}$, to the contemporaneous log of the tax term, $\log \Omega_{i,t}$. Alternatives, listed in equations (B.1a) to (B.1e), replace $I_{i,t}/K_{i,t-1}$ with $k_{i,t}$ or $\log I_{i,t}$ as the dependent variable, consider different horizons, or replace the regressor $\log \Omega_{i,t}$ with the level of the tax term $\Omega_{i,t}$, user cost $R_{i,t}$, or simply the present value of allowances $z_{i,t}$.

In a common labor market, changes in the wage contribute to the intercept term b_0, such that b_1 gives the firm-level response holding the wage fixed. The regression residual $e_{i,t}$ arises due to idiosyncratic changes to productivity, to components of the user cost besides the tax term such as capital goods prices, or to other factor prices (including wages) that vary across firms. Proposition 2 provides a structural interpretation of $b_1^{\text{Coen}I(0)/K,r}$.

[12] Technically, their excluded instrument is the variable $\tilde{Q}_{i,t}$ defined in equation (B.2). As discussed there, the identifying variation is simply the tax term $\Omega_{i,t}$.

Proposition 2 *In the environment of Section 2.7 with quadratic adjustment costs in capital, equation* (48) *recovers* $plim b_1^{CoenI(0)/K,r} = -\chi_i dk_i/dr_i$*, where* χ_i *is the stable eigenvalue given in equation* (43) *and* dk_i/dr_i *is the long-run Coen firm-level elasticity given by equation* (28) *or* (35).

Proof. See equation (45). ■

The close correspondence between the short-run semi-elasticity $b_1^{\text{Coen}I(0)/K,r}$ and the long-run elasticity dk_i/dr_i explains my emphasis on equation (48) over, say, the short-run elasticity with $d\log I_{i,t}$ as the dependent variable.[13] Nonetheless, the alternative variants have similar structural interpretations after rescaling the regression coefficient.

Table 4 reports estimates of the Coen specifications as well as my standardization of the regression coefficients in relation to the long-run elasticity dk_i/dr_i and the eigenvalue χ. Cummins, Hassett and Hubbard (1994) is a landmark, comprehensive analysis of firm-level investment around major U.S. tax reforms and among the most prominently-cited articles for policy analysis. Their first specification (their table 5) is motivated as a variant of Summers (1981), but in fact is equation (48) except with $-\Omega_{i,t}$ as the regressor. The correct interpretation implies values of $-b_1^{\text{Coen}I(0)/K,r} = \chi dk_i/dr_i$ ranging from 0.66-1.18. Their second specification (their table 9) replaces $\log\Omega_{i,t}$ with the level of the user cost $R_{i,t}$ and yields values of $-b_1^{\text{Coen}I(0)/K,r}$ ranging from 0.14 to 0.19 for major tax reform years. The difference in impled ranges across specifications is surprising, since the regressor in their table 9 is simply $-R/\Omega = -(\rho+\delta)$ multiplied by the regressor in table 5. One possible explanation is attenuation bias in table 9, which uses firm-specific ρ based on bond yields and δ based on book capital to construct $R_{i,t}$.

Recent studies have examined two major tax changes that occurred after the Cummins, Hassett and Hubbard (1994) sample: the introduction of bonus depreciation in the early 2000s, and the TCJA in 2017. Zwick and Mahon (2017) study the bonus episode. Their analysis improves on Cummins, Hassett and Hubbard (1994) by focusing exclusively on the variation from tax policy, by measuring the exposure to tax policy changes using administrative tax returns, and by including private firms in their sample. Their specification regresses $\log I_{i,t}$ on $z_{i,t}$, in first differences. The

[13] In particular, the short-run elasticity $d\log I_{i,t}/dr_{i,t} = d[I_{i,t}/K_{i,t}]/dr_{i,t} \times K_{i,t}/I_{i,t} = -\chi/\delta \times dk_i/dr_i$ also divides by δ. This dependence complicates empirical estimation if heterogeneity in δ correlates with changes in the tax term, as may arise due to correlation between economic and tax depreciation rates (see the discussion of Zwick and Mahon (2017) in Appendix B).

Table 4: Estimates of the Coen (1969) Specification

Article	Table (col.)	Estimating equation	Data	Variation	b (s.e.)	Transformation
Cummins, Hassett and Hubbard (1994)	5	$I_{i,t}/K_{i,t-1} = b_0 + b_1\tilde{Q}_{i,t}$	Compustat annual	Firm-level projecting out expectations (het. SEs)		$b \times \Omega$ (Lemma B.3), lagged Ω from table 1 and figure 1
			1963		0.874 (0.23)	$\Omega = 1.35 : -b_1^{\text{Coen}I(0)/K,r} = \chi dk_i/dr_i = 1.18$
			1973		0.47 (0.095)	$\Omega = 1.30 : -b_1^{\text{Coen}I(0)/K,r} = \chi dk_i/dr_i = 0.61$
			1982		0.599 (0.10)	$\Omega = 1.11 : -b_1^{\text{Coen}I(0)/K,r} = \chi dk_i/dr_i = 0.66$
			1987		0.613 (0.09)	$\Omega = 1.31 : -b_1^{\text{Coen}I(0)/K,r} = \chi dk_i/dr_i = 0.80$
Cummins, Hassett and Hubbard (1994)	9	$I_{i,t}/K_{i,t-1} = b_0 + b_1 R_{i,t}$	Compustat annual equipment	Firm-level projecting out expectations (het. SEs)		$-b \times R$ (Lemma B.3), $R = 0.25$ (p. 43):
			1963		-0.605 (0.14)	$-b_1^{\text{Coen}I(0)/K,r} = \chi dk_i/dr_i = 0.15$
			1973		-0.546 (0.14)	$-b_1^{\text{Coen}I(0)/K,r} = \chi dk_i/dr_i = 0.14$
			1982		-0.757 (0.19)	$-b_1^{\text{Coen}I(0)/K,r} = \chi dk_i/dr_i = 0.19$
			1987		-0.747 (0.23)	$-b_1^{\text{Coen}I(0)/K,r} = \chi dk_i/dr_i = 0.19$
Cummins, Hassett and Hubbard (1996)	6	$I_{i,t}/K_{i,t-1} = b_0 + b_1\tilde{Q}_{i,t}$	Global Vantage USA 1987	Firm-level projecting out expectations (het. SEs)	0.603 (0.086)	$b \times \Omega$ (Lemma B.3), $\Omega = 1.21$ (Cummins, Hassett and Hubbard, 1994): $-b_1^{\text{Coen}I(0)/K,r} = \chi dk_i/dr_i = 0.73$
Zwick and Mahon (2017)		$\log I_{i,t} = b_0 + b_1 z_{i,t}$	SOI corporate sample	Four-digit NAICS with year and firm FE (cluster firm)		$b \times \delta\left(1 - \tau z\right)/\tau$ (Lemma B.4), $z = 0.881$ (table 2), $\delta = 0.13$ (FAA), $\tau = 0.35$ (statutory), additional scaling 5/7 (Appendix B):
	3(1)		Pooled		3.69 (0.53)	$-b_1^{\text{Coen}I(0)/K,r} = \chi dk_i/dr_i = 0.68$
	6(1)		Small firms		6.29 (1.21)	$-b_1^{\text{Coen}I(0)/K,r} = \chi dk_i/dr_i = 1.15$
	6(2)		Large firms		3.22 (0.76)	$-b_1^{\text{Coen}I(0)/K,r} = \chi dk_i/dr_i = 0.59$
Curtis et al. (2021)	2(3)	$k_i = b_0 + b_1\left[\mathbb{I}z \leq P_{33}(z)\right]$	Census ASM, CM 2001-2011	Long-difference	0.1047 (0.0192)	$-\left(b/\Delta_{2001,2011}\Delta_{z\leq P_{33}(z),z>P_{33}(z)}\right) \times \left(1 - \tau z\right)/\tau$ (Lemma B.4), $\Delta_{2001,2011}\Delta_{z\leq P_{33}(z),z>P_{33}(z)} = 0.034$, $z = 0.84$ (Appendix B), $\tau = 0.35$ (statutory): $b_1^{\text{Coen}k(10),r} = \left(1 - e^{10\chi}\right) dk_i/dr_i = -6.21$
Chodorow-Reich et al. (2025)	3(3)	$\log I_{i,t} = b_0 + b_1 \log \Omega_{i,t}$	SOI C-corporate sample, 2015-19	Firm-level in first-differences (het. SEs)	-4.27 (0.51)	$-b \times \delta$ (Lemma B.2), $\delta = 0.1$ (sample average): $-b_1^{\text{Coen}I(0)/K,r} = \chi dk_i/dr_i = 0.43$
Kennedy et al. (2026)	6(1)	$I_{i,t}/K_{i,t-1} = b_0 + b_1 \log \Omega_{i,t}$	SOI corporate sample, 2013-2019	C-corp. indicator × post-2017 (cluster firm)	-0.424 (0.066)	None: $-b_1^{\text{Coen}I(0)/K,r} = \chi dk_i/dr_i = 0.42$

implied $-b_1^{\mathrm{Coen}I(0)/K,r}$ pooling over all firms is 0.68. They also find important hetergeneity, with $-b_1^{\mathrm{Coen}I(0)/K,r} = 1.15$ for smaller firms and 0.59 for larger firms. Curtis et al. (2021) extend the Zwick and Mahon (2017) analysis to look at outcomes for manufacturing firms after 10 years. Their estimate for log capital translates into a value of $(1 - e^{10\chi})\, dk_i/dr_i = -6.21$, or, for values of $\chi \subseteq (-0.18, -0.1)$ (see Section 4 for discussion of these values), $-b_1^{\mathrm{Coen}I(0)/K,r} \subseteq (0.98, 1.34)$.

Chodorow-Reich et al. (2025) and Kennedy et al. (2026) study variation induced by the TCJA. Both studies follow Zwick and Mahon (2017) in using high quality tax returns to measure exposure and investment. Using firm-level variation for C-corporations without international presence, Chodorow-Reich et al. (2025) implement equation (48) but with $\log I_{i,t}$ as the dependent variable. Their regression coefficient translates into $-b_1^{\mathrm{Coen}I(0)/K,r} = 0.43$. Kennedy et al. (2026) compare C and S corporations, as the corporate rate cut in TCJA applied only to the former. Their specification regressing $I_{i,t}/K_{i,t-1}$ on $\log \Omega_{i,t}$ implies an almost identical $-b_1^{\mathrm{Coen}I(0)/K,r} = 0.42$, despite the two studies using entirely different sources of variation. Furthermore, because both of these studies use firm-level variation, they report specifications controlling for industry that help to address concerns about correlation between the regression residual and tax changes.

In summary, comparing across the values of $plim\ b_1^{\mathrm{Coen}I(0)/K,r} = -\chi dk_i/dr_i$ in Table 4 may appear to give the contours of the Hassett and Hubbard (2002) range of -0.5 to -1. However, $plim\ b_1^{\mathrm{Coen}I(0)/K,r}$ is the semi-elasticity of investment. Rescaling the values in Table 4 by I/K yields elasticities that are five to ten times larger in absolute value than the Hassett and Hubbard range.[14] The difference reflects larger responses using better data sets and measurement in the more recent analyses, my inclusion of some additional results and several adjustments to the estimates reviewed in Hassett and Hubbard (2002), and my exclusion of Eisner and Nadiri (1968) specifications. The table also contains notable extremes. Only Cummins, Hassett and Hubbard (1994, table 9) implies a magnitude of $-b_1^{\mathrm{Coen}I(0)/K,r}$ below 0.2. Only Cummins, Hassett and Hubbard (1994, table 5, 1963

[14] Indeed, the meaning of the Hassett and Hubbard (2002) range has caused confusion. Zwick and Mahon (2017, figure 4) compare the Hassett and Hubbard range to their coefficient from regressing I/K on the tax term $(1-\Gamma)/(1-\tau)$. Chodorow-Reich, Zidar and Zwick (2024) similarly plot coefficients from this specification and label values between -0.5 and -1 as the Hassett and Hubbard range. Council of Economic Advisers (2019, p.59), Fuest and Neumeier (2023, p.436), and Lester and Olbert (2025, p.8) instead interpret the range as applying to the elasticity $d\log I/d\log R$, although Fuest and Neumeier (2023, p.436) also compare the Hassett and Hubbard range to the Zwick and Mahon (2017) range. Since (starting from steady state) $d\left[I_{i,t}/K_{i,0}\right]/d\left[(1-\Gamma_i)/(1-\tau_i)\right] = (I_{i,0}/K_{i,0})/\left[(1-\Gamma_i)/(1-\tau_i)\right] \times d\log I_{i,t}/d\log\left[(1-\Gamma_i)/(1-\tau_i)\right] = \delta_i/\left[(1-\Gamma_i)/(1-\tau_i)\right] \times d\log I_{i,t}/d\log R_i$, these interpretations of the Hassett and Hubbard range differ by the ratio of the depreciation rate to the tax term, or roughly a factor of 5 or more.

and 1987), Curtis et al. (2021), and Zwick and Mahon (2017, small firms) find magnitudes greater than 0.75. A central tendency range of -0.25 to -0.75 therefore summarizes empirical evidence of the Coen (1969) firm-level short-run semi-elasticity of investment to the user cost.

3.3 Estimates of Hybrid Specifications

Motivated by measurement error in λ, Desai and Goolsbee (2004) and Edgerton (2010) split Q to allow different coefficients multiplying the $\left(\lambda_{i,t}/P_t^K\right)/(1-\tau_{i,t})$ and $\Omega_{i,t}$ components:[15]

$$I_{i,t}/K_{i,t-1} = b_0^{\text{hybrid}} + b_1^{\text{hybrid}} \frac{\lambda_{i,t}/P_t^K}{1-\tau_{i,t}} + b_2^{\text{hybrid}} \Omega_{i,t} + e_{i,t}. \tag{49}$$

This split is formally an over-identification test of the Summers (1981) specification, which requires $b_1 = -b_2$. If this condition fails, no clear structural interpretation of either coefficient exists:

Lemma 1 *In the environment of Section 2.6 with quadratic adjustment costs in capital, plim* $b_1^{hybrid} = -plim\ b_2^{hybrid} = P_t^K/\phi$*, where* ϕ *scales the adjustment cost in equation (36). If* $\lambda_{i,t}$ *is only noise, then plim* $b_1^{hybrid} = 0$ *and plim* $b_2^{hybrid} = (1/\Omega_i) \times plim\ b_1^{CoenI(0)/k,r}$ *as in Lemma B.3. If* $\lambda_{i,t}$ *contains both signal and classical measurement error and* $Cov(\lambda_{i,t}, \Omega_{i,t}) < 0$*, then* $|plim\ b_2^{hybrid}| > |plim\ b_1^{I/K,Q}|$.

Desai and Goolsbee (2004) and Edgerton (2010) find much larger (in absolute value) coefficients multiplying the $\Omega_{i,t}$ component and near zero coefficients multiplying $\left(\lambda_{i,t}/P_t^K\right)/(1-\tau_{i,t})$. Desai and Goolsbee (2004) incorrectly interpret this result as the coefficient multiplying $\Omega_{i,t}$ providing a more accurate measure of adjustment costs.[16] While the interpretation of attenuation bias affecting b_1^{hybrid} may be correct, it does not follow that b_2^{hybrid} recovers the adjustment cost parameter. In the extreme case where measurement of $\left(\lambda_{i,t}/P_t^K\right)/(1-\tau_{i,t})$ results in only noise, the regression instead maps to the Coen (1969) elasticity. Applying this interpretation and $\Omega = 1.25$ (see Cummins, Hassett and Hubbard (1994, table 5) in Table 4) would imply $-b_1^{\text{Coen}I(0)/K,r} \approx 1$.

[15] This exercise was first proposed in the published comment on Cummins, Hassett and Hubbard (1994) by Caballero (1994).

[16] Desai and Goolsbee (2004, p. 315): "the model predicts that these coefficients should be of the same magnitude as those on tax-adjusted q [λ in my notation], but of opposite sign. Here, instead, the coefficients on the equipment tax term are considerably larger. With measurement error in q, the coefficient on the tax term may provide a more realistic estimate of the true coefficient. Such a coefficient is considerably closer to 1 and, consequently, corresponds to more realistic estimates of adjustment costs."

Table 5: Estimates of the Hybrid Specification

Article	Table (col.)	Estimating equation	Data	Variation	b_1 (s.e.)
Desai and Goolsbee (2004)	8(1)	$I_{i,t}/K_{i,t-1} = b_0 + b_1\left(\lambda_{i,t}/P_t^K\right)/(1-\tau_{i,t}) + b_2\Omega_{i,t}^{\text{equipment}} + b_3\frac{CF_{i,t-1}}{K_{i,t-1}}$	U.S. Compustat annual 1962-2003	Four-digit SIC with year and firm FE (cluster by firm); includes control for structures tax term	$b_1 =$ 0.0231 (0.0011), $b_2 = -0.8895$ (0.3173)
Edgerton (2010)	3(2)	$I_{i,t}/K_{i,t-1} = b_0 + b_1\left(\lambda_{i,t}/P_t^K\right)/(1-\tau_{i,t}) + b_2\Omega_{i,t}^{\text{equipment}}$	North America Compustat annual 1967-2005	Four-digit SIC with year and firm FE (cluster by firm); includes control for non-taxable status, its interaction with $\Omega_{i,t}$, and structures tax term	$b_1 =$ 0.038 (0.001), $b_2 = -0.846$ (0.323)

3.4 Estimates of the Eisner and Nadiri (1968) Specification

Table 6 reviews articles that estimate variants of the equation:

$$k_{i,t} = b_0^{\text{E-N}k,r} + b_1^{\text{E-N}k,r} r_{i,t} + b_2^{\text{E-N}k,r} y_{i,t} + e_{i,t}. \tag{50}$$

Two key features distinguish estimation using equation (50). First, the inclusion of firm log revenue $y_{i,t}$ as a second regressor. Second, an explicit focus on long-run outcomes.[17] As a result, it identifies the elasticity of substitution η.

