Payout-Based Asset Pricing

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Abstract

Firms' payout decisions respond to expected returns: everything else equal, firms invest less and pay out more when their cost of capital increases. Given investors' demand for firm payout, market clearing implies that the dynamics of productivity and payout demand fully determine equilibrium asset prices and returns. We use this logic to propose a payout-based asset pricing framework and we illustrate the analogy between our approach and consumption-based asset pricing in a simple two-period model. Then, we introduce a quantitative payout-based asset pricing model and calibrate the productivity and payout demand processes to match aggregate U.S. corporate output and payout empirical moments. We find that model-implied payout yields and firm returns go a long way in reproducing key attributes of their empirical counterparts.

JEL Classification: E10; E13; G10; G11; G12; G35.

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1 Introduction

In capital markets, quantities (capital flows) and prices (expected returns) are jointly determined by the equalization of capital supply and capital demand, so equilibrium expected returns are affected by shifts in both firms' payout supply (the negative of their capital demand) and investors' payout demand (the negative of their capital supply). It follows that, for given payout demand shifts, we can pin down the fluctuations in equilibrium asset prices and returns by considering the properties of firms' optimal payout supply and invoking the clearing of the payout market: expected returns adjust so that firms optimally provide the demanded payout, given firms' production technology and the dynamics of firm productivity. In this paper, we use that logic to introduce a payout-based asset pricing framework.[1]

To operationalize our approach, we introduce a quantitative model which features an equity-financed representative firm that optimally chooses its investment and payout policies, subject to capital adjustment costs. The firm faces an equity payout demand equal to the firm's output times an exogenous payout demand ratio (i.e., payout demand over output). Imposing payout market clearing, the equilibrium expected firm return is a function of firm productivity, as well as the payout demand ratio. It follows that exogenous shocks in that ratio generate fluctuations in the firm's equilibrium expected return. For example, an increase in the payout demand ratio increases the firm's expected return: for the payout market to clear, the firm needs to cut investment and raise payout, which is achieved by an increase in the firm's cost of capital. Our model is simple by design: productivity and the payout demand ratio follow autoregressive processes and the firm faces no frictions when raising capital. That simplicity allows us to easily calibrate the model to match the empirical properties of aggregate firm output and payout.

We solve the model numerically and show that the equilibrium expected firm return increases with the payout demand ratio, but is almost insensitive to firm productivity, indicating that most of the variation in the firm's expected return arises from variation in the payout demand ratio. Intuitively, exogenous fluctuations in the payout demand ratio necessitate corresponding shifts in the firm's payout supply for the payout market to clear, and those supply shifts are achieved by changes in the firm's equilibrium expected rate of return.

We, then, simulate the model and show that it goes a long way in matching key asset pricing moments. Specifically, the model generates an average payout yield (i.e., payout over firm value) of 2.32% and payout yield volatility of 4.01%, which are very close to the respective empirical values of 1.59% and 2.47%. Furthermore, the model implies an average firm return of 4.94% and a firm return volatility of 10.68%, with the corresponding empirical moments being 7.86% and 14.88%. Using

[1] As we discuss in the literature review, our approach is related (and substantially adds) to the production-based asset pricing literature, with important contributions by Cochrane (1991), Zhang (2005), Liu, Whited and Zhang (2009), Belo (2010), and Belo, Lin and Bazdresch (2014), among others.

more sophisticated processes for productivity and the payout demand ratio or introducing standard financing frictions is likely to further improve the ability of the model to reproduce empirical asset pricing moments. However, our main message is that even a simple payout-based asset pricing setup with a reasonable parametrization goes a long way in generating realistic asset pricing implications.

Part of the firm return volatility in the model arises from time-varying expected returns. To explore the properties of expected returns, we consider forecasting regressions of annual firm returns on lagged payout yields. In both the data and the model, there is a positive association between the two, with the model predictive coefficient (1.30) being close to its empirical counterpart (1.81). To determine whether the return predictability we document arises from the firm's optimizing payout behavior, as our model suggests, we consider regressions of annual firm returns on lagged payout ratios, as the payout ratio (payout over output) is the main driver of expected returns in our model. In both the data and the model, we find a positive association between payout ratios and subsequent returns, in line with the intuition that, when payout demand is relatively high, the firm's expected return rises in order to induce the firm to cut investment and raise payout to the demanded level.

Then, we introduce a more complex version of the model, in which the representative firm has to optimally choose its capital structure, as it can finance itself using equity and one-period safe debt. The joint optimization of the firm's investment and capital structure policies yields separate optimal supply schedules for equity and debt payouts. The firm faces exogenous payout demand ratios for debt and equity from investors, so equity and debt returns are endogenously determined by the clearing of the equity and debt payout markets. The model is able to match the properties of firm and equity returns quite well, replicating the good performance of the unlevered firm model, but is less successful in matching debt returns. Our model's limited success in replicating the empirical properties of debt returns partly stems from the assumption that the firm is able to only issue one-period safe debt, which implies that debt returns and risk-free rates are identical. Benchmarking our model-implied debt returns against empirical risk-free rates yields a more favorable assessment of our model.

Our payout-based asset pricing approach is analogous to the consumption-based asset pricing framework (Lucas (1978) and Breeden (1979)). In particular, while consumption-based asset pricing models solve for equilibrium expected returns by equating a postulated payout supply process to endogenous payout demand, in our payout-based asset pricing framework we solve for equilibrium expected returns by equating a postulated payout demand process to endogenous payout supply. Even though the consumption-based asset pricing setup is unrealistic, it generates the same expected return as a fully specified general equilibrium economy (i.e., an economy in which households and firms both optimize their behavior) as long as the postulated payout supply process coincides with the equilibrium payout process in the fully specified economy.[2] Similarly, our payout-based asset pricing framework generates the same expected return as a fully specified economy as long as the postulated payout demand process coincides with the equilibrium payout in that economy.

We illustrate how the two asset pricing frameworks relate to each other in the context of a two-period general equilibrium model. Our simple model consists of a representative firm and a representative household. As standard, we assume that the firm manager maximizes firm value by optimally choosing the firm's investment and payout policies, which yields a firm payout supply as a function of the firm's capital, productivity, and expected return. The household maximizes lifetime expected utility (which is a function of consumption and an exogenous taste shifter) by optimally choosing its consumption and savings policies, generating payout demand as a function of its wealth, the taste shifter, and the firm's expected return. Imposing market payout clearing yields the equilibrium expected firm return, which is a function of the household's taste shifter and the firm's productivity. Then, we show that consumption-based asset pricing arises from imposing an exogenous payout supply process, which effectively replaces firm productivity as a driver of equilibrium expected returns: the firm's equilibrium expected return depends on the taste shifter and the expected growth in payout supply. Similarly, payout-based asset pricing arises from imposing an exogenous payout demand process, which effectively replaces the household preference shifter as a determinant of the equilibrium expected return. In that case, the equilibrium expected return of the firm is a function of firm productivity and the payout demand ratio.

Our paper builds on the production-based asset pricing literature, which aims at providing a link between the production side of the economy and asset prices (see Zhang (2017) for a literature review). There are different broad approaches in this literature and our paper relates to each of them, as we discuss below.

A number of production-based asset pricing papers derive the pricing kernel using firms' optimality conditions (Cochrane (1988), Belo (2010), Jermann (2010), and Cochrane (2021)). Our paper is largely complementary to that strand of the literature. In particular, we show that we can obtain asset prices and returns without solving for a pricing kernel – it is sufficient to specify an exogenous payout demand process and impose market clearing. This is important because solving for the pricing kernel using firms' optimality conditions requires non-trivial modeling assumptions. For instance, Jermann (2010) assumes that there are as many types of capital inputs as there are states of nature, whereas Belo (2010) and Cochrane (2021) use non-standard production functions that allow producers to substitute output across states of nature. In contrast, we specify an exogenous payout demand process calibrated to aggregate corporate payout data and solve for asset prices without solving for the economy's pricing kernel.

[2] For example, Campbell and Cochrane (1999) state that "if the statistical model of the 'endowment' is the same as the equilibrium consumption process from a production economy, then the joint asset price-consumption process is the same whether the economy is truly an endowment or a production economy."

Another strand of the production-based asset pricing literature proposes partial equilibrium models with an exogenous stochastic discount factor (or exogenous risk neutral dynamics), so firms' expected returns arise from their corporate policies, which determine the covariance of firms' returns with the stochastic discount factor (SDF).[3] We add to that literature by providing an alternative approach: instead of specifying an exogenous SDF, researchers can specify an exogenous payout demand process and impose market clearing. The main benefit of our approach is that firm payout is observable, so the payout demand processes can be calibrated to corporate payout data, ensuring that the model calibration is based on quantities, as opposed to prices. In contrast, stochastic discount factors are unobservable and calibrating SDF parameters relies on matching asset pricing moments.

Finally, a number of production-based asset pricing papers build on the q-theory of investment, a strand of the literature known as investment-based asset pricing.[4] Similar to our work, these papers do not specify (or attempt to estimate or derive) the economy's SDF. Instead, they take firms' investment and output, as well as equity and debt returns, as given and estimate firms' technological parameters by matching investment returns to firm returns, as dictated by the firms' optimality conditions. In contrast, our focus is on exploring the properties of model-implied equilibrium returns: we use data on firm output and payout in order to calibrate exogenous processes for firm productivity and the payout demand ratio and solve for equilibrium asset prices by imposing payout market clearing. Moreover, the investment-based asset pricing literature mainly focuses on the cross-section of stock returns, whereas our focus is on the time-series of aggregate returns.

The closest paper to ours in the extant investment-based asset pricing literature is Cochrane (1991), which, like ours, focuses on aggregate returns. Cochrane (1991) postulates a firm production technology, uses aggregate U.S. investment data in order to back out the time-series of U.S. aggregate investment returns (which have to be equal to U.S. aggregate firm returns), and statistically tests the similarity between aggregate investment returns and aggregate firm returns. In contrast, we postulate both a firm production technology and statistical processes for productivity and investor payout demand, simulate that economy, and compare the moments of the simulated returns with the moments of actual returns. Moreover, we introduce a model in which the firm can fund itself by both equity and debt, which allows us to differentiate between firm returns and equity returns. Importantly, we specify an exogenous payout demand process, rather than an exogenous investment

[3]That literature builds on the models developed in Berk, Green and Naik (1999) and Zhang (2005) and includes, inter alia, the models in Kogan and Papanikolaou (2010), Belo and Lin (2012), Belo and Yu (2013), Jones and Tuzel (2013), Belo et al. (2014), Belo, Li, Lin and Zhao (2017), Li (2018), Belo, Lin and Yang (2018), Kogan, Li and Zhang (2023), Grigoris and Segal (2023), Grigoris, Hu and Segal (2023), and Belo and Li (2023). Among the papers in that literature, Belo and Li (2023) is the most related to ours, as they use an exogenous SDF, but rely on firms' optimality decisions to write the SDF in closed form as a function of variables related to firm investment and profitability.

[4]That strand of the literature builds on the insight that, under linear homogeneity, firm returns are equal to investment returns (Cochrane (1991) and Restoy and Rockinger (1994)). Notable contributions include, among others, Liu et al. (2009), Belo, Xue and Zhang (2013), Lin and Zhang (2013), Liu and Zhang (2014), Gonçalves, Xue and Zhang (2020), Belo, Gala, Salomao and Vitorino (2022), Li, Ma, Wang and Yu (2023), and Belo, Deng and Salomao (2023).

process, further differentiating our approach from that in Cochrane (1991). There are two main reasons for this key difference, one conceptual and the other more practical in nature. Conceptually, both investment demand and investment supply arise from firms', rather than investors', optimizing behavior, so exogenously specifying either investment supply or investment demand does not allow for fully endogenous firm behavior, as our framework does. Furthermore, from a practical point of view, measuring investment, which is necessary for calibrating an exogenous investment process, is non-trivial. While the early literature largely focuses on physical capital, several recent papers demonstrate the importance of capital heterogeneity (e.g., Gonçalves et al. (2020) and Belo et al. (2022)), which introduces serious investment measurement issues. On the other hand, firm payout can be unambiguously measured, which makes calibrating and testing a payout-based asset pricing model significantly less complicated.

The rest of this paper is organized as follows. Section 2 focuses on a simple two-period general equilibrium model that illustrates the relationship between payout-based asset pricing and consumption-based asset pricing. Section 3 introduces our quantitative payout-based asset pricing model with an unlevered firm and discusses its properties. Section 4 discusses a more complex version of our quantitative model that includes a levered representative firm, which allows us to study the properties of equity and debt returns separately. Finally, Section 5 concludes. The Internet Appendix includes model derivations, as well as details on data sources and empirical measures, that are omitted from the main text.

2 A Simple Two-Period General Equilibrium Model

In this section, we use a simple two-period general equilibrium model to demonstrate that our payout-based asset pricing framework is the flipside of the consumption-based asset pricing framework: while consumption-based asset pricing focuses on household optimizing behavior and obtains equilibrium asset prices by equating the *endogenous payout demand* of households with an exogenous firm payout supply (i.e., cash flow), payout-based asset pricing relies on the optimal behavior of firms and retrieves equilibrium asset prices by equating the firm's *endogenous payout supply* with exogenous household payout demand. We start this section with characterizing the properties of the general equilibrium model, and then demonstrate that consumption-based (payout-based) asset pricing models generate the same equilibrium returns as the general equilibrium model, provided that payout supply (payout demand) is specified to be consistent with the true equilibrium payout. The derivations of the results in this section can be found in Internet Appendix A.

2.1 The general equilibrium model

The economy has two periods (denoted by t and $t+1$) and consists of a representative equity-financed firm and a representative household. There is a single good that can be either consumed or used as a capital input in the firm's production, and all quantities are expressed in units of that good. The optimizing behavior of the firm generates the payout supply function, while the payout demand function arises from the household's optimal consumption-saving decision.[5]

2.1.1 The firm's problem and the payout supply function

The representative firm is endowed with initial capital stock $K_t > 0$ and faces an exogenous stochastic productivity process Z, to be specified later, with realizations Z_t and Z_{t+1}. The only factor of production is capital, and the firm's output Y (which is equal to its operating profit Π) is given by function $Y_t = \Pi_t = \Pi(K_t, Z_t) = Z_t \cdot K_t$. The firm faces capital adjustment costs, with the adjustment cost function being $\Phi_t = \Phi(K_t, I_t) = \frac{a}{2} \cdot (I_t/K_t)^2 \cdot K_t$. At period t, Z_t is realized and then the firm decides how much of the profit will be distributed to the shareholders and how much will be invested in new capital. At period $t+1$, Z_{t+1} is realized and then the firm is liquidated, so the entirety of the firm's profit, as well as the value of the remaining capital, is distributed as a payout.

The firm chooses payout D_t and investment I_t to maximize the (cum-payout) market value of the firm, V_t:

$$V_t = \max_{\{D_t, I_t\}} \left(D_t + \mathbb{E}_t \left[M_{t+1} D_{t+1} \right] \right), \tag{1}$$

where M_{t+1} is the stochastic discount factor (SDF) in the economy, subject to the capital accumulation process $K_{t+1} = (1-\delta) \cdot K_t + I_t$, where δ is the one-period capital depreciation rate, and the one-period budget constraints,

$$D_t = \Pi(K_t, Z_t) \; - \; I_t - \; \Phi(K_t, I_t), \quad D_{t+1} = \Pi(K_{t+1}, Z_{t+1}) \; + \; (1-\delta) \cdot K_{t+1}.$$

Note that, although the SDF is endogenous in our economy, it is taken as given by the firm when

[5] In our simple economy, the only asset that exists is the equity of the firm, so the household's equity payout demand is equal to the household's consumption demand: simply put, there is no other available source of income for the household, so the entirety of its consumption has to be financed by the equity payout of the firm. However, it is important to stress that in a richer model (that would include, for example, labor income, multiple assets, or a government sector) the household's payout demand for any particular asset would be determined by the solution to the household's optimization problem and would generally differ from its consumption demand. For example, in a model where the household can invest only in a single firm's equity, but earns labor income, its equity payout demand would be equal to the difference between its consumption demand and its (optimally chosen) labor income. In such a model, our payout-based asset pricing approach would entail specifying an exogenous process for the household's equity payout demand, rather than for the household's consumption demand.

optimizing. As shown in the Internet Appendix A, the firm's optimality condition is

$$1 \;=\; \mathbb{E}_t\left[M_{t+1}\cdot\frac{\partial_K\Pi((1-\delta)K_t+I_t,Z_{t+1})+(1-\delta)}{1+\partial_I\Phi(K_t,I_t)}\right]. \tag{2}$$

The intuition is simple: taking M_{t+1} as given, the firm adjusts its investment I_t (and, hence, its payout D_t) so that its optimality condition is satisfied. As a result, the firm's optimality condition yields a payout supply function: conditional on state variables K_t and Z_t, for any given M_{t+1}, the firm chooses the particular investment (and, thus, payout) level that is consistent with its optimization objective.[6]

Before moving on, it is useful to introduce some notation regarding the return on the firm's equity, which is the only asset in our economy. We denote the ex-payout value of the firm by P_t, i.e., $V_t = D_t + P_t$. Thus, the gross return from investing in the firm from t to $t+1$ is given by

$$R_{t+1}=\frac{D_{t+1}}{P_t}=\frac{D_{t+1}}{\mathbb{E}_t\left[M_{t+1}\cdot D_{t+1}\right]}. \tag{3}$$

In what follows, we assume that the productivity process satisfies $Z_{t+1} = Z_t^{\phi_z}\cdot e^{\epsilon_{z,t+1}}$, where $\phi_z\in[0,1]$ and $\epsilon_{z,t+1}\sim N(-\sigma_z^2/2,\sigma_z^2)$, and that capital fully depreciates within one period (i.e., $\delta=1$). Internet Appendix A provides closed-form expressions for the firm's investment and payout policies, taking the firm's expected return $\mathbb{E}_t[R_{t+1}]$ as given. The firm's payout yield is

$$D_t/V_t=(D/V)(Z_t;\mathbb{E}_t[R_{t+1}])=\frac{Z_t-\frac{1}{2a}\left[\left(\frac{Z_t^{\phi_z}}{\mathbb{E}_t[R_{t+1}]}\right)^2-1\right]}{Z_t+\frac{1}{2a}\left(\frac{Z_t^{\phi_z}}{\mathbb{E}_t[R_{t+1}]}-1\right)^2}. \tag{4}$$

Note that, due to the assumption of constant-returns-to-scale technology, the firm's payout yield does not directly depend on its stock of capital K_t. Panel A of Figure 1 displays the family of the firm's D_t/V_t curves for different values of Z_t, setting $a=8$ and $\phi_z=1$. For a given value of Z_t, the payout yield is increasing in the expected return: an increase in the cost of capital raises the hurdle rate for investment, reducing desired investment and increasing the firm's payout. When Z_t changes, the curve D_t/V_t shifts: an increase (decrease) in productivity Z_t shifts the payout supply curve down (up), as higher current productivity implies higher expected productivity (and, hence, profitability), due to the persistence of the productivity process, inducing the firm to invest more and pay out less at time t.

[6] It is worth noting that we can express the firm's optimality condition in more familiar terms by considering the investment return, R^I, defined as the gross return of an extra unit of firm capital

$$R^I_{t+1}\;=\;\frac{\partial_K D_{t+1}}{1+\partial_I\Phi(K_t,I_t)}\;=\;\frac{\partial_K\Pi((1-\delta)K_t+I_t,Z_{t+1})+(1-\delta)}{1+\partial_I\Phi(K_t,I_t)},$$

so the firm's optimality condition reduces to $1=\mathbb{E}_t\left[M_{t+1}\cdot R^I_{t+1}\right]$, as in Cochrane (1991).

