Corporate Taxes, Investment Frictions and Macroeconomic Dynamics*

Isaac Baley† UPF, CREI, BSE, and CEPR

Andrés Blanco ‡ Federal Reserve Bank of Atlanta

Nicolás Oviedo § UPF and BSE

February 14, 2025

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Abstract

We investigate the long-run effects of permanent corporate tax reforms on aggregate capital behavior. In an investment model with fixed adjustment costs and partial irreversibility, we show that corporate taxes and investment frictions jointly determine three interconnected macroeconomic outcomes: (i) capital allocation, (ii) capital valuation, and (iii) capital fluctuations around steady-state. Using corporate tax and firm-level investment data from Chile, we discover that a lower corporate income tax improves the allocation of capital, reduces capital valuation, and accelerates capital fluctuations.

JEL: D30, D80, E20, E30

Keywords: corporate taxes, investment frictions, fixed adjustment costs, irreversibility, lumpiness, capital misallocation, Tobin's q, transitional dynamics, inaction, propagation.

*The views here are those of the authors and not the Federal Reserve Bank of Atlanta or the Federal Reserve System.

†Universitat Pompeu Fabra, Centre de Recerca en Economia International, Barcelona School of Economics, and Centre for Economic Policy Research, isaac.baley@upf.edu

‡Federal Reserve Bank of Atlanta, jablanco@umich.edu

§Universitat Pompeu Fabra and Barcelona School of Economics, nicolas.oviedo@upf.edu

1 Introduction

Corporate tax reforms are back in the spotlight. Current economic developments- including the massive government debts accumulated to finance the recovery from the COVID pandemic, the fierce tax competition for foreign direct investment, the exhaustion of monetary policy after years at the zero lower bound, and the secular increase in business profits- have revived the interest in corporate taxation among policymakers. Since addressing these issues will likely require persistent changes in countries' corporate tax structures, it is key to understand and quantify the long-run macroeconomic effects that these reforms bring.

Corporate tax rates in developed economies have followed a downward trend in the last 40 years, showcasing a systematic shift from high to comparatively low tax rates, particularly in corporate income taxation. This transformation raises important questions about the long-run effects of permanent corporate income tax reforms, specifically their impact on investment behavior and capital accumulation dynamics. Understanding these effects is crucial for evaluating the broader economic implications of tax policy changes.

We study the effects of permanent corporate tax reforms on the propagation of aggregate shocks. We develop a parsimonious investment model with firm heterogeneity; empirically-relevant investment frictions, including a fixed capital adjustment cost (Caballero and Engel, 1999) and a wedge between the purchase and resale prices of capital that makes investment partially irreversible (Abel and Eberly, 1996); and a comprehensive corporate tax schedule, including corporate income, personal income, and capital gain taxes as well as depreciation deductions (Summers, 1981, Abel, 1982). We formalize the mechanisms through which the interaction of corporate taxes and investment frictions distorts the allocation of capital across firms and, in turn, how the capital allocation shapes aggregate capital fluctuations.

We offer three new insights. First, corporate taxes affect aggregate capital behavior through two distinct channels: (i) a neoclassical frictionless user-cost-of-capital channel, which determines the steady-state *level* of capital, and (ii) a frictional dynamic optimization channel, which shapes the *allocation* of capital across firms. Specifically, we show that *after-tax investment frictions*—namely, the fixed cost relative to the after-tax frictionless profits and the price wedge relative to the after-tax frictionless marginal revenue—are the key objects affecting dynamic investment decisions. For instance, reducing the corporate income tax rate raises frictionless profits and thus decreases firms' effective fixed cost the effective fixed costs that firms pay. These results imply that, up to re-scaling, an economy with corporate taxes is isomorphic to an economy without them. Consequently, it suffices to understand the role of investment frictions to assess the dynamic effects of taxation.

Following Alvarez and Lippi (2014), we define *capital fluctuations* around steady-state as the cumulative impulse response (CIR) to an unanticipated small shock to aggregate productivity.[1]

[1]The CIR summarizes the impact and the persistence of the economy's response in one scalar, representing a

Using micro-level investment data, we discipline the magnitude of the channels through which corporate tax reforms operate and predict the direction in which the aggregate capital measures will move after a reform. Our results suggest that an economy with lower after-tax investment frictions features less persistent propagation of productivity shocks (smaller CIR).

We examine the macroeconomic consequences of a shift from a high to a low corporate tax regime. We focus on changes to the top marginal corporate income tax rate, for which we observe a median decrease of about 17 percentage points from 42% in 1980 to 25% in 2020 across OECD countries.[2] According to the theory, a fall in the corporate income tax rate is equivalent to a fall in the after-tax fixed cost. While this reform should unambiguously reduce misallocation, the effects on aggregate fluctuations depend on the magnitude of other forces.

We discipline investment frictions by matching the model-consistent micro micro-moments from Chilean investment data.[3] Using the calibrated model, we examine the elasticity of aggregate capital measures to the corporate income tax. The novelty of our analysis is a parsimonious modeling of the intricacies of the tax code regarding the deductions of capital losses and the capitalization of adjustment costs. Specifically, the corporate income tax effectively reduces the price wedge because capital losses are deducted. This is the first analysis of the macroeconomic consequences of capital loss deductions. Our results suggest that, other things equal, the lower corporate income tax rate decreased capital misallocation across tax regimes as expected. It also reduced the CIR to accelerate the propagation of aggregate productivity shocks.

We conclude the paper by providing suggestive evidence of after-tax investment frictions being an appropriate notion to evaluate the effects of corporate tax reforms. To do this, we exploit cross-sectoral variation in the size of fixed costs recovered from model-implied micro-moments. We confirm the prediction that sectors with initially higher fixed costs suffer a more significant variation in aggregate capital measures following a change in the corporate tax rate.

In summary, we propose a laboratory for examining the macroeconomic effects of persistent corporate tax reforms, focusing on the interaction of taxes with investment frictions. Our analysis puts forward a new channel for policy intervention: Corporate tax policy can effectively change the size of fixed costs or irreversibility wedges- technological constraints or market prices typically outside the control of a policymaker- and structurally change the steady-state behavior of aggregate capital.

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multiplier of aggregate shocks. A higher CIR implies slower propagation and larger effects of the aggregate shock. Alvarez, Le Bihan and Lippi (2016), Baley and Blanco (2019), **?**, and Alexandrov (2021) use the CIR in the context of price-setting models to assess the effects of monetary shocks.

[2] While the median corporate income tax rate has continuously decreased during this period, reforms at the country level are very infrequent. In the US, for instance, only two reforms in the corporate income tax rate have occurred in the last 40 years, from 52% in 1986 to 21% in 2019.

[3] The Chilean context and establishment-level data have various advantages to study changes in the corporate income tax rate, as we explain in Section **??**.

Macroeconomic effects of corporate taxes We introduce a corporate tax schedule (Summers, 1981, Abel, 1982) and show analytically that *after-tax investment frictions*—the fixed adjustment cost relative to the after-tax frictionless profits and the price wedge relative to the after-tax frictionless profit-capital ratio—are the key objects that affect dynamic investment decisions. We then examine a regime shift from a high to a low corporate income tax rate, comparing the macroeconomic outcomes across steady states. There are two opposing effects. On the one hand, a lower tax rate decreases the after-tax fixed adjustment costs. On the other hand, a lower tax rate raises the after-tax price wedge because capital loss deductions fall. The calibrated model suggests that, other things equal, a corporate income tax cut from 42% to 25%—corresponding to the median decrease in OECD countries between 1980 and 2020—improves the allocation of capital, decreases capital valuation (q falls), and causes fluctuations to be more persistent (CIR rises) at the new steady state.

We examine the macroeconomic effects of corporate income tax cuts.[4] Since firms pay capital gain taxes, fundamentally, a price wedge implies capital losses that can be deducted from capital gain tax. Thus, corporate income tax cuts increase the price wedge. We formalized this idea by introducing a comprehensive corporate tax schedule (Summers, 1981, Abel, 1982). Our model's tax schedule includes a corporate income tax, a personal income tax, a capital gains tax, and depreciation deductions. We show analytically that *after-tax investment frictions*—namely, the fixed cost relative to the after-tax frictionless profits and the price wedge relative to the after-tax frictionless profit-capital ratio—are the key objects affecting dynamic investment decisions. We then examine the macroeconomic consequences of a regime shift from high to low corporate income taxes. We focus on changes to the top marginal corporate income tax rate, which showed a median decrease of 17 percentage points from 42% in 1980 to 25% in 2020 across OECD countries. This exercise highlights the need to disentangle the role of price wedges vis-à-vis fixed adjustment costs as corporate taxes interact differently with each investment friction. On the one hand, a lower corporate tax rate decreases effective fixed adjustment costs. On the other hand, it raises an effective price wedge because deductions of capital losses fall.