Proposition 3 *In the environment of Section 2.5 with CES production, equation* (50) *estimated across steady states recovers plim* $b_1^{E\text{-}Nk,r} = -\eta$ *and plim* $b_2^{E\text{-}Nk,r} = \eta + (1-\eta)/\nu$.

Proof. See equations (32) and (33). ■

Taking the Cobb-Douglas case for simplicity, controlling for Y or not changes the "steady state user cost elasticity" from -1 to $-1/(1-\gamma)$.[18]

[17] At short horizons, equation (50) still identifies η for a suitably defined user cost $R_{i,t}$ that includes the marginal adjustment costs and changes to λ (see Footnote 6). In this case, the appropriate control is revenue $y_{i,t}$ in the period in which the capital is used. For example, with time-to-build in capital the appropriate Eisner and Nadiri (1968) specification control is future revenue. Of course, this specification also requires the time-varying, endogenous $r_{i,t}$ rather than the steady state, exogenous r_i as the main regressor, and capital rather than investment as the dependent variable, making clear the differences between Coen (1969) and Eisner and Nadiri (1968) specifications even at short horizons. In addition, there is no theoretical rationale for the regression residual in equation (50) that does not affect the interpretation of the coefficients. For example, variation in productivity $A_{i,t}$ across firms would also affect $y_{i,t}$, making the residual correlated with one of the regressors.

[18] In fact, in the knife-edge case where $\eta = 1$ exactly and with variation across firms only in the log user cost r_i, equation (50) has a multicollinearity problem, since $y_i = \gamma/(1-\gamma) r_i$ plus a constant (see equations (24) and (27)).

Table 6: Estimates of the Eisner and Nadiri (1968) Specification

Article	Table (col.)	Estimating equation	Data	Variation	b (s.e.)	Transformation
Caballero, Engel and Haltiwanger (1995)	Fig. 4	$\Delta(k_{i,t}-y_{i,t}) = b_0 + b_1 r_{i,t} + b_2(k_{i,t-1}-y_{i,t-1}) + b_3 \Delta r_{i,t}$	LRD manufacturing 1972-1988	2-digit SIC industry, constrain b_1, b_2, b_3 by 2 digit sector	Not reported	b_1/b_2 (Lemma B.5): $\eta \subseteq [0.01, 2]$ (mean=1)
Chirinko, Fazzari and Meyer (1999)	4(orth. dev.)	$I_{i,t}/K_{i,t-1} = b_0 + \sum_{h=0}^{H} b_{1,h}\Delta r_{i,t-h} + \sum_{h=0}^{H} b_{2,h}\Delta y_{i,t-h}$	Compustat annual 1981-1991	2-digit SIC industry, Arellano and Bover (1995) orthogonal deviation estimator with $H=2$ for b_1, $H=4$ for b_2, control for cash flow	$\sum_h b_{1,h} = -0.26(0.046)$, $\sum_h b_{2,h} = 0.209(0.072)$	$\eta = -\sum_h b_{1,h}, \alpha+\beta = (1+\sum_h b_{1,h})/\sum_h(b_{1,h}+b_{2,h})$ (Lemma B.6): $\eta = 0.26, \alpha+\beta < 0$
Chirinko, Fazzari and Meyer (2011)	1(1)	$k_{i,t} = b_0 + b_1 r_{i,t} + b_2 y_{i,t}$	Compustat + DRI 1972-1991	Differences of averages over 1972-77, 1978-84, 1985-91, tax-adjusted user cost from DRI	$b_1 = -0.367(0.068), b_2 = 0.925(0.038)$	$\eta = -b_1, \alpha+\beta = (1+b_1)/(b_1+b_2)$ (proposition 3): $\eta = 0.367, \alpha+\beta = 1.135$
Dwenger (2014)	5(1)	$k_{i,t} = b_0 + b_1 r_{i,t-1} + b_2 y_{i,t-1} + b_3 k_{i,t-1}$	Hoppenstedt (German accounting data) 1987-2007	2-digit industry, control current and lagged changes in r and y	$b_1 = -0.606(0.107)$, $b_2 = 0.406(0.075), b_3 = 0.352(0.067)$	$\eta = -b_1/(1-b_3), b_2/(1-b_3) = \eta + \frac{1-\eta}{\alpha+\beta}$ (Lemma B.7): $\eta = 0.935, \alpha+\beta < 0$

Chirinko, Fazzari and Meyer (2011) implement equation (50) by differencing across five-year averages of firm-level capital and tax-adjusted user cost. Treating the five-year periods as distinct steady states, they find an elasticity of substitution of $\eta = 0.367$ and returns to scale in the revenue function of $\alpha + \beta = 1.135$. Other Eisner and Nadiri (1968) specifications replace the dependent variable with either the log capital-output ratio $k_{i,t} - y_{i,t}$ or $I_{i,t}/K_{i,t-1}$ and take alternative approaches to allowing for non-instant adjustment of capital to its desired level. Caballero, Engel and Haltiwanger (1995) estimate the cointegration model (B.3a) and find implied values of η between 0 and 2 across 2 digit manufacturing industries, with a mean η of 1.

Chirinko, Fazzari and Meyer (1999) and Dwenger (2014) make alternative *ad hoc* assumptions about how investment or capital depends on lagged values of "desired capital", denoted by $K^*_{i,t}$ and defined as the solution to equation (32) taking $Y_{i,t}$ as given. Chirinko, Fazzari and Meyer (1999) regress $I_{i,t}/K_{i,t-1}$ on current and lagged changes in $r_{i,t}$ and $y_{i,t}$ and find an elasticity of substitution $\eta = 0.26$.[19] Dwenger (2014) instead estimates an error correction model of log capital regressed on lags of the user cost, output, and capital. Using German data, she finds $\eta = 0.935$.[20] Both studies find negative implied returns to scale.

As described above, Curtis et al. (2021) estimate a 10 year firm-level response of log capital to bonus depreciation. They also estimate the 10 year response of log employment and find a response as high or higher than the capital response. Across steady states, equations (9a), (12), (31a) and (31b) give $dk_i - d\ell_i = -\eta\,(dr_i - dw)$. If dw doesn't vary across firms due to a common labor market and the 10 year response reflects the new steady state, then their result implies an elasticity of substitution $\eta \leq 0$.

[19] Illustrating some of the difficulties in comparing across studies, Chirinko, Fazzari and Meyer (1999, pp. 69-71) directly compares their results to Cummins, Hassett and Hubbard (1994) without taking account of either the difference between the distributed lag specification in Chirinko, Fazzari and Meyer (1999) and the one-year specification in Cummins, Hassett and Hubbard (1994) or the importance of controlling for firm revenue. The same comparison is made in Chirinko (2008).

[20] I include this article because it has featured prominently in the U.S. policy debate (see e.g. Council of Economic Advisers, 2019; Congressional Research Service, 2024; Council of Economic Advisers, 2025) and it offers a methodological critique of and alternative to the distributed lag assumption in Chirinko, Fazzari and Meyer (1999). It also again illustrates the problematic cross-study comparisons prevalent in the literature. Dwenger (2014, pp. 162-163) includes a review of "the user cost elasticity" that discusses quantitative results in Eisner and Nadiri (1968), Auerbach and Hassett (1992), Cummins, Hassett and Hubbard (1994, 1996), Caballero, Engel and Haltiwanger (1995), Chirinko, Fazzari and Meyer (1999), Chirinko, Fazzari and Meyer (2011), and Hassett and Hubbard (2002) without accounting for the key specification differences across these studies in whether they control for output or not and the adjustment horizon. Council of Economic Advisers (2019, 2025) and Hartley, Hassett and Rauh (2025) likewise compare without adjustment the results in Cummins, Hassett and Hubbard (1994) and Dwenger (2014).

In summary, estimates of the Eisner and Nadiri (1968) specification holding revenue fixed yield values for the elasticity of substitution between capital and labor stretching from below zero to 1. Several of these estimates also imply implausible returns to scale in the revenue function, however, suggesting some caution in using tax variation to identify this parameter.

3.5 Estimates of Asset-Level Specifications

All of the studies reviewed so far use variation at the level of the firm or industry. An alternative approach uses variation and outcomes at the asset class level:

$$I_{j,t}/K_{j,t-1} = b_0^{\text{Asset } I/K,R} + b_1^{\text{Asset } I/K,R} R_{j,t} + e_{j,t}, \tag{51}$$

where the index j rather than i indicates asset rather than firm-level analysis.

The interpretation of $b_1^{\text{Asset } I/K,R}$ hinges on the degree to which asset types correspond to specific industries. Concretely, suppose there are capital types $K_1, K_2, \ldots$ and industry revenue functions $F^1(K_1, K_2, \ldots, L), F^2(K_1, K_2, \ldots, L), \ldots$, where $F^i()$ denotes the revenue function for industry i. If each industry uses only one type of capital, i.e. $F^i(K_1, K_2, \ldots, L) = F^i(K_i, L)$, then the variation in equation (51) mimics a Coen (1969) industry-level analysis and Lemma B.3 applies. If instead all industries share the same technology and use all types of capital, i.e. $F^i(K_1, K_2, \ldots, L) = F^{i'}(K_1, K_2, \ldots, L)\ \forall i, i'$, then equation (51) more closely resembles an Eisner and Nadiri (1968) specification but with substitution in the production process occurring across capital types rather than between capital and labor. (Here the regression intercept plays the role of controlling for total output.) However, because proposition 3 relates long-run variation in log capital to the user cost, equation (51) does not afford easy interpretation in this case.

U.S. Bureau of Economic Analysis (2025) provides asset-by-industry data for 74 industries and 94 asset types, which can help to distinguish these cases. For the median asset type, roughly half of economy-wide capital of that type concentrates in one industry. For the median industry, close to 40% of its capital is of one type. These concentration levels may support a Coen (1969) interpretation, but also suggest prudence in comparing to firm-level analyses.

Table 7 reports results from two studies using asset-level variation. Auerbach and Hassett (1991) analyze investment patterns across asset classes after the 1986 reform and find assets with

Table 7: Estimates of Asset-Level Specifications

Article	Table (col.)	Estimating equation	Data	Variation	b (s.e.)	Transformation
Auerbach and Hassett (1991)	7(3)	$I_{j,t}/K_{j,t-1}$ = $b_0 + b_1 R_{j,t}$	BEA equipment by asset type 1987	Asset level weighted by investment, projecting out expectations	-0.82 (0.26)	$-b \times R$ (Lemma B.3), $R = 0.226$ (Appendix B): $-b_1^{\text{Asset } I(0)/K,r} = \chi dk_i/dr_i = 0.15$
Hartley, Hassett and Rauh (2025)		$I_{j,t+h}/K_{j,t+h-1}$ = $b_0 + b_1 R_{j,t}$	BEA Fixed Asset Tables	Asset-level in differences from 2016 (het. SEs)		$-b \times R$ (Lemma B.3), $R = 0.2058$ (Appendix table 2):
	1(2)		2018		-1.689 (0.890)	$-b_1^{\text{Asset } I(0)/K(0),r} = \chi dk_i/dr_i = 0.35$
	1(3)		2019		-1.057 (0.847)	$-b_1^{\text{Asset } I(1)/K(1),r} = \chi e^{\chi} dk_i/dr_i = 0.22$
	1(4)		2020		-1.115 (1.113)	$-b_1^{\text{Asset } I(2)/K(2),r} = \chi e^{2\chi} dk_i/dr_i = 0.23$
	1(5)		2021		-2.873 (1.166)	$-b_1^{\text{Asset } I(3)/K(3),r} = \chi e^{3\chi} dk_i/dr_i = 0.59$
	1(6)		2022		-3.053 (1.180)	$-b_1^{\text{Asset } I(4)/K(4),r} = \chi e^{4\chi} dk_i/dr_i = 0.63$
	1(7)		2023		-1.282 (1.154)	$-b_1^{\text{Asset } I(5)/K(5),r} = \chi e^{5\chi} dk_i/dr_i = 0.26$

larger declines in the user cost had larger increases in investment.[21] Applying a Coen (1969) interpretation, their coefficient implies $-b_1^{\text{Coen}I(0)/K,r} = 0.15$, below the range established in Section 3.2. Hartley, Hassett and Rauh (2025) use variation induced by the TCJA and report separate regressions for changes in the investment-capital ratio from 2016 to each year in 2018-2023. Applying a Coen (1969) interpretation, their 2018 coefficient translates into $-b_1^{\text{Coen}I(0)/K,r} = 0.35$. Dividing each horizon's rescaled coefficient by $e^{\chi h}$ and averaging across their coefficients for 2018-2023, for $\chi \subseteq (-0.18, -0.1)$ the translated values imply $-b_1^{\text{Coen}I(0)/K,r} \subseteq (0.51, 0.65)$, in the upper-middle part of the range shown in Table 4.

4 Implied Parameters

This section asks what light the evidence summarized in Section 3 can shed on primitive parameters of the revenue function. This step formally connects the firm-level empirical evidence to the macroeconomic elasticities in the next section.

I consider a "representative" firm and drop the i index on parameters. Under the maintained assumption that labor is a flexible input, the labor share of revenue β^* is observable in national

[21] Bosworth (1985) is the first article of which I am aware to examine the cross-sectional pattern of investment following a tax reform. It reported correlations of investment surprises and tax changes and concluded that non-tax forces dominated investment in the years after the 1981 and 1982 tax changes.

income data. I externally calibrate it to 0.65. I also set the discount rate $\rho = 0.06$ and the user cost $R = 0.2$.[22] This leaves the following parameters: the adjustment cost scalar ϕ, the capital-labor substitution elasticity η, and either the total returns to scale in the revenue function ν or, equivalently, the revenue elasticity of capital $\alpha^* = \nu - \beta^*$. In principle, the different specifications reviewed in Section 3 can identify all of these objects.

Table 3 reviewed studies that estimate the adjustment cost parameter ϕ. Using tax variation as an instrument, Cummins, Hassett and Hubbard (1996, table 7) found a value $\phi = 1.5$. The other studies found much larger values, but may suffer from attenuation bias. Most subsequent work has attempted to identify adjustment costs using non-tax moments, reflecting the difficulty of distinguishing marginal and average Q and interest in non-convex adjustment costs (Cooper and Haltiwanger, 2006; Winberry, 2021).

Table 6 reviewed studies that estimate the capital-labor substitution elasticity η. Values ranged from 0.3 to above 1, with 0.9 being from the most recent study. By comparison, Chirinko (2008), Knoblach, Roessler and Zwerschke (2020), and Gechert et al. (2022) conduct meta-analyses of both tax and non-tax based approaches and argue for values of between 0.4 and 0.6, between 0.5 and 0.9, and 0.3, respectively. Congressional Budget Office (2018*b*) uses a value of 0.7, while Council of Economic Advisers (2019, 2025) use a value of 1.

Table 4 reviewed studies estimating variants of the Coen (1969) elasticity. The long-run Coen (1969) elasticity depends only on α^*, β^*, and η. A short-run specification also involves the eigenvalue χ given in equation (43), and hence the adjustment cost parameter ϕ. Intuitively, with constant returns to scale in the firm's revenue function, $\alpha^* + \beta^* = \nu = 1$, the long-run elasticity diverges to $-\infty$ (see equation (35)); the finite empirical values found in Table 4 must then indicate either $\alpha^* + \beta^* < 1$ or short-run adjustment costs. Formally:

$$plim b_1^{\mathrm{Coen} I(0)/K,r} = -\chi dk_i/dr_i = -\left(\frac{\rho}{2} - \sqrt{\left(\frac{\rho}{2}\right)^2 - \left(\frac{dk_i}{dr_i}\right)^{-1}\frac{R}{\phi}}\right) \times \left(\frac{dk_i}{dr_i}\right), \tag{52}$$

where dk_i/dr_i is given by equation (35) (see equations (43) and (45) and proposition 2).

The literature has pursued two approaches to distinguish the roles of decreasing returns to

[22] While these values may have changed over time, sampling uncertainty in the empirical studies likely swamps variation due to changes in these parameters, and it facilitates comparisons to keep them fixed. For example, the corporate labor share in the U.S. fell from roughly 0.65 in the 1980s to 0.6 in the 2010s (Karabarbounis and Neiman, 2014) and the cost of debt has also declined (Gormsen and Huber, 2023).

scale and adjustment costs. Auerbach and Hassett (1992) assign values of α^*, β^*, and η, which collectively characterize dk_i/dr_i, and back out ϕ using equation (52). Chodorow-Reich et al. (2025) instead set χ directly, which recovers the implied long-run coefficient and hence the value of α^* given calibrated values for β^* and η, as well as a value for ϕ using the expression for χ in equation (43). The advantages of the second approach are: (i) calibration of χ can incorporate external information on adjustment costs and transition dynamics such as from moments of the firm investment distribution, (ii) the ratio of the short-to-long-run elasticity is a portable statistic that continues to apply under more complicated adjustment cost models than quadratic costs, and (iii) the transparency of setting χ directly allows readers to easily substitute their own preferred rescaling. The drawback is that χ is not a deep structural parameter (in fact it depends on policy—see the presence of R_i in equation (43)).

Figure 2 presents implications for α^* and ϕ under both approaches, taking as inputs various combinations of $b_1^{\text{Coen}I(0)/K,r}$, χ, and η, given the labor share β^*. The figure contains "trees" based on representative values for the short-run semi-elasticity of the investment-capital ratio to the user cost $b_1^{\text{Coen}I(0)/K,r} \in \{-0.25, -0.5, -0.75\}$ (see Table 4). The top "branches" assume a Cobb-Douglas revenue function with constant returns to scale, $\alpha^* + \beta^* = \eta = 1$, such that equation (46) applies and $\phi = -R/\left(\rho b_1^{\text{Coen}I(0)/K,r}\right)$. While a useful and common benchmark, the persistent coexistence of firms with different tax-adjusted user costs provides a *prima facie* steady state moment that argues against constant returns in the revenue function. The other branches vary $\chi \in \{-0.12, -0.16\}$ and $\eta \in \{0.5, 1\}$. The value $-\chi/\delta$ has the interpretation of the ratio of the short-run to the long-run impulse response shown in Figure 1(b). In that figure's calibration $\chi \approx -0.15$, with an impact response of 1.24% and long-run response of 0.84% yielding a ratio of $-\chi/\delta = 1.5$.[23] Thus, a larger magnitude of χ implies a more steeply declining impulse response of investment. The values of $\eta \in \{0.5, 1\}$ span the Cobb-Douglas value of 1 and a lower elasticity of substitution as found in some of the studies in Table 6 and in the meta-analysis by Knoblach, Roessler and Zwerschke (2020).