2.1.2 The household's problem and the payout demand function

We now turn to the representative household. It is endowed with initial wealth $W_t > 0$, which (although taken as given in the household's optimization problem) equals the cum-payout value of the firm V_t. The household chooses consumption C_t and savings S_t to maximize its utility

$$\max_{\{C_t, S_t\}} \left(U(C_t, \theta_t) \; + \; \beta \cdot \mathbb{E}_t \left[U(C_{t+1}, \theta_{t+1}) \right] \right) \tag{5}$$

where β is the subjective discount factor, and $U(C, \theta) = \theta_t \cdot \frac{C_t^{1-\gamma}}{1-\gamma}$ is the household's utility function, which has as its arguments household consumption C and the taste shifter θ, an exogenous stochastic process to be specified later. The household is able to shift resources over time by investing in the firm's equity, so the household optimizes subject to the following one-period budget constraints:

$$C_t = W_t - S_t, \quad C_{t+1} = S_t \cdot R_{t+1}.$$

As seen in the Internet Appendix A, the household's optimality condition is the familiar Euler equation,

$$1 = \mathbb{E}_t \left[\beta \frac{\partial_C U((W_t - C_t) \cdot R_{t+1}, \theta_{t+1})}{\partial_C U(C_t, \theta_t)} \cdot R_{t+1} \right]. \tag{6}$$

Again, the intuition is straightforward: taking the properties of the firm return R_{t+1} as given, the household chooses consumption (and, hence, payout demand) C_t so that its optimality condition is satisfied. Thus, the household optimality condition yields a payout demand function: conditional on the state variable W_t, for any given R_{t+1} process, the firm chooses the particular consumption level (i.e., demands the particular payout level) that satisfies its optimization problem.

In what follows, we assume that process θ has law of motion $\theta_{t+1} = \theta_t^{\phi_\theta} e^{\epsilon_{\theta,t+1}}$, where $\phi_\theta \in [0, 1]$ and $\epsilon_{\theta,t+1} \sim N(-\sigma_\theta^2/2, \sigma_\theta^2)$. Furthermore, we assume that shocks $\epsilon_{\theta,t+1}$ and $\epsilon_{z,t+1}$ are independent of each other. As shown in Internet Appendix A, the household's payout demand function (i.e., its consumption-wealth ratio) is

$$C_t/W_t \; = \; (C/W)(\theta_t; \mathbb{E}_t[R_{t+1}]) \; = \; \frac{1}{1 + \beta^{1/\gamma} \cdot \theta_t^{(\phi_\theta - 1)/\gamma} \cdot \mathbb{E}_t[R_{t+1}]^{1/\gamma - 1} \cdot e^{(\gamma-1)\sigma_z^2/2}}. \tag{7}$$

Panel B of Figure 1 shows the family of the household's C_t/W_t curves for different values of θ_t, setting $\gamma = 5$, $\beta = 0.9$, $\phi_\theta = 0.1$, $\sigma_z = 1$. Since $\gamma > 1$, the household's wealth-consumption ratio is increasing in the firm's expected return.[7] Furthermore, an increase (decrease) in the current value

[7] As known, the magnitude of the risk aversion coefficient γ is crucial for the behavior of the household's consumption-wealth ratio: the consumption-wealth ratio is increasing (decreasing) in $\mathbb{E}_t[R_{t+1}]$ if $\gamma > 1$ ($\gamma < 1$) and does not depend on the expected return when $\gamma = 1$. Intuitively, when $\gamma > 1$ the income effect dominates, in which case a higher expected return induces the household to increase its current consumption and, hence, demand

of the taste shifter, θ_t, shifts the consumption-wealth curve up (down): due to the mean reversion of the taste shifter, when the current value of the shifter is high, and thus the utility benefit of current consumption is elevated, the household desires to bring consumption to the present, in order to intertemporally maximize its utility.

2.1.3 Equilibrium

In equilibrium, both the goods market and the asset market clear. At period t, the goods market clears when the firm's output equals the sum of consumption demand from the household, investment demand from the firm, and capital adjustment costs: $\Pi(Z_t, K_t) = C_t + I_t + \Phi(K_t, I_t)$. At period $t+1$, the only demand for the good is consumption demand, so the market clearing condition is $\Pi(Z_{t+1}, K_{t+1}) = C_{t+1}$. Using the firm's and household's budget constraints, it can easily be shown that the two goods market clearing conditions above reduce to a single *payout market clearing condition*: $C_t = D_t$. For the asset market to clear, period t asset supply (given by the ex-payout value of the firm, P_t) needs to equate period t asset demand (given by household savings S_t), so the *asset market clearing condition* is $P_t = S_t$.

It is easy to show that the two market clearing conditions, one for the payout market and one for the asset market, can be substituted by one. For our purposes, it is convenient to choose the condition $\frac{D_t}{D_t+P_t} = \frac{C_t}{C_t+S_t}$, which can be more simply written as the equalization of the firm's payout yield and the household's consumption-wealth ratio, $\frac{D_t}{V_t} = \frac{C_t}{W_t}$. Thus, the market clearing condition is

$$(D/V)(Z_t; \mathbb{E}_t[R^*_{t+1}]) = (C/W)(\theta_t; \mathbb{E}_t[R^*_{t+1}]), \tag{8}$$

and yields the equilibrium expected return function $\mathcal{R}^*(Z_t, \theta_t) \equiv \mathbb{E}_t[R^*_{t+1}]$. Since the firm's payout yield does not directly depend on the firm's capital stock K_t, the equilibrium expected return also does not depend on K_t.

Figure 2 displays the equilibrium in the payout market and the dependence of the equilibrium expected return on each of state variables Z_t and θ_t. We set all parameter values as in Figure 1. Panels A and B consider the impact of changes in productivity Z_t. As seen in Panel A, an increase in Z_t shifts the payout supply (D_t/V_t) curve down, as the firm wants to increase current investment and reduce current payout, in anticipation of higher future profitability. As a result, payout market clearing requires an increase in the equilibrium expected return $\mathcal{R}^*$. It follows that $\mathcal{R}^*$ is increasing in Z_t (Panel B). Finally, Panels C and D present the impact of changes in the household taste shifter θ_t. Panel C shows that an increase in θ_t shifts the payout demand (C_t/W_t) curve up, as the household desires a higher level of current consumption. For the payout market to clear, the firm

a higher payout from the firm. On the other hand, for $\gamma < 1$, the substitution effect dominates and the household prefers to defer consumption and reduce its present demand for a payout.

needs to accommodate the higher payout demand by increasing its payout supply, so the expected return increases. Thus, the equilibrium expected return is increasing in θ_t (Panel D).

In what follows, we show that payout-based asset pricing is nothing more than the flipside of the familiar consumption-based asset pricing framework: payout-based asset pricing retrieves equilibrium expected returns from firms' payout supply functions, postulating exogenous payout demand, whereas consumption-based asset pricing retrieves equilibrium expected returns from households' payout demand functions, taking exogenous payout supply as given.

2.2 Consumption-based asset pricing

In consumption-based asset pricing, the payout supply (i.e., the firm's payout policy) is exogenous, and the expected return is determined from the equalization of the exogenous payout supply with the endogenous household payout demand. For market clearing to hold, the household's equilibrium consumption has to be equal to the firm's exogenous payout supply (i.e., the household's endowment), so the equilibrium expected return is pinned down by the household's optimality condition: it is the expected return that satisfies the Euler equation when the market clearing condition is imposed, i.e. the expected return for which the household optimally consumes the firm's exogenous payout supply. If the exogenously specified payout supply process in the consumption-based model is equal to the endogenously determined equilibrium firm payout supply in the full economy, then the expected return process in the consumption-based model retrieves the expected return process of the full economy.

In the context of our simple economy, we assume that the household faces the same problem as in the full model, but that payout supply is the exogenous process D^s, with realizations D^s_t and D^s_{t+1}. Furthermore, we assume that the payout supply process satisfies $D^s_{t+1} = \mathbb{E}_t[D^s_{t+1}] \cdot e^{\epsilon_{d,t+1}}$, where $\epsilon_{d,t+1} \sim N(-\sigma_d^2/2, \sigma_d^2)$. Crucially, to retain the correspondence with the full economy, process D^s needs to be carefully chosen, so that it reflects the equilibrium path of the omitted state variables K and Z.[8]

As in the full economy, the household's payout demand is given by Equation 7, which is nothing more than the household's optimality condition. The market clearing condition is now $C_t = D^s_t$, which implies $\frac{C_t}{W_t} = \frac{D^s_t}{D^s_t + \frac{\mathbb{E}_t[D^s_{t+1}]}{\mathbb{E}_t[R_{t+1}]}}$, so plugging that condition in the household's optimality condition and solving for the expected return of the firm, we get

$$\mathbb{E}_t[R^*_{t+1}] = \mathcal{R}^*(\theta_t, \mathbb{E}_t[D^s_{t+1}/D^s_t]) = \frac{\left(\mathbb{E}_t[D^s_{t+1}/D^s_t]\right)^\gamma}{\beta \cdot \theta_t^{\phi_\theta - 1} \cdot e^{\gamma(\gamma-1)\sigma_d^2/2}}. \tag{9}$$

[8]In the full economy, $D_t = Z_t K_t - I^*_t - \frac{a}{2}\left(I^*_t/K_t\right)^2 K_t$ and $D_{t+1} = Z_t^{\phi_z} I^*_t e^{\epsilon_{z,t+1}}$, where I^*_t is the equilibrium investment level and $\epsilon_{z,t+1} \sim N(-\sigma_z^2/2, \sigma_z^2)$. Hence, the consumption-based asset pricing economy maps to the full economy if $D^s_t = Z_t K_t - I^*_t - \frac{a}{2}\left(I^*_t/K_t\right)^2 K_t$, $\mathbb{E}_t[D^s_{t+1}] = Z_t^{\phi_z} I^*_t$, and $\sigma_d = \sigma_z$.

Note that the expected return is a function of two variables: the household's taste shifter θ and the expected growth rate of the payout supply. Effectively, the expected growth rate of the payout supply replaces productivity Z, which appears in the expression for the equilibrium expected return in the full economy. As long as $\mathbb{E}_t[D^s_{t+1}/D^s_t]$ is equal to the equilibrium expected growth rate of the firm's payout in the full model, then the consumption-based model has the same asset pricing implications as the full economy.

We can illustrate the asset pricing equivalence between the full model and the (correctly specified) consumption-based model with a graph. Panel A of Figure 3 presents the equilibrium in the consumption-based asset pricing model: the equilibrium expected return is pinned down by the point of intersection of the household's C_t/W_t curve with the "endowment curve" $D^s_t/V_t = \frac{D^s_t}{D^s_t + \frac{\mathbb{E}_t[D^s_{t+1}]}{\mathbb{E}_t[R_{t+1}]}}$, which replaces the full-model firm payout yield curve. If D^s_t and $\mathbb{E}_t[D^s_{t+1}]$ are chosen so as to match the corresponding full-model equilibrium values, then the C_t/W_t curve and the "endowment curve" have exactly the same point of intersection as the C_t/W_t curve and the full-model D_t/V_t curve, as is the case in Panel A of Figure 3.

2.3 Payout-based asset pricing

In our payout-based asset pricing framework, the payout demand (which, in the context of our simple model, is equal to the household consumption demand) is exogenous and the expected return is pinned down by the equalization of the firm's endogenous payout supply with the exogenous payout demand. As in the consumption-based asset pricing paradigm, it is the market clearing condition that pins down the equilibrium expected return: since the firm's payout needs to be equal to the exogenous payout demand, the equilibrium expected return is the expected return that satisfies the Euler equation, i.e. the expected return for which the firm optimally supplies the household's exogenous payout demand. Provided that the exogenously specified payout demand process in the payout-based model is equal to the endogenously determined equilibrium household payout demand in the full economy, then the payout-based model retrieves the expected return process of the full economy.[9]

In our simple economy, we assume that the firm faces the same problem as in the full economy, but that payout demand is an exogenous process D^d, with realizations D^d_t and D^d_{t+1}. Importantly, for the payout-based model to map to the full economy, the process D^d needs to be chosen carefully so that it maps to the equilibrium household consumption process in the full economy.[10]

[9] In a payout-based asset pricing model with multiple assets, multiple payout demand processes would need to be specified, one for each asset. That is analogous to the consumption-based asset pricing framework: in a consumption-based model with multiple assets (sometimes called a Lucas orchard – see, for example, Martin (2013)), there is one exogenous payout supply process per asset.

[10] To do so, a necessary (but not sufficient) condition is feasibility of market clearing: the exogenous process D^d must be consistent with the firm's intertemporal budget constraint. Inter alia, that requires that D^d_t and $\mathbb{E}_t[D^d_{t+1}]$

Payout supply arises from the firm's optimization problem and is given by Equation IA.7. Plugging in the market clearing condition ($D_t = D_t^d$, which implies $\frac{D_t}{V_t} = \frac{D_t^d}{D_t^d + \frac{\mathbb{E}_t[D_{t+1}^d]}{\mathbb{E}_t[R_{t+1}]}}$) yields the following expression for the equilibrium expected return of the firm:

$$\mathbb{E}_t[R_{t+1}^*] = \mathcal{R}^*(Z_t, D_t^d/Y_t) = \frac{Z_t^{\phi_z}}{\sqrt{1 + 2a(1 - D_t^d/Y_t)Z_t}}, \tag{10}$$

Thus, in the payout-based asset pricing framework the equilibrium expected return is a function of the firm's productivity Z and the payout demand ratio D^d/Y. In effect, the payout demand ratio replaces the taste shifter θ, which appears in the expression for the equilibrium expected return in the full economy. As long as D^d/Y reflects the equilibrium behavior of the household in the full model, then the payout-based model yields the same asset pricing results as the full economy.

As seen in Panel B of Figure 3, in the payout-based asset pricing model the equilibrium expected return is determined by the intersection between the firm's D_t/V_t curve and the "payout curve" $D_t^d/V_t = \frac{D_t^d}{D_t^d + \frac{\mathbb{E}_t[D_{t+1}^d]}{\mathbb{E}_t[R_{t+1}]}}$, which in effect replaces the full-model household consumption-wealth curve. If D_t^d and $\mathbb{E}_t[D_{t+1}^d]$ match their full-model equilibrium values, then the D_t/V_t curve and the "payout curve" have the same point of intersection as the D_t/V_t and C_t/W_t curves in the full model, as happens in Panel B of Figure 3.

3 A Quantitative Payout-Based Asset Pricing Model

In this section, we introduce our quantitative payout-based asset pricing model and discuss its properties and solution. All derivations for the results in this section can be found in Internet Appendix B.

3.1 Setting

Consider an equity-financed representative firm with operating profit

$$\Pi(K, Z) = \alpha \cdot Z \cdot K = \alpha \cdot Y, \tag{11}$$

satisfy $D_t^d = Z_t K_t - \frac{\mathbb{E}_t[D_{t+1}^d]}{Z_t^{\phi_z}} - \frac{a}{2}\left(\frac{\mathbb{E}_t[D_{t+1}^d]}{Z_t^{\phi_z}}\right)^2 \frac{1}{K_t}$, which implies an association between D_t^d/Y_t and $\mathbb{E}_t[D_{t+1}^d]/Y_t$: $D_t^d/Y_t = 1 - \frac{\mathbb{E}_t[D_{t+1}^d]/Y_t}{Z_t^{\phi_z}} - \frac{a}{2} Z_t \left(\frac{\mathbb{E}_t[D_{t+1}^d]/Y_t}{Z_t^{\phi_z}}\right)^2$.

where K is the firm's capital stock, Z is an exogenous productivity process, $Y = Z \cdot K$ is the firm's output, and $\alpha \in (0,1)$ is the firm's operating profit margin.[11] The exogenous productivity process Z satisfies $Z_t = e^{z_t}$, where z is a stationary process that has law of motion

$$z_{t+1} = \mu_z + \phi_z(z_t - \mu_z) + \sigma_z \epsilon^z_{t+1}, \tag{12}$$

with $\epsilon^z_{t+1} \sim N(0,1)$, $\phi_z \in (0,1)$, and $\sigma_z > 0$. Capital depreciates at a constant rate $\delta \in [0,1]$ per period, so capital accumulation satisfies

$$K_{t+1} = I_t + (1-\delta)K_t, \tag{13}$$

where I is the firm's investment. Finally, we assume that the firm faces capital adjustment costs, with the adjustment cost function being

$$\Phi(K,I) = \frac{a}{2} \cdot (I/K)^2 \cdot K. \tag{14}$$

As standard, we assume that the capital adjustment costs are tax-deductible. It follows that the firm's flow payout is given by

$$D_t = (1-\tau)\left(\Pi(K_t,Z_t) - \Phi(K_t,I_t)\right) - I_t + \tau\delta K_t, \tag{15}$$

where $\tau \in (0,1)$ is the corporate tax rate.

The firm's manager chooses investment I and payout D in order to maximize the cum-payout firm value V_t,

$$V_t = \max_{\{I_{t+h},D_{t+h}\}_{h=0}^{\infty}} \{D_t + \sum_{h=1}^{\infty} \mathbb{E}_t[M_{t,t+h}D_{t+h}]\}, \tag{16}$$

where $\{M_{t,t+h}\}_{h=1}^{\infty}$ is the set of stochastic discount factors, the properties of which the firm takes as given when optimizing.

Finally, the firm faces an exogenous payout demand $D^d_t = D^d(K_t, Z_t, d_t)$ from investors, where d is an exogenous stochastic process. In particular, the payout demand process D^d satisfies

$$D^d(K,Z,d) = d \cdot Z \cdot K = d \cdot Y, \tag{17}$$

[11] Our specification is consistent with a constant returns to scale production function that includes additional inputs (such as energy, purchased services, and costlessly adjustable labor). Footnote 4 in Gonçalves et al. (2020) provides a detailed discussion. Inter alia, that implies that our model is consistent with an economy in which labor is a factor of production and, thus, households' consumption demand is different from their firm payout demand, as they also receive labor income.

where the exogenous stochastic process d (payout demand per unit of output) has law of motion

$$d_{t+1} = \mu_d + \phi_d \cdot (d_t - \mu_d) + \sigma_{d,t} \cdot \epsilon^d_{t+1}, \tag{18}$$

where $\phi_d \in (0, 1)$, $\epsilon^d_{t+1} \sim N(0, 1)$ and $corr(\epsilon^z_{t+1}, \epsilon^d_{t+1}) = \rho_{z,d}$. The conditional volatility process is

$$\sigma_{d,t} \ = \sigma_d \cdot \sqrt{d^{max} - d_t}, \tag{19}$$

where $\sigma_d > 0$ and $d^{max} = (1 - \tau)\alpha$ is the upper bound of process d.

In our specification, the payout demand function D^d is linear in the firm's capital stock K. That assumption is necessary in order for the exogenous payout demand to be consistent with the firm's behavior: given its technology, the firm's optimal payout is always (i.e., for any SDF specification) proportional to its capital stock, so a postulated D^d process that violates that restriction cannot be consistent with any investor preferences. Similarly, the assumption that the realizations of d have an upper bound ensures that the payout demand process leads to a feasible equilibrium firm payout process: in the absence of such bound, payout demand could have realizations too large to be satisfied by any feasible firm investment policy. Furthermore, as will be made clear when we derive the equilibrium properties of our model, our postulated upper bound d^{max} ensures that the equilibrium marginal q of the firm is always real-valued and increasing in productivity Z.

3.2 Payout supply

The firm's problem can be rewritten recursively as

$$V(K_t, Z_t; \{f_t(M_{t,t+h})\}_{h=1}^{\infty}) = \max_{\{I_t\}} \{D_t + \mathbb{E}_t[M_{t,t+1} V(K_{t+1}, Z_{t+1}; \{f_{t+1}(M_{t+1,t+1+h})\}_{h=1}^{\infty})]\}, \tag{20}$$

where $f_t(\cdot)$ denotes the probability distribution conditional on information available at time t. This specification is consistent with the fact that the firm picks the optimal investment-payout policy taking the conditional distribution of the current and future SDFs as given. Note that the exogenous payout demand process D^d (and, hence, the state variable d) does not *directly* enter the firm's problem. To clarify, that does not mean that the distribution of *equilibrium* current and future SDFs is independent of d. Rather, the meaning is that, taking the conditional distribution of current and future SDFs as given, the firm's optimal policy depends on the state variables Z and K, but not on d.