Contributions We contribute to the literature by studying the interaction of corporate taxes with investment frictions. Early work focused on the user-cost channel of taxation in frictionless environments. Subsequent work incorporated firm heterogeneity and non-convex adjustment costs to investigate the frictional taxation channel (Miao, 2019, Gourio and Miao, 2010, Miao and Wang, 2014). We show how to reduce the complex interactions between corporate taxes and investment frictions to a rescaling of the appropriate friction. This idea considerably simplifies the analysis and highlights the channels through which corporate tax reforms affect private investment.

The effects of permanent corporate tax reforms on the long-run behavior of aggregate capital

[4] See Miao (2019), Gourio and Miao (2010), Miao and Wang (2014), **?** for complementary structural work on taxation in models with firm heterogeneity and investment frictions.

has been widely studied. Early contributions by Summers (1981), Abel (1982), Poterba and Summers (1983), King and Fullerton (1984), Auerbach (1986) and Auerbach and Hines (1986) were framed in a neoclassical model with a representative firm and convex adjustment costs. Subsequent work incorporated certain stances of firm heterogeneity as well as non-convex adjustment frictions (Gourio and Miao, 2010, Miao and Wang, 2014). Most of these studies focused on the long-run capital stock and Tobin's q. While our model has large heterogeneity and is complicate, we show that an economy with corporate tax is isomorphic to an economy without them, after a re-scaling of the investment friction. We think this idea should guide future empirical and quantitative work.

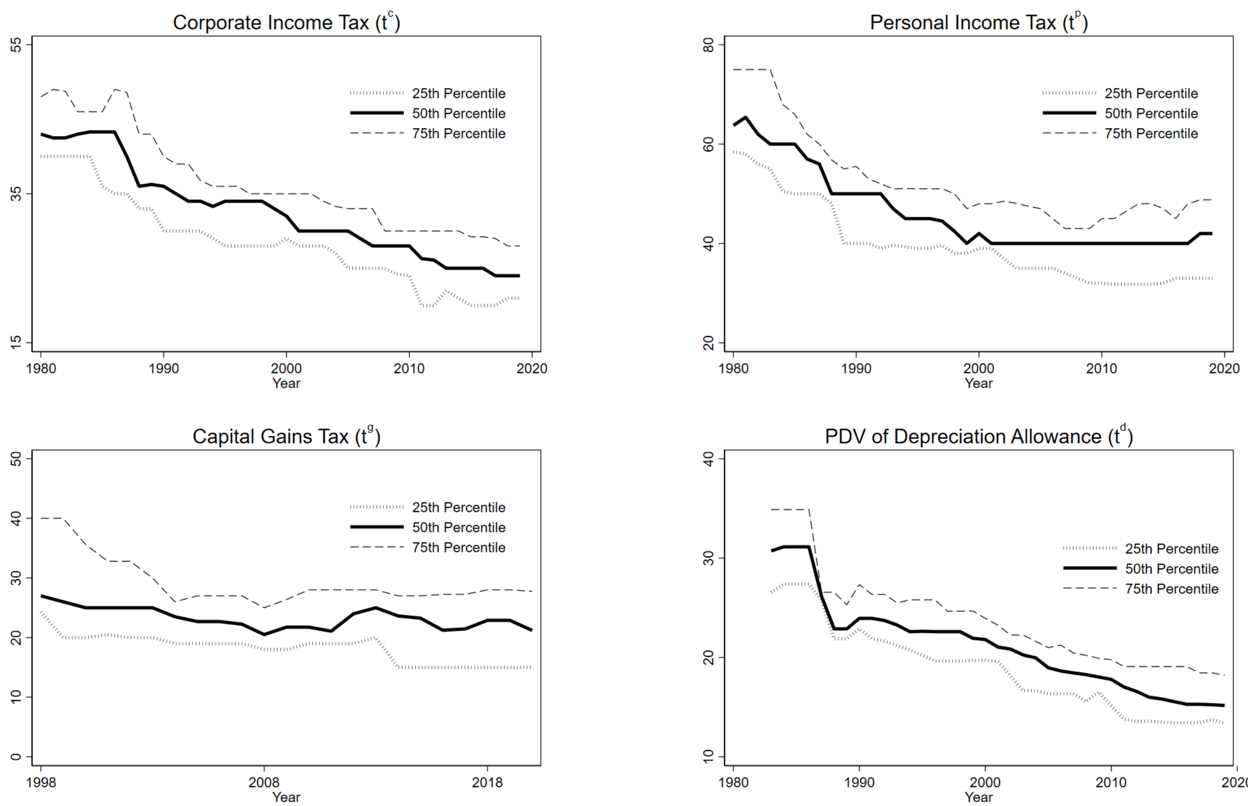
Since Hall and Jorgenson (1967), there is another literature that studies the short-run stimulus of permanent or transitory tax reforms using firm-level data. Our analysis is most closely related to the work by Winberry (2021) and **?**. They study the stimulus effect of corporate taxation in models with rich heterogeneity which replicate features of the empirical studies. Other papers assessing the stimulating role of corporate tax policy, from an applied public finance perspective, including investment tax credits (Lerche, 2019); bonus depreciation (Hassett and Hubbard, 2002, House and Shapiro, 2008, Zwick and Mahon, 2017, Maffini, Xing and Devereux, 2019); dividend taxes (Ohrn, 2018, Boissel and Matray, 2019); and corporate income tax (Yagan, 2015). We complement this literature by considering their effect on the long-run capital behavior whenever these reforms are permanent. We contribute by establishing structural relationships between capital misallocation, valuation, and fluctuations, and by showing how to discipline investment frictions with microdata. Finally, we show

Third, we contribute to the literature studying the role of micro-level adjustment frictions for economic fluctuations (see Caplin and Spulber, 1987, Caballero and Engel, 1991, 1993, for early work). Recent work identifies a small set of observable micro-moments that capture the role of adjustment frictions for the propagation of aggregate shocks (see Alvarez, Le Bihan and Lippi, 2016, Baley and Blanco, 2021). We contribute to this line of work in three ways. First, we consider the role of corporate taxes in shaping the observable micro-moments. Second, we move beyond the study of fluctuations and characterize other steady-state outcomes such as productivity and aggregate q with a few micro-statistics. Third, we show how to handle the history dependence arising from partial irreversibility (Bertola and Caballero, 1994, Abel and Eberly, 1996, Veracierto, 2002, Lanteri, 2018). In this way, we expand the breadth of problems that can be analyzed with this type of methodology to include history dependence, also labeled as problems with reinjection by Alvarez and Lippi (2021).

2 Corporate Taxation Trends

Tax rates in developed countries have followed a downward trend from 1980 through 2019. Figure I illustrates these trends for top statutory rates across different types of taxation in OECD countries[5]. The corporate income tax (CIT) rate, shown in the top left panel, demonstrates the most striking decline, both in magnitude and consistency over time. The median top statutory CIT rate fell from 43% to 24%. As indicated by the gray dashed lines, this decline occurred across the entire distribution, with rates becoming both lower and more consistent across countries[6].

Figure I: Taxation trends



Top statutory tax rates data for OECD countries. Source: Authors' dataset. Refer to the Data Appendix for the sources and availability of each series.

The remaining panels present trends in other tax categories. The top right panel shows personal income tax (PIT) rates, where the median top statutory rate decreased from 63.75% to 42%. However, this downward trend moderated after 2000, with rates at the 50th and 75th percentiles stabilizing while those at the lower end continued to decline, leading to greater dispersion[7].

Capital gains (CG) taxation showed a more modest decline, with the median top rate falling

[5]Sample includes all 2025 OECD members except Costa Rica. Data coverage begins in 1980, with later start dates for some countries. See Data Appendix for details.

[6]The standard deviation of top statutory CIT rates decreased from 8.75 in 1980 to 6.01 in 2019.

[7]All in all, the cross-country variance of top statutory PIT rates increased from 9.36 in 1980 to 10.89 in 2019.

from 27% in 1998 to 22% in 2019. Notably, the rate at the 75th percentile decreased from 40% to 28%, resulting in reduced dispersion across countries. The present discounted value of depreciation allowance (DA)depicted in the bottom right panel, mirrors the CIT trend, with the median rate declining from 30.72% in 1983 to 15.16% in 2019.[8]

While the median corporate income tax rate has continuously decreased during this period, reforms at the country level are very infrequent. In the US, for instance, only four reforms occurred in the last 40 years. The US statutory federal corporate tax rate was 46% from 1979-1986, 40% in 1987, 34% from 1988-1993, 35% from 1994-2017, and has been 21% since 2018. See Data Appendix **??**. The low frequency of reforms makes the case for comparing fluctuations in each of the steady states.

[8]The measure that we plot here, t^d, is the present discounted value of depreciation allowances, but adjusted by the remaining taxes. Technical details regarding the calculation of depreciation allowances have been confined to the Data Appendix.

3 A General Equilibrium Investment Framework

We present a general equilibrium model to examine the effects of corporate tax reforms. Its key elements are capital-quality shocks, investment frictions, and an exogenous interest rate.