[23] Chodorow-Reich et al. (2025) argue that $\chi = -0.14$ is a plausible value based on calibrations of firm-level adjustment costs such as in Winberry (2021). Their analysis focuses on the ratio of the short-to-long run elasticity $-\chi/\delta$. Using $\delta = 0.1$, this ratio is 1.4, consistent with their analysis of Winberry (2021). With fixed in addition to convex costs of adjustment, the hazard rate of adjustment and hence the ratio of the short-to-long run impulse response may depend on the magnitude of the shock. This scale dependence is a second-order feature of the transition and disappears when idiosyncratic shocks dominate policy variation in determining when firms adjust.

Figure 2: Regression Coefficients, Firm Parameters, and Aggregate Elasticities

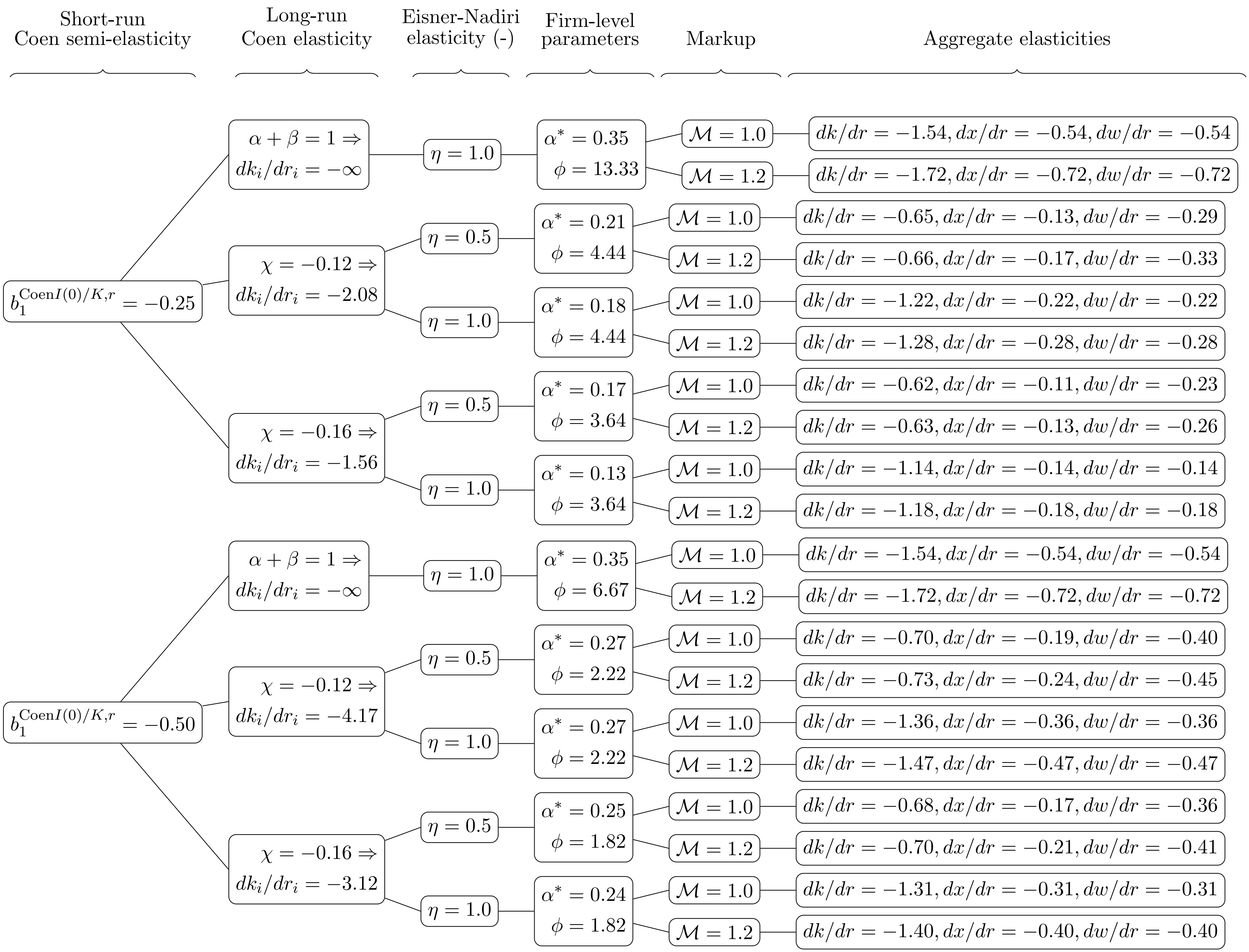
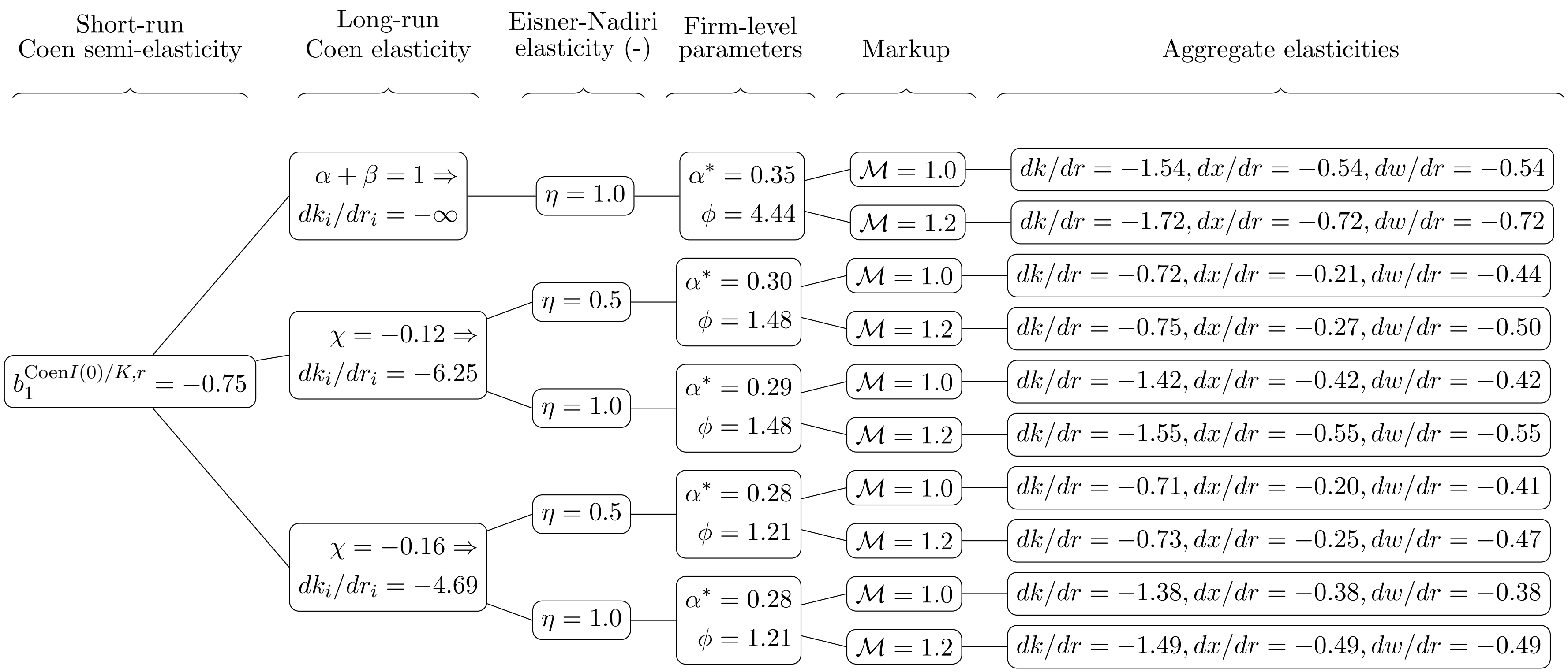


Figure 2: continued



Notes: Each "tree" starts from a value for the short-run semi-elasticity of I/K to the user cost r of $b_1^{\text{Coen}I(0)/K,r}$. The first "branch" sets either the total returns to scale $\alpha+\beta$ to 1, or a value for the ratio of the short-run semi-elasticity to the long-run elasticity $-\chi$. These values determine the long-run Coen elasticity dk_i/dr_i. The next branch sets the elasticity of subsitution η, which determines the firm-level revenue elasticity of capital α^* and the adjustment cost scalar ϕ. The last branch sets the markup $\mathcal{M}$. The final "leaves" give the implied values for the long-run general equilibrium user cost elasticity of capital, output, and the wage. All trees use a value for the labor share $\beta^* = 0.65$.

Figure 2 contains several lessons, with the focus here on the four left-most nodes; the next section will discuss the nodes labeled "Aggregate elasticities". First, the long-run Coen (1969) firm-level elasticity of capital to the user cost, dk_i/dr_i, is always below -1 and sometimes substantially so. Equation (28) showed this inequality analytically in the Cobb-Douglas case, but it does not necessarily carry over to the CES case, where small enough η and ν can make the long-run elasticity close to zero. For the mid-point short-run semi-elasticity of investment, the long-run elasticity is around -3 or below. This conclusion highlights the difference between the long-run Coen (1969) firm-level elasticity, on the one hand, and the Hassett and Hubbard (2002) range or the elasticity of substitution between capital and labor and associated "neoclassical benchmark" of -1 on the other. Notably, it does not depend on the assumption of quadratic adjustment costs, but only the existence of some plausibly-valued scalar relating the short and long-run elasticities.

Second, the values of α^* vary only slightly with η within a χ branch of a tree. This result obtains because the total returns to scale are not too far from 1 (see equation (35)). The fact that ϕ does not vary with η follows from equation (43), which shows that χ depends only on $\rho, R, dk_i/dr_i$, and ϕ.

Third, for the middle value $b_1^{\text{Coen}I(0)/K,r} = -0.5$, the implied values of α^* range from 0.24 to 0.35 and the values of ϕ vary between 1.8 and 6.7. The upper bounds come from the constant returns to scale branches. In the remainder, $\alpha^* \subseteq [0.24, 0.27]$, implying total returns to scale ν above 0.89, consistent with evidence favoring near-constant returns to scale (Basu and Fernald, 1997), and $\phi \leq 2.2$, consistent with the (untargeted) Cummins, Hassett and Hubbard (1996) value.

The reasonableness of the ranges of ν and ϕ constitutes a victory for microeconometric assessment of the neoclassical model. This point deserves amplication for those tempted to jump to the aggregate analysis in the next section. *A priori*, the microeconometric studies could have implied much smaller or larger values. Smaller microeconometric semi-elasticities would have required more sharply decreasing returns to scale at the firm level than typically assumed, or introducing some additional non-neoclassical elements into the analysis. As we will see, they would also imply smaller macroeconomic effects. Larger elasticities would imply near constant returns to scale in the firm's revenue function, or quite small adjustment costs.

5 From Microeconometric Studies to Aggregate Outcomes

This section explores what the parameter values found in Section 4, based on firm or asset-level regressions, imply for the aggregate long-run elasticity of capital to the user cost as well as the effect on output, wages, and tax revenue. The firm-level and aggregate elasticities differ because the individual firm takes the wage and aggregate demand as fixed, while in general equilibrium, these variables are endogenous. Changes to variables that affect all firms instead appear in the constant term of a firm-level regression, giving rise to a "missing intercept".[24]

Section 5.1 derives the general equilibrium Barro and Furman (2018) user cost elasticity and provides values consistent with the cross-sectional evidence. Section 5.2 discusses important extensions. Section 5.3 moves from a user cost to tax term elasticity by allowing the interest rate or capital goods price to respond to higher investment. Section 5.4 derives the neoclassical revenue-maximizing corporate tax rate and shows that the current U.S. regime likely lies far below it.

5.1 The General Equilibrium User Cost Elasticity

Interest in the long-run aggregate elasticity dates to Hall and Jorgenson (1967), who as noted reported counterfactual exercises assuming an elasticity of capital of -1 and no feedback effect from output. Their reply to the Coen (1969) critique anticipates some of the inconsistencies of subsequent approaches: "Another question which could be asked is the general equilibrium one: What were the overall effects of tax incentive policies, assuming no alternative compensatory policy? The answer waits for the development of a satisfactory model of general equilibrium in the United States economy" (Hall and Jorgenson, 1969, p. 394).

In fact, under some simplifying assumptions the Coen (1969) elasticity has an analytic general equilibrium counterpart. Maintain the following assumptions in addition to the environment considered in Section 2:

1. The economy consists of a large number of identical firms of mass one, all subject to the same tax schedule.

[24] Following this logic, if firms have monopsony power and face upward-sloping labor supply curves, the gap between the cross-firm and general equilibrium user cost elasticities of capital is reduced. Kennedy et al. (2026) and Curtis et al. (2021) both test for and find no evidence that their treated firms increase wages for most workers relative to control firms, despite their increasing relative employment.

2. Aggregate labor is fixed.

Assumption 1 implies that all firms make the same choices. This property resolves the component of the "missing intercept" due to aggregate output. Recall that variables without i subscripts denote aggregate quantities and prices. By symmetry, $P_{i,t} = P_t$ and hence $X_{i,t} = Y_{i,t} = X_t$. Using $da_{i,t} = \left(\frac{\mathcal{M}-1}{\mathcal{M}}\right) dx_t + \left(\frac{1}{\mathcal{M}}\right) d\tilde{a}_{i,t}$ (see equation (5)) and the linearization of the revenue function (17):

$$dx_t = dy_t = \alpha^* dk_t + \beta^* d\ell_t + \left(\frac{\mathcal{M}-1}{\mathcal{M}}\right) dx_t + \left(\frac{1}{\mathcal{M}}\right) d\tilde{a}_{i,t} = \mathcal{M}\left(\alpha^* dk_t + \beta^* d\ell_t\right) + d\tilde{a}_{i,t}. \quad (53)$$

Thus, the aggregate output elasticity scales the firm-level revenue elasticity by the factor $\mathcal{M}$. For an individual firm facing the demand schedule (2), the value $\mathcal{M}$ equals the ratio of price to marginal cost, which I refer to as the markup.[25] Intuitively, when $\mathcal{M} > 1$ the elasticity of revenue to changes in capital or labor at all firms exceeds the firm-level revenue elasticity to idiosyncratic changes in factor inputs, because higher output at other firms also increases own firm revenue by shifting out the firm's demand curve.[26]

Assumption 2 holds for example with balanced growth path preferences in which the income and substitution effects of a change in the wage on labor supply perfectly offset each other. Assumptions 1 and 2 together imply that each firm's labor input remains the same before and after a tax change, $d\ell = 0$. The property that aggregate labor remains fixed while the wage adjusts resolves the appearance of the wage in the "missing intercept" and delivers the general equilibrium user cost elasticity as a comparative static of the first order condition for capital, now holding fixed labor rather than revenue (as in Eisner and Nadiri (1968)) or the wage (as in Coen (1969)).

Start with the Cobb Douglas case. Assumptions 1 and 2 imply that the aggregate economy behaves as if there is a single representative firm with production function:

$$X_t = Y_t = \tilde{A}_t K_t^{\mathcal{M}\alpha} \bar{L}^{\mathcal{M}\beta}.$$

Thus, while an atomistic firm's revenue elasticity of capital holding the wage fixed is $\gamma \equiv \alpha/(1-\beta)$

[25] Some of the studies reviewed in Section 3 exploit industry-level variation. In this case, the cross-sectional elasticities may still reflect downward-sloping demand even if no individual firm has price-setting power and charges a markup. Hence equations (54) to (57) still apply for an appropriately-calibrated demand elasticity.

[26] One can more directly arrive at equation (53) by totally differentiating the production function (1) and using $d \log \tilde{F}\left(K_{i,t}, L_{i,t}\right) = \mathcal{M} d \log F\left(K_{i,t}, L_{i,t}\right)$ (see equation (4)). This approach does not however convey the intuition that the elasticities differ because of spillovers from other firms.