The firm's first order condition is

$$\underbrace{\mathbb{E}_t[M_{t+1} \partial_K V(K_{t+1}, Z_{t+1}; \{f_{t+1}(M_{t+1,t+1+h})\}_{h=1}^{\infty})]}_{\equiv q_t} = 1 + (1 - \tau)\partial_I \Phi(K_t, I_t), \tag{21}$$

where q is Tobin's marginal q. That condition yields the familiar investment function

$$I_t = I(K_t; q_t) = \frac{q_t - 1}{a(1-\tau)} K_t, \tag{22}$$

which specifies that the firm's optimal investment is proportional to its capital stock and increasing in the marginal q.[12] Therefore, the firm's payout supply satisfies

$$D_t = (1-\tau)\left(\Pi(K_t, Z_t) - \Phi(K_t, I(K_t; q_t))\right) - I(K_t; q_t) + \tau\delta K_t, \tag{23}$$

which, plugging in the investment function of Equation 22, yields the payout supply function

$$D_t = D(K_t, Z_t; q_t) = \left[(1-\tau)\alpha Z_t - \frac{q_t^2 - 1}{2a(1-\tau)} + \tau\delta\right] K_t. \tag{24}$$

The period t payout supply is increasing in productivity Z_t and capital stock K_t and decreasing in q_t. The negative relationship between payout supply and marginal q is intuitive: higher marginal q implies higher investment, which reduces the firm resources available to be paid out. Notably, the firm's marginal q is a sufficient statistic for investor preferences as regards characterizing the firm's optimal payout behavior – no other information regarding conditional SDF distributions is needed. In other words, any configuration of conditional SDF distributions that yields the same q process leads to the same firm investment and payout processes.

Using the envelope condition, we obtain[13]

$$q_t = \mathbb{E}_t\left[M_{t+1}\left((1-\tau)(\partial_K \Pi(K_{t+1}, Z_{t+1}) - \partial_K \Phi(K_{t+1}, I_{t+1})) + \tau\delta + (1-\delta)q_{t+1}\right)\right]. \tag{26}$$

For any given set of conditional SDF distributions, Equation 26 implies a particular q_t process, which potentially depends on both the current state of the economy and the properties of future SDFs. Plugging that q_t into $I(K_t; q_t)$ and $D(K_t, Z_t; q_t)$ yields firm investment and payout policies. This is the approach taken by the subset of the production-based asset pricing literature that specifies exogenous SDFs (e.g., Zhang (2005)). We take a different approach: instead of specifying

[12] Since the firm's capital stock has to be non-negative, investment needs to satisfy $I_t \geq -(1-\delta)K_t$ for all t. We assume that capital adjustment costs are sufficiently large so that the non-negativity constraint never binds and, hence, the firm always optimally picks an interior solution for investment. In particular, we assume that the adjustment cost parameter a satisfies the condition $a > \frac{1}{(1-\tau)(1-\delta)}$. That condition ensures the feasibility of the interior solution, given the non-negativity of the firm's marginal q. Indeed, for $0 \leq q_t < 1$, we have $I_t = \frac{q_t - 1}{a(1-\tau)} K_t > (q_t - 1)(1-\delta)K_t \geq -(1-\delta)K_t$. For $q_t \geq 1$, the interior optimality condition yields $I_t \geq 0 \geq -(1-\delta)K_t$.

[13] As in the two-period model, we can write Equation 26 as

$$\mathbb{E}_t\left[M_{t+1} \cdot R^I_{t+1}\right] = 1, \tag{25}$$

where $R^I_{t+1} = \frac{(1-\tau)(\partial_K \Pi(K_{t+1}, Z_{t+1}) - \partial_K \Phi(K_{t+1}, I_{t+1})) + \tau\delta + (1-\delta)q_{t+1}}{q_t}$ is the one-period investment return, as in Cochrane (1991). Intuitively, taking SDF properties (and, hence, state prices) as given, the firm should adjust its investment (and, therefore, payout) until the investment return is such that the firm is adequately compensated for the risk that it takes and, thus, no arbitrage opportunities remain.

an exogenous SDF, we specify a payout demand process (Equation 18), which allows us to recover the equilibrium q process by imposing payout market clearing, as we detail next.

3.3 Equilibrium

We have seen that, in our economy, the firm's payout supply depends on the state variables K and Z, as well as the firm's q, which summarizes investor preferences. We now show that payout market clearing allows us to back out the firm's equilibrium q and, hence, all the information regarding investor preferences that is relevant to the firm's decisions. In other words, specifying the investor payout demand process D^d (and then imposing payout market clearing) is enough for backing out the equilibrium q – no further information about investor preferences is needed.

Indeed, in equilibrium the firm's endogenous payout supply needs to equal the exogenous payout demand:

$$D(K_t, Z_t; q_t) = D^d(K_t, Z_t, d_t). \tag{27}$$

Using Equations 17 and 24, we can rewrite the payout market clearing condition as

$$\left[(1-\tau)\alpha Z_t - \frac{q_t^2 - 1}{2a(1-\tau)} + \tau\delta\right] K_t = d_t Z_t K_t, \tag{28}$$

so we can solve for the *equilibrium* q, denoted by q^*, as a function of the exogenous state variables z_t and d_t:

$$q_t^* = q^*(z_t, d_t) = \sqrt{1 + 2a(1-\tau)\left[((1-\tau)\alpha - d_t)e^{z_{t+1}} + \tau\delta\right]}. \tag{29}$$

Notably, q_t^* does not depend on the firm's capital stock K_t. As discussed previously, our d specification (which imposes the restriction that $d_t \leq (1-\tau)\alpha$ for all t) ensures that q_t^* is always real-valued and increasing in productivity Z_t. Furthermore, it implies a lower bound for q^*: $q_t^* \geq \sqrt{1 + 2a(1-\tau)\tau\delta}$.

Determining the firm's equilibrium marginal q allows us to write the equilibrium investment rate and equilibrium payout ratio as a function of the state variables z_t and d_t:

$$I_t^*/K_t^* = i^*(z_t, d_t) = \frac{\sqrt{1 + 2a(1-\tau)\left[((1-\tau)\alpha - d_t)e^{z_{t+1}} + \tau\delta\right]} - 1}{a(1-\tau)}, \tag{30}$$

and, of course,

$$D_t^*/Y_t^* = d^*(z_t, d_t) = d_t, \tag{31}$$

respectively.

3.4 Equilibrium asset prices

In Internet Appendix B, we show the firm's optimality conditions imply

$$V_t = D_t + q_t K_{t+1}, \tag{32}$$

so that

$$Q_t = q_t, \tag{33}$$

where the firm's average Tobin's q is defined as the ex-dividend value of the firm (P_t) per unit of capital: $Q_t \equiv \frac{P_t}{K_{t+1}} = \frac{V_t - D_t}{K_{t+1}}$.[14]

It follows that the firm's equilibrium Q is a function of the exogenous stationary variables z and d:

$$Q_t^* = Q^*(z_t, d_t) = \sqrt{1 + 2a(1-\tau)\left[((1-\tau)\alpha - d_t)e^{z_t} + \tau\delta\right]}, \tag{34}$$

We now turn to the firm's return, which satisfies $R_{t+1} = (P_{t+1} + D_{t+1})/P_t$. The equilibrium expected firm return function is

$$\mathcal{R}^*(z_t, d_t) = \mathbb{E}\left[R_{t+1}^* \,\middle|\, z_t, d_t\right], \tag{35}$$

where

$$R_{t+1}^* = \frac{d_{t+1}e^{z_{t+1}} + Q^*(z_{t+1}, d_{t+1})\left(1 - \delta + \frac{Q^*(z_{t+1}, d_{t+1}) - 1}{a(1-\tau)}\right)}{Q^*(z_t, d_t)}. \tag{36}$$

We evaluate the functions $Q^*(z, d)$ and $\mathcal{R}^*(z, d)$ using Equations 34 and 35 and the laws of motion for the stationary state variables z and d (Equations 12 and 18, respectively). The integral needed for the evaluation of the $\mathcal{R}^*(z, d)$ function is computed using Gauss-Hermite quadrature, with 31 grid points per shock.

Figure 4 displays the equilibrium average q function, $Q^*(z, d)$, and the equilibrium expected return function, $\mathcal{R}^*(z, d)$, under the calibration described in the following subsection. Panels A and B show the value of Q^* for different values of z and d, respectively, keeping the other state variable constant. We see that Q^* is increasing in z and decreasing in d. For a given level of d, the average price of a unit of installed capital is higher when firm productivity is higher. On the other hand, for a given level of z, the firm's Q^* is lower when the demanded payout is higher, suggesting a higher cash flow discount rate.

Panels C and D of Figure 4 show the value of $\mathcal{R}^*$ for different values of z and d, respectively, everything else constant. $\mathcal{R}^*$ is increasing in both z and d. As regards z, there are two opposing

[14] It is worth noting that, as shown in Internet Appendix B, the firm return is identical to the investment return: $R_{t+1} = R_{t+1}^I$. This result is effectively the return version of the $Q_t = q_t$ result.

forces operating on the equilibrium expected return. On the one hand, higher current productivity increases the firm's current operating profit and, hence, tends to increase the firm's desired payout, so payout market clearing requires a lower equilibrium expected return, given a fixed payout demand. On the other hand, due to the persistence of process z, higher current productivity implies higher future productivity, which entices the firm to increase current investment and lower current payout, pushing the equilibrium expected return higher. Under our parametrization, the latter effect slightly dominates. As regards the payout demand process, an increase in d, other things equal, raises the payout demand from investors, without affecting the firm's operating profit, so payout market clearing requires an increase in the firm's cost of capital, which lowers investment and increases the firm's payout supply. Crucially, the firm's expected return exhibits very moderate variation across different values of z, but is very sensitive with respect to d, underscoring the importance of payout demand as a driver of equilibrium returns. For the same reason, the firm's Q^* is much more sensitive to changes in d than to changes in z.

3.5 Quantitative Results

This section provides the quantitative results from calibrating and simulating our payout-based asset pricing model.

3.5.1 Calibration

We report our model calibration in the third column of Table 1. Tax and technological parameters are calibrated following the extant literature. In particular, we set $\tau = 0.35$ and $\delta = 0.15$, following DeAngelo, DeAngelo and Whited (2011). Since the investment adjustment cost specification in DeAngelo et al. (2011) is not comparable to ours, we set the capital adjustment cost parameters to $a = 8$, as in Favilukis, Lin and Zhao (2020).

The rest of the parameters are calibrated so as to match empirical moments. The data sample used to calculate those moments comprises annual observations of aggregate profit Π, output Y, and payout D from 1974 to 2017. We construct those measures using CRSP and COMPUSTAT data, as well as the dataset in Davydiuk, Richard, Shaliastovich and Yaron (2023), with D representing total payout of U.S. public firms to equity and debt investors (which includes dividends, interest payments, equity repurchases and issuances, and debt paydowns and issuances). The sample period is restricted by the Davydiuk et al. (2023) dataset, which is important for our analysis since it provides information on debt payouts as well as the market value of corporate debt. Internet Appendix D provides details on the data sources and empirical measurement for Π, Y, and D. It also discusses the methodology we use to generate the productivity (Z) time series, which relies on combining the Y and D data with the model equations for Q, investment, and capital accumulation.

The time series for the U.S. aggregate firm payout ratio (i.e., firm payout divided by firm output) from 1974 to 2017 is plotted in Figure 5. The figure also plots its two components, the aggregate equity payout ratio and the aggregate debt payout ratio. As seen in the figure, the firm payout ratio exhibits considerable time variation, taking both positive and negative values over the sample period. It is worth noting that the payout ratio turns sharply negative in the late 1990s and spikes up during the global financial crisis: since the former period is generally associated with low expected returns and the latter period with high expected returns in the asset pricing literature, there appears to be a positive relationship between firm payout ratios and firm expected returns, in line with the predictions of our model.

The profit-to-output parameter is set to $\alpha = 0.164$, in order to match the average empirical profit-to-output ratio. Furthermore, we set $\mu_z = 0.783$, $\phi_z = 0.760$, and $\sigma_z = 0.059$ to match the average log productivity level, the autocorrelation of the log productivity process, and the volatility of the log productivity autoregressive shocks, respectively. The payout demand parameters are set to $\mu_d = 0.015$, $\phi_d = 0.595$, and $\sigma_d = 0.092$ in order to match the mean and the autocorrelation of the empirical payout-to-output ratio d, as well as the unconditional volatility of the payout-to-output ratio autoregressive shocks, respectively.[15] Finally, we set $\rho_{d,z} = -0.104$ so as to match the unconditional correlation between the d and z autoregressive shocks.

3.5.2 Simulation

We run 10,000 model simulations, each of which consists of 44 annual observations (after a burn-in period of 1,000 years). In our simulations, we update state variables according to their law of motion (with no state space discretization). Table 2 provides key asset pricing statistics in the data and in model simulations. Importantly, none of those statistics was used as a target moment for calibrating the model. For each simulation statistic, we report the median value across the 10,000 simulations, as well as the corresponding 1st and 99th percentiles.

Panel A presents unconditional moments of the output growth, the payout yield, and the return of the representative firm. As we see, the model generates realistic output growth properties: the output growth of the simulated firm closely matches the first and second moments of the U.S. aggregate output growth. In addition, in line with the properties of actual U.S. aggregate returns, simulated firm returns are uncorrelated with the firm's output growth rates, weakly positively correlated with the firm's productivity shocks, and strongly negatively correlated with the firm's payout shocks (although that correlation is stronger in the simulated data than in the U.S. data).

[15] Note that we calibrate d to match *equilibrium* firm payout data, rather than data related to the household payout demand curve. This approach is analogous to how consumption growth is calibrated in consumption-based asset pricing models. It is also consistent with our theoretical results: recall that our payout-based asset pricing model yields the same asset pricing implications as a fully specified general equilibrium model only if the exogenous payout ratio reflects the properties of the *equilibrium* payout ratio in the fully specified model.

Hence, in both the model and the data, aggregate firm returns are mainly associated with payout shocks.

Furthermore, the model captures payout yield dynamics quite well. In the data, the payout yield has an unconditional mean of 1.59%, an unconditional volatility of 2.47% and unconditional autocorrelation of 0.44. Those moments are well-matched by the model: the median values are $\mathbb{E}[D/P] = 2.32\%$, $\sigma[D/P] = 4.01\%$ and $\mathbb{AC}[D/P] = 0.52$. The model also yields empirically plausible return dynamics: the model-implied median values for the firm return mean and volatility ($\mathbb{E}[R] = 4.94\%$ and $\sigma[R] = 10.68\%$) are not far from the corresponding empirical values ($\mathbb{E}[R] = 7.86\%$ and $\sigma[R] = 14.88\%$). Despite that success, the model is not perfect: both those empirical values are above the 99th percentile of the simulated moment values and, therefore, very unlikely to be generated in the model. Nonetheless, our payout-based asset pricing model goes a long way in capturing the key moments of firm returns. It is worth noting that expected returns are very volatile in our model: the median unconditional volatility of $\mathbb{E}[R]$ is 4.70%. Due to the large discount rate fluctuations, the simulated realized returns exhibit negative autocorrelation: in the model, the median return autocorrelation is -0.20 (very close to the corresponding empirical value of -0.17).

Panel B reports the output of regressions of annual returns, R_{t+1}, on the lagged payout yield, D_t/P_t. Those forecasting regressions allow us to explore the properties of time variation in expected returns in a setting analogous to the one typically used in the evaluation of consumption-based asset pricing models. In the data, high payout yields forecast high future returns: the predictive coefficient is 1.81 (and significant at the 1% level) and the regression adjusted R^2 is 9.20%. The model yields a median predictive coefficient of 1.30 and a median regression adjusted R^2 of 22.09%, with the corresponding empirical values being well within the range of simulated outcomes.

Another important feature of return predictability is the underlying mechanism that generates it. In our model, return predictability arises from the payout decisions of the firm: when the payout demand is relatively high, the equilibrium expected return increases to induce the firm to cut investment and optimally supply the demanded payout level, which suggests a positive relationship between the firm's payout ratio, D/Y, and its future return. Notably, there is no mechanical relationship between the payout ratio and future returns, as the payout ratio (unlike the payout yield) is not scaled by firm value. Panel C of Table 2 reports the output of regressions of R_{t+1} on D_t/Y_t. Both in the data and in our model, the predictive coefficient is positive: 1.36 (significant at the 1% level) and 1.57 (median value), respectively. In the data, the predictive regression adjusted R^2 is 8.6%, indicating that the payout ratio D/Y and the payout yield D/P have a quantitatively similar predictive ability for future returns. However, the model tends to generate much stronger return predictability for D/Y: the median adjusted R^2 is 21.1%, more than double the corresponding empirical value. That said, due to substantial variation in that measure across simulations, the empirical value of 8.6% is firmly within the range of simulated outcomes.

To explore the relationship between firm productivity and future returns, we regress R_{t+1} on both D_t/Y_t and Z_t, and report our findings in Panel D of Table 2. We find that, both in simulated and actual data, the dividend ratio D_t/Y_t is a strong predictor of R_{t+1}, but Z_t is not.[16] It follows that the model-implied mechanism for return predictability, which relies on variation in the investor payout demand ratio, rather than in productivity, is consistent with the data.

Recall that (as shown in Figure 4), the main source of variation in firm value and expected returns in our model is payout demand variation, whereas productivity fluctuations have a muted effect. To further illustrate that point, we run a single 100-year simulation of the model and report the paths of state variables z and d, as well as the paths of the firm's equilibrium Q and expected return, in Figure 6. As seen in Panels A and B, both z and d exhibit substantial variation across time. Nevertheless, Panels C and D show that Q and expected returns vary mainly due to variation in d. Specifically, Panel C plots the simulated path of the firm's equilibrium Q, as well as two counterfactual paths, each allowing for time variation in only one state variable. Similarly, Panel D plots the simulated path, and the two counterfactual paths, of the firm's equilibrium expected return. As seen in both panels, almost all of the variation in the firm's Q and its expected return is due to variation in d.

4 A Quantitative Payout-Based Asset Pricing Model with Firm Leverage

In this section, we retain all our previous assumptions, with the exception that we now allow for firm leverage. The assumption that the firm can finance itself using both equity and debt allows us to separately consider firm equity returns and firm debt returns. In the interests of simplicity, the only type of debt we consider is one-period risk-free debt. Following Hennessy and Whited (2005), we assume that the firm is subject to a collateral constraint which ensures that all the debt that it issues is riskless. Due to the deductability of interest payments, debt is beneficial to the firm, as it yields a tax shield. On the other hand, debt generates financial distress costs, which we model in reduced form as convex leverage costs.[17] It follows that the firm optimally chooses its capital structure by trading off the tax benefits of debt against the costs of leverage.

[16] This result is not a consequence of our methodology of measuring Z_t without directly using profitability data. Replacing Z_t with Π_t/A_t, where A_t represents total assets from COMPUSTAT, yields predictability results very similar to the ones reported in Panel D of Table 2: the coefficient on D_t/Y_t remains positive and significant, whereas the coefficient on Π_t/A_t is not significant.

[17] Note that financial distress costs arise despite the fact that debt is riskless from the perspective of outside investors. Those costs refer to the operational and financial costs that the firm incurs to ensure that it always pays back its debt. For example, Hennessy and Whited (2005) propose a model in which financial distress costs arise from the fact that the firm may have to engage in costly fire sales of capital in order to raise resources to pay back the firm's (safe) debt in full. In our model, we do not take a stand on the particular nature of financial distress costs.

The firm determines its supply of debt and equity payouts by jointly optimizing its investment and capital structure decisions, taking the SDF as given. As we will show, determining the optimal debt and equity payouts for a given SDF is equivalent to determining those optimal payouts taking the firm's marginal q and the risk-free rate as given, respectively. Then, we pin down the equilibrium marginal q and the equilibrium risk-free rate by imposing market clearing in the debt and equity payout markets.