3.1 Economic environment

Time is continuous, extends forever, and indexed by s. Five types of agents live in the economy: (i) A representative household, (ii) a capital–goods producer, subject to an investment irreversibility constraint, (iii) a final–good producer, (iv) a unit mass of intermediate–good firms indexed by $f \in [0,1]$ who are subject to fixed capital adjustment costs, and (v) a government.

3.1.1 Representative household

An infinitely lived representative household discounts the future at rate ρ. It chooses consumption C_s, labor supply L_s, and financial holdings to maximize expected utility:

$$\max_{\{C_s, L_s, B_s, \{E_s^f\}_{f\in[0,1]}\}_{s=0}^{\infty}} \mathbb{E}_0 \left[\int_0^\infty e^{-\rho t} \left(\log C_s - \chi L_s \right) \mathrm{d}s \right]. \tag{1}$$

There are two types of financial assets. Risk-free bonds B_s that pay a real return r_s. Equity shares E_s^f of each intermediate-good firm $f \in [0,1]$ that have price Q_s^f and deliver dividend payouts D_s^f. Thus the household's nominal wealth W_s is the sum of bond and equity holdings:

$$W_s \equiv B_s + \int_0^1 Q_t^f E_s^f \, \mathrm{d}f. \tag{2}$$

Let $\mathcal{Y}_s$ be disposable income, which includes labor income from wages w_s, capital income from dividends and bond returns, and government lump-sum transfers T_s, all taxed at the personal income tax rate t^p :[9]

$$\mathcal{Y}_s \equiv (1 - t^p) \left(w_s L_s + \int_0^1 D_s^f E_s^f \, \mathrm{d}f + r_s B_s + T_s \right). \tag{3}$$

Given initial holdings B_0 and $\{E_0^f\}_f$. the household's budget constraint evolves according to

$$\mathrm{d}B_s + \int_0^1 Q_s^f \, \mathrm{d}E_s^f \, \mathrm{d}f = (\mathcal{Y}_s - C_s) \, \mathrm{d}s - t^g \int_0^1 \mathrm{d}Q_s^f E_s^f \, \mathrm{d}f, \tag{4}$$

where t^g is the capital gains tax paid on changes in the equity value.

[9] We omit dividends of the final–good producer and the capital–good since they have constant returns to scale and do not generate dividends for the household. Thus, we omit those sectors' profits from the household budget constraint.

3.1.2 Capital–goods producer

The capital-goods producer manufactures firm-specific investment goods $\{i_s^f\}_{f\in[0,1]}$ in a competitive market, according to a linear technology

$$(5) \qquad i_s = \int_0^1 \left(\frac{\varphi(i_s^f)i_s^f}{u_{fs}}\right) \mathrm{d}f,$$

where i_s is the aggregate production of capital goods. We refer to u_{fs} as *capital quality shocks*. The function $\varphi\left(i_s^f\right)$ takes two values depending on the investment sign:

$$(6) \qquad \varphi\left(i_s^f\right) = \begin{cases} \varphi^- & \text{if } i_s^f > 0 \\ \varphi^+ & \text{if } i_s^f \leq 0 \end{cases}.$$

The parameters $\varphi^- > \varphi^+$ measure the degree of *technological irreversibility.* Taking the prices of firm-specific investment goods π_{js} as given, the capital–good firm problem maximizes her profits

$$(7) \qquad \max_{\{i_s^f,i_s\}_{s=0}^{\infty}} (1-t^c)\left(\int_0^1 \pi_s^f i_s^f \,\mathrm{d}f \; - \; i_s\right),$$

subject to the production technology of capital goods in (5). Here, t^c denotes the corporate income tax, Note that i_s^f may be positive or negative as its sign has no technological constraint.

3.1.3 Final–good producer

The final–good producer assembles output Y_s using intermediate inputs $\{\hat{y}_s^f\}_{f\in[0,1]}$ according to a Dixit-Stiglitz aggregator with elasticity η

$$(8) \qquad Y_s = \left(\int_0^1 \left(\frac{\hat{y}_f^f}{u_s^f}\right)^{1-\varepsilon} \mathrm{d}f\right)^{\frac{1}{1-\epsilon}},$$

where capital quality u_s^f decreases the marginal product of the intermediate good f. Taking the prices of intermediate inputs p_s^f as given, the producer's problem at date s entails choosing final–good supply Y_s and input demands $\hat{y}_s^f$ to maximize static profits:

$$(9) \qquad \max_{Y_s,\{\hat{y}_s^f\}_{f\in[0,1]}} (1-t^c)\left(Y_s - \int_0^1 p_s^f \hat{y}_s^f \,\mathrm{d}f\right),$$

the aggregator in (8).

3.1.4 Intermediate-good firms

These are the most important economic agents for our question as they make investment choices subject to fixed capital adjustment costs.

Technology and shocks Intermediate–good firm $f \in [0,1]$ produces output y_s^f using capital k_s^f according to a production function with decreasing returns to scale

$$y_s^f \;=\; u_s^{1-\alpha}(k_s^f)^{\alpha}, \quad \alpha < 1. \tag{10}$$

Idiosyncratic components drive a firm's total productivity

$$\mathrm{dlog}(u_f^f) \;=\; \mu\,\mathrm{d}s + \sigma\,\mathrm{d}W_s^f \qquad W_s^f \sim Wiener, \tag{11}$$

where the stochastic processes W_s^f are independent across intermediate-good firms.

Corporate taxes The firm pays the corporate income tax rate t^c on its cash flow $P_t^f y_s^f$ net of deductions $\xi^d k_s^f$, where ξ^d denotes the deduction rate. Since the physical and the legal depreciation rates differ, we distinguish deductions from the capital stock and denote these with d_{fs}. The state space now includes deductions (k, u, d). The corporate income tax and deductions jointly determine the after-tax profit rate

$$\pi_s^f \;=\; P_t^f y_s^f - t^c(P_t^f y_s^f - \xi^d d_{fs}) \;=\; (1-t^c)P_t^f y_s^f + t^c \xi^d d_{fs}, \tag{12}$$

and the evolution of deductions

$$\log d_{fs} \;=\; \log d_0 - \xi^d s + \sum_{h:T_{fh}\leq s}\left(1 + \frac{p^k(\hat{i}_{fT_{fh}})\hat{i}_{fT_{fh}} + \theta_{fT_h}}{d_{fT_{fh}^-}}\right). \tag{13}$$

Here, $\theta_s = \theta u_s$ where $\theta > 0$ is constant and $\hat{i}$ is firm's investment.

Taking the prices of the intermediate goods p_{ft}, the marginal investor discount factor Q_t, and firm-specific capital goods $p_{ft}^k(\hat{i})$ as given, together with the adjustment friction θ_{ft}, each firm f chooses a sequence of capital adjustment dates $\{T_{fh}\}_{h=1}^{\infty}$ and investments $\{i_{f,T_{fh}}\}_{h=1}^{\infty}$ to maximize its expected discounted stream of profits

$$\max_{\{T_{fh},\hat{i}_{f,T_{fh}}\}_{h=1}^{\infty}} \mathbb{E}\left[\int_0^{\infty} Q_t \pi_s^f \;\mathrm{d}s - \sum_{h\,=\,1}^{\infty} Q_{T_{fh}} p_{f,T_{fh}}^k \left(\theta_{fT_{fh}} + p_{fT_{fh}}^k(\hat{i}_{fT_{fh}})\hat{i}_{fT_{fh}}\right)\right], \tag{14}$$

subject to the profits function in (12) and the law of motion for its capital stock

$$\log(k_{ft}) \;=\; \log(k_{f0}) - \zeta t + \sum_{h:T_{fh}\leq t} \log\left(1 + \frac{\hat{\imath}_{f,T_{fh}}}{k_{T_{fh}^{-}}}\right). \tag{15}$$

3.1.5 Government

Since Ricardian equivalence holds, we assume the government follows a period-by-period balance budget without loss of generality. The period expenditures, given by the lump-sum transfers R_s, has to be equal to the revenue from the firms $\int_0^1 T_{js}\,\mathrm{d}f$ and the household T_s^h

$$\begin{aligned} R_s &= \int_0^1 T_{fs}\,\mathrm{d}f + T_s^h, \\ T_{fs} &= t^c\left(P_t^f y_s^f - \xi^d d_{js}\right), \\ T_s^h &= t^p\left(\int_0^1 D_{fs}E_s^f\,\mathrm{d}f + r_s B_s\right) + t^g \int_0^1 P_t^f E_s^f\,\mathrm{d}f. \end{aligned} \tag{16}$$

3.1.6 Market structure

There are three types of goods (respectively, markets) in the economy: (i) final goods, (ii) intermediate goods, and (iii) firm-specific investment goods. There are two assets: (i) risk-free bonds and (ii) equity. All good and asset markets are competitive. We assume equity can only be held by the representative household. Thus, we have segmented the equity market, and the bond market freely trades across countries. The market clearing conditions, respectively, are as follows:

$$E_s^f \;=\; 1 \quad \text{for all } t \text{ and } f, \tag{17}$$

$$\hat{y}_s^f \;=\; y_s^f \quad \text{for all } s \text{ and } f, \tag{18}$$

$$\hat{\imath}_{fs} \;=\; i_s^f \quad \text{for all } s \text{ and } f. \tag{19}$$

3.2 Equilibrium

We now define and describe the equilibrium determination of prices and quantities in that order.