(see equation (27)), the general equilibrium output elasticity holding labor fixed is $\mathcal{M}\alpha$.[27] The general equilibrium steady state user cost elasticity follows from applying the chain rule using equation (53) to equation (24):

$$\frac{dk}{dr} = -1 + \frac{\partial y}{\partial k}|_{d\ell=0} \times \frac{dk}{dr} = -\frac{1}{1-\mathcal{M}\alpha} \leq -1. \tag{54}$$

I refer to equation (54) as the Barro and Furman (2018) elasticity, as these authors use it with $\mathcal{M} = 1$ to model the aggregate effects of the TCJA. In that case, the mapping from the firm-level Coen (1969) long-run elasticity to the aggregate elasticity is particularly simple: the firm-level Coen elasticity recovers $\gamma = \alpha/(1-\beta)$, so specifying a value for the labor share β recovers α and hence the Barro and Furman (2018) general equilibrium elasticity. Notably, even with constant returns to scale in the revenue function, $\alpha + \beta = 1$, the Barro-Furman elasticity is finite due to labor being a fixed factor. The aggregate elasticity thereby sidesteps the "serious shortcomings" asserted by Hall and Jorgenson (1969) in the firm-level approach.[28]

Similar calculations give the Barro and Furman (2018) general equilibrium elasticity with CES production. Specifically, implicitly differentiate the capital first order condition (32), now holding labor fixed and allowing A_i to vary, and use the expressions above for da and dy:

$$\begin{aligned}\frac{dk}{dr} &= -\left(\frac{1}{\eta} - \left(1 + \frac{1-\eta}{\eta\nu}\right)\frac{\partial y}{\partial k}|_{d\ell=0} + \left(\frac{1-\eta}{\eta\nu}\right)\frac{\partial a}{\partial x}\frac{\partial x}{\partial k}|_{d\ell=0}\right)^{-1} \\ &= -\left(\frac{1}{\eta} - \left(1 + \frac{1-\eta}{\eta\mathcal{M}\nu}\right)\mathcal{M}\alpha^*\right)^{-1}.\end{aligned} \tag{55}$$

The output elasticity follows from equation (53):

$$\frac{dx}{dr} = \mathcal{M}\alpha^* \times \frac{dk}{dr}. \tag{56}$$

[27] While this as-if representative firm has output and real revenue elasticities $\mathcal{M}\alpha$ and $\mathcal{M}\beta$, α and β continue to give the revenue shares of capital and labor and the first order conditions (24) and (26) hold. Using this fact, with Cobb-Douglas one can generalize the aggregate labor supply equation to $L_t = c_w W_t^{\xi}$ for a constant c_w and wage elasticity ξ. To that end, substitute for W_t in equation (26) to find $L_t = \left(c_W^{1/\xi}\beta A_t K_t^{\alpha}\right)^{\frac{\xi}{1+(1-\beta)\xi}}$ and hence $d\ell/dk = \frac{\xi}{1+(1-\beta)\xi}(\alpha + da/dk)$, with $da/dk = (\mathcal{M}-1)(\alpha + \beta d\ell/dk)$ (see the expression above equation (53)). Using equation (53), the output elasticity of capital incorporating the positive labor supply response becomes $dy/dk = \mathcal{M}\alpha + \mathcal{M}\beta d\ell/dk = \mathcal{M}\alpha\left(1 + \frac{\mathcal{M}\beta\xi}{1+(1-\mathcal{M}\beta)\xi}\right)$, which exceeds $\mathcal{M}\alpha$ if $\xi > 0$. Using this expression in place of $\frac{\partial y}{\partial k}|_{d\ell=0}$ in equation (54) gives the general equilibrium elasticity of capital to the user cost. A positive labor supply elasticity therefore simply increases the effective output elasticity of capital.

[28] The notation for the general equilibrium elasticity, dk/dr, differs from the firm-level Coen elasticity, dk_i/dr_i, in one subtle but revealing aspect. Under the identical firm assumption, $dk = dk_i$. The derivative dk_i/dr_i is the firm's capital change when only its user cost changes, holding all other firms' user costs (and hence aggregate variables) fixed, while dk_i/dr is the response when all firms' user costs change together.

The wage elasticity equals the output elasticity plus the change in the labor share:

$$\frac{dw}{dr} = \frac{dx}{dr} + \frac{\partial \log \beta^*}{\partial k} \times \frac{dk}{dr}, \tag{57}$$

where $\partial \log \beta^* / \partial k = \left(\frac{1-\eta}{\eta \nu}\right) \alpha^*$ denotes the elasticity of the labor share of revenue to a change in capital, holding labor fixed (see equation (A.8)). Thus, as previewed in Section 2.3, both the Eisner and Nadiri (which identifies η) and Coen (which helps to identify ν and α^*) firm-level specifications provide important parameter inputs to the aggregate capital, output, and wage elasticities.[29]

Figure 2 summarizes values for these elasticities consistent with the short-run cross-firm evidence, now with the focus on the final node, labeled "Aggregate elasticities". To arrive at this node from the firm-level parameters, I consider $\mathcal{M} \in \{1, 1.2\}$.[30] Continuing from firm-level revenue elasticities and branching for $\mathcal{M}$ acknowledges the difficulty of measuring markups directly and hence distinguishing market power from physical decreasing returns at the firm level. Put differently, while the primitive technology parameters come from the production function, $\mathcal{M}\alpha$ and $\mathcal{M}\beta$, the observable calibration targets are the labor share of revenue β^* and (using the evidence from Section 3 and the firm-level branches) the revenue elasticity of capital α^*.

Several lessons again emerge. First, under Cobb Douglas, the long-run Barro and Furman (2018) elasticity is always below -1, ranging from -1.2 to -1.7, illustrating again the difference between a general equilibrium elasticity and the "neoclassical benchmark" of -1. This range is notably tighter than the range of long-run firm-level Coen (1969) elasticities, which varied between -1.6 and $-\infty$ (or -1.6 and -6.3 away from the constant returns case). The reason is that labor is a fixed factor in general equilibrium, which dampens the overall response. The elasticity of -1.6 used in the actual Barro and Furman (2018) article lies at the upper end of this range (they set $\alpha = 0.38$ implying $-1/(1-\alpha) = -1.6$).

Second, the capital and output elasticities are smaller with $\eta = 0.5$, about half of their values with Cobb Douglas. Qualitatively, as the elasticity of substitution between capital and labor declines, the fixed factor of labor generates faster decreasing returns to capital accumulation. Quantitatively, with constant returns to scale in the production function, $\mathcal{M}\nu = 1$, the Barro and

[29]In fact, from this perspective a firm-level specification controlling for changes in labor would also appear quite informative for the aggregate capital elasticity. I am not aware of any such empirical work.

[30]As noted by Oberfield and Raval (2021), the firm-level and aggregate elasticities of substitution can differ due to cross-firm substitution. Assumption 1 rules out cross-firm substitution; in the more general case, the appropriate macroeconomic η would include such substitution.

Furman (2018) elasticity (55) simplifies to $-\eta/(1-\mathcal{M}\alpha^*)$ and hence scales with η.[31] The empirical evidence from Table 4 requires values of ν large enough that this approximation roughly holds.

Third, although capital and output respond less when η is smaller, the wage elasticity is nearly invariant. Qualitatively, while capital responds less when $\eta < 1$, the wage responds more per unit of capital. Quantitatively, with constant returns in the production function the general equilibrium wage elasticity simplifies to $-\mathcal{M}\alpha^*/(1-\mathcal{M}\alpha^*)$ and hence does not depend on η.

Fourth, the general equilibrium elasticities are increasing (in absolute value) in $\mathcal{M}$. In partial equilibrium and fixing the returns to scale in the production function, a higher markup reduces the Coen (1969) elasticity because it lowers the returns to scale in the revenue function. Fixing the Coen (1969) elasticity as estimated in the data, however, a larger markup implies a larger output elasticity, increasing the general equilibrium response.

5.2 Extensions of the Baseline Model

The baseline neoclassical model used so far contains several simplifications and parameter restrictions. The article's conclusion will highlight directions for future research that develop various departures from this setup. It is important to clarify here two of the easier extensions.

First, the production and revenue functions in equations (1) and (3) do not explicitly include intermediate inputs, which can matter to aggregation (Basu and Fernald, 1997). For the realistic benchmark case of a constant share of intermediate input costs in gross revenue (Atalay, 2017), Appendix A.5 shows that the Eisner and Nadiri (1968) revenue-fixed and Coen (1969) wage-fixed user cost elasticities again remain unchanged, with α_i^* and β_i^* still the shares of capital and labor income in revenue net of intermediate input costs. Therefore, the mapping from firm-level regressions to parameters remains unchanged. Furthermore, with a roundabout production structure (Basu, 1995), the formula for the Barro and Furman (2018) labor-fixed elasticity also remains unchanged, except that the markup parameter $\mathcal{M}$ is replaced by $\hat{\mathcal{M}} \equiv \frac{\mathcal{M}(1-\kappa)}{1-\mathcal{M}\kappa}$, where κ denotes the share of intermediate inputs in gross revenue. For $\mathcal{M} \approx 1$ and $\kappa \approx 0$, the parameters

[31] One can also arrive at this formula by following a cobweb adjustment process analogous to that in Section 2.4. With CES, the direct effect on capital holding output fixed is $dk_0 = -\eta dr$. This additional capital increases output by $dy_0 = -\mathcal{M}\alpha^*\eta dr$ (see equation (53)). With constant returns to scale, additional output increases desired log capital one-for-one (see equation (32)), yielding capital after one round of output feedback of $dk_1 = -\eta dr\,(1+\mathcal{M}\alpha^*)$. The additional capital further increases output and hence desired log capital by $\mathcal{M}\alpha^* dk_1$, giving $dk_2 = -\eta dr\left(1+\mathcal{M}\alpha^*+\mathcal{M}^2\alpha^{*2}\right)$. Iterating forward, $dk = -\eta dr/\left(1-\mathcal{M}\alpha^*\right)$.

$\hat{\mathcal{M}}$ and $\mathcal{M}$ differ only in second-order terms. Quantitatively, given a ratio of intermediate inputs to gross output in the U.S. private sector of about $\kappa = 0.43$, a value for $\mathcal{M}$ of 1.1 implies $\hat{\mathcal{M}} = 1.2$.

Second, the corporate tax rate applies only to C-corporations in the U.S., which accounted for 43% of private sector employment in 2022 (U.S. Census Bureau, 2022). For changes to the corporate rate only, the formulas in equations (55) to (57) assume full segmentation of labor markets across these sectors. Otherwise, the presence of a non C-corporate sector makes the responses of C-corporate capital and output larger, offset by the decline in the non C-corporate sector as labor migrates out. Locally, if firms in different sectors differ only in their form of taxation, then the responses of aggregate capital, output, and the wage simply scale their counterparts in Figure 2 by the factor 0.43 of initial activity in the corporate sector (see Appendix A.6).[32]

5.3 The General Equilibrium Tax-term Elasticity

The general equilibrium elasticities summarized in Figure 2 apply to changes in the user cost $R = (\rho + \delta)P^K \times \Omega$. As a result, they apply holding fixed the non-tax component $(\rho + \delta)P^K$ when the tax term $\Omega \equiv (1 - \Gamma)/(1 - \tau)$ changes. However, the non-tax component could change endogenously, for example due to crowd-out from an upward-sloping savings curve that makes ρ a function of K, or an upward-sloping capital supply curve that makes P^K a function of K. Let $\zeta \equiv d\left[\log(\rho + \delta) + p^K\right]/dk$ denote the inverse supply elasticity.

Figure 3 summarizes the equilibrium inclusive of any changes to the non-tax component of the user cost. The vertical axis is the log of the non-tax component. The downward sloping lines have slope $(dk/dr)^{-1}$. A decline from Ω to $\Omega' < \Omega$ shifts the schedule to the right by the amount $dk/dr \times d\log\Omega$. With $\zeta = 0$, this shift gives the total effect of the tax change. With $\zeta > 0$, $dk/d\log\Omega$ is reduced. Algebraically, the equilibrium is the solution to the system of equations:

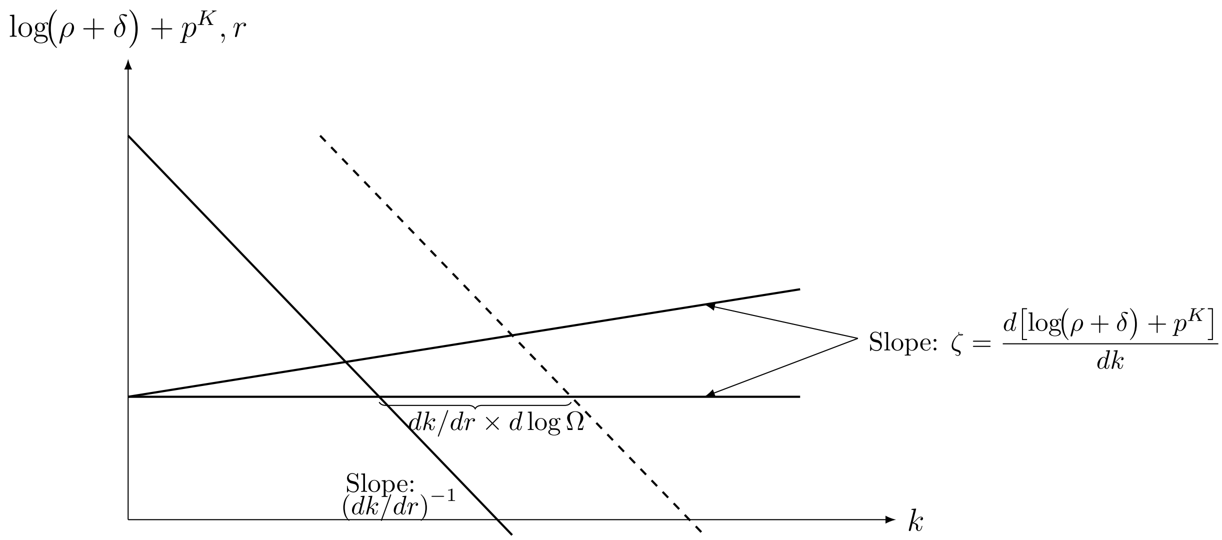
$$\text{Capital demand:} \qquad dk = (dk/dr)\, d\left[\log(\rho + \delta) + p^K + \log\Omega\right],$$

$$\text{Capital supply:} \qquad d\left[\log(\rho + \delta) + p^K\right] = \zeta dk,$$

$$\text{Equilibrium:} \qquad dk = \frac{dk/dr}{1 - \zeta\,(dk/dr)} d\log\Omega.$$

[32] Empirically, Kennedy et al. (2026, table 8) find that workers moved from S corporations to C corporations following the TCJA (which had provisions that affected both firms, but applied larger rate cuts to C-corporations). Their market-level analysis implies general equilibrium wage elasticities slightly smaller than the range implied by scaling values in Figure 2 by 0.43.

Figure 3: General Equilibrium Tax Elasticity



The total general equilibrium elasticity of capital to a tax change therefore combines dk/dr with a value for ζ. In an infinite horizon Ramsey economy or a small open economy facing a world interest rate, the discount rate ρ remains fixed. Moll, Rachel and Restrepo (2022) provide several microfoundations for a departure from this assumption and advocate a semi-elasticity of savings to the interest rate of 50, implying $\zeta = 1/(\rho+\delta) \times 1/50 = 0.125$ using $\rho+\delta = 0.16$ if $P^K = 1$. This value provides an upper bound for the response of $\rho+\delta$ to corporate tax changes, since corporate capital is only about 40% of the total capital stock. Goolsbee (1998) finds a large response of capital goods prices to tax incentives, $dp^k/dr < 0$. House and Shapiro (2008) and House, Mocanu and Shapiro (2022) dispute this conclusion, with House, Mocanu and Shapiro (2022) finding that the Goolsbee (1998) result disappears with revised data or in longer samples and arguing instead that $dp^K/dk \approx 0$. The reverse sign, $dp^k/dr > 0$, could also arise if the tax incentives concentrate in capital goods-producing firms that respond by increasing production, similar to investment-specific technical change (Greenwood, Hercowitz and Krusell, 1997).

5.4 The General Equilibrium Elasticity of Tax Revenue

The elasticity of tax revenue to changes in tax policy plays a key role in policy debates and in the optimal tax literature. It also provides another opportunity to illustrate the importance of distinguishing firm-level and aggregate elasticities.

To begin, define steady state corporate taxable profits $\pi(K,L) = Y - WL - z(\rho+\delta) P^K K$.[33] The general equilibrium elasticity of corporate taxes with respect to the corporate rate, holding labor fixed, is:

$$\frac{d\log\tau\pi}{d\log\tau} = 1 - \left(\frac{\tau}{1-\tau}\right)\frac{d\log\pi}{d\log(1-\tau)}, \tag{58}$$

$$\text{where: } \frac{d\log\pi}{d\log(1-\tau)} = \left(\left(\mathcal{M}\alpha^* - z\Omega^{-1}\alpha^*\right)\frac{dk}{d\log(1-\tau)} - \beta^*\frac{dw}{d\log(1-\tau)}\right) / \left(\frac{\pi}{Y}\right) \tag{59}$$

is the elasticity of taxable profits to the net-of-tax corporate rate (see equation (A.31)). The taxable profits elasticity has the following intuition. In the numerator, the change in the corporate tax base when capital increases equals the change in output, $\mathcal{M}\alpha^* dk$, less the additional depreciation deductions $z\Omega^{-1}\alpha^* \times dk = z(\rho+\delta) P^K dK/Y$, less the change in the wage dw multiplied by the labor share of output β^*. The denominator scales this change by the profit ratio $\pi/Y = 1 - \beta^* - z\Omega^{-1}\alpha^*$.[34] The elasticities of capital and the wage to the net of tax rate in equation (59) relate to the user cost elasticities in equations (55) and (57) by $dk/d\log(1-\tau) = dk/dr \times dr/d\log(1-\tau)$ and $dw/d\log(1-\tau) = dw/dr \times dr/d\log(1-\tau)$, where using $R = (\rho+\delta)P^K \times (1-\tau z)/(1-\tau)$:

$$\frac{dr}{d\log(1-\tau)} = -\frac{1-z}{1-\tau z}. \tag{60}$$

The elasticity of labor taxes with respect to the corporate rate is:

$$\frac{d\log\tau^L WL}{d\log\tau} = -\left(\frac{\tau}{1-\tau}\right)\frac{dw}{d\log(1-\tau)}, \tag{61}$$

where τ^L denotes the labor tax rate. The same elasticities also govern the response of tax revenue to the present value of depreciation incentives z (see equation (A.32)).

These elasticities collectively inform the revenue-maximizing corporate tax rate (holding z fixed), a key object in the optimal tax literature (Swonder and Vergara, 2025). This rate solves

[33] To streamline the analysis, this sub-section assumes uniform taxation of all business income, which with abuse of terminology I refer to as the corporate tax system. It also ignores payout taxes (e.g. dividend taxes) and the transition path and sets $\zeta = 0$. See Chodorow-Reich et al. (2025) for a quantitative evaluation of TCJA incorporating these features. To understand why steady state corporate profits deduct $z(\rho+\delta) P^K K$ from taxable income, note that the annuity value of a one-time present value deduction of zP^K per unit of investment equates to a flow deduction of $z(\rho+\delta) P^K$ per unit of capital.

[34] With Cobb-Douglas and $z = 0$, this formula simplifies considerably to $d\log\pi/d\log(1-\tau) = \mathcal{M}\alpha \times dk/d\log(1-\tau)$. Intuitively, in this case higher k simply increases output and profits by $\mathcal{M}\alpha$.