4.1 Setting

The firm's capital structure decision has the following characteristics. At each period t, the firm raises B_{t+1} in debt and agrees to pay $R^b_{t+1}B_{t+1}$ at $t+1$, where R^b_{t+1} is the gross borrowing rate. Thus, B_{t+1} is the market value of debt and $F_{t+1} = R^b_{t+1}B_{t+1}$ is the corresponding face value of debt, both determined at period t. The firm can expense interest payments, so the period $t+1$ interest tax shield is $\tau(R^b_{t+1}-1)B_{t+1}$ and the after-tax gross bond return is $R^{b,a}_{t+1} = R^b_{t+1} - \tau(R^b_{t+1}-1)$. Therefore, the firm's period t debt payout, denoted by D^b_t, is the difference between the repayment of existing debt and the funds raised by issuing new debt:

$$D^b_t = R^b_t B_t - B_{t+1}. \tag{37}$$

Firm borrowing has to satisfy a collateral constraint that ensures that the firm issues safe debt. In particular, the amount promised to the debtholders cannot exceed the minimum resources available to them, i.e.,

$$R^b_{t+1}B_{t+1} \le (1-\delta)K_{t+1} + \alpha Z^{\min}_{t+1}K_{t+1} + \tau\delta K_{t+1} + \tau(R^b_{t+1}-1)B_{t+1}, \tag{38}$$

where $Z^{\min}_{t+1}$ is the minimum value that Z_{t+1} can attain conditional on the information available at period t. The right-hand side collects the minimum resources available to the firm's creditors. Those resources consist of the price of the firm's installed capital, plus the combined value of the firm's operating cost, depreciation tax shield, and interest tax shield. Using the definition of the after-tax bond return, we can write the collateral constraint as

$$b_{t+1} \le \frac{(1-\delta) + \alpha Z^{\min}_{t+1} + \tau\delta}{R^{b,a}_{t+1}}, \tag{39}$$

where $b_{t+1} \equiv \frac{B_{t+1}}{K_{t+1}}$ is the firm's leverage ratio.[18]

[18] Since the firm issues safe debt, its pre-tax cost of debt R^b_{t+1} is the (pre-tax) risk-free rate in the economy: $1 = \mathbb{E}_t[M_{t+1}R^b_{t+1}] = \mathbb{E}_t[M_{t+1}]R^b_{t+1} = \frac{R^b_{t+1}}{R^f_{t+1}} \implies R^b_{t+1} = R^f_{t+1} = \frac{1}{\mathbb{E}_t[M_{t+1}]}$. It follows that the firm's after-tax cost of debt, $R^{b,a}_{t+1} = R^b_{t+1} - \tau(R^b_{t+1}-1)$, also depends solely on the SDF and, thus, is taken as given by the firm. Our derivation implicitly assumes that the investor tax rate, denoted by τ^i, is zero. If, instead, $\tau^i > 0$, then R^b_{t+1} is still

Since interest payments are tax deductible, debt yields a benefit to the firm in the form of a tax shield. In the absence of any countervailing leverage cost, the firm would choose to borrow up to its collateral constraint. Instead, we assume that leverage entails costs to the firm (such as potential costs of financial distress), which we model in reduced form by assuming that the firm pays a (non-deductible) cost $G_t = G(B_t, K_t)$ at period t. In particular, we assume that

$$G(B_t, K_t) = \frac{\kappa}{2}\left(\frac{B_t}{K_t}\right)^2 K_t, \tag{40}$$

for $\kappa > 0$, so the leverage cost is increasing and convex in the firm's debt B_t.[19]

At each period t, the firm's manager chooses investment I_t, equity payout D_t^e, and debt issuance B_{t+1} in order to maximize the cum-payout value of firm equity V_t^e:

$$V_t^e = \max_{\{I_{t+h}, D_{t+h}^e, B_{t+1+h}\}_{h=0}^{\infty}} \{D_t^e + \sum_{h=1}^{\infty} \mathbb{E}_t[M_{t,t+h} D_{t+h}^e]\}, \tag{41}$$

where $\{M_{t,t+h}\}_{h=1}^{\infty}$ is the set of stochastic discount factors and D_t^e is the period t equity payout of the firm, given by

$$D_t^e = (1-\tau)(\Pi(K_t, Z_t) - \Phi(I_t, K_t)) + \tau\delta K_t - I_t - R_t^{b,a} B_t + B_{t+1} - G(B_t, K_t). \tag{42}$$

Finally, there is an exogenous equity payout demand process $D_t^{e,d}$ and an exogenous debt payout demand process $D_t^{b,d}$ from investors. In particular, the equity payout demand process $D^{e,d}$ satisfies

$$D^{e,d}(K, Z, d) = Z \cdot K \cdot d^e = Y \cdot d^e, \tag{43}$$

and the debt payout demand process $D^{b,d}$ satisfies

$$D^{b,d}(K, Z, d^b) = Z \cdot K \cdot d^b = Y \cdot d^b. \tag{44}$$

We also define total payout demand $D^d = D^{e,d} + D^{b,d} = Y \cdot d$, where $d = d^e + d^b$. It follows that d^e, d^b, and d are the firm's equity payout, debt payout, and total payout, respectively, per unit of output.

The law of motion for d is given by Equation 18. As in the case of the unvelered firm, the upper bound for d ensures that the firm's equilibrium marginal q is real-valued and increasing in

the pre-tax gross risk-free rate, but the investor Euler equation is $1 = \mathbb{E}_t[M_{t+1}(R_{t+1}^b - \tau^i(R_{t+1}^b - 1))]$. In our paper, we assume $\tau > \tau^i = 0$. That assumption ensures that the firm optimally chooses positive debt (i.e., that $B_{t+1} \geq 0$) when the net risk-free rate is positive (i.e., when $R_{t+1}^b \geq 1$).

[19] In principle, B can be negative, in which case the firm holds cash and R^b represents the (pre-tax) interest rate that the firm receives on its cash position. In that case, G is assumed to reflect the agency cost of holding cash. In our model, B is negative if and only if the (net) riskless rate is negative. In our simulation, this is a relatively rare event, as it only happens in less than 0.5% of the years.

productivity Z. The debt payout ratio process, d^b, is stationary, with law of motion

$$d^b_{t+1} = \mu_b + \phi_b \cdot (d^b_t - \mu_b) + \sigma_b \cdot \epsilon^b_{t+1}, \tag{45}$$

where $\phi_b \in (0,1)$, $\sigma_b > 0$, $\epsilon^b_{t+1} \sim N(0,1)$, $corr(\epsilon^z_{t+1}, \epsilon^b_{t+1}) = \rho_{z,b}$, and $corr(\epsilon^d_{t+1}, \epsilon^b_{t+1}) = \rho_{d,b}$. It follows that the equity payout ratio process, d^e, is implicitly determined by the relationship $d^e = d - d^b$.

4.2 Payout supply

The firm's problem can be rewritten recursively as

$$V^e(K_t, B_t, Z_t; \{f_t(M_{t,t+h})\}_{h=1}^{\infty}) = \max_{\{I_t, B_{t+1}\}} \{D^e_t + \mathbb{E}_t[M_{t,t+1} V^e(K_{t+1}, B_{t+1}, Z_{t+1}; \{f_{t+1}(M_{t+1,t+1+h})\}_{h=1}^{\infty})]\}, \tag{46}$$

where, as before, $f_t(\cdot)$ denotes the distribution conditional on information available at time t. The firm's optimality conditions for investment and debt jointly determine the firm's equity and debt payout supply, taking the SDF properties as given.

We start with the firm's capital structure choice. The firm's interior optimality condition for B_{t+1} yields

$$1 + \mathbb{E}_t[M_{t+1} \partial_B V^e(K_{t+1}, B_{t+1}, Z_{t+1}; \{f_t(M_{t+1,t+1+h})\}_{h=1}^{\infty})] = 0, \tag{47}$$

and the envelope condition with respect to B_t is

$$\partial_B V^e(K_t, B_t, Z_t; \{f_t(M_{t,t+h})\}_{h=1}^{\infty}) = -R^{b,a}_t - \partial_B G_t. \tag{48}$$

Together, Equations 47 and 48 yield the Euler equation

$$\mathbb{E}_t \left[M_{t,t+1} \cdot (R^{b,a}_{t+1} + \partial_B G_{t+1}) \right] = 1. \tag{49}$$

The left-hand side of the equation is the present value of the firm's effective cost of one additional unit of debt raised at period t: at period $t+1$, the firm pays both the after-tax return $R^{b,a}_{t+1}$ and the marginal leverage cost $\partial_B G_{t+1}$. Conversely, the right-hand side of the equation is the marginal benefit to the firm of one unit of additional debt raised at t, which is always equal to 1. Intuitively, for a given SDF, the firm's optimal capital structure is the one that eliminates any arbitrage opportunities for the firm.

We can alternatively characterize the firm's optimal capital structure in more familiar terms: since $R^{b,a}_{t+1}$, K_{t+1}, and B_{t+1} are known at period t, and using the fact that $\mathbb{E}_t \left[M_{t,t+1} \cdot R^b_{t+1} \right] = 1$, we can rewrite the Euler equation above as

$$\tau(R^b_{t+1} - 1) = \kappa \left(\frac{B_{t+1}}{K_{t+1}}\right). \tag{50}$$

The left-hand side is the firm's interest tax shield and, thus, corresponds to the firm's marginal benefit of debt at period $t+1$, whereas the right-hand side is the firm's marginal cost of leverage at period $t+1$. Thus, we get a simple trade-off condition: the optimal (interior) capital structure of the firm is the one that equates the firm's marginal cost and marginal benefit of debt. Solving for the firm's optimal leverage ratio b_{t+1}, we get

$$b_{t+1} = \frac{\tau}{\kappa}(R^b_{t+1} - 1). \tag{51}$$

Therefore, for a given SDF (and, hence, for a given risk-free rate R^b_{t+1}), the firm's optimal leverage ratio b_{t+1} is increasing in the risk-free rate (as a higher rate is associated with a more valuable interest tax shield). As regards comparative statics, the optimal leverage ratio is increasing in the corporate tax rate τ (as a higher tax rate implies a larger tax shield) and decreasing in the leverage cost parameter κ.

We now turn to the firm's investment policy. The firm's interior optimality condition for investment I_t is

$$\underbrace{\mathbb{E}_t[M_{t+1}\partial_K V^e(K_{t+1}, B_{t+1}, Z_{t+1}; \{f_t(M_{t+1,t+1+h})\}_{h=1}^{\infty})]}_{\equiv q_t} = 1 + (1-\tau)\partial_I \Phi(K_t, I_t), \tag{52}$$

which yields the firm's investment function:

$$I_t = \frac{q_t - 1}{a(1-\tau)} K_t. \tag{53}$$

As in the case of the unlevered firm, the firm's optimal investment is increasing in its marginal q and proportional to its capital stock.[20]

After solving for the firm's optimal investment and capital structure policies, we are ready to characterize the firm's optimal debt and equity payout policies. Substituting the firm's optimal investment policy (Equation 53) and optimal debt policy (Equation 51) into Equation 37, we get the firm's debt payout function,

$$D^b_t = \left[R^b_t b_t - \left(\frac{\tau}{\kappa}(R^b_{t+1} - 1)\right)\left((1-\delta) + \frac{q_t - 1}{a(1-\tau)}\right)\right] K_t. \tag{55}$$

[20] Using the envelope condition with respect to K_t, we can show that the firm's optimal investment decision satisfies the condition

$$q_t = \mathbb{E}_t\left[M_{t,t+1}\left((1-\tau)\left(\partial_K \Pi(K_{t+1}, Z_{t+1}) - \partial_K \Phi(I_{t+1}, K_{t+1})\right) + \tau\delta - \partial_K G(B_{t+1}, K_{t+1}) + (1-\delta)q_{t+1}\right)\right]. \tag{54}$$

This condition is analogous to Equation 26 for the unlevered firm.

Similarly, substituting the firm's optimal investment and debt policy into Equation 42, we derive the firm's equity payout function,

$$D_t^e = \left[\alpha(1-\tau)Z_t + \tau\delta - \frac{q_t^2 - 1}{2a(1-\tau)} - R_t^{b,a} b_t + \left(\frac{\tau}{\kappa}(R_{t+1}^b - 1)\right)\left((1-\delta) + \frac{q_t - 1}{a(1-\tau)}\right) - \frac{\kappa}{2} b_t^2\right] K_t. \tag{56}$$

In summary, the firm's optimality conditions determine the firm's optimal payout supply functions (Equations 55 and 56), for given SDF properties. Notably, the firm's period t optimal payouts are functions of one contemporaneous exogenous variable (productivity Z_t), two contemporaneous endogenous variables (the firm's marginal q_t and the risk-free rate R_{t+1}^b), and one pre-determined endogenous variable (R_t^b – note that b_t is a function of R_t^b through Equation 51). It is easy to see that the firm's marginal q and the risk-free rate are summary statistics for investor preferences regarding firm payout: keeping the exogenous productivity process Z the same, any SDFs that yield the same q and R^b processes also yield the same debt payout D^b and equity payout D^e processes. What remains is to pin down the *equilibrium* q_t and R_{t+1}^b at each period t. For that, we rely on the two market clearing conditions, one for debt payout and the other for equity payout.

4.3 Equilibrium

In equilibrium, both payout markets clear. We start with the debt payout market, which has the following market clearing condition:

$$D_t^b = D_t^{b,d}. \tag{57}$$

Substituting for the firm's debt payout supply (Equation 55) and investors' debt payout demand (Equation 44), and using Equation 51 in order to write R_t^b as a function of b_t, we get an expression for the equilibrium risk-free rate:

$$R_{t+1}^{b,*} = \frac{\kappa}{\tau} \frac{\left(\frac{\kappa}{\tau} b_t^* + 1\right) b_t^* - d_t^b e^{z_t}}{(1-\delta) + \frac{q_t^* - 1}{a(1-\tau)}} + 1. \tag{58}$$

We now turn to the equity payout market. Imposing the market clearing condition

$$D_t^e = D_t^{e,d}, \tag{59}$$

substituting for the firm's equity payout supply (Equation 56) and investors' equity payout demand (Equation 43), imposing the expression for the equilibrium risk-free rate (Equation 58) and rearranging, we get an expression for the firm's equilibrium marginal q:

$$q_t^* = \sqrt{1 + 2a(1-\tau)\left[\left(\alpha(1-\tau) - d_t\right) e^{z_t} + \tau\delta + \frac{\kappa}{2}(b_t^*)^2\right]}. \tag{60}$$

To summarize, payout market clearing yields Equations 58 and 60, which express $R^{b,*}_{t+1}$ and q^*_t, respectively, as functions of contemporaneous exogenous variables (z_t, d_t, and d^b_t) and an endogenous pre-determined variable (b^*_t). Moreover, Equation 37 and the firm's debt optimality condition (Equation 51) yield the following expression for the evolution of the firm's equilibrium leverage ratio:

$$b^*_{t+1} = \frac{\left(\frac{\kappa}{\tau} b^*_t + 1\right) b^*_t - d^b_t e^{z_t}}{(1-\delta) + \frac{q^*_t - 1}{a(1-\tau)}}. \tag{61}$$

4.4 Equilibrium asset prices

In Internet Appendix C, we show that the firm's optimality conditions imply that the ex-payout equity value is given by

$$P^e_t = q_t K_{t+1} - B_{t+1} = (q_t - b_{t+1}) K_{t+1}. \tag{62}$$

As a result, the ex-payout firm value is

$$P_t = P^e_t + B_{t+1} = q_t K_{t+1}, \tag{63}$$

which implies that the firm's average Tobin's q is equal to its marginal Tobin's q, denoted by Q:

$$Q_t = q_t, \tag{64}$$

where Q is defined as before: $Q_t \equiv \frac{P_t}{K_{t+1}}$. Therefore, the equilibrium Q function is

$$Q^*_t = Q^*(b^*_t, z_t, d_t) = \sqrt{1 + 2a(1-\tau)\left[(\alpha(1-\tau) - d_t)\, e^{z_t} + \tau\delta + \frac{\kappa}{2}(b^*_t)^2\right]}, \tag{65}$$

and the equilibrium expected firm return function is

$$\mathcal{R}^*(b^*_t, z_t, d_t, d^b_t) = \mathbb{E}\left[R^*_{t+1} \,\middle|\, b^*_t, z_t, d_t, d^b_t\right], \tag{66}$$

where

$$R^*_{t+1} = \frac{d_{t+1} e^{z_{t+1}} + Q^*(b^*_{t+1}, z_{t+1}, d_{t+1})\left(1 - \delta + \frac{Q^*(b^*_{t+1}, z_{t+1}, d_{t+1}) - 1}{a(1-\tau)}\right)}{Q^*(b^*_t, z_t, d_t)}. \tag{67}$$

We can also characterize the firm's equity and debt expected returns separately. As regards the equity return, $R^e_{t+1} = (P^e_{t+1} + D^e_{t+1})/P^e_t$, Equations 62 and 64 imply the equilibrium expected equity return function

$$\mathcal{R}^{e,*}(b^*_t, z_t, d_t, d^b_t) = \mathbb{E}\left[R^{e,*}_{t+1} \,\middle|\, b^*_t, z_t, d_t, d^b_t\right], \tag{68}$$

where

$$R_{t+1}^{e,*} = \frac{d_{t+1} Z_{t+1} + Q^*(b_{t+1}^*, z_{t+1}, d_{t+1}) \left(1 - \delta + \frac{Q^*(b_{t+1}^*, z_{t+1}, d_{t+1}) - 1}{a(1-\tau)}\right) - \left(\frac{\kappa}{\tau} b_{t+1}^* + 1\right) b_{t+1}^*}{Q^*(b_t^*, z_t, d_t) - b_{t+1}^*}. \tag{69}$$

As regards debt, the equilibrium realized debt return satisfies

$$R_{t+1}^{b,*} = \frac{\kappa}{\tau} b_{t+1}^* + 1, \tag{70}$$

which is nothing more than the equilibrium version of the firm's debt optimality condition (Equation 51). Intuitively, the risk-free rate needs to adjust so that, in equilibrium, the firm's leverage ratio b_{t+1}^*, which is pinned down by the payout market clearing conditions, is optimal for the firm. In other words, the equilibrium risk-free rate is the rate that clears the debt payout market, i.e., the rate that makes the firm *optimally* issue the amount of debt that is desired by investors.[21]

Substituting Equation 61 into Equation 70, taking conditional expectations, and using Equation 64, we get the equilibrium expected debt return,

$$\mathcal{R}^{b,*}(b_t^*, z_t, d_t, d_t^b) = \frac{\kappa}{\tau} \frac{\left(\frac{\kappa}{\tau} b_t^* + 1\right) b_t^* - d_t^b e^{z_t}}{(1-\delta) + \frac{Q^*(b_t^*, z_t, d_t) - 1}{a(1-\tau)}} + 1, \tag{71}$$

which equals the equilibrium realized debt return, $R_{t+1}^{b,*}$, as the firm issues one-period riskless debt.

To solve for the expected firm, equity, and debt returns, we use Equations 66, 68, and 71, as well as the expression for the firm's equilibrium Q (Equation 65), the laws of motion of the exogenous processes z, d, and d^b, and the law of motion for the equilibrium leverage ratio, b^* (Equation 61).

Figures 7, 8, and 9 display the expected equilibrium firm return $\mathcal{R}^*$, the expected equilibrium equity return $\mathcal{R}^{e,*}$, and the expected equilibrium debt return $\mathcal{R}^{b,*}$, respectively, as functions of the four state variables: productivity z, demanded firm payout ratio d, demanded debt payout ratio d^b, and lagged leverage ratio b. For our calculations, we use the calibrated parameter values discussed in the next section and Gauss-Hermite quadrature (with 31 grid points per shock) to compute the integrals needed for the evaluation of the $\mathcal{R}^*$ and $\mathcal{R}^{e,*}$ functions.

As seen in Figure 7, the firm's expected return is slightly increasing in productivity z and sharply

[21]The intuition is analogous to risk-free determination in the consumption-based asset pricing framework: in that framework, there are no firms and debt is in zero net supply amongst households, so the risk-free rate is the rate that makes the representative household *optimally* demand zero debt each period. Thus, economies that feature different preferences for the representative household generate different risk-free rate processes, even if the aggregate endowment is the same, as optimal debt demand is preference-specific. In our economy, debt is also in zero net supply economy-wide: the representative firm has negative debt holdings (as it issues debt) and investors have perfectly offsetting positive debt holdings. Furthermore, economies that feature different firm technologies (for example, different leverage cost functions) generate different risk-free rate processes, even if the investor debt payout demand process is the same, as optimal debt supply is technology-specific.

increasing in total payout d, whereas it is essentially flat with respect to both the debt payout d^b and the lagged leverage ratio b. Thus, as in the case of the unlevered firm, most of the variation in the firm's expected return arises from fluctuations in the investors' demanded total payout ratio d. As seen in Panel C (in which d is kept fixed, whereas the relative magnitudes of d^e and d^b change), it is just the size of the overall payout d that matters for the magnitude of the firm's expected return, but not its composition.