Equilibrium definition *Given a stochastic processes for capital quality $\{u_{fs}\}_{fs}$, and adjustment costs θ_{ft}, an equilibrium is a set of stochastic processes for prices $\{r_s, \{P_t^f, \pi_t^f(i), P_t^f\}_{f\in[0,1]}\}_{s=0}^{\infty}$, the household's policy $\{C_s, B_s, \{E_s^f\}_{f\in[0,1]}\}_{t=0}^{\infty}$, the final–good producer's policy $\left\{Y_s, \{\hat{y}_s^f\}_{f\in[0,1]}\right\}_{t=0}^{\infty}$, the capital–good producer's policy $\left\{\{i_s^f\}_{f\in[0,1]}, i_s\right\}_{t=0}^{\infty}$, and the intermediate–good firms' policy $\left\{\{T_{fh}, i_{f,T_{hf}}\}_{h=1}^{\infty}\right\}$ such that:*

(i) Given prices $\{r_s, P_t^f\}$, the household solves (1).

(ii) Given prices $\{\pi_s^f\}$, the capital–good producer solves (7).

(iii) Given prices $\{P_s^f\}$, the final–good producer solves (9).

(iv) Given prices $\{Q_s, P_s^f, \pi_s^f\}$, intermediate–good firms solve (14).

(v) Market clears in (17) to (19).

From now on, we assume that the interest rate is constant: $r_s = r$.

Equilibrium prices The household's optimality conditions over bonds and equity are

$$r(1-t^p)\,\mathrm{d}s = \chi\,\mathrm{d}s - \frac{\mathrm{d}(1/C_s)}{1/C_s} \quad \forall s$$

$$\frac{(1-t^g)\mathbb{E}[dP_t^f(i)] + (1-t^p)D_s^f(i)\,\mathrm{d}s}{P_{js}(i)} = \chi\,\mathrm{d}s - \frac{\mathrm{d}(1/C_s)}{1/C_s} \quad \forall s, f \tag{20}$$

The differential equations in (20) jointly imply a unique equilibrium for the price of equity. Under the equilibrium condition of a unit supply of equity in (17), we see that

$$V_0 \;=\; P_0 \;=\; \frac{1-t^p}{1-t^g}\,\mathbb{E}_0\left[\int_0^\infty e^{-r\frac{1-t^p}{1-t^g}s} D_s\,\mathrm{d}s\right]. \tag{21}$$

Finally, the zero profit conditions for the final– and capital-good producers imply the following relationships for the input and output prices of the respective goods:

$$p_{ft} \;=\; \frac{1}{u_{ft}} \quad ; \quad p_{ft}^k(i) \;=\; p_{ft}\varphi(i), \tag{22}$$

where $\varphi(i) = \varphi^+\mathbb{1}_{\{i<0\}} + \varphi^-\mathbb{1}_{\{i>0\}}$ and $p_{ft}^k(i)$ stands for the relative price of capital.

Equilibrium policy of intermediate good firms With these facts about equilibrium prices established, we turn to the problem facing an individual intermediate–good firm. Let $V(k,u,d)$ be the firm's value with capital k, productivity u, and depreciation deductions d. The sufficient optimality conditions satisfied by a firm's policy are (i) the HJB equation valid during periods of inactivity, (ii) the value matching conditions, and (iii) the smooth pasting conditions. The firm policy consists of an inaction region $\mathcal{R} \equiv \{(k,u,d) : k^-(u,d) \leq k \leq k^+(u,d)\}$, where $k^-(u,d)$ and $k^+(u,d)$ are the lower and upper inaction thresholds, together with a reset capital $k^{*-}(u,d)$ and $k^{*+}(u,d)$ for positive and negative investments upon adjustment.

Define the PDV of depreciation deductions:

$$z \equiv \frac{\xi^d}{r\frac{1-t^p}{1-t^g} + \xi^d}. \tag{23}$$

Also, let $r \equiv r(1-t^p)(1-t^g) - \mu$[10] Let $v(\hat{k}) : \mathbb{R} \to \mathbb{R}$ be a function of the log capital-productivity ratio equal to

$$v(\hat{k}) = \max_{\tau,\Delta\hat{k}} \mathbb{E}\left[\int_0^\tau (1-t^c)e^{-rs+\alpha\hat{k}_s}\,\mathrm{d}s + e^{-r\tau}\left(-\theta(1-t^c z) - p(\Delta\hat{k})(e^{\hat{k}_\tau+\Delta\hat{k}} - e^{\hat{k}_\tau}) + v(\hat{k}_\tau + \Delta\hat{k})\right)\Big|\hat{k}_0 = \hat{k}\right] \tag{24}$$

where the price function with taxes is now given by:

$$p\left(i_s\right) = \left(1 - t^c z\right)\left(\varphi^- \mathbb{1}_{\{i_s>0\}} + \varphi^+ \mathbb{1}_{\{i_s<0\}}\right). \tag{25}$$

Then the firm value equals $V_0 = \frac{1-t^p}{1-t^g}\left[v(\hat{k}_0) + \ t^c z d_0\right]$.

A few remarks about the firms' investment policy are in place. The formulations of the capital quality shocks and the adjustment costs allow us to collapse the state-space of the firms (k, u) into the capital-to-productivity ratio $\hat{k} = k/u$. Note that the level of productivity does not scale the value of the firm $v(\hat{k}_0)$ to recover the time-0 value V_0.The prices of intermediate goods p_{ft} and capital goods p^k_{ft}, as well as the fixed capital adjustment costs θ_{ft}, are proportional to capital quality u_{ft}, making profits and investment scaled by total productivity the relevant variables for the firm.

3.3 Remarks on the economic framework

General equilibrium structure Capital quality u_{ft} was first used in Baley and Blanco (2021) in the investment context. In the pricing literature, an analogous formulation was first used by Woodford (2009) to keep the tractability of their model. It is also used by Midrigan (2011), Alvarez and Lippi (2014), Baley and Blanco (2019), and Blanco (2020), among others. This formulation implies that aggregate feasibility only depends on firms' capital-to-productivity ratios instead of capital and productivity separately. As a result, capital quality shocks reduce the dimensionality of the aggregate state space from the joint distribution of capital and productivity to the distribution of their ratio.

Ireversibility The price wedge is a technological constraint in the capital–good producer; therefore, it is exogenous. We choose this modeling strategy to focus on its consequences for capital allocation, valuation, and dynamics. This formulation follows Veracierto (2002) and Khan and

[10](without subtracting $\sigma^2/2$, in contrast to the main text) be the adjusted discount factor.

Thomas (2008). Alternatively, partial irreversibility could be the outcome of distortionary taxation. For example, **?** uses China's 2009 VAT reform to study changes in the level of partial irreversibility. It would be easy to extend our framework to micro-found partial irreversibility as an outcome of a tax system as in **?**. See Lanteri (2018) for a model that endogenies partial irreversibility.

Financial markets. We assume that the representative household can trade in the bond market, but the economy is close to the equity market. That is, only the household in the small open economy is the firm's owner, and it provides the firms' discount factor. While these are extreme assumptions, they reasonably approximate small open economies. On empirical grounds, it is well known that central banks, firms, and households in emerging economies tend to save in dollar-denominated risk–free assets (e.g., T-bill). Moreover, it is also well known that despite the globalization of finance and financial institutions, market participants put most of their wealth into assets from their own countries. This "home bias" might be due to regulatory constraints, information, and transaction costs, but some are considered a matter of taste. While the current version of the model is an extreme version of the "home bias" facts, it provides a starting point to analyze the macroeconomic consequence of corporate taxation without considering the effect of personal taxation in other countries through its impact on the firm's discount factor.

Tractability Given the novelty of the general equilibrium framework, a further discussion of the assumptions and economic adjusting mechanisms is warranted. The tractability of our framework arises from three features. First, all aggregate variables are expressed in terms of the distribution of capital-to-productivity ratios. This result comes directly from how we introduce capital quality shocks and the shape of capital adjustment costs. Second, the model generates a constant real interest rate due to the small open economy assumption. Third, by the close equity market assumption, we can determine the first discount factor as a function of the world interest rate and the personal taxation in the economy.

The theory in Sections **??** and 5 takes as given that the cross-sectional distribution of capital-to-productivity ratios is the relevant aggregate state, exogenous interest rate, and taxation in general equilibrium. The general equilibrium framework presented here provides a microfoundation to analyze the macroeconomic consequences of corporate tax changes.