$\max_\tau \tau\pi + \tau^L WL$, giving:

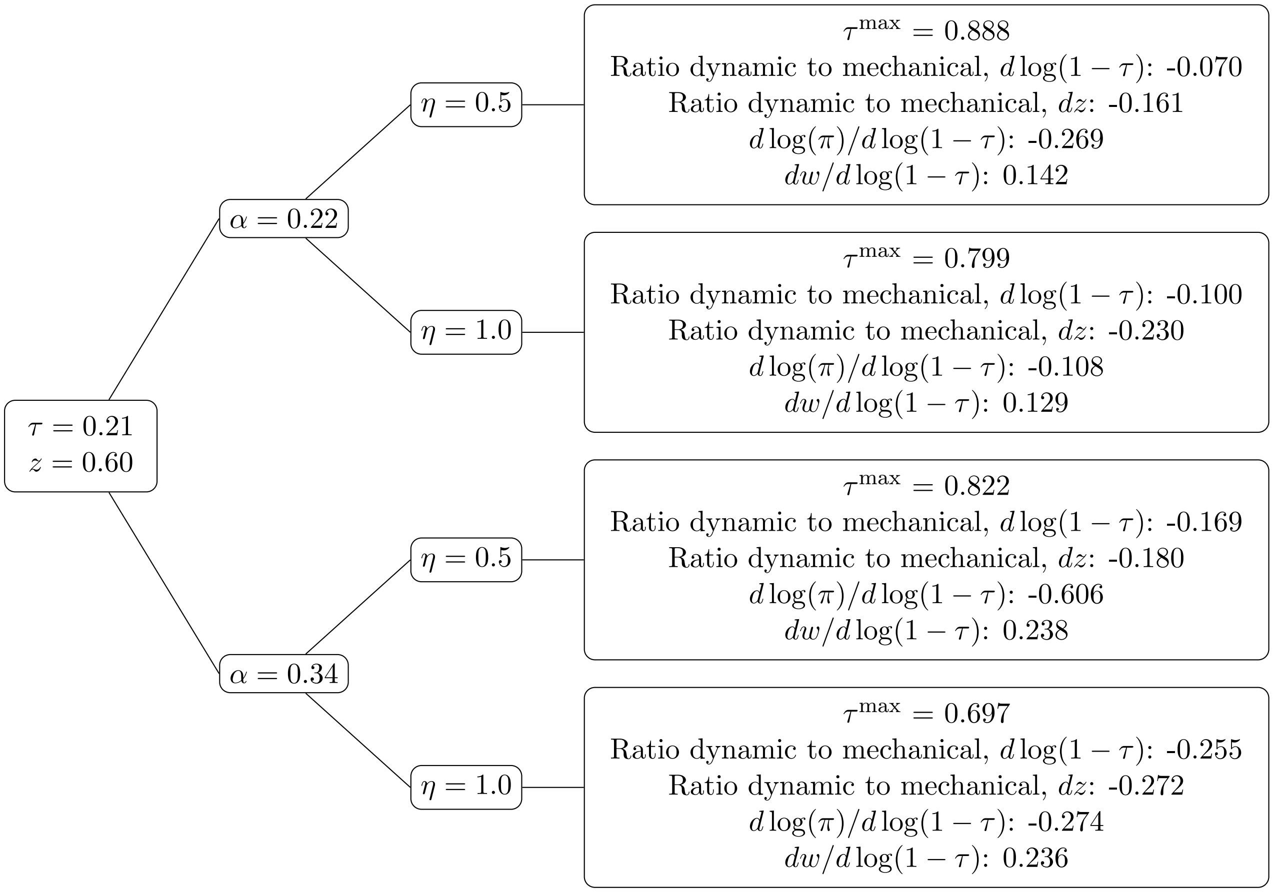
$$\tau^{\max} = \frac{1 - \frac{\tau^L WL}{\pi}\frac{dw}{d\log(1-\tau)}}{1 + \frac{d\log\pi}{d\log(1-\tau)}}. \tag{62}$$

However, as shown in equations (59) to (61), the elasticities $d\log\pi/d\log(1-\tau)$ and $dw/d\log(1-\tau)$ are general equilibrium elasticities that depend on τ. Thus, one cannot treat them as sufficient statistics measured locally and stable globally; the Lucas critique applies. Furthermore, firm-level variation such as the bunching estimators reviewed in Swonder and Vergara (2025) do not directly recover the general equilibrium elasticities. Instead, the neoclassical approach calls for obtaining values of α, β, and η and using them to simulate the elasticities as τ varies.

Figure 4 carries out this program and reports the revenue-maximizing corporate rate for $z = 0.6$ and $\tau^L = 0.28$ (approximate average values for tangible capital in 2025) and values of $\alpha \in \{0.22, 0.34\}$ and $\eta \in \{0.5, 1\}$. The rate varies between 0.7 and 0.9, with the lower values of α and η giving the highest rates. These high rates reflect a relatively high z; in the limit when $z = 1$, the corporate tax becomes a tax on pure profits (i.e. it exempts all labor and capital payments) and hence the revenue-maximizing rate becomes 1. Figure 4 also shows the taxable profits and wage elasticities calculated at $\tau = 0.21$, the current U.S. statutory rate. Using these elasticities in equation (62) would instead imply revenue-maximizing rates above 1, as $\frac{d\log\pi}{d\log(1-\tau)} < 0$ and $|\frac{d\log\pi}{d\log(1-\tau)}| > \frac{\tau^L WL}{\pi}\frac{dw}{d\log(1-\tau)}$. This difference also illustrates the importance of using the general equilibrium taxable profit elasticity in equation (62). The firm-level elasticity in response to an idiosyncratic tax change, holding the wage fixed, is always weakly positive (see equation (A.34)). In contrast, the general equilibrium elasticity may be negative, as individual firms neglect the effect of their own capital choices on the aggregate wage.

An alternative perspective characterizes the revenue raised from changing the corporate rate or z, starting from $\tau = 0.21$. The dynamic component from changing τ offsets between 7% and 26% of the mechanical decline in steady state revenue. Likewise, the dynamic offset from a change in z offsets between 16% and 27% of the mechanical revenue loss. These values reflect the fact that the current marginal rate lies well below the revenue-maximizing rate. Several other caveats apply: these formulas do not account for international capital mobility and profit shifting, changes in corporate form, non-deductible outlays associated with firm entry or certain investments in unmeasured intangible capital, or differences in the discounting of future depreciation allowances

Figure 4: General Equilibrium Dynamic Tax Responses



Notes: The "tree" starts from a value for the corporate rate τ and present value of expensing z. The "branches" set the capital output elasticity α and elasticity of substitution between capital and labor η. The "leaves" give the implied values for the revenue-maximizing corporate tax rate given the z and the dynamic offsets to the mechanical revenue change from changes to τ or z, given by $-\left(\frac{\tau}{1-\tau}\right)\left(\frac{d\log\pi}{d\log(1-\tau)}+\frac{\tau^L WL}{\tau\pi}\frac{dw}{d\log(1-\tau)}\right)$ and $-\left(\frac{(\rho+\delta)P^K K}{\pi}\right)^{-1}\left(\left(\frac{\tau}{1-z}\right)\left(\frac{d\log\pi}{d\log(1-\tau)}\right)+\left(\frac{\tau^L WL}{\tau\pi}\right)\frac{dw}{dr}\frac{dr}{dz}\right)$, respectively. All trees and branches use $\tau^L = 0.28$ and $\mathcal{M} = 1$.

by firms and the government. They also do not incorporate higher interest payments if the interest rate increases (see Section 5.3), which may be non-trivial when the debt-GDP ratio is large.

6 Comparison to Other Approaches

This article has demonstrated how to use the neoclassical theory to interpret microeconometric evidence of the effect of taxes on investment and to rigorously link the implied parameters to aggregate analysis. This section compares this approach to time series analysis that directly estimates the aggregate response and to models used at leading policy institutions.

6.1 Time Series

Time series analysis can provide causal evidence of the effect of taxation on aggregate variables, without requiring the structure imposed by the neoclassical framework or the calibration steps required to move from firm-level variation to aggregate outcomes. Blanchard and Perotti (2002) provide an early analysis based on a timing assumption that the federal government does not change the tax code or spending in response to innovations in output in the same calendar quarter. Romer and Romer (2010) instead use a narrative approach to isolate legislated tax changes not taken for a countercyclical reason or to offset government spending. While both papers find that taxes reduce output, neither separates personal from corporate taxes.

Mertens and Ravn (2013) split the Romer and Romer (2010) tax series into personal and corporate tax changes. They find that a corporate rate cut causes aggregate investment and output to increase. However, a correction to their confidence intervals reveals that their approach cannot reject a zero effect at conventional confidence levels of 90 or 95% (Jentsch and Lunsford, 2019; Mertens and Ravn, 2019). A review of Table 4 explains why — the U.S. historical record contains only a handful of large changes in corporate tax policy, severely curtailing the power of time series analysis. In contrast, the firm-level analysis reviewed in Section 3 exploits large cross-sectional variation in each historical episode.

6.2 Existing Policy Approaches

Major policy institutions routinely provide estimates of the effects of changes to corporate taxation on capital and output. Council of Economic Advisers (2019, 2025) evaluate the TCJA using the methodology of Hall and Jorgenson (1967). Their approach differs in two important ways from the analysis above. First, as in Hall and Jorgenson (1967), they apply the "neoclassical benchmark" elasticity of -1.0 without allowing for feedback from higher output back into higher capital or distinguishing firm-level from aggregate responses. Remarkably, these omissions roughly cancel in the sense that -1 lies in the range of values summarized in Figure 2. Second, they advocate a "consensus user-cost elasticity" of -1 based on a literature review that mixes the Coen (1969) and Eisner and Nadiri (1968) specifications.[35]

[35] See the literature review in Council of Economic Advisers (2019, p. 58). In addition, Council of Economic Advisers (2019, p. 58) refers to Cummins, Hassett and Hubbard (1994, 1996) as finding "an estimated long-run

Congressional Research Service (2024, pp. 16-17) likewise omits feedback from higher output into higher capital. They apply an elasticity of -0.6 based on an average of Dwenger (2014) and a comparable study finding a smaller Eisner and Nadiri (1968) elasticity. Thus, Council of Economic Advisers (2019, 2025) and Congressional Research Service (2024) take only the first step of the cobweb adjustment process, as originally critiqued by Coen (1969).

The Congressional Budget Office (CBO) conventional score applies an aggregate Eisner and Nadiri (1968) investment elasticity of -0.7 to a user cost change holding output fixed (Congressional Budget Office, 2018*a*,*b*). The value of -0.7 comes from CBO's own analysis and is compared to the Hassett and Hubbard (2002) range of -0.5 to -1 (Congressional Budget Office, 2018*b*, p. 3), despite that range coming from studies mostly estimating the Coen (1969) specification across firms and at short horizons. CBO's dynamic score inputs the change in investment into a Solow-style macroeconomic model featuring feedback from output into investment as well as crowding out due to higher interest rates and inelastic labor (using an elasticity of labor supply of 0.2).

7 Conclusion

This article has re-connected the modern empirical literature studying firm-level responses to tax reforms to the neoclassical theory of the firm. I have divided the firm-level evidence into Eisner and Nadiri specifications that hold output fixed and identify the elasticity of substitution between capital and labor η, and Coen specifications that hold input costs and the demand curve fixed and shed light on the returns to scale of the firm and hence the revenue elasticity of capital α^*. Both parameters matter to the long-run general equilibrium user cost elasticity of capital, which instead holds labor fixed in the comparative static of the first order condition for capital. Establishing this structural link between microeconometric evidence and aggregate counterfactuals has particular import in settings such as corporate tax policy, where the infrequency of exogenous, major tax reforms limits the power of direct estimation of long-run aggregate effects on capital, wages, or tax revenue. Throughout, I have suggested magnitudes consistent with the empirical evidence.

With the neoclassical interpretation of the firm-level evidence established, the door opens to relaxing the many simplifying features of this environment. (More accurately, this door opened

elasticity of the capital stock of -0.67", despite these articles using short-run variation.

long ago in response to the apparent shortcomings of the Summers specification involving Q, but the traffic through it has mostly not confronted the evidence from tax reforms, with Koby and Wolf (2020) an important exception.) As the macroeconomic literature turns to firm-level dynamics incorporating rich heterogeneity in production technology, product differentiation, financial frictions, and market size (Winberry et al., 2025), the evidence summarized here can provide useful discipline. At the same time, key parameters such as the elasticity of substitution between capital and labor may change with the arrival of new technologies such as generative artificial intelligence, renewing the need for more empirical work.

Corporate tax policy itself often now involves features that stretch the neoclassical user cost setting. One aspect pertains to intangible capital (Crouzet and Eberly, 2023), which poses new measurement challenges. Indeed, in an endogenous growth environment, taxation of R&D investment can affect the growth rate and not just the level of output (Lee and Gordon, 2005). Another concerns the taxation of multinational companies and international tax cooperation designed to address profit-shifting across tax jurisdictions. While the neoclassical setting can accommodate these features (Chodorow-Reich et al., 2025), a full treatment requires integration with modern models of intangible capital choice and multinational plant location.

In short, research on corporate taxation informs and is informed by many areas of economics. The field should continue its resurgence, pushing the boundaries of the neoclassical paradigm while retaining a close connection to the firm's investment decision and the proper aggregation of microeconometric evidence.

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Online Appendix:

The Neoclassical Theory of Firm Investment and Taxes: A Reassessment

Gabriel Chodorow-Reich

A Theory Appendix

This appendix provides additional results used in Sections 2 and 5.

A.1 Elasticities with General Production Function

This appendix shows that the CES functional form entails no loss of generality for the three elasticities defined in Section 2.3, in the sense that the curvature properties of $F(.,.)$ can be written in terms of η, ν, and the revenue shares α_i^* and β_i^* as defined for the CES functional form in Section 2.5.

Define:

$$\eta \equiv -\left(\omega_{KK}-\omega_{LK}\right)^{-1}=-\frac{\partial k_i}{\partial r_i}|_{dy_i=0}. \tag{A.1}$$

In the CES case, η is also the elasticity of substitution between capital and labor. The definition in equation (A.1) is more general and directly links η to the Eisner and Nadiri (1968) elasticity. Rearrange (A.1) and use equations (15d) and (22):

$$\omega_{KK}=-\frac{1}{\eta}+\omega_{LK}=-\frac{1}{\eta}+\left(\nu-1-\omega_{KK}\right)\frac{\alpha_i^*}{\nu-\alpha_i^*}=\left(1+\frac{1-\eta}{\nu\eta}\right)\alpha_i^*-\frac{1}{\eta}. \tag{A.2}$$

Substitute equation (A.2) back into equation (A.1):

$$\omega_{LK}=\omega_{KK}+\frac{1}{\eta}=\left(1+\frac{1-\eta}{\nu\eta}\right)\alpha_i^*. \tag{A.3}$$

Use equation (15d):

$$\omega_{KL}=\omega_{LK}\frac{\beta_i^*}{\alpha_i^*}=\left(1+\frac{1-\eta}{\nu\eta}\right)\beta_i^*. \tag{A.4}$$

Finally, use equations (A.3) and (22):

$$\omega_{LL}=\nu-1-\omega_{LK}=\alpha_i^*+\beta_i^*-1-\left(1+\frac{1-\eta}{\nu\eta}\right)\alpha_i^*=\left(1+\left(\frac{1-\eta}{\nu\eta}\right)\right)\beta_i^*-\frac{1}{\eta}. \tag{A.5}$$

The expressions for $\omega_{KK},\omega_{LL},\omega_{KL},\omega_{LK}$ in equations (A.2) to (A.5) depend only on the parameters $\eta,\nu,\alpha_i^*,\beta_i^*$. Furthermore, they coincide with the expressions obtained by applying the revenue function curvature definitions in equations (15a) to (15d) directly to the parametric CES function in equation (30). Thus, the the parametric form of the CES function entails no loss of generality for the definitions of the Eisner and Nadiri (1968) and Coen (1969) elaticities and the mapping from these firm-level microeconometric elasticities to general equilibrium.

A.2 Additional CES Derivations

This appendix expands on results in Sections 2.5 and 5.1. In the partial equilibrium Coen (1969) elasticity, the wage remains fixed. Then substituting equation (31b) into equation (9a), log differentiating, and setting $dw=0$:

$$d\ell_i=\left(\eta+\frac{1-\eta}{\nu}\right)dy_i=\left(\eta+\frac{1-\eta}{\nu}\right)\left(\alpha_i^*dk_i+\beta_i^*d\ell_i\right)=\frac{\left(\eta+\frac{1-\eta}{\nu}\right)\alpha_i^*}{1-\left(\eta+\frac{1-\eta}{\nu}\right)\beta_i^*}dk_i. \tag{A.6}$$

Substitute $\frac{dy_i}{dk_i} = \frac{\alpha_i^*}{1-\left(\eta+\frac{1-\eta}{\nu}\right)\beta_i^*}$ from equation (A.6) into equation (34):

$$\frac{dk_i}{dr_i} = \left(\left(\frac{\left(1+\frac{1-\eta}{\eta\nu}\right)\alpha_i^*}{1-\left(\eta+\frac{1-\eta}{\nu}\right)\beta_i^*}\right) - \frac{1}{\eta}\right)^{-1} = \left(\frac{1-\left(\eta+\frac{1-\eta}{\nu}\right)\beta_i^*}{\left(1+\frac{1-\eta}{\eta\nu}\right)\alpha_i^* - \frac{1}{\eta}\left(1-\left(\eta+\frac{1-\eta}{\nu}\right)\beta_i^*\right)}\right)$$
$$= -\left(\frac{1-\beta_i^*\left(\eta+\frac{1-\eta}{\nu}\right)}{1-\alpha-\beta}\right). \tag{A.7}$$

In general equilibrium, labor remains fixed. Using:

$$\beta^* = \frac{F_L\left(K_{i,t},L_{i,t}\right)L_{i,t}}{F\left(K_{i,t},L_{i,t}\right)} = \beta F\left(K_{i,t},L_{i,t}\right)^{\frac{1-\eta}{\eta\nu}} L_{i,t}^{1-1/\eta} = \frac{\beta}{\left(\frac{\alpha}{\nu}\right)\left(K_{i,t}/L_{i,t}\right)^{1-1/\eta} + \left(\frac{\beta}{\nu}\right)},$$
$$\alpha^* = \frac{F_K\left(K_{i,t},L_{i,t}\right)K_{i,t}}{F\left(K_{i,t},L_{i,t}\right)} = \alpha F\left(K_{i,t},L_{i,t}\right)^{\frac{1-\eta}{\eta\nu}} K_{i,t}^{1-1/\eta} = \frac{\alpha}{\left(\frac{\alpha}{\nu}\right) + \left(\frac{\beta}{\nu}\right)\left(K_{i,t}/L_{i,t}\right)^{1/\eta-1}},$$

the partial (holding labor fixed) semi-elasticity of the labor share of revenue to capital is:

$$\frac{\partial \log \beta^*}{\partial k} = \left(\frac{1-\eta}{\eta\nu}\right)\alpha^*. \tag{A.8}$$

A.3 General Convex Adjustment Costs

Equation (37) extends straightforwardly to any convex (not necessarily quadratic) adjustment cost. Thus, let $\Phi\left(I_{i,t},K_{i,t}\right) = c\left(I_{i,t}/K_{i,t}\right)K_{i,t}$, where $c(.)$ is a convex function. Using $\Phi_I\left(I_{i,t},K_{i,t}\right) = c'\left(I_{i,t}/K_{i,t}\right)$ in the investment necessary condition (9c) yields:

$$c'\left(I_{i,t}/K_{i,t}\right) = Q_{i,t},$$

where $Q_{i,t}$ is still given by equation (38). Implicitly differentiating by $Q_{i,t}$ gives the generalized version of equation (37):

$$\frac{dI_{i,t}/K_{i,t}}{dQ_{it}} = \frac{1}{c''\left(I_{i,t}/K_{i,t}\right)}. \tag{A.9}$$

In particular, quadratic adjustment costs give $c''\left(I_{i,t}/K_{i,t}\right) = \phi$, connecting equation (37) and equation (A.9).