The composition of the firm's total demanded payout becomes important when we focus on the firm's expected equity and debt returns separately. As seen in Panel C of Figure 8, the firm's expected equity return is decreasing in the debt payout ratio d^b, holding everything else (including the total payout ratio d) fixed. This is because, for d to remain fixed, an increase in d^b has to be offset by an equivalent decline in the equity payout ratio d^e. To satisfy a lower demanded equity payout ratio, the firm has to cut its equity payout and increase investment, so the equity discount rate has to fall to incentivize the firm to do so. An increase in d^b, keeping d fixed, decreases not only the firm's cost of equity, but also its cost of debt: as seen in Panel C of Figure 9, the firm's debt return is negatively associated with d^b. Intuitively, a reduction of d^b, everything else equal, implies that investors desire to hold less newly-issued debt. Taking into account the positive relationship between the firm's debt supply and the risk-free rate in our model, the firm's cost of debt has to fall in order for the firm to want to supply the reduced amount of new debt that investors want to hold. On the other hand, the firm's debt return is strongly increasing in the lagged leverage ratio b (Panel D of Figure 9). This is because a higher b, keeping everything else (and, in particular d^b) the same, implies a stronger investor desire for holding newly-issued debt. To match the higher investor demand for debt, the equilibrium risk-free rate needs to rise, so that the firm is willing to issue more debt.

4.5 Quantitative Results

We investigate the quantitative properties of the model with a levered representative firm by considering a simulation exercise. The calibrated parameter values for our model are reported in the last column of Table 1. All parameters common to both the levered and the unlevered firm model are calibrated using the methodology discussed in the previous section.[22] The new parameters are the leverage cost parameter κ and the debt payout ratio parameters (μ_b, ϕ_b, σ_b, $\rho_{z,b}$, and $\rho_{d,b}$). The leverage cost parameter κ is calibrated to match the average U.S. aggregate leverage ratio,[23] whereas the debt payout parameters are calibrated to match the corresponding moments of the U.S. aggregate debt payout ratio.

[22] All common parameter values are identical across the two models, with the exception of the values of the productivity parameters, which change slightly because the implied productivity process changes slightly due to the different Q functions in the two models (compare Equations 34 and 65).

[23] We back out the time series for the aggregate leverage ratio (market value of debt per unit of capital) by multiplying the market value of debt per unit of output by productivity, which is equal to output per unit of capital.

Again, we run 10,000 model simulations, each of which consists of 44 annual observations (after an initial period of 1,000 years, to reduce the dependence on initial conditions). We report empirical and simulated moments for firm returns, equity returns, and debt returns in Tables 3, 4, and 5, respectively.[24]

As seen in Table 3, our model is able to capture many of the salient properties of U.S. aggregate firm returns. This is not surprising: the simulated moments in Table 3 are almost identical to the simulated moments of the unlevered firm discussed in the previous section (Table 2). The only new component of Table 3 is Panel E, which reports the output of return forecasting regressions that use equity and debt payout ratios as the predictive variables. In both the data and the model, both ratios have a positive forecasting coefficient, underscoring the ability of the model to accurately capture important return predictability attributes.

When we consider equity and debt returns separately, the performance of the model gets more mixed. As seen in Panel A of Table 4, the model generates realistic correlations of equity returns with output growth rates, productivity shocks, equity payout shocks, and debt payout shocks. However, simulated equity payout yields are higher on average, and more volatile, than their empirical counterparts. On the other hand, the model is able to generate realistic equity return unconditional moments: the average equity return is 8.61% and the unconditional equity return volatility is 18.21%, both quite close to their empirical values (8.96% and 17.76%, respectively). Furthermore, the model is able to produce empirically plausible conditional expected returns, as evidenced by the fact that the output of the simulated return predictability regressions (Panels B–E of Table 4) matches well the output of the corresponding regressions that use U.S. aggregate firm data.

When we turn to debt prices and returns (Table 5), we see that the model is able to generate realistic unconditional moments for debt payout yields, but not for debt returns: in the model, debt returns are low (mean of 0.36%) and almost constant (unconditional volatility of 0.06%), quite different from actual U.S. aggregate debt returns (which have a mean of 4.84% and an unconditional volatility of 7.47%). Given that the model generates essentially constant debt returns, it is unable to match the empirical debt return predictability properties: as seen in Panels B–E, all simulated forecasting coefficient estimates are extremely close to zero. It should be noted that a key reason for the inability of our model to match the empirical debt return properties is the fact that our representative firm is constrained to only issue one-period safe debt, so the debt return is always equal to the risk-free rate. If we compare the debt returns in our model with the empirical risk-free

[24] For the law of motion of z, given in Equation 12, $Z_t^{\min} = 0$ for all t, since the normally distributed shocks have infinite support, which sometimes leads to a binding collateral constraint. To ensure that the collateral constraint binds very infrequently (and, hence, can be ignored when solving the model), we introduce the following slight modification: we set the value of $Z_{t+1}^{\min}$ to be equal to the value that Z_{t+1} would take if the realization of the productivity shock at $t+1$ were equal to four standard deviations below zero. Since realizations below four standard deviations from zero are extremely rare for normally distributed shocks, our modification helps ensure that the collateral constraint almost never binds without substantially violating our distributional assumptions for z.

rate time series, then the performance of our model improves significantly: in the data, the average (real) risk-free rate has a mean of 0.82% and an unconditional volatility of 2.56%.

Finally, in order to quantify the contribution of each state variable to the overall volatility of key asset pricing measures, we run a single 100-year simulation of the model and report the paths of the firm's equilibrium Q, expected firm return, expected equity return, and expected debt return in Figure 10. As seen in Panels A, B, and C, fluctuations in the firm payout ratio d account for almost all of the variation in the firm's Q, firm expected returns, and equity expected returns. On the other hand, the volatility of the firm's expected debt returns is mainly due to changes in the debt payout ratio d^b and the lagged leverage ratio b.

5 Conclusion

In this paper, we propose a payout-based asset pricing framework that is analogous to consumption-based asset pricing: while consumption-based asset pricing solves for equilibrium expected returns by equating postulated payout supply to endogenous payout demand, payout-based asset pricing equates postulated payout demand to endogenous payout supply. We demonstrate this parallel in the context of a simple two-period model. Then, we explore the asset pricing implications of our framework in a quantitative model, finding that it goes a long way in reproducing key asset pricing moments. In particular, our model generates empirically plausible payout yields, firm returns, and equity returns, as well as return predictability that is consistent with the model mechanism.

Our model is very simple on purpose, as our aim is to identify the baseline implications of our payout-based asset pricing framework. As a result, there is plenty of scope for richer, more realistic, models that may be able to better match the key properties of asset prices and returns. For example, our model does not include any financing frictions for the firm. Given the importance of those frictions for firms' payout decisions, it would be interesting to explore the asset pricing implications of such frictions in our framework. Furthermore, our approach opens the door to new potential research paths. For instance, future work can extend payout-based asset pricing to the cross-section of firm returns, with the aim of addressing well-known anomalies.

References

Bai, Hang, Erica X. N. Li, Chen Xue, and Lu Zhang, "Asymmetric Investment Rates," 2022. Working Paper.

Belo, Frederico, "Production-based measures of risk for asset pricing," *Journal of Monetary Economics*, 2010, *57* (2), 146–163.

___ **and Jianfeng Yu**, "Government investment and the stock market," *Journal of Monetary Economics*, 2013, *60* (3), 325–339.

___ **and Xiaoji Lin**, "The Inventory Growth Spread," *Review of Financial Studies*, 2012, *25* (1), 278–313.

___ **and Xinwei Li**, "Production-based Stochastic Discount Factors," 2023. Working Paper.

___ **, Chen Xue, and Lu Zhang**, "A Supply Approach to Valuation," *Review of Financial Studies*, 2013, *26* (12), 3029–3067.

___ **, Jun Li, Xiaoji Lin, and Xiaofei Zhao**, "Labor-Force Heterogeneity and Asset Prices: The Importance of Skilled Labor," *Review of Financial Studies*, 2017, *30* (10), 36693709.

___ **, Vito Gala, Juliana Salomao, and Maria Ana Vitorino**, "Decomposing Firm Value," *Journal of Financial Economics*, 2022, *143* (2), 619–639.

___ **, Xiaoji Lin, and Fan Yang**, "External Equity Financing Shocks, Financial Flows, and Asset Prices," *Review of Financial Studies*, 2018, *Forthcoming.*

___ **,** ___ **, and Santiago Bazdresch**, "Labor Hiring, Investment, and Stock Return Predictability in the Cross Section," *Journal of Political Economy*, 2014, *122* (1), 129–177.

___ **, Yao Deng, and Juliana Salomao**, "Estimating and Testing Investment-based Asset Pricing Models," 2023. Working Paper.

Berk, Jonathan B., Richard C. Green, and Vasant Naik, "Optimal Investment, Growth Options, and Security Returns," *Journal of Finance*, 1999, *54* (5), 1553–1607.

Breeden, Douglas T., "An intertemporal asset pricing model with stochastic consumption and investment opportunities," *Journal of Financial Economics*, 1979, *7* (3), 265–296.

Campbell, John Y. and John H. Cochrane, "By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior," *Journal of Political Economy*, 1999, *107* (2), 205–251.

Cochrane, John, "Production based asset pricing," 1988. Working Paper.

Cochrane, John H., "Production-Based Asset Pricing and the Link Between Stock Returns and Economic Fluctuations," *Journal of Finance*, 1991, *46* (1), 209–237.

——, "Rethinking Production under Uncertainty," *Review of Asset Pricing Studies*, 2021, *11*, 1–59.

Davydiuk, Tetiana, Scott Richard, Ivan Shaliastovich, and Amir Yaron, "How Risky are U.S. Corporate Assets?," *Journal of Finance*, 2023, *78* (1), 141–208.

DeAngelo, Harry, Linda DeAngelo, and Toni M. Whited, "Capital structure dynamics and transitory debt," *Journal of Financial Economics*, 2011, *99* (2), 235–261.

Favilukis, Jack, Xiaoji Lin, and Xiaofei Zhao, "The Elephant in the Room: The Impact of Labor Obligations on Credit Markets," *American Economic Review*, 2020, *110* (6), 1673–1712.

Gonçalves, Andrei S., Chen Xue, and Lu Zhang, "Aggregation, Capital Heterogeneity, and the Investment CAPM," *Review of Financial Studies*, 2020, *33* (6), 2728–2771.

Grigoris, Fotis and Gill Segal, "The Utilization Premium," *Management Science*, 2023. Forthcoming.

——, Yunzhi Hu, and Gill Segal, "Counterparty Risk: Implications for Network Linkages and Asset Prices," *Review of Financial Studies*, 2023, *36* (2), 814–858.

Hennessy, Christopher A. and Tony M. Whited, "Debt Dynamics," *Journal of Finance*, 2005, *60* (3), 1129–1165.

Jermann, Urban J., "The equity premium implied by production," *Journal of Financial Economics*, 2010, *98* (2), 279–296.

Jones, Christopher S. and Selale Tuzel, "Inventory investment and the cost of capital," *Journal of Financial Economics*, 2013, *107*, 557–579.

Jr, Robert E. Lucas, "Asset Prices in an Exchange Economy," *Econometrica*, 1978, *46* (6), 1429–1445.

Kogan, Leonid and Dimitris Papanikolaou, "Growth Opportunities and Technology Shocks," *American Economic Review: Papers & Proceedings*, 2010, *100*, 532–536.

——, Jun Li, and Harold H. Zhang, "Operating Hedge and Gross Profitability Premium," *Journal of Finance*, 2023. Forthcoming.

Li, Erica X. N., Guoliang Ma, Shujing Wang, and Cindy Yu, "Fundamental Anomalies," 2023. Working Paper.

Li, Jun, "Explaining Momentum and Value Simultaneously," *Management Science*, 2018, *Forthcoming.*

Lin, Xiaoji and Lu Zhang, "The Investment Manifesto," *Journal of Monetary Economics*, 2013, *60* (3), 351–366.

Liu, Laura Xiaolei and Lu Zhang, "A Neoclassical Interpretation of Momentum," *Journal of Monetary Economics*, 2014, *67*, 109–128.

____ , Toni M. Whited, and Lu Zhang, "Investment-Based Expected Stock Returns," *Journal of Political Economy*, 2009, *117* (6), 1105–1139.

Martin, Ian, "The Lucas Orchard," *Econometrica*, 2013, *81* (1), 55–111.

Newey, Whitney K. and Kenneth D. West, "A Simple, Positive-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix," *Econometrica*, 1987, *55* (3), 703–708.

____ and ____ , "Automatic Lag Selection in Covariance Matrix Estimation," *Review of Economic Studies*, 1994, *61* (4), 631–653.

Restoy, Fernando and G. Michael Rockinger, "On Stock Market Returns and Returns on Investment," *Journal of Finance*, 1994, *49* (2), 543–556.

Zhang, Lu, "The Value Premium," *Journal of Finance*, 2005, *60* (1), 67–103.

____ , "The Investment CAPM," *European Financial Management*, 2017, *23* (4), 545–603.

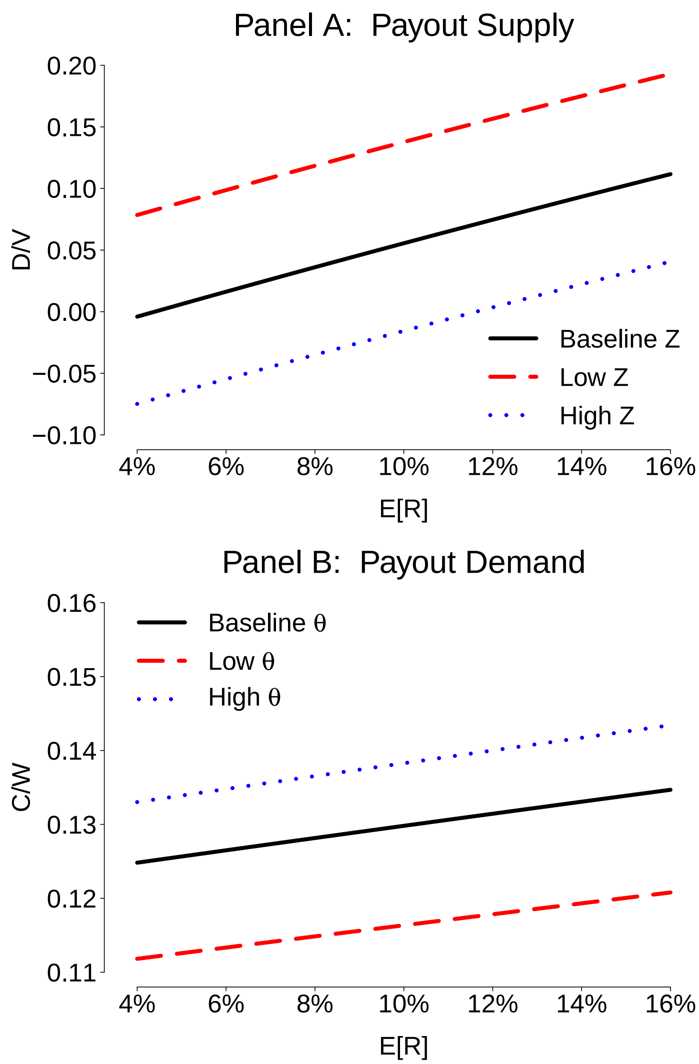

Fig. 1: Payout yield and consumption-wealth ratio in the two-period model

This figure presents the payout yield of the representative firm (Panel A) and the consumption-wealth ratio of the representative household (Panel B) in the two-period model. Panel A presents the firm's payout yield curve as a function of the firm's expected return for different values of the firm's productivity Z. Panel B presents the households's consumption-wealth curve as a function of the firm's expected return for different values of the taste shifter θ.

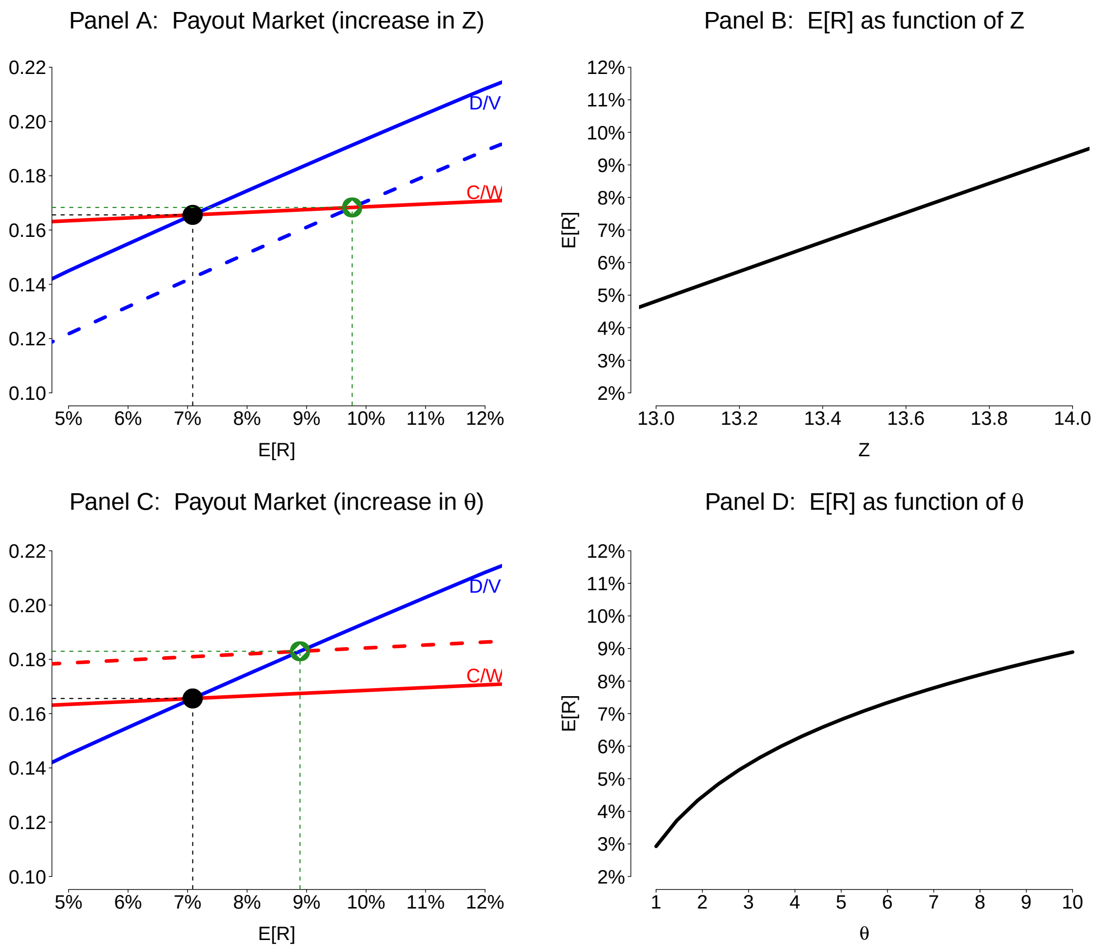

Fig. 2: Payout market equilibrium in the two-period model

Panels A and C this figure illustrate the payout market equilibrium by plotting the payout yield of the representative firm and the consumption-wealth ratio of the representative household, respectively, in the two-period model as functions of the firm's expected return. In particular, Panel A shows the impact of a shift of the firm's payout yield curve when the firm's productivity Z increases, and Panel C shows the impact of a shift of the household's consumption-wealth ratio curve when the taste shifter θ increases. Panels B and D of this figure plot the equilibrium expected return as a function of firm productivity Z and the taste shifter θ, respectively, keeping everything else constant.