4 Adding Corporate Taxes

We introduce a comprehensive tax schedule and characterize the role of corporate taxation in shaping macroeconomic outcomes. We do this in three steps. First, corporate taxes change four parameters: profitability A, the discount factor ρ, the fixed cost θ, and the investment prices $p(\Delta\hat{k})$. Once we redefine these parameters, the investment problem is identical to the one described in Section 3. Second, we analyze the effect of taxation using the notion of *after-tax* effective frictions, which summarize the complex interaction of taxes with investment frictions with an appropriate rescaling of each friction. Third, we assess the effects of corporate income tax cuts using the mappings between macroeconomic outcomes, cross-sectional moments, and microdata.

4.1 A comprehensive tax schedule

The firm pays the corporate income tax rate t^c on its cash flow Ay_s net of deductions, where ξ^d denotes the deduction rate. Since the physical and legal depreciation rates differ, we distinguish deductions from the capital stock and denote these with d_s. The state space now includes deductions $V(k, u, d)$.

The after-tax profit per unit of time π_s is given by

$$\pi_s = (1 - t^c)Ay_s + \underbrace{t^c\xi^d d_s}_{\text{depreciation allowances}} - t^c \underbrace{p\omega i_s \mathbb{1}_{\{i_s<0\}}}_{\text{capital losses}}, \tag{26}$$

where deductions evolve as

$$\log d_s = \log d_0 - \xi^d s + \sum_{h:T_h \leq s} \log\left(1 + \frac{p i_{T_h}}{d_{T_h^-}} + \underbrace{\frac{\theta_{T_h}}{d_{T_h^-}}}_{\text{fixed cost capitalization}}\right). \tag{27}$$

Let us explain how we model the interaction of taxes with investment frictions. First, we assume that the payments of fixed adjustment costs are capitalized and enter the law of motion of capital deductions in (27). This assumption is sensible to the extent that the fixed costs associated with investment or disinvestment are not fully deducted when they are paid. In contrast, when a firm sells its capital, it loses the future deductions valued at the buying price. For example, if $\omega = 1$ and the firm buys and sells capital immediately, then the capital depreciation allowance does not change. Second, we assume that capital losses are fully deducted from ordinary income in (41) on the date on which they are accrued.

In the U.S., the capital gains tax in the corporate sector is computed on observed transactions, as for households. Different from household taxation of capital gains, however, firms do not receive a preferential tax rate; that is, firms are not allowed to use capital losses to offset ordinary income taxation. Instead, as with the corporate income tax, losses are carried backward or forward to compensate for gains. We abstract from these dimensions and assume that the corporate income tax is linear and applies to the sum of ordinary and capital income. See Desai and Gentry (2004) for a detailed discussion of capital gains taxes for the corporate sector.[11]

The personal income tax t^p and the capital gains tax t^g alter the firms' discount factor. We assume that equity is purchased by a representative investor with access to a riskless bond with return ρ per unit of time. Let D_s be the dividend per share, P_s the equity price per share, and $E_s = 1$ the number of shares, which we normalize to unity without loss of generality. From the investor's perspective, dividends and bond returns are taxed at the rate t^p, while capital gains that arise from changes in equity prices are taxed at the rate t^g. For any dividend process, no-arbitrage implies equal after-tax returns:

$$(1 - t^p)\rho \, \mathrm{d}s \;=\; (1 - t^g)\frac{\mathbb{E}[\mathrm{d}P_s]}{P_s} \;+\; (1 - t^p)\frac{D_s}{P_s}\,\mathrm{d}s. \tag{28}$$

Condition (43) pins down the time-0 value of the firm, which equals the equity price:

$$V(k_0, u_0, d_0) \;=\; P_0 \;=\; \frac{1 - t^p}{1 - t^g}\,\mathbb{E}_0\left[\int_0^\infty e^{-\rho\frac{1-t^p}{1-t^g}s} D_s \,\mathrm{d}s\right]. \tag{29}$$

This expression says that the firm maximizes the cum-dividends market value of equity P_0 using the investor's after-tax discount factor $\rho(1 - t^p)/(1 - t^g)$, as in Auerbach (1979). We follow the "tax capitalization" view of the dividend decision and consider dividends as residuals, equal to the cash flow π_s net of investment and capital adjustment costs[12]

$$D_s \,\mathrm{d}s \;=\; \pi_s \,\mathrm{d}s - (\theta_s + (p(i_s) - t^c p\omega \mathbb{1}_{\{i_s<0\}})i_s)\mathcal{D}(s = T_h), \qquad \mathcal{D}(\cdot) \sim \mathit{Dirac}. \tag{30}$$

4.2 Model with taxes

Given the tax schedule, Lemma 1 characterizes the firm's problem with corporate taxation. The strategy consists of defining the discounted value of deductions per unit of investment z and using it to rewrite the 3-state problem (k, u, d) as the 1-state problem in terms of the capital-productivity ratio $\hat{k} = \log(k/u)$ already examined in Section **??**, with four parametric changes and an additive term that reflects deductions d.

[11]We thank Jim Hines for helpful advice on these assumptions.

[12]In the model without corporate taxes, the Modigliani-Miller theorem holds, that is, the firm's value and investment policy—and the implicit dividend policy—are independent of the capital structure. Introducing taxes, in principle, could break this independence (for example, under the trade-off theory of the capital structure; see Hines and Park, 2017). Nevertheless, following the arguments in Miller (1977) and more recently in Abel (2018), we continue to work under the Modigliani-Miller paradigm.

Proposition 1. *Define the discounted value of deductions z as follows:*

$$z \equiv \frac{\xi^d}{\rho\frac{1-t^p}{1-t^g} + \xi^d} < 1. \tag{31}$$

The firm's value with taxes can be decomposed as:

$$V(k,u,d) = \frac{1-t^p}{1-t^g}\left[uv(\hat{k}) + t^c z d\right], \tag{32}$$

where $v(\hat{k})$ solves the investment problem in Lemma **??** *with the following four parametric changes:*

$$A \rightarrow (1-t^c)A, \tag{33}$$

$$\rho \rightarrow \frac{(1-t^p)}{(1-t^g)}\rho, \tag{34}$$

$$\theta \rightarrow (1-t^c z)\theta, \tag{35}$$

$$p(\Delta\hat{k}) \rightarrow \left(1 - t^c z - \omega(1-t^c)\mathbb{1}_{\{\Delta\hat{k}<0\}}\right)p. \tag{36}$$

The parametric changes established in Proposition 1 highlight the different channels through which taxes affect the firm value and optimal policy. The corporate income tax t^c directly affects after-tax profitability A in (48). The personal income tax t^p and the capital gains tax t^g scale the discount factor ρ in (49).[13] The discounted value of deductions z affects the firm value through an income effect, as deductions increase additively the firm value in (47), and a substitution effect, as deductions promote investment by reducing the after-tax adjustment costs and after-tax prices in (50) and (51). Additionally, t^p and t^g operate indirectly through z, and t^c directly affects the effective level of partial irreversibility.

4.3 After-tax investment frictions

Next, we formalize the channels through which taxes affect investment through their interaction with frictions. To simplify the notation, we define the *after-tax* discount $\tilde{r}$ and the *after-tax* user cost of capital $\tilde{\mathcal{U}}$:

$$\tilde{r} \equiv \frac{1-t^p}{1-t^g}\rho - \mu - \frac{\sigma^2}{2}, \tag{37}$$

$$\tilde{\mathcal{U}} \equiv \frac{1-t^p}{1-t^g}\rho + \xi^k - \sigma^2. \tag{38}$$

[13] The factor $(1-t^p)/(1-t^g)$ also scales A, θ, and $p(\hat{k})$. However, these parameters divide each other in all the expressions that follow, so we can safely ignore this factor.

In particular, the after-tax user cost $\tilde{\mathcal{U}}$ decreases with the personal income tax and increases with the capital gains tax. For the problem to be well defined, we assume $\tilde{r} > 0$ and $\tilde{\mathcal{U}} > 0$.

Proposition 4 introduces the notion of after-tax investment frictions, which are analogous to the effective frictions defined in (55) and (56) with the addition of taxes. Then, it signs the relationships with investment frictions.

Proposition 2. *Let* $z \equiv \xi^d / (\rho \frac{1-t^p}{1-t^g} + \xi^d) < 1$*. With corporate taxes, the effective fixed cost* $\tilde{\theta}$ *and effective price wedge* $\tilde{\omega}$ *are given by*

$$\tilde{\theta} = \left(\frac{1 - t^c z}{1 - t^c} \frac{1}{A} \right)^{\frac{1}{1-\alpha}} \left(\frac{p\tilde{\mathcal{U}}}{\alpha} \right)^{\frac{\alpha}{1-\alpha}} \theta, \tag{39}$$

$$\tilde{\omega} = \frac{(1 - t^c)\alpha}{\tilde{\mathcal{U}}} \omega. \tag{40}$$

Corporate taxes have the following effects on the after-tax investment frictions:

1. *The effective fixed adjustment cost* $\tilde{\theta}$ *increases with* t^c *and the after-tax user cost* $\tilde{\mathcal{U}}$*, and decreases with the PDV of deductions* z*.*

2. *The effective price wedge* $\tilde{\omega}$ *decreases with the corporate income tax* t^c *and after-tax user cost* $\tilde{\mathcal{U}}$*, and does not change with the PDV of deductions* z*.*

Let us focus on the effects of the corporate income tax, which has opposing effects on after-tax investment frictions. On the one hand, a lower corporate income tax t^c increases profits and therefore *reduces the after-tax fixed cost*. This effect is mediated by the depreciation allowance rate, being lowest when $z = 1$ (in this case t^c is a pure profit tax) and highest when $\xi^d = z = 0$. On the other hand, a lower corporate income tax t^c *increases the after-tax price wedge* because it provides a smaller subsidy to capital losses. As anticipated, a corporate income tax cut generates an inward *displacement* together with a movement *along* the isoquant of after-tax frictions $(\tilde{\theta}, \tilde{\omega})$ (recall Figure **??**). Next, we apply these insights to study the aggregate effects of corporate taxes.