A.4 Linearized Transition Path

This appendix expands on results in Section 2.7. Take a Taylor expansion in the neighborhood of the steady state, using the result that $\Phi_K\left(I_{i,t},K_{i,t}\right) = 0$ in the steady state and hence $d\Phi_K\left(I_{i,t},K_{i,t}\right) = -\phi\delta d\dot{K}_{i,t}/K_{i,t} = -\delta/\left(1-\tau_i\right)\left(\lambda_{i,t}-\lambda_i\right)$, and using the concavity of $G(.)$:[1]

$$\begin{pmatrix}\dot{\lambda}_{i,t}\\ \dot{K}_{i,t}\end{pmatrix} = \begin{pmatrix}\rho & -\left(1-\tau_i\right)G_i''\left(K_i\right)\\ K_i/\left(\phi\left(1-\tau_i\right)\right) & 0\end{pmatrix}\begin{pmatrix}\lambda_{i,t}-\lambda_i\\ K_{i,t}-K_i\end{pmatrix}. \tag{A.10}$$

[1] Using equation (9a) and defining $H_{i,t}\left(K_{i,t}\right) = L_{i,t}$ as the mapping from capital to labor, $G_{i,t}'\left(K_{i,t}\right) = A_{i,t}F_K\left(K_{i,t},L_{i,t}\right) + \left(A_{i,t}F_L\left(K_{i,t},L_{i,t}\right)-W_t\right)H_{i,t}'\left(K_{i,t}\right) = A_{i,t}F_K\left(K_{i,t},L_{i,t}\right)$, and $G_{i,t}''\left(K_{i,t}\right) = A_{i,t}\left(F_{KK}\left(K_{i,t},L_{i,t}\right) + F_{LL}\left(K_{i,t},L_{i,t}\right)H_{i,t}'\left(K_{i,t}\right)^2 + 2F_{KL}\left(K_{i,t},L_{i,t}\right)H_{i,t}'\left(K_{i,t}\right)\right)$.

Denote by $(\chi_1, \mathbf{f}_1)$ and $(\chi_2, \mathbf{f}_2)$ the eigenvalue/eigenvector pairs of the coefficient matrix in equation (A.10), with:

$$\chi_1 = \frac{\rho}{2} - \sqrt{\left(\frac{\rho}{2}\right)^2 - \frac{G_i''\left(K_i\right)K_i}{\phi}} < 0, \chi_2 = \frac{\rho}{2} + \sqrt{\left(\frac{\rho}{2}\right)^2 - \frac{G_i''\left(K_i\right)K_i}{\phi}} > 0, \tag{A.11}$$

$$\mathbf{f}_1 = \begin{pmatrix}\chi_1 & K_i/\left(\left(1-\tau_i\right)\phi\right)\end{pmatrix}', \mathbf{f}_2 = \begin{pmatrix}\chi_2 & K_i/\left(\left(1-\tau_i\right)\phi\right)\end{pmatrix}'. \tag{A.12}$$

The general solution is:

$$\begin{pmatrix}\lambda_{i,t} - \lambda_i \\ K_{i,t} - K_i\end{pmatrix} = c_1 e^{\chi_1 t}\mathbf{f}_1 + c_2 e^{\chi_2 t}\mathbf{f}_2.$$

Immediately, $G'' < 0 \Rightarrow \chi_2 > \rho$, which requires $c_2 = 0$ or the transversality condition would be violated. Thus:

$$\begin{pmatrix}\lambda_{i,t} - \lambda_i \\ K_{i,t} - K_i\end{pmatrix} = c_1 e^{\chi_1 t}\begin{pmatrix}\chi_1 \\ K_i/\left(\left(1-\tau_i\right)\phi\right)\end{pmatrix}. \tag{A.13}$$

The initial condition $K_{i,0}$ gives:

$$c_1 = \left(\frac{K_{i,0} - K_i}{K_i}\right)\left(1-\tau_i\right)\phi. \tag{A.14}$$

Then defining $\chi_i \equiv \chi_1$ and using the approximation $k_{i,t} - k_i \approx (K_{i,t} - K_i)/K_i$ gives equations (42), (41a) and (41b) in the main text.

A.5 Elasticities with Intermediate Inputs

This appendix extends the results in Sections 2.5 and 5.1 to the case of a production function that uses intermediate inputs. Let $G_{i,t}$ now denote gross real revenue. The cleanest exposition assumes Cobb-Douglas over intermediate inputs and a composite of capital and labor:

$$G_{i,t} = A_{i,t}V\left(K_{i,t}, L_{i,t}\right)^{\alpha+\beta} M_{i,t}^{\kappa}, \tag{A.15}$$

$$\text{where: } A_{i,t} \equiv \left(\xi_{i,t}G_t\right)^{\frac{\mathcal{M}-1}{\mathcal{M}}} \tilde{A}_{i,t}^{\frac{1}{\mathcal{M}}}, \tag{A.16}$$

$M_{i,t}$ denotes intermediate inputs, G_t denotes aggregate gross output (equal to aggregate gross revenue), $A_{i,t}$ is defined analogous to equation (5), and:

$$V\left(K_{i,t}, L_{i,t}\right) \equiv \left(\left(\frac{\alpha}{\alpha+\beta}\right)K_{i,t}^{1-1/\eta} + \left(\frac{\beta}{\alpha+\beta}\right)L_{i,t}^{1-1/\eta}\right)^{\frac{\eta}{\eta-1}}.$$

The relative price of the intermediate input is 1, giving the first order condition for intermediate purchases:

$$M_{i,t} = \kappa G_{i,t}.$$

Substitute this expression for intermediate inputs into the gross revenue function:

$$G_{i,t} = A_{i,t}V\left(K_{i,t}, L_{i,t}\right)^{\alpha+\beta}\left(\kappa G_{i,t}\right)^{\kappa} = \left(A_{i,t}\kappa^{\kappa}\right)^{\frac{1}{1-\kappa}} V(K_{i,t}, L_{i,t})^{\frac{\alpha+\beta}{1-\kappa}}.$$

Now define $Y_{i,t} \equiv G_{i,t} - M_{i,t}$ as revenue net of intermediate input costs, with:

$$Y_{i,t} = \hat{A}_{i,t} F\left(K_{i,t}, L_{i,t}\right), \tag{A.17}$$

$$\text{where: } \hat{A}_{i,t} = (1-\kappa)\kappa^{\frac{\kappa}{1-\kappa}} A_{i,t}^{\frac{1}{1-\kappa}}, \tag{A.18}$$

$$F\left(K_{i,t}, L_{i,t}\right) = V\left(K_{i,t}, L_{i,t}\right)^{\nu}, \tag{A.19}$$

and $\nu \equiv \frac{\alpha+\beta}{1-\kappa}$ denotes the returns to scale in $F(.,.)$. Using this definition, the steady state maximization problem after concentrating out intermediate inputs takes the same form as in Section 2.2:

$$\max_{K_i, L_i} Y_i - R_i K_i - W L_i.$$

The necessary conditions equations (9a) and (12) become:

$$R_i = \frac{\alpha}{1-\kappa} \hat{A}_i^{\frac{\eta-1}{\eta\nu}} Y_i^{1+\frac{1-\eta}{\eta\nu}} K_i^{-1/\eta}, \tag{A.20}$$

$$W = \frac{\beta}{1-\kappa} \hat{A}_i^{\frac{\eta-1}{\eta\nu}} Y_i^{1+\frac{1-\eta}{\eta\nu}} L_i^{-1/\eta}. \tag{A.21}$$

And:

$$dy_i = \alpha_i^* dk_i + \beta_i^* d\ell_i + d\hat{a}_i, \tag{A.22}$$

with $\alpha_i^* \equiv R_i K_i / Y_i,\ \beta_i^* \equiv W_i L_i / Y_i,\ \alpha_i^* + \beta_i^* = \nu$.

The first order conditions (A.20) and (A.21) have the same form as in the main text (see e.g. equation (32)), except for the $1-\kappa$ in the denominator. Likewise, α_i^* and β_i^* continue to give the elasticities of value-added revenue to capital and labor. It follows that the firm-level Eisner and Nadiri (1968) and Coen (1969) elasticities have the same functional forms as in equations (33) and (35), respectively. In particular, empirical estimation of the Eisner and Nadiri (1968) elasticity holding revenue fixed continues to recover the capital-labor substitution elasticity η, and empirical estimation of the Coen (1969) elasticity together with a value for η and a labor share of value added β_i^* continues to recover the parameter α_i^*.

Consider now the general equilibrium elasticity holding labor fixed. Let G_t denote aggregate gross output and X_t aggregate value-added. To close the inputs market, assume roundabout production, hence $M_t = M_{i,t} = \kappa G_{i,t} = \frac{\kappa}{1-\kappa} Y_{i,t} = \frac{\kappa}{1-\kappa} X_t$. Note that:

$$\begin{aligned}
dg_t &= (\alpha+\beta)\, dv_t + \kappa dm_t + da_t = \nu dv_t + (1-\kappa)^{-1} da_t, \\
da_t &= \left(\frac{\mathcal{M}-1}{\mathcal{M}}\right) dg_t + \frac{1}{\mathcal{M}} d\tilde{a}_t \\
&= \left(\frac{(\mathcal{M}-1)(1-\kappa)\,\nu}{1-\mathcal{M}\kappa}\right) dv_t + \frac{1-\kappa}{1-\mathcal{M}\kappa} d\tilde{a}_t, \\
\text{with: } dv_t &= \frac{d\log F\left(K_i, L_i\right)}{\nu} = \frac{1}{\nu}\left(\alpha^* dk + \beta^* d\ell\right).
\end{aligned}$$

Then:

$$dx_t = dy_t = \alpha^* dk + \beta^* d\ell + \frac{da}{1-\kappa}$$
$$= \alpha^* dk + \beta^* d\ell + \left(\frac{(\mathcal{M}-1)\,\nu}{1-\mathcal{M}\kappa}\right) dv_t + \frac{1}{1-\mathcal{M}\kappa} d\tilde{a}_t$$
$$= \left(\frac{\mathcal{M}\,(1-\kappa)}{1-\mathcal{M}\kappa}\right)(\alpha^* dk + \beta^* d\ell) + \frac{1}{1-\mathcal{M}\kappa} d\tilde{a}_t. \tag{A.23}$$

Define:

$$\hat{\mathcal{M}} \equiv \frac{\mathcal{M}\,(1-\kappa)}{1-\mathcal{M}\kappa}. \tag{A.24}$$

With this definition, equation (A.23) mirrors equation (53) in the main text, except with $\hat{\mathcal{M}}$ in place of $\mathcal{M}$ and a different coefficient multiplying $d\tilde{a}_t$. Accordingly, following the same steps as in the main text, the Barro and Furman (2018) elasticity becomes:

$$\frac{dk}{dr} = \left(\left(1 + \frac{1-\eta}{\hat{\mathcal{M}}\eta\nu}\right)\hat{\mathcal{M}}\alpha^* - \frac{1}{\eta}\right)^{-1}. \tag{A.25}$$

To summarize, extending the baseline model to include a constant share of intermediate inputs has no effect on the firm-level Eisner and Nadiri (1968) and Coen (1969) elasticities. It affects the general equilibrium elasticity insofar as $\hat{\mathcal{M}}$ differs from $\mathcal{M}$. By inspection of equation (A.24), with perfect competition, $\hat{\mathcal{M}} = \mathcal{M} = 1$ and the inclusion of intermediate inputs has no effect on the general equilibrium elasticity either. A second-order Taylor expansion around this benchmark and $\kappa = 0$ gives $\hat{\mathcal{M}} = \mathcal{M} + (\mathcal{M}-1)\,\kappa + O\left(||\mathcal{M}-1,\kappa||^3\right)$. Thus, including intermediate inputs has no first order effect on the general equilibrium elasticity. In the U.S., the ratio of intermediate inputs to gross output in private industries is about 0.43. Using this share, a value $\mathcal{M} = 1.1$ implies $\hat{\mathcal{M}} = 1.19$, while $\mathcal{M} = 1.2$ implies $\hat{\mathcal{M}} = 1.41$.

In deriving these results, the assumption of a constant intermediate inputs share provides analytical tractability. It also has empirical backing, with Atalay (2017) estimating a value for the elasticity of substitution between value added and intermediate inputs of about one for the U.S. and Peter and Ruane (2026) a value of 0.97 for India. Furthermore, the statement that including intermediate inputs has no first order effect on the general equilibrium elasticity would also hold for an expansion including first order deviations from a constant intermediate inputs share. Still, it merits mention that others have advocated a smaller short-run elasticity of substitution between value added and the materials sub-component of intermediate inputs (Castro-Vincenzi and Kleinman, 2026). With perfect competition, this case still collapses to the same microeconometric and macro elasticities as in the main text. Otherwise, the Eisner and Nadiri (1968) relationship remains unchanged, but the Coen (1969) elasticity has an additional term that depends on the elasticity of substitution between intermediate inputs and the value added bundle. If the factor inputs capital and labor do not inhabit a separate nest from intermediate inputs, then a more complicated characterization of the capital-labor substitution elasticity is required.

A.6 Elasticities with Non-corporate Sector

This appendix derives the results with two sectors. Thus, modify assumption 1 to:

3. The economy consists of a C-corporate sector and non C-corporate sector, each of which consists of a large number of identical firms. Firms exogenously choose their sector. The production function parameters α, β, and η and technology A are common across the sectors.

4. Workers are indifferent between the two sectors.

Assumption 3 ensures that starting from *ex ante* identical taxation, firms in the two sectors look identical.[2] Assumption 4 requires that the wage equalizes across sectors, with the labor market clearing condition $L_c + L_n = \bar{L}$ for corporate and non-corporate labor L_c and L_n, respectively.

Let $\omega_c \equiv L_c/\bar{L}$ denote the share of labor in the C-corporate sector. Set $\mathcal{M} = 1$ and $\alpha_i^* = \alpha, \beta_i^* = \beta$ for notational simplicity. Let $\xi \equiv 1 + \frac{1-\eta}{\eta\nu}$. Applying the first order conditions (9a) and (12), the CES revenue function derivatives (31a) and (31b), the output elasticity formula (53), and the labor market clearing condition across steady states with changes in the user cost of dr_c and dr_n, respectively, gives a linear system of 7 equations in the 7 unknowns $dw, dk_i, d\ell_i, dx_i$:

$$dw = \xi dx_i - \frac{1}{\eta} d\ell_i,\ \ i \in \{c, n\}\,, \tag{A.26a}$$

$$dr_i = \xi dx_i - \frac{1}{\eta} dk_i,\ \ i \in \{c, n\}\,, \tag{A.26b}$$

$$dx_i = \alpha dk_i + \beta d\ell_i,\ \ i \in \{c, n\}\,, \tag{A.26c}$$

$$d\ell_c = -\left(\frac{1-\omega_c}{\omega_c}\right) d\ell_n. \tag{A.26d}$$

In addition, $dm = \omega_c dm_c + (1-\omega_c)\, dm_n$ for $m \in \{k, \ell, x\}$.

Using equation (A.26c),

$$d\ell_i = \frac{dx_i - \alpha dk_i}{\beta}.$$

Substitute into equation (A.26a):

$$dw = \xi dx_i - \frac{dx_i - \alpha dk_i}{\beta\eta},$$

$$dk_i = \frac{\beta\eta}{\alpha}\left(dw - \left(\xi - \frac{1}{\beta\eta}\right) dx_i\right).$$

Rewrite equation (A.26b) as $dx_i = \left(\frac{1}{\eta} dk_i + dr_i\right)/\xi$ and substitute:

$$\begin{aligned} dk_i &= \frac{\beta\eta}{\alpha}\left(dw - \left(\xi - \frac{1}{\beta\eta}\right)\frac{1}{\xi}\left(\frac{1}{\eta} dk_i + dr_i\right)\right) \\ &= \beta\eta\left(\frac{\eta\xi}{\eta\nu\xi - 1}\right)\left(dw - \left(1 - \frac{1}{\beta\eta\xi}\right) dr_i\right). \end{aligned} \tag{A.27}$$

Next solve for labor as a function of prices using equations (A.26a) and (A.26b) to write $d\ell_i = -\eta\,(dw - dr_i) + dk_i$:

$$\begin{aligned} d\ell_i &= -\eta\,(dw - dr_i) + \beta\eta\left(\frac{\eta\xi}{\eta\nu\xi - 1}\right)\left(dw - \left(1 - \frac{1}{\beta\eta\xi}\right) dr_i\right) \\ &= \eta\left(\frac{1 - \alpha\eta\xi}{\eta\nu\xi - 1}\right) dw + \eta\left(\frac{\alpha\eta\xi}{\eta\nu\xi - 1}\right) dr_i. \end{aligned} \tag{A.28}$$

[2] In fact, C-corporations have higher average capital per worker and productivity. The results in this section therefore serve as a benchmark without these differences as well as without an endogenous choice of corporate form.