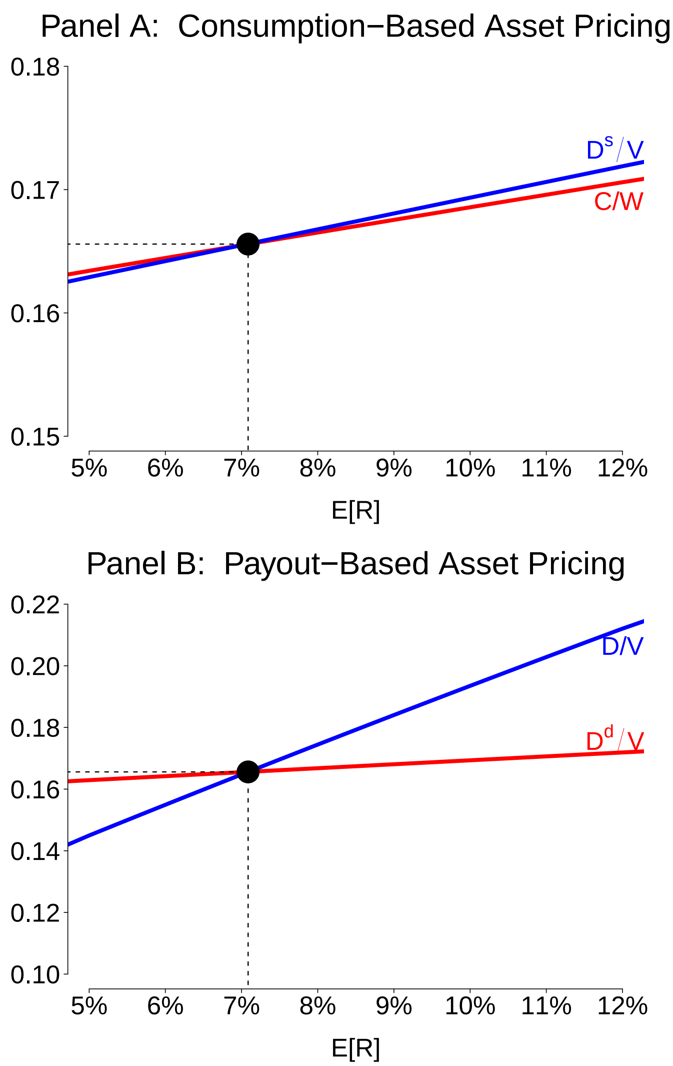

Fig. 3: Consumption-based and payout-based asset pricing in the two period model

Panels A and B of this figure illustrate the payout market equilibrium in the consumption-based model and payout-based model, respectively, that corresponds to our full two-period model. Panel A plots the consumption-wealth curve of the representative household, as well as the "endowment curve" (denoted by D^s/V) that reflects the exogenous payout supply. Panel B plots the payout yield curve of the representative firm, as well as the "payout curve" (denoted by D^d/V) that reflects the exogenous payout demand.

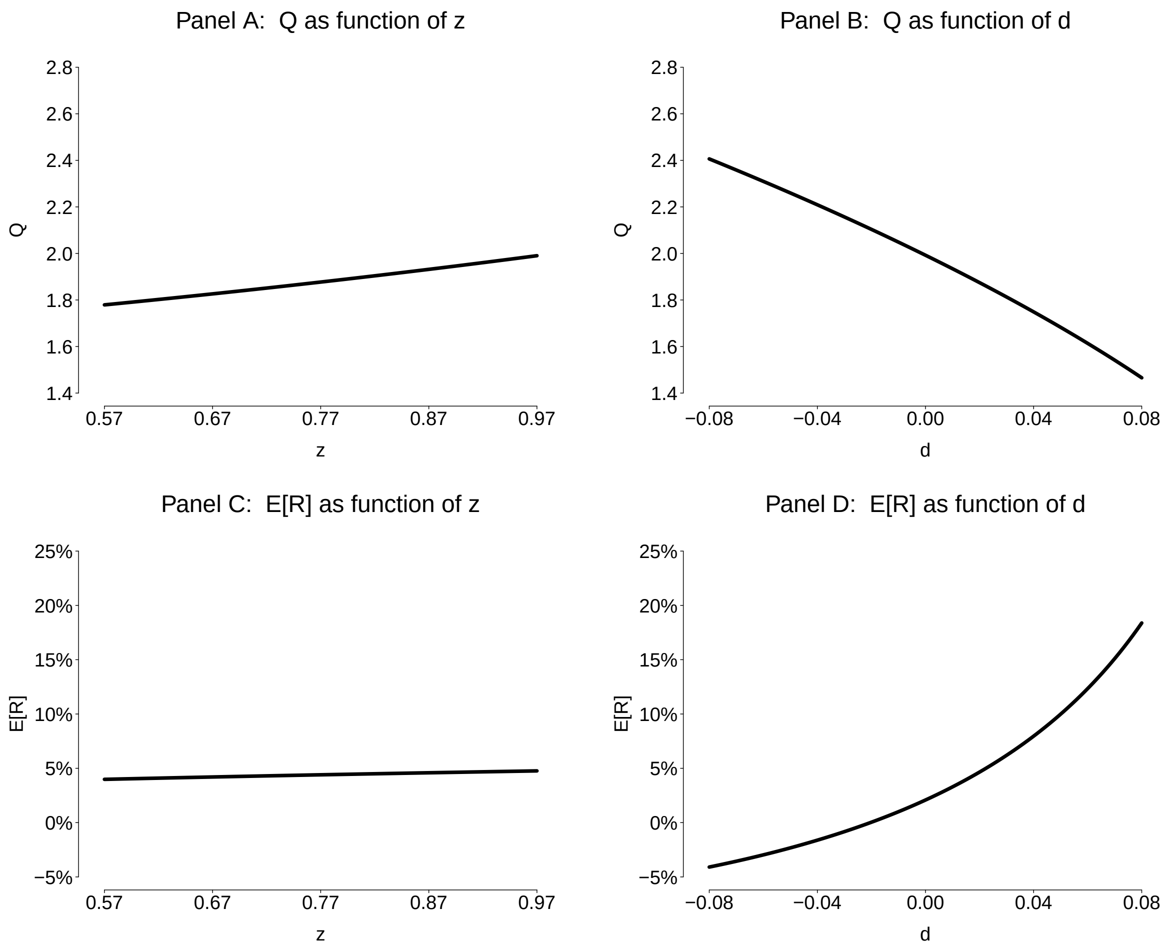

Fig. 4: Equilibrium Q and expected firm return as functions of the state variables

This figure presents the equilibrium average Tobin's q, denoted by Q, and the equilibrium expected return of the representative firm in the quantitative model with an unlevered firm. Panels A and B of this figure plot the firm's Q as a function of the state variable z and d, respectively, keeping the other state variable constant. Panels C and D of this figure plot the equilibrium expected firm return as a function of the state variable z and d, respectively, keeping the other state variable constant.

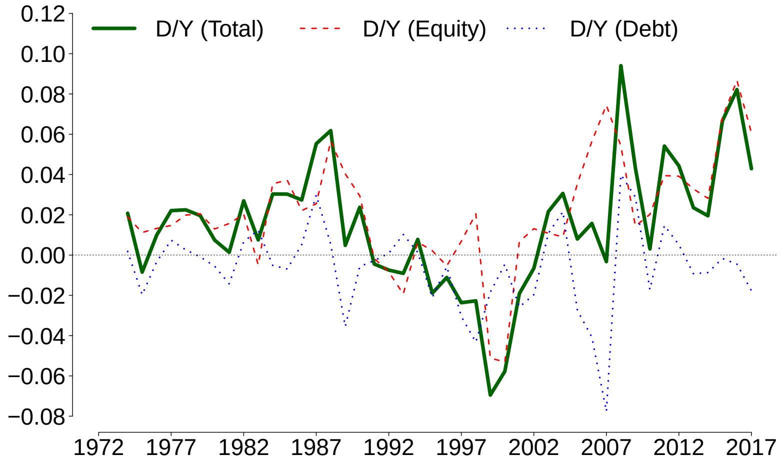

Fig. 5: U.S. aggregate payout ratio

This figure plots the annual time series of the U.S. aggregate firm payout ratio (firm payout divided by firm revenue) from 1974 to 2017 (solid green line). The figure also plots the annual time series of the U.S. aggregate equity and debt payout ratio (dashed red line and blue dotted line, respectively) for the same time period.

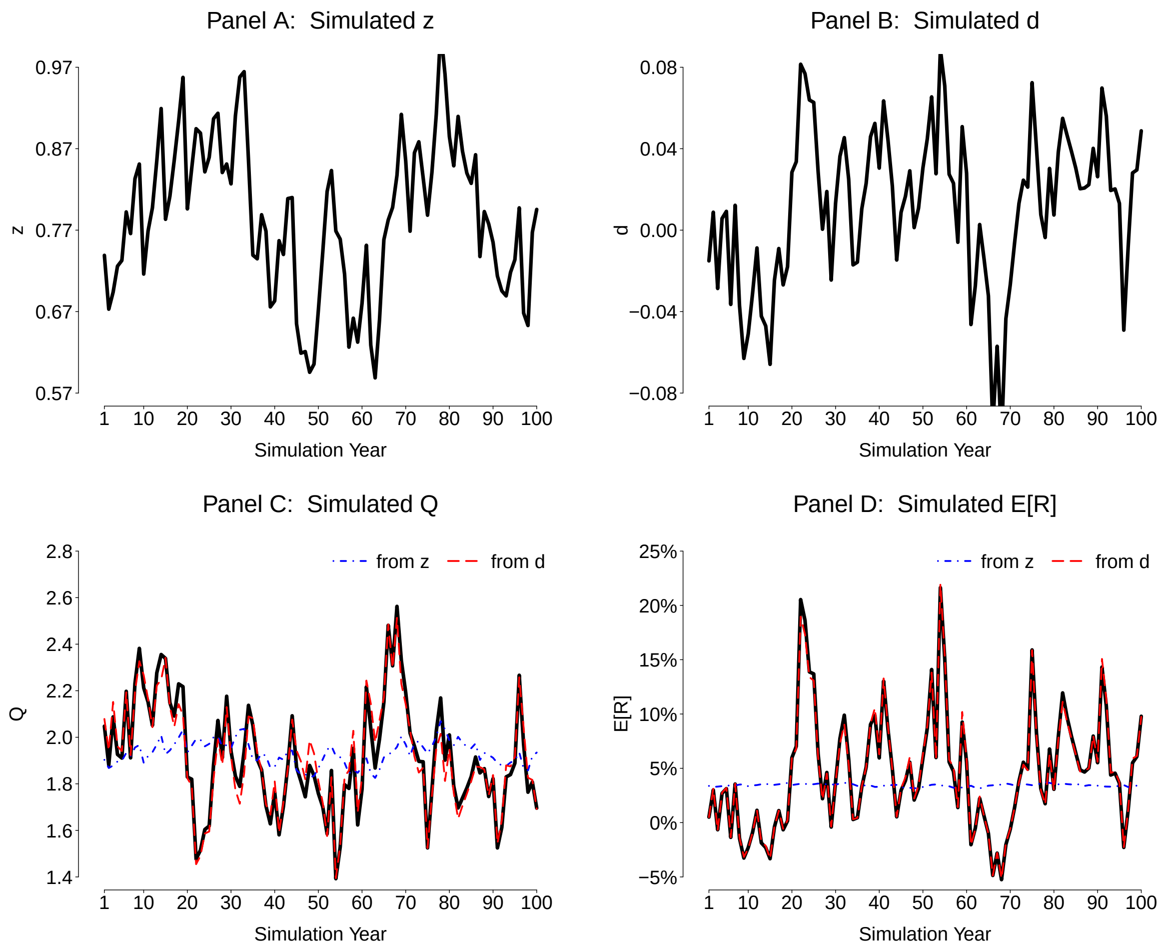

Fig. 6: Simulated paths: model with unlevered firm

This figure reports the output of a 100-year simulation of the quantitative model with an unlevered representative firm. Panels A and B plot the simulated paths of the state variables z and d, respectively. Panels C and D plot the simulated path of the firm's average Tobin's q, denoted by Q, and the firm's equilibrium expected return (in black solid line), respectively, as well as the equilibrium Q path and expected return path when z and d varies (in red and blue dotted line, respectively) and the other state variable is kept constant.

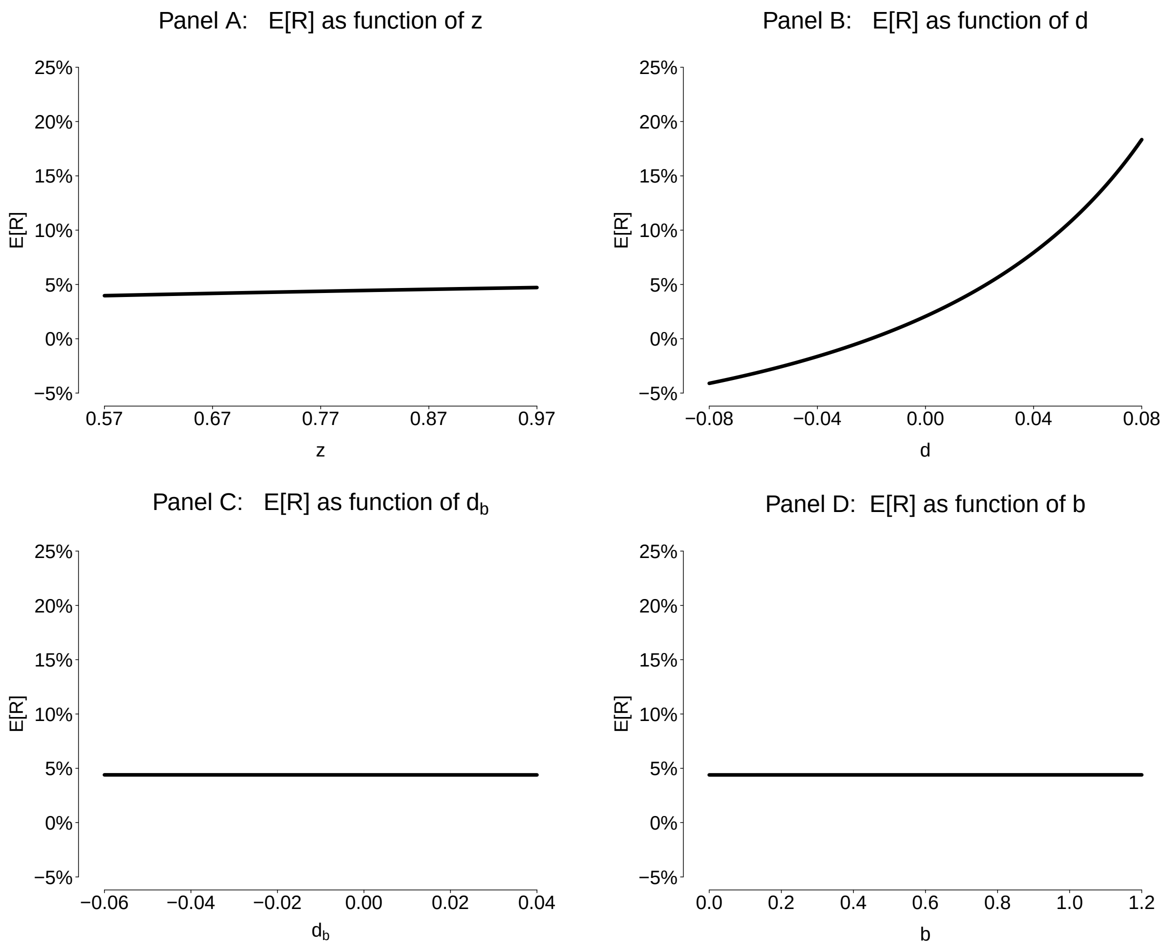

Fig. 7: Expected return of the levered firm as a function of the state variables

This figure presents the equilibrium expected return of the representative firm in the quantitative model with a levered representative firm. In particular, Panels A, B, C, and D of this figure plot the firm's equilibrium expected return as a function of the state variable z, d, d^b, and b, respectively, keeping the other state variables constant.

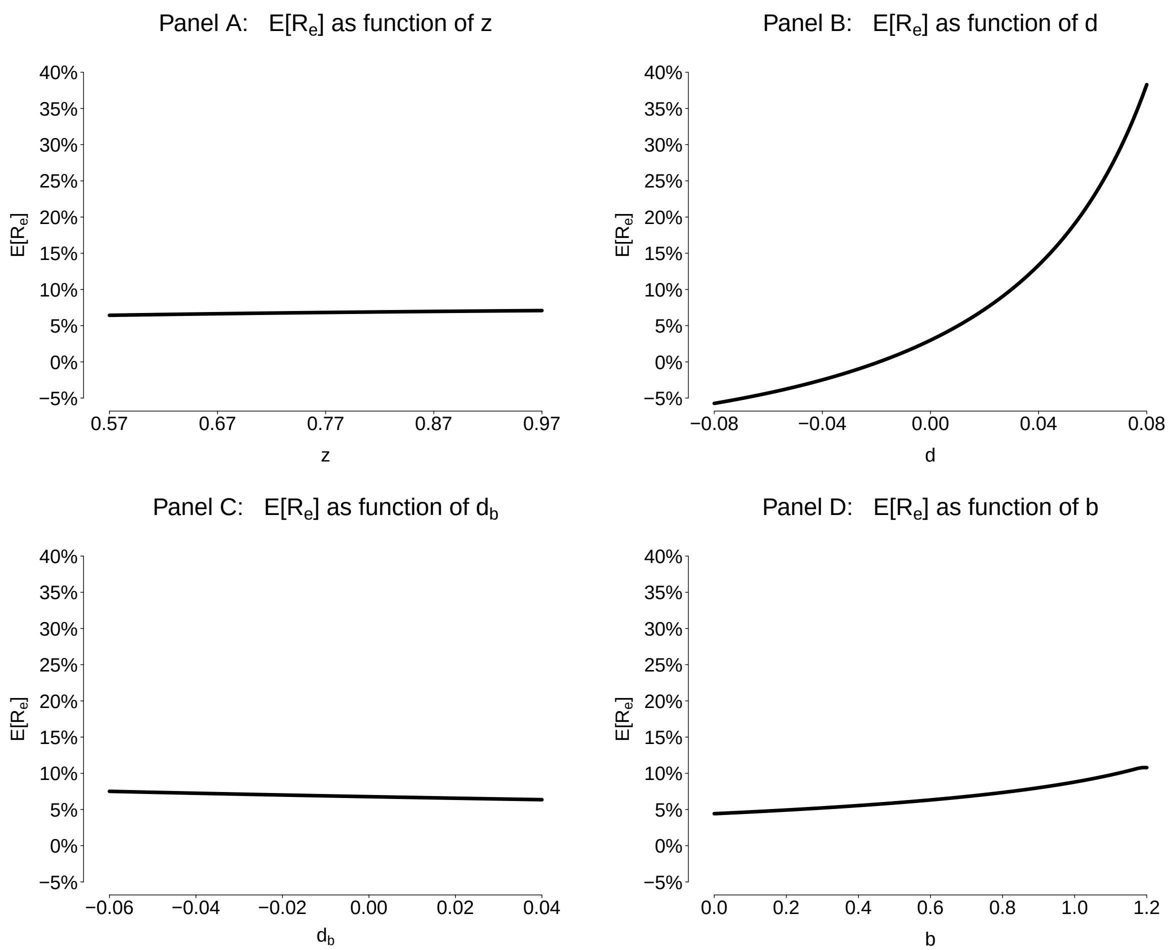

Fig. 8: Equity expected return of the levered firm as a function of the state variables

This figure presents the equilibrium equity expected return of the levered representative firm in the quantitative model with a levered representative firm. In particular, Panels A, B, C, and D of this figure plot the firm's equilibrium equity expected return as a function of the state variable z, d, d^b, and b, respectively, keeping the other state variables constant.