5 The Macroeconomic Effects of Corporate Taxes

This section introduces a comprehensive tax schedule into the firm problem and analytically characterizes the role of corporate taxation in shaping macroeconomic outcomes. We do this in three steps. First, we show that taxes change four parameters: profitability A, the discount factor ρ, the fixed cost θ, and the investment prices $p(\Delta\hat{k})$. Once we redefine these parameters, the investment problem is identical to the one described in Section 3. Second, we decompose the firm investment policy into a neoclassical component, which reflects the effects of taxation through the user cost of capital, and a dynamic component, which reflects the interaction of taxes and investment frictions. Third, we isolate the various mechanisms at play by considering two benchmark cases: a driftless case where irreversibility has an important role and a large-drift case where irreversibility is innocuous.

5.1 A comprehensive tax schedule

Following Summers (1981) and Abel (1982), we introduce a corporate tax system into the firm problem. It includes a corporate income tax t^c, deduction allowance ξ^d, personal income tax t^p, and capital gains tax t^g.[14]

The firm pays the corporate income tax rate t^c on its cash flow Ay_s net of deductions $\xi^d k_s$, where ξ^d denotes the deduction rate. Since the physical and the legal depreciation rates differ, we distinguish deductions from the capital stock and denote these with d_s. The state space now includes deductions $V(k,u,d)$. The corporate income tax and deductions jointly determine the after–tax profit rate

$$\pi_s \;=\; Ay_s - t^c(Ay_s - \xi^d d_s) \;=\; (1-t^c)Ay_s + t^c\xi^d d_s, \tag{41}$$

and the evolution of deductions[15]

$$\log d_s \;=\; \log d_0 - \xi^d s + \sum_{h:T_h\leq s}\left(1 + \frac{\theta_{T_h} + p(i_{T_h})i_{T_h}}{d_{T_h^-}}\right). \tag{42}$$

The personal income tax t^p and the capital gain tax t^g alter the firms' discount factor. We assume that equity is purchased by a representative investor with access to a riskless bond with return ρ per unit of time. Let D_s be the dividend per share, P_s the equity price per share, and $E_s = 1$ the number of shares, which we normalize to unity without loss of generality. From the investor's perspective, dividends and bond returns are taxed at the rate t^p, while capital

[14] This taxation schedule is also used in the investment models by Poterba and Summers (1983), King and Fullerton (1984), Auerbach (1986), Auerbach and Hines (1986), Hassett and Hubbard (2002).

[15] We assume that the fixed adjustment cost are capitalized and enter into the expression for deductions. We thank Jim Hines for helpful advice on this modelling assumption.

gains arising from changes in equity prices are taxed at the rate t^g. For any dividend process, no-arbitrage implies equal after-tax returns:

$$(1 - t^p)\rho \,\mathrm{d}s \;=\; (1 - t^g)\frac{\mathbb{E}[\mathrm{d}P_s]}{P_s} \;+\; (1 - t^p)\frac{D_s}{P_s}\,\mathrm{d}s. \tag{43}$$

Condition (43) pins down the time-0 value of the firm, which equals the equity price:

$$V(k_0, u_0, d_0) \;=\; P_0 \;=\; \frac{1 - t^p}{1 - t^g}\,\mathbb{E}_0\left[\int_0^\infty e^{-\rho\frac{1-t^p}{1-t^g}s} D_s\,\mathrm{d}s\right]. \tag{44}$$

This expression says that the firm maximizes the cum-dividends market value of equity P_0 using the investor's after-tax discount factor $\rho(1 - t^p)/(1 - t^g)$, as in Auerbach (1979). We follow the "tax capitalization" view of the dividend decision and consider dividends as residuals, equal to the cash flow π_s net of investment and capital adjustment costs[16]

$$D_s\,\mathrm{d}s \;=\; \pi_s\,\mathrm{d}s - (\theta_s + p(i_s)i_s)\mathcal{D}(s = T_h), \qquad \mathcal{D}(\cdot) \sim \mathit{Dirac}. \tag{45}$$

Given the tax schedule, Lemma 1 characterizes the problem with corporate taxation. The strategy consists of defining the discounted value of deductions per unit of investment z and using it to rewrite the 3-state problem as the 1-state problem with the capital-productivity ratio solved before in Section **??**, under four parametric changes and an additive term that reflects deductions.

Lemma 1. *Define the discounted value of deductions as*

$$z \;\equiv\; \frac{\xi^d}{\rho\frac{1-t^p}{1-t^g} + \xi^d} < 1. \tag{46}$$

The firm value with taxes can be decomposed as:

$$V(k, u, d) \;=\; \frac{1 - t^p}{1 - t^g}\left[uv(\hat{k}) \;+\; t^c z d\right], \tag{47}$$

[16]In the previous sections without corporate taxes, the Modigliani-Miller theorem holds, that is, the firms' values and investment policies—and the implicit dividend policy—were independent of the capital structure. Introducing taxes, in principle, could break this independence (for example, under the trade-off theory of the capital structure, see Hines and Park, 2017). Nevertheless, following the arguments in Miller (1977), and more recently in Abel (2018), we continue working under the Modigliani-Miller paradigm.

where $v(\hat{k})$ solves the investment problem in Lemma **??** *with the following four parametric changes:*

$$A \rightarrow (1-t^c)A, \tag{48}$$

$$\rho \rightarrow \frac{(1-t^p)}{(1-t^g)}\rho, \tag{49}$$

$$\theta \rightarrow (1-t^c z)\theta, \tag{50}$$

$$p(\Delta\hat{k}) \rightarrow (1-t^c z)\, p(\Delta\hat{k}). \tag{51}$$

The parametric changes established in Lemma 1 highlight the different channels through which taxes affect the firm value and optimal policy. The corporate income tax t^c directly affects after-tax profitability A in (48). The personal income tax t^p and the capital gains tax t^g scale the discount factor ρ in (49).[17] The discounted value of deductions z affects the firm value through an income effect, as deductions increase additively the firm value in (47), and a substitution effect, as deductions promote investment by reducing the after-tax adjustment costs and after-tax prices in (50) and (51). Additionally, t^p and t^g operate indirectly through z. Next, we formalize how taxes affect investment through their interaction with investment frictions.

5.2 Frictionless and frictional effects of corporate taxation

Proposition 3 decomposes the optimal investment policy into a neoclassical frictionless component and a dynamic component that comprises the investment frictions. It shows that, from a firm's perspective, what matters for investment decisions is the fixed cost and the price wedge relative to *after-tax* profits. To simplify the notation, we define the *after-tax* discount $\tilde{r}$ and the *after-tax* user cost of capital $\tilde{\mathcal{U}}$ as:

$$\tilde{r} \equiv \frac{1-t^p}{1-t^g}\rho - \mu - \frac{\sigma^2}{2}, \tag{52}$$

$$\tilde{\mathcal{U}} \equiv \frac{1-t^p}{1-t^g}\rho + \xi^k - \sigma^2. \tag{53}$$

In particular, the after-tax user cost $\tilde{\mathcal{U}}$ is determined by the the personal income and capital gains taxes, the discount rate, the depreciation rate, and idiosyncratic volatility. For the problem to be well-defined, we assume $\tilde{r} > 0$ and $\tilde{\mathcal{U}} > 0$.