Using equation (A.28) for sector n and equation (A.26d):

$$d\ell_c = -\left(\frac{1-\omega_c}{\omega_c}\right)\left(\eta\left(\frac{1-\alpha\eta\xi}{\eta\nu\xi-1}\right)dw + \eta\left(\frac{\alpha\eta\xi}{\eta\nu\xi-1}\right)dr_n\right).$$

Equate with equation (A.28) for sector c and solve for w:

$$dw = -\left(\frac{\alpha\eta\xi}{1-\alpha\eta\xi}\right)(\omega_c dr_c + (1-\omega_c)\,dr_n)\,. \tag{A.29}$$

Putting equations (A.27) to (A.29) and (A.26c) together gives the solution:

$$\frac{dw}{dr_c} = -\left(\frac{\alpha\eta\xi}{1-\alpha\eta\xi}\right)\omega_c, \tag{A.30a}$$

$$\frac{dk_n}{dr_c} = \beta\eta\left(\frac{\eta\xi}{\eta\nu\xi-1}\right)\frac{dw}{dr_c}, \tag{A.30b}$$

$$\frac{dk_c}{dr_c} = \frac{dk_n}{dr_c} - \eta\left(\frac{\beta\eta\xi-1}{\eta\nu\xi-1}\right), \tag{A.30c}$$

$$\frac{d\ell_n}{dr_c} = \eta\left(\frac{1-\alpha\eta\xi}{\eta\nu\xi-1}\right)\frac{dw}{dr_c}, \tag{A.30d}$$

$$\frac{d\ell_c}{dr_c} = \frac{d\ell_n}{dr_c} + \eta\left(\frac{\alpha\eta\xi}{\eta\nu\xi-1}\right), \tag{A.30e}$$

$$\frac{dx_i}{dr_c} = \alpha\frac{dk_i}{dr_c} + \beta\frac{d\ell_i}{dr_c}. \tag{A.30f}$$

Figure A.1 shows general equilibrium elasticities in the economy with two sectors, starting from initial symmetry. Since the focus concerns only the general equilibrium component, the figure starts with values for the firm-level revenue elasticity of capital α^*.

A.7 Tax Revenue

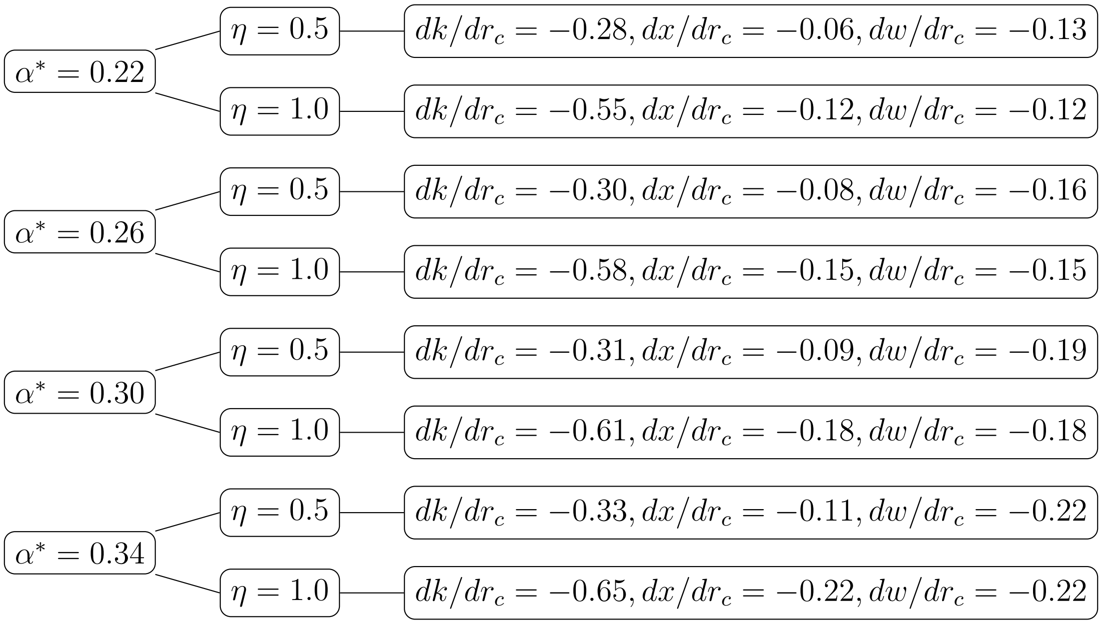
This appendix expands on results in Section 5.4. Recall the definition $\pi(K,L) = Y - WL - z(\rho+\delta)P^K K$.

Elasticity of taxable profits The elasticity of taxable profits with respect to $1-\tau$ is:

$$\begin{aligned}
\frac{d\log\pi}{d\log(1-\tau)} &= \left(\frac{1}{\pi}\right)\left(\left(\frac{dY}{dK} - z(\rho+\delta)P^K\right)\frac{dK}{d\log(1-\tau)} - L\frac{dW}{d\log(1-\tau)}\right) \\
&= \left(\frac{Y}{\pi}\right)\left(\left(\frac{K}{Y}\frac{dY}{dK} - \frac{z(\rho+\delta)P^K K}{Y}\right)\frac{dk}{d\log(1-\tau)} - \frac{WL}{Y}\frac{dw}{d\log(1-\tau)}\right) \\
&= \left(\left(\mathcal{M}\alpha^* - z\Omega^{-1}\alpha^*\right)\frac{dk}{d\log(1-\tau)} - \beta^*\frac{dw}{d\log(1-\tau)}\right)/\left(\frac{\pi}{Y}\right),
\end{aligned} \tag{A.31}$$

where in the last line dk/dy follows from equation (53) and $\pi/Y = 1-\beta^* - z\Omega^{-1}\alpha^*$.

Figure A.1: General Equilibrium Elasticities with Two Sectors



Notes: Each "tree" starts from a value for the revenue elasticity of capital α. The "branches" set the elasticity of substitution between capital and labor η. The "leaves" give the implied values for the long-run general equilibrium user cost elasticity of corporate capital, corporate value added, and the wage. In all branches the markup is set to $\mathcal{M} = 1$ and the share of labor in the C-corporate sector is set to $\omega_c = 0.43$.

Change in z We have:

$$\begin{aligned} \frac{d\log\tau\pi}{dz} = \frac{d\log\pi}{dz} &= \left(\frac{Y}{\pi}\right)\left(\left(\frac{K}{Y}\frac{dY}{dK} - \frac{z(\rho+\delta)P^K K}{Y}\right)\frac{dk}{dz} - \frac{WL}{Y}\frac{dw}{dz}\right) - \frac{(\rho+\delta)P^K K}{\pi} \\ &= -\frac{(\rho+\delta)P^K K}{\pi} + \left(\frac{\tau}{1-z}\right)\frac{d\log\pi}{d\log(1-\tau)}, \end{aligned} \tag{A.32}$$

where the second line uses $dm/dz = dm/dr \times dr/dz = dm/d\log(1-\tau) \times (dr/d\log(1-\tau))^{-1} \times dr/dz = dm/d\log(1-\tau) \times \tau/(1-z)$ for $m \in \{k, w\}$. Thus, while the mechanical effect of a change in z differs from the mechanical effect of a change in $\log\tau$, the dynamic coefficient for corporate taxes also depends on the taxable profits elasticity, which in turn depends on the capital elasticity. Likewise:

$$\frac{d\log\tau^L WL}{dz} = \frac{dw}{dz} = \frac{dw}{dr}\frac{dr}{dz}. \tag{A.33}$$

Firm-level elasticity of taxable profits Swonder and Vergara (2025) review estimates of the firm-level elasticity of taxable profits. This object differs from equation (A.31). Let $\pi_i(K_i, L_i)$ denote firm profits. The elasticity of taxable firm profits with respect to an idiosyncratic change to $1-\tau_i$, holding the wage fixed, is:

$$\begin{aligned}
\frac{d\log\pi_i}{d\log(1-\tau_i)} &= \left(\frac{1}{\pi_i}\right)\left(\frac{dA_iF(K_i,L_i)}{dK_i} - z(\rho+\delta)P^K - W\frac{\partial L_i}{\partial K_i}\right)\frac{dK_i}{d\log(1-\tau_i)} \\
&= \left(\frac{Y_i}{\pi_i}\right)\left(A_i\left(\frac{F_K(K_i,L_i)K_i}{Y_i} + \frac{F_L(K_i,L_i)L_i}{Y_i}\frac{\partial \ell_i}{\partial k_i}\right) - \frac{z(\rho+\delta)P^K K_i}{Y_i} - \frac{WL_i}{Y_i}\frac{\partial \ell_i}{\partial k_i}\right) \\
&\times \frac{dk_i}{d\log(1-\tau_i)} \\
&= \left(\alpha^* - z\Omega^{-1}\alpha^*\right)\left(\frac{dk_i}{d\log(1-\tau_i)}\right) / \left(\frac{\pi_i}{Y_i}\right) \geq 0, \qquad \text{(A.34)}
\end{aligned}$$

where $dk_i/d\log(1-\tau_i) = dk_i/dr_i \times dr_i/d\log(1-\tau_i)$, with dk_i/dr_i given by equation (35). In particular, while the individual firm's profit elasticity is weakly positive (equal to zero when $z=1$), the aggregate profit elasticity may be negative, as individual firms do not internalize the effect of their own increases on capital on the aggregate wage.

B Additional Notes on the Literature

This appendix describes the additional specifications in the literature and provides further detail on my translation of regression coefficients in individual papers listed in Tables 3 to 6.

B.1 Coen (1969) Specifications

The additional Coen (1969) estimating equations are:

$$k_{i,t} = b_0^{\text{Coen}k,r} + b_1^{\text{Coen}k,r}\log\Omega_{i,t} + e_{i,t}, \qquad \text{(B.1a)}$$

$$\log I_{i,t} = b_0^{\text{Coen}\log I,r} + b_1^{\text{Coen}\log I,r}\log\Omega_{i,t} + e_{i,t}, \qquad \text{(B.1b)}$$

$$I_{i,t}/K_{i,t-1} = b_0^{\text{Coen}I/K,\Omega} + b_1^{\text{Coen}I/K,\Omega}\Omega_{i,t} + e_{i,t}, \qquad \text{(B.1c)}$$

$$I_{i,t}/K_{i,t-1} = b_0^{\text{Coen}I/K,R} + b_1^{\text{Coen}I/K,R}R_{i,t} + e_{i,t}, \qquad \text{(B.1d)}$$

$$\log I_{i,t} = b_0^{\text{Coen}\log I,z} + b_1^{\text{Coen}\log I,z}z_{i,t} + e_{i,t}. \qquad \text{(B.1e)}$$

Lemmas B.1 to B.4 provide the structural interpretations. Equation (B.1a) across steady states directly mirrors equations (28) and (35):

Lemma B.1 *In the environment of Section 2.4 with Cobb-Douglas production across steady states, plim* $b_1^{Coenk,r} = dk_i/dr_i = -1/(1-\gamma)$*, where* $\gamma = \alpha/(1-\beta)$ *as in* **??**. *In the general CES case, plim* $b_1^{Coenk,r} = dk_i/dr_i = -\left(\frac{1-\beta_i^*\left(\eta+\frac{1-\eta}{\alpha+\beta}\right)}{1-\alpha-\beta}\right)$.

Lemma B.1 also applies to equation (B.1b) estimated across steady states, since $d\log I_i = dk_i$.

Let $k(h)$ and $I(h)$ denote log capital and investment h periods after a tax change; for compactness, continue to use the shorthand $k = k(\infty)$ when no explicit argument for h is given. Using equations (44) and (45):

Lemma B.2 *In the environment of Section 2.7 with quadratic adjustment costs in capital, equation (B.1a) estimated* h *periods after a tax reform recovers plim* $b_1^{Coenk(h),r} = \left(1-e^{\chi_i h}\right)dk_i/dr_i$, *where χ_i is the stable eigenvalue given in equation (43). Using $dI_{i,0}/K_{i,0} = \delta d \log I_{i,0}$, equation (B.1b) estimated immediately after a tax reform recovers plim $b_1^{Coen \log I(0),r} = (1/\delta)$ plim $b_1^{CoenI(0)/K,r} = -(\chi_i/\delta)\, dk_i/dr_i$.*

Equations (B.1c) to (B.1e) require additional steps since their regressors are $\Omega_{i,t}$, $R_{i,t}$, or $z_{i,t}$, respectively, rather than $\log \Omega_{i,t}$ as in equations (B.1a), (B.1b) and (48). Equation (B.1c) appears close to the Summers specification (47); both specifications have $I_{i,t}/K_{i,t-1}$ on the left hand side and they differ only in whether the regressor includes the component $\lambda_{i,t}/(1-\tau_{i,t})$ in $Q_{i,t}$. From the perspective of equation (47), this difference has an interpretation of omitted variables bias in equation (B.1c), since the tax change also causes a change in $\lambda_{i,t}$, as shown in Figure 1. The correct interpretation of equation (B.1c) therefore comes from equation (45) after rescaling the regression coefficient by $\Omega_{i,t}$, since equation (45) and Lemma B.2 relate $I_{i,t}/K_{i,t}$ to the log rather than the level of the tax term. A similar interpretation applies to equation (B.1d):

Lemma B.3 *In the environment of Section 2.7 with quadratic adjustment costs in capital, equation (B.1c) estimated immediately after a tax reform recovers plim $b_1^{CoenI(0)/K,\Omega} = (1/\Omega_i)$plim $b_1^{CoenI(0)/K,r} = -(\chi_i/\Omega_i)\, dk_i/dr_i$ and equation (B.1d) recovers plim $b_1^{CoenI(0)/K,R} = (1/R_i)$plim $b_1^{CoenI(0)/K,r} = -(\chi_i/R_i)\, dk_i/dr_i$. Equation (B.1d) estimated h periods after a tax reform recovers plim $b_1^{CoenI(h)/K(h),R} = -(\chi_i/R_i)e^{\chi_i h} dk_i/dr_i$.*

Finally:

Lemma B.4 *Assume the environment of Section 2.7 with quadratic adjustment costs in capital and tax policy changes to z only. Using $dz = \left(\frac{1-\Gamma}{\tau}\right)\frac{d\tau z}{1-\Gamma} = -\left(\frac{1-\Gamma}{\tau}\right) d\log(1-\Gamma)$, plim $b_1^{Coen \log I(0),z} = -(1/\delta)(\tau/(1-\Gamma))\, b_1^{CoenI(0)/k,r}$; also using Lemma B.2, plim $b_1^{Coenk(h),z} = -(\tau/(1-\Gamma))\left(1-e^{\chi_i h}\right) dk_i/dr_i$.*

Cummins, Hassett and Hubbard (1994, table 5) The first main specification in Cummins, Hassett and Hubbard (1994) (equations (10)-(11) in their paper with results shown in their table 5) is motivated as a variant of the Summers (1981) specification in (47), but setting the regressor to $\tilde{Q}_{i,t} - \mathbb{E}_{i,t-1}\tilde{Q}_{i,t}$, where:

$$\tilde{Q}_{i,t} = \frac{\lambda_{i,t-2} - P^K_{i,t-2}(1-\Gamma_{i,t})}{1-\tau_{i,t}}, \tag{B.2}$$

and $\mathbb{E}_{i,t-1}$ is an expectation operator implemented by projecting on lags of investment, cash flow, and a time trend. The purging of lagged information using $\mathbb{E}_{i,t-1}$ is innocuous (it isolates the shock). The definition of $\tilde{Q}_{i,t}$ as including $\lambda_{i,t-2}$, however, instead of $\lambda_{i,t}$ as in equation (38), changes the interpretation of their regression in a manner unrecognized at the time or since. Cummins, Hassett and Hubbard (1994, p.30) describe this substitution as intended to "focus on the tax surprise" given the possibility of measurement error in the λ component. Yet, this substitution also removes the endogenous response of $\lambda_{i,t}$ to tax changes. Furthermore, nonparametrically purging $\tilde{Q}_{i,t}$ of lagged information would remove the $\lambda_{i,t-2}$ term from the regressor altogether. Thus, their specification in fact is closest to equation (48) except with $-\Omega_{i,t}$ as the regressor. Their interpretation of the regression coefficient in terms of the magnitude of adjustment costs is therefore incorrect. Rather, focusing on the years with major tax reforms, their estimates map into values of $-b_1^{\mathrm{Coen}I(0)/K,r} = \chi dk_i/dr_i$ ranging from 0.66-1.18. Cummins, Hassett and Hubbard (1996, table 6) implement the same specification and find a value of 0.73.

Cummins, Hassett and Hubbard (1994, table 9) This specification replaces $\log \Omega_{i,t}$ with the level of the user cost $R_{i,t}$, as in equation (B.1d). Using Lemma B.3, these estimates map into values of $-b_1^{\text{Coen}I(0)/K,r}$ ranging from 0.14 to 0.19 for major tax reform years, notably smaller than the values implied by their table 5. This difference is surprising, since the specifications should differ only in that the regressor in their table 9 is $-R/\Omega = -(\rho+\delta)$ multiplied by the regressor in their table 5. If $\rho+\delta$ were fixed across firms and ignoring the differences between their $\widetilde{Q}$ and Ω, then the regression coefficients should also differ by a factor of $1/(\rho+\delta)$, or about five. Instead, Cummins, Hassett and Hubbard (1994) obtain coefficients of similar magnitude. One possible explanation is attenuation bias. Cummins, Hassett and Hubbard (1994) use firm-specific ρ based on bond yields and δ based on book capital; if these values have measurement error, the table 9 estimates will be attenuated.