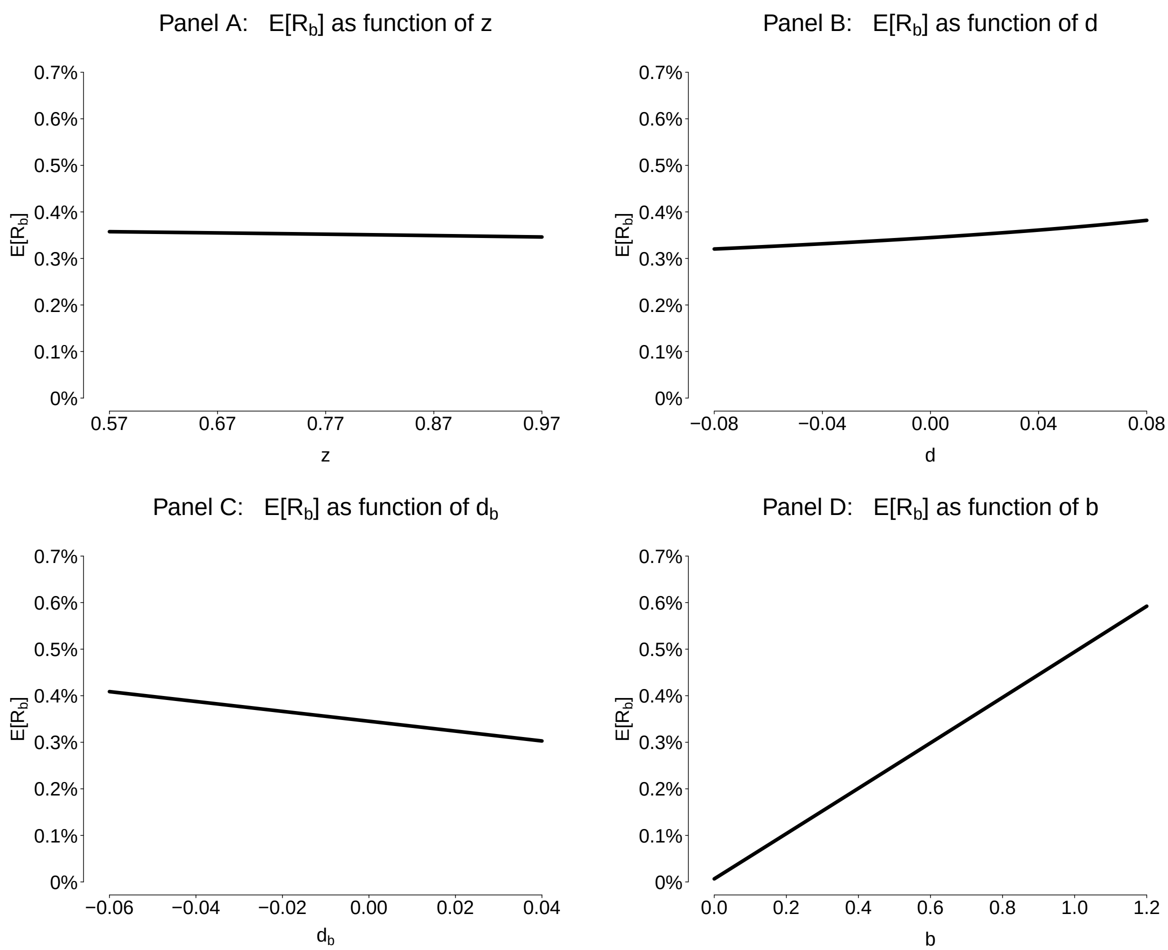

Fig. 9: Debt expected return of the levered firm as a function of the state variables

This figure presents the equilibrium debt expected return of the levered representative firm in the quantitative model with a levered representative firm. In particular, Panels A, B, C, and D of this figure plot the firm's equilibrium debt expected return as a function of the state variable z, d, d^b, and b, respectively, keeping the other state variables constant.

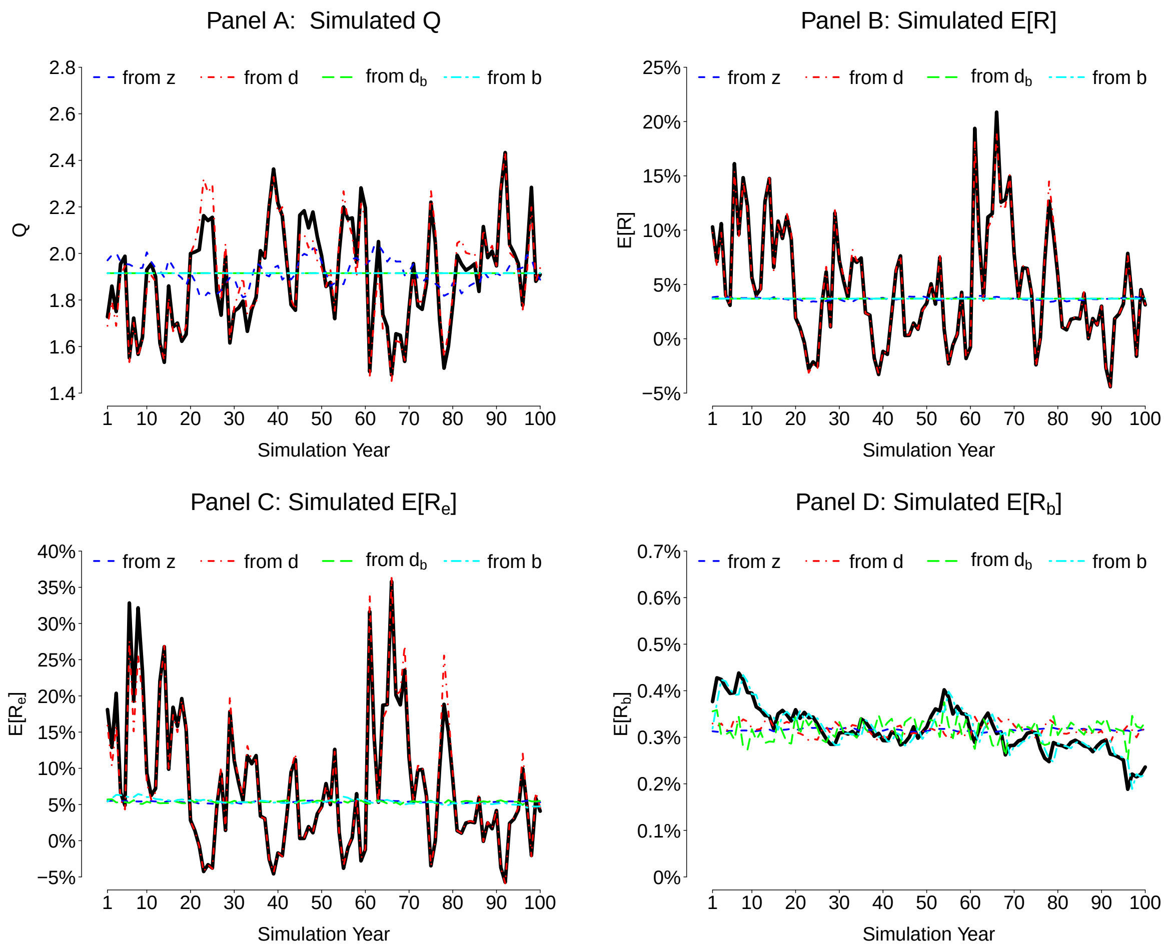

Fig. 10: Simulated paths: model with levered firm

This figure reports the output of a 100-year simulation of the quantitative model with a levered representative firm. In particular, Panels A, B, C, and D plot the simulated path of the firm's average Tobin's q (denoted by Q), the firm's equilibrium expected return, the firm's equilibrium expected equity return, and the firm's equilibrium expected debt return, respectively (in solid black line). Furthermore, each plot reports the corresponding variable path when each of z, d, d^b or b varies (in blue, red, green, and turquoise dotted line, respectively) and the other state variables are kept constant.

Table 1: Model calibration

This table reports the calibrated parameters in our quantitative model. For each parameter, the first column provides its description, the second column shows its symbol, and the third and fourth columns report its calibrated value in the model with an unlevered and a levered firm, respectively.

		Calibrated Value	
Parameter Description	**Symbol**	**Unlevered Firm**	**Levered Firm**
Adjustment Cost Parameter	a	8.000	8.000
Depreciation Rate	δ	0.150	0.150
Corporate Tax Rate	τ	0.350	0.350
Profit Margin	α	0.164	0.164
Leverage cost parameter	κ	–	0.002
Average z	μ_z	0.783	0.781
Autocorrelation of z	ϕ_z	0.760	0.759
Volatility Parameter of z	σ_z	0.059	0.059
Average d	μ_d	0.015	0.015
Autocorrelation of d	ϕ_d	0.595	0.595
Volatility Parameter of d	σ_d	0.092	0.092
Average d^b	μ_b	–	-0.006
Autocorrelation of d^b	ϕ_b	–	0.167
Volatility Parameter of d^b	σ_b	–	0.021
Correlation(z , d)	$\rho_{z,d}$	-0.104	-0.104
Correlation(z , d^b)	$\rho_{z,b}$	–	-0.068
Correlation(d , d^b)	$\rho_{d,b}$	–	0.525

Table 2: Empirical and simulated moments: unlevered firm

This table reports empirical and simulated asset pricing moments. For each moment, it reports its description, its notation, its empirical value, and its median and 1st and 99th percentile values across 10,000 simulations of the model with an unlevered representative firm. Panel A reports unconditional moments. Panel B reports the slope coefficient and the adjusted R^2 of regressions of firm returns on lagged payout yields. Panel C reports the slope coefficient and the adjusted R^2 of regressions of firm returns on lagged payout ratios. Panel D reports the slope coefficients and the adjusted R^2 of regressions of firm returns on lagged payout ratios and lagged productivity. For regression coefficients estimated in the data, we also provide statistical significance information, with *, **, and *** reflecting statistical significance at the 10% level, 5% level, and 1% level, respectively. Standard errors are based on Newey and West (1987) with lag selection by Newey and West (1994).

			Model		
Description	**Notation**	**Data**	**Q(1%)**	**Median**	**Q(99%)**
Panel A: Unconditional moments					
Average Output Growth	$\mathbb{E}[g^Y]$	2.75%	-0.31%	2.35%	5.56%
Volatility of Output Growth	$\sigma[g^Y]$	5.95%	5.41%	7.23%	9.33%
Correlation of Return with Output Growth	$corr(R, g^Y)$	0.02	-0.31	0.02	0.35
Correlation of Return with Productivity Shock	$corr(R, z - \mathbb{E}[z])$	0.22	-0.04	0.32	0.60
Correlation of Return with Payout Shock	$corr(R, d - \mathbb{E}[d])$	-0.54	-0.93	-0.86	-0.74
Average Payout Yield	$\mathbb{E}[D/P]$	1.59%	-0.62%	2.32%	4.99%
Volatility of Payout Yield	$\sigma[D/P]$	2.47%	2.73%	4.01%	5.57%
Autocorrelation of Payout Yield	$\mathbb{AC}[D/P]$	0.44	0.15	0.52	0.76
Average Return	$\mathbb{E}[R]$	7.86%	3.58%	4.94%	6.42%
Volatility of Return	$\sigma[R]$	14.88%	7.94%	10.68%	13.75%
Reward-to-Risk	$\mathbb{E}[R]/\sigma[R]$	0.53	0.34	0.46	0.63
Autocorrelation of Return	$\mathbb{AC}[R]$	-0.17	-0.49	-0.20	0.12
Volatility of $\mathbb{E}[R]$	$\sigma[\mathbb{E}[R]]$	–	3.13%	4.70%	6.78%
Panel B: Regressions of R_{t+1} on D_t/P_t					
Predictive Coefficient	b	1.81***	0.59	1.30	2.26
Adjusted R-squared	R^2_{adj}	9.20%	6.25%	22.09%	42.09%
Panel C: Regressions of R_{t+1} on D_t/Y_t					
Predictive Coefficient	b	1.36***	0.60	1.57	3.06
Adjusted R-squared	R^2_{adj}	8.60%	5.17%	21.12%	42.16%
Panel D: Regressions of R_{t+1} on D_t/Y_t and Z_t					
D_t/Y_t Predictive Coefficient	b_d	1.38***	0.60	1.63	3.15
Z_t Predictive Coefficient	b_z	-0.03	-0.24	0.00	0.22
Adjusted R-squared	R^2_{adj}	6.44%	4.08%	21.38%	43.28%

Table 3: Empirical and simulated moments: returns of levered firm

This table reports empirical and simulated asset pricing moments. For each moment, it shows its description, its notation, its empirical value, and its median and 1st and 99th percentile values across 10,000 simulations of the model with a levered representative firm. Panel A reports unconditional moments of firm returns. Panel B reports the slope coefficient and the adjusted R^2 of regressions of firm returns on lagged firm payout yields. Panel C reports the slope coefficient and the adjusted R^2 of regressions of firm returns on lagged firm payout ratios. Panel D reports the slope coefficients and the adjusted R^2 of regressions of firm returns on lagged firm payout ratios and lagged productivity. Panel E reports the slope coefficients and the adjusted R^2 of regressions of firm returns on lagged equity and debt payout ratios. For regression coefficients estimated in the data, we also provide statistical significance information, with *, **, and *** reflecting statistical significance at the 10% level, 5% level, and 1% level, respectively. Standard errors are based on Newey and West (1987) with lag selection by Newey and West (1994).

			Model		
Description	**Notation**	**Data**	**Q(1%)**	**Median**	**Q(99%)**
Panel A: Unconditional moments					
Average Output Growth	$\mathbb{E}[g^Y]$	2.75%	-0.42%	2.32%	5.53%
Volatility of Output Growth	$\sigma[g^Y]$	5.95%	5.43%	7.20%	9.26%
Correlation of Firm Return with Output Growth	$corr(R, g^Y)$	0.02	-0.31	0.02	0.36
Correlation of Firm Return with Productivity Shock	$corr(R, z - \mathbb{E}[z])$	0.22	-0.03	0.32	0.61
Correlation of Firm Return with Payout Shock	$corr(R, d - \mathbb{E}[d])$	-0.54	-0.93	-0.86	-0.74
Average Firm Payout Yield	$\mathbb{E}[D/P]$	1.59%	-0.50%	2.30%	5.04%
Volatility of Firm Payout Yield	$\sigma[D/P]$	2.47%	2.74%	4.01%	5.58%
Autocorrelation of Firm Payout Yield	$\mathbb{AC}[D/P]$	0.44	0.16	0.51	0.76
Average Firm Return	$\mathbb{E}[R]$	7.86%	3.56%	4.92%	6.38%
Volatility of Firm Return	$\sigma[R]$	14.88%	8.00%	10.67%	13.75%
Reward-to-Risk	$\mathbb{E}[R]/\sigma[R]$	0.53	0.33	0.46	0.63
Autocorrelation of Firm Return	$\mathbb{AC}[R]$	-0.17	-0.49	-0.20	0.12
Volatility of $\mathbb{E}[R]$	$\sigma[\mathbb{E}[R]]$	–	3.11%	4.70%	6.75%
Panel B: Regressions of R_{t+1} on D_t/P_t					
Predictive Coefficient	b	1.81***	0.62	1.30	2.26
Adjusted R-squared	R^2_{adj}	9.20%	6.34%	22.18%	42.10%
Panel C: Regressions of R_{t+1} on D_t/Y_t					
Predictive Coefficient	b	1.36***	0.61	1.57	2.98
Adjusted R-squared	R^2_{adj}	8.60%	5.05%	21.25%	41.57%
Panel D: Regressions of R_{t+1} on D_t/Y_t and Z_t					
D_t/Y_t Predictive Coefficient	b_d	1.38***	0.61	1.64	3.10
Z_t Predictive Coefficient	b_z	-0.03	-0.24	-0.01	0.21
Adjusted R-squared	R^2_{adj}	6.44%	4.24%	21.52%	43.02%
Panel E: Regressions of R_{t+1} on D^e_t/Y_t and D^b_t/Y_t					
D^e_t/Y_t Predictive Coefficient	b_e	0.86**	0.46	1.59	3.17
D^b_t/Y_t Predictive Coefficient	b_b	2.29**	-0.15	1.61	3.55
Adjusted R-squared	R^2_{adj}	10.07%	4.04%	21.23%	42.89%

Table 4: Empirical and simulated moments: equity returns of levered firm

This table reports empirical and simulated asset pricing moments. For each moment, it shows its description, its notation, its empirical value, and its median and 1st and 99th percentile values across 10,000 simulations of the model with a levered representative firm. Panel A reports unconditional moments of equity returns. Panel B reports the slope coefficient and the adjusted R^2 of regressions of equity returns on lagged equity payout yields. Panel C reports the slope coefficient and the adjusted R^2 of regressions of equity returns on lagged firm payout ratios. Panel D reports the slope coefficients and the adjusted R^2 of regressions of equity returns on lagged firm payout ratios and lagged productivity. Panel E reports the slope coefficients and the adjusted R^2 of regressions of equity returns on lagged equity and debt payout ratios and lagged productivity. For regression coefficients estimated in the data, we also provide statistical significance information, with *, **, and *** reflecting statistical significance at the 10% level, 5% level, and 1% level, respectively. Standard errors are based on Newey and West (1987) with lag selection by Newey and West (1994).

			Model		
Description	**Notation**	**Data**	**Q(1%)**	**Median**	**Q(99%)**
Panel A: Unconditional moments					
Correlation of Equity Return with Output Growth	$corr(R^e, g^Y)$	0.02	-0.34	0.00	0.34
Correlation of Equity Return with Productivity Shock	$corr(R^e, z - \mathbb{E}[z])$	0.26	-0.06	0.31	0.60
Correlation of Equity Return with Equity Payout Shock	$corr(R^e, d^e - \mathbb{E}[d^e])$	-0.27	-0.76	-0.55	-0.24
Correlation of Equity Return with Debt Payout Shock	$corr(R^e, d^b - \mathbb{E}[d^b])$	-0.26	-0.68	-0.43	-0.09
Average Equity Payout Yield	$\mathbb{E}[D^e/P^e]$	2.49%	0.51%	5.05%	16.35%
Volatility of Equity Payout Yield	$\sigma[D^e/P^e]$	2.54%	3.47%	6.55%	20.82%
Autocorrelation of Equity Payout Yield	$\mathbb{AC}[D^e/P^e]$	0.54	0.10	0.48	0.74
Average Equity Return	$\mathbb{E}[R^e]$	8.96%	4.85%	8.61%	19.84%
Volatility of Equity Return	$\sigma[R^e]$	17.76%	10.46%	18.21%	45.42%
Reward-to-Risk	$\mathbb{E}[R^e]/\sigma[R^e]$	0.50	0.34	0.47	0.63
Autocorrelation of Equity Return	$\mathbb{AC}[R^e]$	-0.17	-0.48	-0.18	0.14
Volatility of $\mathbb{E}[R^e]$	$\sigma[\mathbb{E}[R^e]]$	–	4.29%	8.68%	34.53%
Panel B: Regressions of R^e_{t+1} on D^e_t/P^e_t					
Predictive Coefficient	b	1.64*	0.51	1.25	2.28
Adjusted R-squared	R^2_{adj}	4.40%	1.80%	19.27%	61.42%
Panel C: Regressions of R^e_{t+1} on D_t/Y_t					
Predictive Coefficient	b	1.91***	0.91	2.83	9.63
Adjusted R-squared	R^2_{adj}	12.20%	5.92%	23.56%	45.19%
Panel D: Regressions of R^e_{t+1} on D^e_t/Y_t and D^b_t/Y_t					
D^e_t/Y_t Predictive Coefficient	b_e	1.25***	0.79	2.88	9.55
D^b_t/Y_t Predictive Coefficient	b_b	3.13***	-0.19	2.83	10.49
Adjusted R-squared	R^2_{adj}	14.46%	5.12%	23.60%	46.31%
Panel E: Regressions of R^e_{t+1} on D^e_t/Y_t, D^b_t/Y_t, and Z_t					
D^e_t/Y_t Predictive Coefficient	b_e	1.22	0.81	2.98	9.93
D^b_t/Y_t Predictive Coefficient	b_b	3.15**	-0.15	2.92	10.90
Z_t Predictive Coefficient	b_z	0.02	-0.53	-0.02	0.45
Adjusted R-squared	R^2_{adj}	12.34%	4.40%	23.79%	47.45%

Table 5: Empirical and simulated moments: debt returns of levered firm

This table reports empirical and simulated asset pricing moments. For each moment, it shows its description, its notation, its empirical value, and its median and 1st and 99th percentile values across 10,000 simulations of the model with a levered representative firm. Panel A reports unconditional moments of debt returns. Panel B reports the slope coefficient and the adjusted R^2 of regressions of debt returns on lagged debt payout yields. Panel C reports the slope coefficient and the adjusted R^2 of regressions of debt returns on lagged firm payout ratios. Panel D reports the slope coefficients and the adjusted R^2 of regressions of debt returns on lagged firm payout ratios and lagged productivity. Panel E reports the slope coefficients and the adjusted R^2 of regressions of debt returns on lagged equity and debt payout ratios and lagged productivity. For regression coefficients estimated in the data, we also provide statistical significance information, with *, **, and *** reflecting statistical significance at the 10% level, 5% level, and 1% level, respectively. Standard errors are based on Newey and West (1987) with lag selection by Newey and West (1994).