Proposition 3. *Let $\mathcal{K} \equiv \{\hat{k}^-, \hat{k}^{*-}, \hat{k}^{*+}, \hat{k}^+\}$ denote the firms' optimal investment policy characterized in Lemma* **??**. *Consider the static log capital-productivity ratio $\hat{k}^{ss}$ that firms would set in*

[17] The factor $(1-t^p)/(1-t^g)$ also scales A, θ, and $p(\hat{k})$. However, these parameters divide each other in all the expressions that follow, so we can safely ignore this factor.

the absence of the fixed cost and the price wedge:

$$\hat{k}^{ss} = \frac{1}{1-\alpha} \log\left(\frac{1-t^c}{1-t^c z} \frac{\alpha A}{p\tilde{\mathcal{U}}}\right). \tag{54}$$

With the static policy $\hat{k}^{ss}$, define the effective fixed cost $\tilde{\theta}$ (scaled by the after-tax static profits) and the effective prices $\tilde{p}^{sell}$ and $\tilde{p}^{buy}$ (scaled by the after-tax static profit-capital ratio):

$$\tilde{\theta} \equiv \frac{1-t^c z}{1-t^c} \frac{\theta}{Ae^{\alpha \hat{k}^{ss}}}, \tag{55}$$

$$(\tilde{p}^{buy}, \tilde{p}^{sell}) \equiv \frac{1-t^c z}{1-t^c} \frac{(p^{buy}-p, p^{sell}-p)}{Ae^{(\alpha-1)\hat{k}^{ss}}}. \tag{56}$$

Consider the normalized capital-productivity ratio $x \equiv \hat{k} - \hat{k}^{ss}$. Then the optimal investment policy can be decomposed as the sum of a static and a dynamic component

$$\mathcal{K} = \hat{k}^{ss} + \mathcal{X}, \tag{57}$$

where the dynamic component $\mathcal{X} \equiv \{x^-, x^{*-}, x^{*+}, x^+\}$ solves the following stopping problem:

$$\begin{aligned} \mathcal{V}(x) &= \max_{\tau, \Delta x} \mathbb{E}\Bigg[\int_0^\tau e^{-\tilde{r}\tau}\left(e^{\alpha x_s} - \alpha e^{x_s}\right) \mathrm{d}s \\ &\quad + e^{\tilde{r}\tau}\left(-\tilde{\theta} + \tilde{p}(\Delta x)(e^{x_\tau + \Delta x} - e^{x_\tau}) + \mathcal{V}(x_\tau + \Delta x)\right) \Bigg| x_0 = x\Bigg], \end{aligned} \tag{58}$$

$$\mathrm{d}x_t = -\nu \,\mathrm{d}t + \sigma \,\mathrm{d}W_t, \tag{59}$$

$$\tilde{p}(\Delta x) = \tilde{p}^{buy} \mathbb{1}_{\{\Delta x > 0\}} + \tilde{p}^{sell} \mathbb{1}_{\{\Delta x < 0\}}. \tag{60}$$

Proposition 3 provides several insights regarding the effects of corporate taxation on investment. The static optimal policy $\hat{k}^{ss}$ in (54) sets the capital-productivity ratio to a constant, and its value reflects after-tax profitability $(1-t^c)\alpha A$, the average after-tax user cost of capital $\tilde{\mathcal{U}}$ in (53), and the average after-tax investment price $(1-t^c z)p$. Studying the effects of corporate taxes on a frictionless investment policy and its implications for aggregate capital accumulation have been widely studied (see Summers, 1981, for early work).

By definition, investment frictions do not affect the static choice $\hat{k}^{ss}$. In contrast, the dynamic policy $\mathcal{X}$ characterized by (58), (59), and (60) takes into account the fixed cost and the price wedge, but these frictions enter scaled by after-tax static profits or by after-tax profit-capital ratio (recall the definition of effective frictions in (55) and (56)). Moreover, the flow payoff in the dynamic problem $e^{\alpha x_s} - \alpha e^{x_s}$ only depends on the curvature of the profit function α, and thus it is tax invariant. Together, these observations imply that taxes have effects on the dynamic component $\mathcal{X}$ of the optimal policy exclusively through the effective investment frictions.

The fact that *after-tax* frictions are the key determinants for investment puts forward a novel channel for policy intervention: Corporate tax policy can change the effective size of fixed adjustment costs and the price wedge—technological constraints typically considered outside the control of a policymaker—and thus affect the dynamic component of investment. Proposition 4 formalizes the channels through which the corporate tax schedule shapes firm investment and signs the relationships with investment frictions.

Proposition 4. *The effective fixed cost $\tilde{\theta}$ and effective price wedge $\tilde{p}^{buy} - \tilde{p}^{sell}$ relate to the fundamental frictions as follows:*

$$\tilde{\theta} = \left(\frac{1 - t^c z}{1 - t^c}\frac{1}{A}\right)^{\frac{1}{1-\alpha}} \left(\frac{p\tilde{\mathcal{U}}}{\alpha}\right)^{\frac{\alpha}{1-\alpha}} \theta, \tag{61}$$

$$\tilde{p}^{buy} - \tilde{p}^{sell} = \frac{\alpha}{\tilde{\mathcal{U}}}\,\frac{p^{buy} - p^{sell}}{p}. \tag{62}$$

If $t^c > 0$ and $\tilde{\mathcal{U}} > 0$, corporate taxes have the following effects on the after-tax investment frictions:

1. *The effective fixed costs $\tilde{\theta}$ increases with t^c and t^g; it decreases with ξ^d and t^p.*

2. *The effective price wedge $\tilde{p}^{buy} - \tilde{p}^{sell}$ increases with t^p and decreases with t^g. It does not change with t^c or ξ^d as long as $p = \overline{\mathbb{E}}[p(\Delta\hat{k})]$ is fixed.*

We focus the explanation on the effects of the corporate income tax. We derive three lessons from Proposition 4. First, a higher corporate income tax t^c reduces profits and therefore increases the effective fixed cost that are scaled by after-tax profits. This effect is mediated by the depreciation allowance rate, being lowest when $z = 1$ (in this case t^c is a pure profit tax) and highest when $\xi^d = z = 0$.

Second, the corporate income tax t^c does not affect the effective price wedge as long as the average price p remains fixed. This is because the profit-capital ratio $(1-t^c)Ae^{(\alpha-1)\hat{k}^{ss}}$ that divides the price wedge is invariant to t^c as t^c also enters the static policy $\hat{k}^{ss}$. If the average price p does change, which would only happen if the relative shares of upward and downward adjustments react to the tax, then the effective price wedge would change as well. However, this effect is second order and quantitatively small.

And third, the effective fixed cost $\tilde{\theta}$ in (61) equals the fixed cost θ scaled by $(1 - t^c z)/(1 - t^c)$, and its derivative with respect to t^c is increasing in θ (for $z < 1$):

$$\tilde{\theta} \propto \left(\frac{1 - t^c z}{1 - t^c}\right)^{\frac{1}{1-\alpha}} \theta. \tag{63}$$

This result suggests that cross-sectional differences in θ (say across firms, industries, or sectors) bring heterogeneous responses to an identical change in t^c across the board. In particular, industries with high fixed costs should be susceptible to tax reforms; correspondingly, industries with zero fixed costs should be the ideal control group.[18] These observations offer a complementary identification strategy that exploits ex-ante heterogeneity instead of heterogeneity in the treatment.

In summary, to study the effects of corporate taxation on the macroeconomy, one can separate the static and dynamic components, and to study the dynamic component, it suffices to assess how corporate taxes change the effective investment frictions.

5.3 Two benchmark cases

The dynamic policy $\mathcal{X}$ solves the stopping time problem in (58), which closely resembles the price-setting and investment problems with fixed costs, analyzed first by Barro (1972), Sheshinski and Weiss (1977), Dixit (1991), but with the addition of a price wedge. We leverage on this work to characterize analytically the effect of taxes on individual policies and aggregate outcomes, extending previous results to the case with partial irreversibility. We consider two benchmark cases that isolate different mechanisms at play. Specifically, we show that the relative size of frictions matters and that the role of the price wedge crucially depends on the size of the drift. In what follows, recall that we now work with normalized capital-productivity ratios $x \equiv \hat{k} - \hat{k}^{ss}$.

Zero drift. We begin by characterizing the investment policy and the macroeconomic outcomes in driftless environments, that is, with zero drift and a symmetric price wedge. In this case, we demonstrate that capital misallocation ($\mathbb{V}ar[x]$) is a sufficient statistic for the role of corporate taxation on capital valuation (q) and capital fluctuations (CIR). Additionally, these driftless and symmetric environments clearly showcase the role of irreversibility. Specifically, the price wedge constitutes an important friction as firms expect to purchase and sell capital with equal probability. As in Figure **??**, we consider three cases: only fixed cost, only price wedge, and both frictions. Proposition 5 characterizes these cases with a second-order approximation to the profit function.

Proposition 5. *Assume $\nu \to 0$ and symmetric effective price deviations $\tilde{p}^{buy} = -\tilde{p}^{sell} = \tilde{p}$. Without drift, the after-tax user cost of capital is $\tilde{\mathcal{U}} = \frac{1-t^p}{1-t^g}\rho - \sigma^2$ and the after-tax discount factor is $\tilde{r} = \frac{1-t^p}{1-t^g}\rho - \sigma^2/2$. In all symmetric cases we have: $\mathbb{E}[x] = 0$, $\mathbb{E}[\hat{k}] = \hat{k}^{ss}$ and $\mathbb{C}ov[x, a] = 0$.*

(i) ***Only fixed cost:*** *The inaction thresholds are $\bar{x} = \pm\left(\frac{6\tilde{\theta}\sigma^2}{\alpha(1-\alpha)}\right)^{1/4}$, the reset point is $x^* = 0$, and the macro outcomes are:*

$$(64) \qquad \mathbb{V}ar[x] = \frac{\overline{x}^2}{6}; \qquad q = 1 - \frac{\tilde{\mathcal{U}}}{\tilde{r}}\frac{\alpha(1-\alpha)}{2}\mathbb{V}ar[x]; \qquad \frac{CIR(\delta)}{\delta} = \frac{\mathbb{V}ar[x]}{\sigma^2}.$$

[18] Alternatively, cross-sectional differences in depreciation allowances z, as documented in House and Shapiro (2008) and Zwick and Mahon (2017), should bring heterogenous responses to t^c, controlling for fixed costs.