Zwick and Mahon (2017) I report their specification using $\log I$ because it is their preferred outcome and the only outcome for which they report results separately by firm size. Lemma B.4 provides the translation to $b_1^{\text{Coen}I(0)/K,r}$. However, their specification requires a possible additional adjustment to account for heterogeneity in economic depreciation δ that correlates with the change in z under bonus. Specifically, suppose that all firms have the same long-run elasticity dk_i/dr_i, but differ in economic depreciation δ_i. The short-run investment elasticity for firm i is $d\log I_{i,0}/dr_i = -(\chi_i/\delta_i) \times dk_i/dr_i$ (see equation (45) or Lemma B.2) and hence scales with δ_i. Denote the present value of tax depreciation without bonus as $z_{i,N} \equiv \int_0^\infty e^{-\rho h} c_{i,h} dh$. Consider a simplified, cross-sectional version of the Zwick and Mahon (2017) specification with $d\log I_{i,0}$ regressed on dz_i, where the difference operator computes the change in log investment and z from before to after bonus turns on. If industries with lower rates of economic depreciation also have lower rates of no-bonus tax depreciation, $\text{Corr}(\delta_i, z_{i,N}) > 0$, then the regressor dz_i correlates positively with the firm-specific treatment effect $d\log I_{i,0}/dr_i$. That is, firms with low economic depreciation will tend to have larger increases in the investment incentive dz when bonus occurs, and these firms' investment also responds more per unit of investment incentive. In this situation, the regression coefficient exceeds the average treatment effect.

To assess the possible magnitude of this effect, I merge the replication data from Zwick and Mahon (2017) covering 258 four-digit NAICS industries with economic depreciation rates from the BEA for the year 2000. (Since the BEA data set covers 74 industries, this merge necessarily assigns the same depreciation rate to several four-digit industries.) I find $\text{Corr}(\delta_i, z_{i,N}) = 0.36$. I then set $\rho = 0.07, dk_i/dr_i = -3.5$, and $\phi = 2$ as common inputs across all industries (note that dk_i/dr_i as defined in equation (35) does not depend on δ_i; the value for ρ comes from Zwick and Mahon (2017, page 225)) and construct the theoretical change in log investment in each industry as $d\log I_{i,0} = dk_i/dr_i \times d\log(1-\Gamma_i) \times (-\chi_i/\delta_i)$, where $d\log(1-\Gamma_i) = -\tau dz_i/(1-\tau z_{i,N})$ and χ_i is defined in equation (43). The average true absolute value of the short-run semi-elasticity is $-\chi_i dk_i/dr_i = -0.50$. I next run the regression of the theoretical value of $d\log I_{i,0}$ on dz_i, which gives a regression coefficient of 2.8. Applying Lemma B.4 to this coefficient gives an implied average value of $-\chi_i dk_i/dr_i = -0.70$. Thus, this simulation suggests reducing the value of $\chi_i dk_i/dr_i$ implied by the Zwick and Mahon (2017) regression by a factor of about 5/7, which I apply in Table 4.[3]

[3] With quadratic adjustment costs, the convergence rate χ_i also depends on δ_i, through the presence of the user cost R_i (see equation (43)). The adjustment accounts for this dependence. Still, it raises the question of the comparative bias in a short-run regression with $I_{i,t}/K_{i,t}$ or $\log I_{i,t}$ on the left hand side. Using the same merged Zwick and Mahon (2017) and BEA data set, a regression of $dI_{i,t}/K_{i,t}$ on $d\log(1-\Gamma_{i,t})$, rescaled by the same average value of $-\chi_i$, yields an implied long-run elasticity of -2.9, slightly smaller than the true value of $dk_i/dr_i = -3.5$. A

Alternatively, Zwick and Mahon (2017) also report a regression of I/K on the tax term Ω. This specification also requires an adjustment, because they define I as bonus-eligible investment but K as the total capital stock (based on private correspondence with Eric Zwick). The mean share of equipment capital in the BEA data is 0.47. Applying this ratio and converting the tax term to a semi-elasticity would require essentially doubling the regression coefficient of -1.60, giving a value of $\chi_i dk_i/dr_i = 3.60$. Two further caveats apply to this calculation: (i) The K in the Zwick and Mahon data set is gross book capital, which differs from economic capital (e.g., it will exclude capital fully depreciated in an accounting sense). (ii) The interpretation here also assumes that firms choose equipment capital independent of structures capital.

Curtis et al. (2021) This paper regresses the long-difference in equipment capital on an indicator for a firm's no-bonus z, denoted z_N, being in the bottom tercile of the distribution. Lemma B.4 provides the translation to $b_1^{\text{Coen}I(0)/K,r}$. The change in z given a value of bonus of B is $B + (1-B)\,z_N - z_N = B\,(1-z_N)$. Thus, the mean difference-in-difference change in z across the "treated" and "control" firms is $-B \times (\mathbb{E}_i[z_{i,N}|z_{i,N} \leq P_{33}(z_N)] - \mathbb{E}_i[z_{i,N}|z_{i,N} > P_{33}(z_N)])$. In the main text I use the difference-in-difference notation $\Delta_{2001,2011}\Delta_{z\leq P_{33}(z),z>P_{33}(z)}$ for this difference. Figure A.1 of their paper shows mean values of z_N in the "treated" and "control" groups of 0.795 and 0.863, respectively.[4] The value of bonus fluctuated during their sample period. I use $B = 50\%$ as the modal value, implying $\Delta_{2001,2011}\Delta_{z\leq P_{33}(z),z>P_{33}(z)} = 0.034$. Since these zs apply only to equipment, I report the equipment capital result in their table 2.

Chodorow-Reich et al. (2025) I report their results for domestic-only firms, since these firms fit into the theory in Section 2.1. While the specification in Chodorow-Reich et al. (2025) could give rise to the same issue as described above in Zwick and Mahon (2017), in practice Chodorow-Reich et al. (2025) report a much lower correlation of their Γ and δ, likely reflecting the additional variation driving Γ in their setting.

Kennedy et al. (2026) Their featured regression estimates: $I_{i,t}/K_{i,t-1} = b_1 d\log(1-\tau) \times \mathbb{I}\text{year} \geq 2018 + \text{firm FE} + \text{industry} \times \text{size} \times \mathit{yearFE}$ in a panel of C and S corporations from 2013-2019. They treat $d\log(1-\tau)$ as an endogenous variable and use an indicator for being a C-corporation as the excluded instrument, since the corporate rate cut applied to C but not S corporations. One can relate this specification to a regression with $d\log\Omega$ as the regressor using $d\log\Omega = d\log(1-\Gamma) - d\log(1-\tau) = -\frac{\tau dz}{1-\Gamma} + \left(\frac{z}{\Omega} - 1\right) d\log(1-\tau)$. Since the expensing provisions applied to both, dz is the same for both C and S corporations and its effect is essentially absorbed by the industry-size-year fixed effects. However, $d\log(1-\Gamma)$ depends on both dz and $d\tau$, requiring a re-scaling, as shown in the second term. Table 4 instead reports the coefficient from their regression with $d\log\Omega$ as the regressor, where they construct Ω taking account of credits, deductions, and NOLs.

regression of $d\log I_{i,t}$ on $d\log(1-\Gamma_{i,t})$, rescaled by the sample average value of $-\chi_i/\delta_i$, instead yields an implied long-run elasticity of -6.9. This difference underscores my preference for summarizing the short-run evidence with the semi-elasticity of investment rather than the elasticity.

[4] The precise values were provided via personal communication from the authors.

B.2 Eisner and Nadiri (1968) Specifications

The additional Eisner and Nadiri (1968) estimating equations are:

$$\Delta\left(k_{i,t}-y_{i,t}\right)=b_0^{\text{E-NCRS}}+b_1^{\text{E-NCRS}}r_{i,t}+b_2^{\text{E-NCRS}}\left(k_{i,t-1}-y_{i,t-1}\right)+b_3^{\text{E-NCRS}}\Delta r_{i,t}+e_{i,t}, \tag{B.3a}$$

$$I_{i,t}/K_{i,t-1}=b_0^{\text{E-NDLM}}+\sum_{h=0}^{H}b_{1,h}^{\text{E-NDLM}}\Delta r_{i,t-h}+\sum_{h=0}^{H}b_{2,h}^{\text{E-NDLM}}\Delta y_{i,t-h}+e_{i,t}, \tag{B.3b}$$

$$\begin{aligned}k_{i,t}&=b_0^{\text{E-NECM}}+b_1^{\text{E-NECM}}r_{i,t-1}+b_2^{\text{E-NECM}}y_{i,t-1}+b_3^{\text{E-NECM}}k_{i,t-1}\\&+\sum_{h=0}^{H-1}\left(b_{1,h}^{\text{E-NECM}}\Delta r_{i,t-h}+b_{2,h}^{\text{E-NECM}}\Delta y_{i,t-h}\right)+e_{i,t}.\end{aligned} \tag{B.3c}$$

Caballero, Engel and Haltiwanger (1995) This paper implements (B.3a) using annual data from the U.S. manufacturing sector. They motivate a steady state relationship between the capital-output ratio and user cost by starting from a Cobb-Douglas production function and an *ad hoc* coefficient scaling the user cost. Thus, instead of $k_i - y_i = \log\alpha - r_i$ (see equation (24)), they assume $k_i - y_i = \log\alpha - cr_i$ for a scalar c. Specifically, their Appendix B starts from the Cobb-Douglas case with (ignoring productivity) $Y_{i,t} = K_{i,t}^{\gamma}$ (see equation (27)) and the associated first order condition for steady state capital $\gamma K_i^{\gamma-1} = R_{i,t}$, where $R_{i,t}$ here denotes the steady state user cost, which may vary over time. Subtract $k_{i,t}$ from both sides of the first order condition (in logs) to find:

$$k_i-k_{i,t}=-\frac{1}{1-\gamma}r_{i,t}-k_{i,t}=\frac{1}{1-\gamma}\left(y_{i,t}-k_{i,t}-r_{i,t}\right),$$

where the second equality uses the production function identity $y_{i,t}-k_{i,t}=(\gamma-1)k_{i,t}$. Caballero, Engel and Haltiwanger (1995) insert an *ad hoc* scalar multiplying $r_{i,t}$ and assume the left hand side is stationary to motivate a cointegrating relationship between the log capital-output ratio and the log user cost.

One can instead rigorously derive this relationship by starting from CES with constant returns to scale, in which case the scalar c equals the elasticity of substitution η. Using equation (32), take logs and rearrange to find:

$$k_{i,t}=\left(\eta+\frac{1-\eta}{\nu}\right)y_{i,t}-\eta r_{i,t}-\frac{1-\eta}{\nu}a_{i,t}+\log\alpha.$$

Lemma B.5 summarizes:

Lemma B.5 *In the environment of Section 2.5 with CES production and constant returns to scale in the revenue function, $\nu=1$, equation (B.3a) recovers $\eta=b_1^{E\text{-}NCRS}/b_2^{E\text{-}NCRS}$.*

Thus, a long-run cointegrating relationship between the log capital-output ratio and log user cost holds exactly only under constant returns to scale, $\alpha+\beta=1$, or the Cobb Douglas case $\eta=1$.

Chirinko, Fazzari and Meyer (1999) Let $K_{i,t}^*$ denote the firm's "desired capital" at date t, defined as the solution to equation (32) taking $Y_{i,t}$ as given. Instead of an explicit function for adjustment costs, Chirinko, Fazzari and Meyer (1999) assume that net investment is a function of lagged changes in log desired capital:

$$\frac{I_{i,t}}{K_{i,t-1}}=\delta+\sum_{h=0}^{H}\omega_h\Delta k_{i,t-h}^*,$$

where $\sum_{h=0}^{H}\omega_h = 1$. Substitute for $\Delta k^*_{i,t-h}$ using equation (32):

$$\frac{I_{i,t}}{K_{i,t-1}} = \delta + \sum_{h=0}^{H}\omega_h\left(-\eta\Delta r_{i,t-h} + \left(\eta + \frac{1-\eta}{\alpha+\beta}\right)\Delta y_{i,t-h}\right) + \epsilon_{i,t},$$

where $\epsilon_{i,t}$ is a summation of past productivity changes. Summarizing:

Lemma B.6 *Assume $I_{i,t}/K_{i,t-1} = \delta + \sum_{h=0}^{H}\omega_h \Delta k^*_{i,t-h}$, where $\sum_{h=0}^{H}\omega_h = 1$. Then in the environment of Section 2.5 with CES production, equation (B.3b) recovers $\sum_{h=0}^{H} b^{\textit{E-NDLM}}_{1,h} = -\eta$ and $\sum_{h=0}^{H} b^{\textit{E-NDLM}}_{2,h} = \eta + \frac{1-\eta}{\alpha+\beta}$.*

Their preferred specification uses lagged values as instruments (Arellano and Bover, 1995).

Dwenger (2014) Dwenger assumes that current log capital is a function of lagged capital and current and lagged desired capital. After substituting using equation (32) as above:

$$k_{i,t} = \phi k_{i,t-1} + \sum_{h=0}^{H}\omega_h\left(-\eta r_{i,t-h} + \left(\eta + \frac{1-\eta}{\alpha+\beta}\right) y_{i,t-h}\right) + \epsilon_{i,t}.$$

Dwenger (2014) manipulates this expression as follows. In a steady state, we must have:

$$(1-\phi)\, k_i = k_i \sum_{h=0}^{H}\omega_h.$$

Using this fact, one can show that for any x:

$$\sum_{h=0}^{H}\omega_h x_{i,t-h} = (1-\phi)\, x_{i,t-1} - \sum_{h=0}^{H-1}\mu_h \Delta x_{i,t-h},$$

$$\text{where: } \mu_0 = -\omega_0,$$

$$\mu_h = \sum_{j=h+1}^{H}\omega_j \ \forall k > 0.$$

Thus:

$$\begin{aligned} k_{i,t} = {} & \phi k_{i,t-1} - (1-\phi)\,\eta r_{i,t-1} + (1-\phi)\left(\eta + \frac{1-\eta}{\alpha+\beta}\right) y_{i,t-1} \\ & - \sum_{h=0}^{H-1}\mu_h\left(-\eta\Delta r_{i,t-h} + \left(\eta + \frac{1-\eta}{\alpha+\beta}\right)\Delta y_{i,t-h}\right) + \epsilon_{i,t}. \end{aligned}$$

Dwenger (2014) also includes a sample attrition term in her preferred specification. Summarizing:

Lemma B.7 *Assume $k_{i,t} = \phi k_{i,t-1} + \sum_{h=0}^{H}\omega_h k^*_{i,t-h}$, where $\sum_{h=0}^{H}\omega_h = 1-\phi$. Then in the environment of Section 2.5 with CES production, equation (B.3c) recovers $b^{\textit{E-NECM}}_1/(1-b^{\textit{E-NECM}}_3) = -\eta$ and $b^{\textit{E-NECM}}_2/(1-b^{\textit{E-NECM}}_3) = \eta + \frac{1-\eta}{\alpha+\beta}$.*

B.3 Asset-level Specifications

Auerbach and Hassett (1991) They do not report summary statistics for the value of the user cost. For the non tax component, they use a discount rate $\rho = 0.04$ (p. 203). Using their table 1, I calculate an asset-weighted average depreciation rate for equipment of $\delta = 0.15$, where the asset weights come from assuming 1985 investment is equal to the replacement level of investment. For the tax component, Cummins, Hassett and Hubbard (1994, figure 1) implies a value $\Omega = 1.17$ for equipment in 1985. Together, this gives an average user cost for equipment $R = (\rho + \delta)\Omega = 0.226$. Note that this is close to the value of 0.25 reported in Cummins, Hassett and Hubbard (1994) for their full sample.

Hartley, Hassett and Rauh (2025) Their abstract concludes that their results are "larger than prior estimates of the responsiveness of investment with respect to the user cost of capital." Their conclusion differs from mine because they compare their asset-level regression coefficients to estimates of the elasticity of substitution between capital and labor based on the Eisner and Nadiri (1968) specification in Dwenger (2014) and Bitros and Nadiri (2017), as well as to only Cummins, Hassett and Hubbard (1994, table 9) in Table 4 (Hartley, Hassett and Rauh, 2025, p.13). They also compare their implied elasticity $d \log I_j / dr_j$ of -1.8 to -3.3 (obtained from multiplying their regression coefficients by the sample average of $R/(I/K)$) to a value of -0.7 reported in Congressional Budget Office (2018*b*). As discussed in Section 6.2, CBO applies that value to compute the elasticity holding output fixed and subsequently allows capital to adjust as output increases.

B.4 Policy Institutions

Council of Economic Advisers (2019, 2025) Council of Economic Advisers (2025, p. 68) describes the method in these studies:

> Calculations yield an estimated decline in the average user cost of capital of about 9 percent. Assuming a consensus user-cost elasticity of investment of -1.0, a 9 percent decline in the average user cost of capital would induce a 9 percent increase in the demand for capital. Following Jensen, Mathur, and Kallen (2017), it is then possible to use the Multifactor Productivity Tables from the Bureau of Labor Statistics in a growth accounting framework to increment the Congressional Budget Office's 10-year GDP growth projections by the additional contribution to output from a larger capital stock, assuming constant capital income shares, until we attain a new steady state.

The phrase "until we attain a new steady state" may seem to imply feedback from output to capital, but it does not. Jensen, Mathur and Kallen (2017) fully document the method. Starting from a baseline path of investment from 2017 forward, investment in each year is increased by 9% relative to the baseline path. This alternative path of investment implies an alternative path of capital using the perpetual inventory relationship $K_{t+1} = (1 - \delta) K_t + I_t$. Multiplying the additional capital by the capital-income share gives the increase in GDP in each year.