(ii) ***Only price wedge:*** *The inaction thresholds and reset points coincide* $\overline{x}^* = \pm\left(\frac{3\tilde{p}\sigma^2}{2\alpha(1-\alpha)}\right)^{1/3}$*, and the macro outcomes are:*

$$(65)\quad \mathbb{V}ar[x] = \frac{\overline{x}^{*2}}{3}; \quad q = 1 - \left(1 + \frac{2}{\alpha}\right)\frac{\tilde{\mathcal{U}}}{\tilde{r}}\frac{\alpha(1-\alpha)}{2}\mathbb{V}ar[x]; \quad \frac{CIR(\delta)}{\delta} = \left(1 + \frac{1}{\sigma^2}\right)\mathbb{V}ar[x].$$

(iii) ***Both frictions:*** *The thresholds of the inaction region* $\pm\,\overline{x}$ *and the reset points* $\pm\,x^*$ *solve:*

$$(66)\quad \overline{x}x^*(\overline{x} + x^*) = \frac{3\tilde{p}\sigma^2}{\alpha(1-\alpha)}; \qquad \overline{x}^4 - x^{*4} = \frac{3\tilde{p}\sigma^2}{\alpha(1-\alpha)}(\overline{x} - x^*)\left(1 + \overline{x} + x^*\right) + \frac{6\tilde{\theta}\sigma^2}{\alpha(1-\alpha)},$$

and the macro outcomes are:

$$(67)\quad \mathbb{V}ar[x] = \frac{\overline{x}^2 + x^{*2}}{6}$$

$$(68)\quad q = 1 - \frac{\tilde{\mathcal{U}}}{\tilde{r}}\frac{\alpha(1-\alpha)}{2}\left(\mathbb{V}ar[x] + \frac{2}{\alpha}\frac{\overline{x}x^*}{3}\right)$$

$$(69)\quad \frac{CIR(\delta)}{\delta} = \frac{\mathbb{V}ar[x]}{\sigma^2} + \frac{x^*\overline{x}}{3}.$$

When only one friction is active, a marginal increase in the other friction has no effect on the macro outcomes:

$$(70)\quad \left.\frac{\mathrm{d}\mathbb{V}ar[x]}{\mathrm{d}\tilde{p}}\right|_{\tilde{\theta}>0,\,\tilde{p}=0} = 0; \quad \text{and} \quad \left.\frac{\mathrm{d}M}{\mathrm{d}\tilde{\theta}}\right|_{\tilde{\theta}=0,\,\tilde{p}>0} = 0, \quad \text{for} \quad M \in \{\mathbb{V}ar[x], q, CIR\}.$$

When only one friction is active, in cases (i) and (ii), there is a positive relationship between the corresponding effective investment friction ($\tilde{\theta}$ or $\tilde{p}$) and capital misallocation $\mathbb{V}ar[\hat{k}]$. This relationship results from the expressions for the inaction region and the cross-sectional variance. In turn, higher misallocation reduces q by lowering aggregate productivity $\hat{Y}/\hat{K}$, and increases the CIR, slowing down the propagation of aggregate productivity shocks. If effective frictions were of the same size, that is $\tilde{\theta} = \tilde{p}$, expressions (64) and (65) reveal that a price wedge generates a higher $\mathbb{V}ar[x]$, a lower q, and a larger CIR compared to the case with only fixed costs.

Now let us discuss case (iii) in which both frictions are present. In this case, the sufficient statistics for q and CIR are misallocation $\mathbb{V}ar[x]$ and the product $\overline{x}x^*$. When $\overline{x} \approx x^*$ this product is proportional to $\mathbb{V}ar[x]$ (as in the case with only partial irreversibility). The first observation is that the inaction region $(-\overline{x}, \overline{x})$ and the reset points $\{-x^*, x^*\}$ are jointly determined by the size of both frictions. Frictions have opposing effects on the within and between components of misallocation, so the effect on the total misallocation is ambiguous. When the price wedge is positive, introducing a fixed cost shrinks the distance between the two reset points, reducing between variance. When the fixed costs is positive, introducing a price wedge generates two different reset points, increasing the between variance. In the limits where only one friction is active, the result in (70) teaches us that a marginal increase in the other friction has no effect on the macro outcomes (recall our earlier discussion around Figure **??**).

Large drift. Next we characterize the case with a large drift relative to idiosyncratic shocks. In this case, we demonstrate that the price wedge is irrelevant. The reason is that firms upsize by actively purchasing capital but downsize by letting the drift shrink its capital-productivity ratio. Thus the purchase price $\tilde{p}^{buy}$ is the only relevant price. Proposition 6 shows this result.[19]

Proposition 6. *Let $\nu > 0$ and $\sigma^2 \to 0$ such that $\nu/\sigma^2 \to \infty$. In this case, the after-tax user cost is $\tilde{\mathcal{U}} = \frac{1-t^p}{1-t^g}\rho + \xi^k$ and the after-tax discount is $\tilde{r} = \frac{1-t^p}{1-t^g}\rho - \mu$. The policy is a one-sided inaction region with lower threshold x^- and one reset point x^*. The cross-sectional distribution is Uniform over $[x^-, x^*]$ with moments:*

$$\text{(71)} \qquad \mathbb{E}[x] \;=\; \frac{(x^* + \overline{x})}{12}; \qquad \mathbb{V}ar[x] \;=\; \frac{(x^* - \overline{x})^2}{12}.$$

The policy solves the non-linear system

$$\text{(72)} \qquad \mathbb{E}[x]\sqrt{\mathbb{V}ar[x]} \;=\; -\frac{\tilde{r}\tilde{\theta}}{\sqrt{12}\alpha(1-\alpha)}; \qquad \frac{\mathbb{E}[x]}{\mathbb{V}ar[x] + \mathbb{E}[x]^2} \;=\; -\left(\frac{\tilde{r}}{\nu} + \frac{\alpha+1}{2}\right),$$

and the macro outcomes are

$$\text{(73)} \qquad q \;=\; 1 \;-\frac{\tilde{\mathcal{U}}}{\tilde{r}}(1-\alpha)\left(\mathbb{E}[x] + \frac{\alpha}{2}\mathbb{V}ar[x]\right); \qquad \frac{CIR(\delta)}{\delta} \;=\; 0.$$

The case with a large drift reveals new mechanisms absent in symmetric environments. As we have already mentioned, the price wedge has no effect. Comparing the expression for aggregate q and the CIR with large drift against the three driftless cases in Proposition 5, we see how the average $\mathbb{E}[x]$ now matters in this environment. Moreover, it is the frictional average $\mathbb{E}[x]$ and not the frictionless average $\mathbb{E}[\hat{k}]$ the relevant statistic for the marginal value of capital. The non-linear system in (72) that pins down the investment policy shows that larger effective fixed costs $\tilde{\theta}$ increase both the average $\mathbb{E}[x]$ (in absolute value) and the variance $\mathbb{V}ar[x]$ of the normalized capital-productivity ratios x. In fact, the first equation is an indifference curve that mediates the trade-off between these two moments.[20] The same system shows that the average $\mathbb{E}[x]$ is negative, thus $\mathbb{E}[\hat{k}] = \hat{k}^{ss} + \mathbb{E}[x] < \hat{k}^{ss}$. As the mean becomes more negative, q goes up; but as the variance increases, q goes down. The overall effect depends on the relative elasticities of these moments

[19] Instead of taking the drift to infinity, we take an equivalent limit towards zero idiosyncratic shocks.

[20] A larger fixed cost lengthens the inaction period and firms accumulate more drift, reducing the average capital-productivity ratio relative to a frictionless economy. As firms anticipate a larger drift, they increase the reset point widening the distance between x^- and x^*, increasing the variance.

with respect to $\tilde{\theta}$. Lastly, as shown in Corollary 2 of Baley and Blanco (2021), the CIR equals zero: aggregate productivity shocks are immediately absorbed by firms and there are no deviations from steady-state.

The benchmark cases with zero and large drift teach us two lessons. First, the importance of the effective price wedge (and the taxes that shape it) crucially depends on the drift. Without drift, the price wedge is an important source of misallocation; in environments with large drift relative to idiosyncratic shocks, it is not. Second, the effect of taxes on q depend on the relative size of the mean $\mathbb{E}[x]$ and the variance $\mathbb{V}ar[x]$ of normalized capital-productivity ratios. In symmetric environments, the mean is zero and thus higher misallocation always decreases q. With a large drift, the mean is negative, reflecting capital scarcity. Scarcity increases q and could in principle dominate the misallocation effect that reduces q.

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