			Model		
Description	**Notation**	**Data**	**Q(1%)**	**Median**	**Q(99%)**
Panel A: Unconditional moments					
Correlation of Debt Return with Output Growth	$corr(R^b, g^Y)$	-0.04	-0.35	0.06	0.44
Correlation of Debt Return with Productivity Shock	$corr(R^b, z - \mathbb{E}[z])$	-0.15	-0.31	0.04	0.38
Correlation of Debt Return with Equity Payout Shock	$corr(R^b, d^e - \mathbb{E}[d^e])$	-0.21	-0.46	-0.17	0.19
Correlation of Debt Return with Debt Payout Shock	$corr(R^b, d^b - \mathbb{E}[d^b])$	-0.15	-0.25	0.11	0.43
Average Debt Payout Yield	$\mathbb{E}[D^b/B]$	-1.69%	-4.61%	-1.52%	3.74%
Volatility of Debt Payout Yield	$\sigma[D^b/B]$	7.13%	3.48%	6.47%	33.49%
Autocorrelation of Debt Payout Yield	$\mathbb{AC}[D^b/B]$	0.14	-0.27	0.12	0.47
Average Debt Return	$\mathbb{E}[R^b]$	4.84%	0.07%	0.36%	0.56%
Volatility of Debt Return	$\sigma[R^b]$	7.47%	0.02%	0.06%	0.13%
Reward-to-Risk	$\mathbb{E}[R]/\sigma[R^b]$	0.65	1.01	6.02	22.18
Autocorrelation of Debt Return	$\mathbb{AC}[R^b]$	-0.04	0.67	0.93	0.99
Volatility of $\mathbb{E}[R^b]$	$\sigma[\mathbb{E}[R^b]]$	–	0.02%	0.06%	0.14%
Panel B: Regressions of R^b_{t+1} on D^b_t/B_{t+1}					
Predictive Coefficient	b	-0.01	-0.01	0.00	0.00
Adjusted R-squared	R^2_{adj}	-2.44%	-2.38%	2.39%	29.26%
Panel C: Regressions of R^b_{t+1} on D_t/Y_t					
Predictive Coefficient	b	-0.23	-0.01	0.00	0.01
Adjusted R-squared	R^2_{adj}	-1.26%	-2.38%	1.25%	38.10%
Panel D: Regressions of R^b_{t+1} on D^e_t/Y_t and D^b_t/Y_t					
D^e_t/Y_t Predictive Coefficient	b_e	-0.46*	-0.01	0.00	0.02
D^b_t/Y_t Predictive Coefficient	b_b	0.19	-0.02	-0.01	0.01
Adjusted R-squared	R^2_{adj}	-0.93%	-4.34%	8.02%	44.43%
Panel E: Regressions of R^b_{t+1} on D^e_t/Y_t, D^b_t/Y_t, and Z_t					
D^e_t/Y_t Predictive Coefficient	b_e	-0.36	-0.01	0.00	0.02
D^b_t/Y_t Predictive Coefficient	b_b	0.14	-0.02	-0.01	0.01
Z_t Predictive Coefficient	b_z	-0.09**	0.00	0.00	0.00
Adjusted R-squared	R^2_{adj}	1.40%	-5.15%	15.70%	59.61%

Internet Appendix

This Internet Appendix is organized as follows. Section A provides the derivations for the two-period model. Sections B and C report the derivations for the quantitative payout-based asset pricing model with an unlevered representative firm and a levered representative firm, respectively. Finally, Section D describes our data sources and discusses the construction of the empirical measures that we use in our quantitative analysis.

A Derivations for the Two-Period Model

This section contains the derivations for our simple two-period general equilibrium model.

A.1 Payout supply

Imposing the expression for capital accumulation and the budget constraints, the firm's problem simplifies to

$$\max_{\{D_t\}} \left(D_t + \mathbb{E}_t \left[M_{t+1} \left(\Pi((1-\delta)K_t \; + \; I_t, Z_{t+1}) \; + \; (1-\delta)((1-\delta)K_t \; + \; I_t)\right)\right]\right), \tag{IA.1}$$

so that the only choice variable for the firm is *payout supply* D_t. Investment I_t can be retrieved from the period t budget constraint. Although most of the literature expresses the firm's problem as an optimal investment problem (in which case the firm's payout is pinned down from the period t budget constraint), the two approaches are equivalent and, for our purposes, it is more convenient to focus on the firm's payout problem.

Assuming an interior solution, the firm's payout optimality condition is

$$1 = \mathbb{E}_t \left[M_{t+1} \cdot (-\partial_D I_t) \cdot (\partial_K \Pi((1-\delta)K_t \; + \; I_t, Z_{t+1}) + (1-\delta))\right], \tag{IA.2}$$

so optimality is achieved when the marginal value of an extra unit of payout is equated with the present discounted value of the marginal loss of future payout due to the decreased current investment that it will entail. The firm's period t budget constraint yields $\partial_D I_t = -\frac{1}{1+\partial_I \Phi(K_t, I_t)}$, so we can rewrite the firm's optimality condition as

$$1 = \mathbb{E}_t \left[M_{t+1} \cdot \frac{\partial_K \Pi((1-\delta)K_t + I_t, Z_{t+1}) + (1-\delta)}{1 + \partial_I \Phi(K_t, I_t)}\right]. \tag{IA.3}$$

In what follows, we assume that the productivity process satisfies $Z_{t+1} = Z_t^{\phi_z} \cdot e^{\epsilon_{z,t+1}}$, where $\phi_z \in [0,1]$ and $\epsilon_{z,t+1} \sim N(-\sigma_z^2/2, \sigma_z^2)$, and that capital fully depreciates within one period (i.e.,

$\delta = 1$).

Substituting the expressions for Π_t and Φ_t into the firm's optimality condition (Equation 2), we get

$$1 \ = \mathbb{E}_t\left[M_{t+1} \cdot \frac{Z_{t+1}}{1+a(I_t/K_t)}\right] = \mathbb{E}_t\left[M_{t+1} \cdot \frac{D_{t+1} \cdot I_t^{-1}}{1+a(I_t/K_t)}\right] = \frac{I_t^{-1} \cdot \mathbb{E}_t\left[M_{t+1} \cdot D_{t+1}\right]}{1+a(I_t/K_t)}. \qquad \text{(IA.4)}$$

Then, we can use the expression for the firm's expected return, $\mathbb{E}_t[R_{t+1}] = \frac{\mathbb{E}_t[D_{t+1}]}{P_t} = \frac{\mathbb{E}_t[D_{t+1}]}{\mathbb{E}_t[M_{t+1} \cdot D_{t+1}]}$, to get

$$1 = \frac{I_t^{-1} \cdot \mathbb{E}_t[D_{t+1}]/\mathbb{E}_t[R_{t+1}]}{1+a(I_t/K_t)} = \frac{Z_t^{\phi_z}/\mathbb{E}_t[R_{t+1}]}{1+a(I_t/K_t)}. \qquad \text{(IA.5)}$$

Finally, rearranging terms yields the following expression for the firm's investment function:

$$I_t = I(K_t, Z_t; \mathbb{E}_t([R_{t+1}]) = \frac{1}{a}\left[\frac{Z_t^{\phi_z}}{\mathbb{E}_t[R_{t+1}]} - 1\right] K_t. \qquad \text{(IA.6)}$$

Substituting the investment function into the firm's period t budget constraint yields the payout supply function:

$$D_t = D(K_t, Z_t; \mathbb{E}_t[R_{t+1}]) = \left[Z_t - \frac{1}{2a}\left(\left(\frac{Z_t^{\phi_z}}{\mathbb{E}_t[R_{t+1}]}\right)^2 - 1\right)\right] K_t. \qquad \text{(IA.7)}$$

Note that firm investment is decreasing in, and firm payout is increasing in, $\mathbb{E}_t[R_{t+1}]$: for any $\{K_t, Z_t\}$, the higher the hurdle rate, the less the firm invests and the more it pays out at time t.

Finally, Equation 4 follows from dividing the expression for payout supply (Equation IA.7) by the expression for the firm's cum-payout value,

$$V_t \ = D_t + \frac{\mathbb{E}_t[D_{t+1}]}{\mathbb{E}_t[R_{t+1}]} = Z_t \cdot K_t - I_t - \frac{a}{2} \cdot (I_t/K_t)^2 \cdot K_t + \frac{Z_t^{\phi_z} \cdot I_t}{\mathbb{E}_t[R_{t+1}]},$$

which yields

$$V_t \ = \left(Z_t - I_t/K_t - \frac{a}{2} \cdot (I_t/K_t)^2 + \frac{Z_t^{\phi_z} \cdot (I_t/K_t)}{\mathbb{E}_t[R_{t+1}]}\right) \cdot K_t = \left(Z_t + \frac{1}{2a} \cdot \left(\frac{Z_t^{\phi_z}}{\mathbb{E}_t[R_{t+1}]} - 1\right)\right) \cdot K_t,$$

where the last step follows from plugging in the expression in Equation IA.6.

A.2 Payout demand

We can combine the household's two one-period budget constraints into the intertemporal budget constraint

$$C_{t+1} = (C_t - W_t) \cdot R_{t+1}. \tag{IA.8}$$

Imposing the intertemporal budget constraint simplifies the household's problem to

$$\max_{\{C_t\}} \left(U(C_t) \; + \; \beta \cdot \mathbb{E}_t\left[U((W_t - C_t) \cdot R_{t+1})\right]\right). \tag{IA.9}$$

Therefore, the only choice variable for the household is consumption C_t, with optimal savings being pinned down by the period t budget constraint. Notably, since the only source of income (and, hence, consumption) for the household is the firm payout, the household's equilibrium consumption is equivalent to its payout demand. The household's interior consumption optimality condition is

$$1 = \mathbb{E}_t\left[\beta \frac{\partial_C U((W_t - C_t) \cdot R_{t+1})}{\partial_C U(C_t)} \cdot R_{t+1}\right]. \tag{IA.10}$$

In order to derive Equation 7, we work as follows. First, we note that our specification implies that

$$D_{t+1} \; = \; \Pi_{t+1} \; = \; Z_{t+1} \cdot I_t \; = \; \alpha \cdot Z_t^{\phi_z} \cdot I_t \cdot e^{\epsilon_{z,t+1}}, \tag{IA.11}$$

which yields

$$\mathbb{E}_t[D_{t+1}^{1-\gamma}] \; = \; (Z_t^{\phi_z} \cdot I_t)^{1-\gamma} \cdot e^{\gamma\cdot(\gamma-1)\cdot\sigma_z^2/2} \; = \; \mathbb{E}_t[D_{t+1}]^{1-\gamma} \cdot e^{\gamma\cdot(\gamma-1)\cdot\sigma_z^2/2}. \tag{IA.12}$$

We can use that result to get the following useful return property in our model:

$$\mathbb{E}_t[R_{t+1}^{1-\gamma}] \; = \; \frac{\mathbb{E}_t[D_{t+1}^{1-\gamma}]}{V_t^{1-\gamma}} \; = \; \frac{\mathbb{E}_t[D_{t+1}]^{1-\gamma}}{V_t^{1-\gamma}} \cdot e^{\gamma\cdot(\gamma-1)\cdot\sigma_z^2/2} \; = \; \mathbb{E}_t[R_{t+1}]^{1-\gamma} \cdot e^{\gamma\cdot(\gamma-1)\cdot\sigma_z^2/2}. \tag{IA.13}$$

The household's optimality condition is

$$1 \; = \; \mathbb{E}_t\left[\beta \cdot \frac{\theta_{t+1}}{\theta_t} \cdot \left(\frac{W_t - C_t}{C_t} \cdot R_{t+1}\right)^{-\gamma} \cdot R_{t+1}\right] \; = \; \beta \cdot \mathbb{E}_t\left[\frac{\theta_{t+1}}{\theta_t}\right] \cdot \left(\frac{W_t - C_t}{C_t}\right)^{-\gamma} \cdot \mathbb{E}_t\left[R_{t+1}^{1-\gamma}\right],$$

which can be rewritten as

$$\left(\frac{W_t}{C_t} - 1\right)^{-\gamma} \; = \; \frac{1}{\beta \cdot \theta_t^{(\phi_\theta - 1)} \cdot \mathbb{E}_t\left[R_{t+1}^{1-\gamma}\right]}.$$

Finally, solving for C_t, we get

$$C_t = \frac{W_t}{1 + \left(\beta \cdot \theta_t^{(\phi_\theta - 1)}\right)^{1/\gamma} \cdot \mathbb{E}_t[R_{t+1}^{1-\gamma}]^{1/\gamma}}, \tag{IA.14}$$

which, using Equation IA.13, yields Equation 7.

B Derivations for Payout-Based Asset Pricing Model

This section provides all derivations of the results related to our dynamic payout-based asset pricing model.

B.1 Payout supply

In what follows, in the interests of notational convenience, we drop the dependence on the conditional distribution of current and future SDFs (which the firm takes as given) from the firm's value function and, thus, instead of writing $V(K_t, Z_t; \{f_t(M_{t,t+h})\}_{h=1}^{\infty})$, we write $V(K_t, Z_t)$.

The firm's first order condition is

$$\mathbb{E}_t[M_{t+1}\partial_K V(K_{t+1}, Z_{t+1})] = 1 + (1-\tau)\partial_I \Phi(K_t, I_t). \tag{IA.15}$$

We define $q_t \equiv \mathbb{E}_t[M_{t+1}\partial_K V(K_{t+1}, Z_{t+1})]$, so we can write

$$q_t = 1 + (1-\tau)\partial_I \Phi(K_t, I_t). \tag{IA.16}$$

That condition yields the firm's investment function $I_t = I(K_t, q_t)$.

The envelope condition (with respect to K_t) is

$$\partial_K V(K_t, Z_t) = (1-\tau)(\partial_K \Pi(K_t, Z_t) - \partial_K \Phi(K_t, I_t)) + \tau\delta + (1-\delta)\mathbb{E}_t[M_{t+1}\partial_K V(K_{t+1}, Z_{t+1})], \tag{IA.17}$$

so, using the definition for q_t, we can write

$$\partial_K V(K_t, Z_t) = (1-\tau)(\partial_K \Pi(K_t, Z_t) - \partial_K \Phi(K_t, I_t)) + \tau\delta + (1-\delta)q_t. \tag{IA.18}$$

Finally, the investment return is

$$R_{t+1}^I = \frac{(1-\tau)(\partial_K \Pi(K_{t+1}, Z_{t+1}) - \partial_K \Phi(K_{t+1}, I_{t+1})) + \tau\delta + (1-\delta)q_{t+1}}{q_t}, \tag{IA.19}$$

so, using Equation IA.18, the equilibrium investment return satisfies

$$R^I_{t+1} = \frac{\partial_K V(K_{t+1}, Z_{t+1})}{q_t}. \tag{IA.20}$$

Plugging in Equation IA.20 into IA.15, we get

$$\mathbb{E}_t[M_{t+1} R^I_{t+1} q_t] = q_t, \tag{IA.21}$$

which yields Equation 26.

B.2 Equilibrium prices

Following Liu et al. (2009), we start by noting that functions $\Pi(Z, K) = \alpha Z K$ and $\Phi(K, I) = \frac{a}{2}\left(\frac{I}{K}\right)^2 K$ have the following properties:

$$\Pi(Z, K) = K \cdot \partial_K \Pi(Z, K), \tag{IA.22}$$

and

$$\Phi(K, I) = K \cdot \partial_K \Phi(K, I) + I \cdot \partial_I \Phi(K, I), \tag{IA.23}$$

respectively.

Using Equation IA.23, the firm's investment optimality condition can be written as follows:

$$q_t = 1 + \partial_I \Phi(K_t, I_t) = 1 + (1 - \tau)(\Phi(K_t, I_t) - K_t \partial_K \Phi(K_t, I_t))/I_t. \tag{IA.24}$$

Recall that the firm payout is given by

$$D_t = (1 - \tau)(\Pi(Z_t, K_t) - \Phi(I_t, K_t)) - I_t + \tau\delta K_t, \tag{IA.25}$$

so, using Equations IA.22 and IA.24, the firm's optimal payout satisfies

$$D_t = (1 - \tau)\left(\partial_K \Pi(Z_t, K_t) - \partial_K \Phi(K_t, I_t)\right) \cdot K_t - q_t I_t + \tau\delta K_t = \partial_K D_t \cdot K_t - q_t I_t. \tag{IA.26}$$

Equation IA.26 implies that

$$\mathbb{E}_t[M_{t+1} D_{t+1}] = \mathbb{E}_t[M_{t+1}(\partial_K D_{t+1} \cdot K_{t+1} - q_{t+1} I_{t+1})]. \tag{IA.27}$$

We can now use the optimality condition $q_t = \mathbb{E}_t\left[M_{t+1}\left(\partial_K D_{t+1} + (1 - \delta) q_{t+1}\right)\right]$ to rewrite Equation

IA.27 as follows:

$$\mathbb{E}_t[M_{t+1}D_{t+1}] = (q_t - \mathbb{E}_t[M_{t+1}(1-\delta)q_{t+1}])\,K_{t+1} - \mathbb{E}_t[M_{t+1}q_{t+1}I_{t+1}] = q_tK_{t+1} - \mathbb{E}_t[M_{t+1}q_{t+1}K_{t+2}]. \tag{IA.28}$$

Iterating and applying the law of iterated expectations, we get

$$\mathbb{E}_t[M_{t+1}D_{t+1}] = q_tK_{t+1} - \mathbb{E}_t[M_{t+2}(D_{t+2} + q_{t+2}K_{t+3})], \tag{IA.29}$$

which yields

$$\mathbb{E}_t[M_{t+1}D_{t+1}] + \mathbb{E}_t[M_{t+2}D_{t+2}] = q_tK_{t+1} - \mathbb{E}_t[M_{t+2}q_{t+2}K_{t+3}]. \tag{IA.30}$$

Finally, iterating forward and imposing the transversality condition $\lim_{n\to\infty}\mathbb{E}_t[M_{t+n}q_{t+n}K_{t+n+1}] = 0$, we get

$$q_tK_{t+1} = \mathbb{E}_t\left[\sum_{s=1}^{\infty} M_{t+s}D_{t+s}\right] = V_t - D_t, \tag{IA.31}$$

or, equivalently,

$$V_t = D_t + q_tK_{t+1}. \tag{IA.32}$$

Finally, note that the firm's average Tobin's q, $Q_t = \frac{V_t - D_t}{K_{t+1}}$, is equal to the its marginal Tobin's q:

$$Q_t = q_t. \tag{IA.33}$$

It is important to note that we only use the firm's optimality conditions, but not the market clearing condition, for the above derivation. In other words, Equation IA.32 holds for any conditional SDF distributions that the firm takes as given. Of course, different assumptions about the conditional SDF distributions lead to a different q process (and, hence, a different firm value process), but the message of Equation IA.32 is simple: due to the linear homogeneity conditions (Equations IA.22 and IA.23), the only information regarding conditional SDF distributions that is needed to price the firm is q. All the market clearing condition (Equation 27) is needed for is to pin down the equilibrium q, denoted by q^*. By pinning down q^*, the market clearing condition is providing all the information regarding investor preferences that is needed in order to price the firm. Thus, in equilibrium we have

$$V_t^* = D_t^* + q_t^*K_{t+1}^*, \quad Q_t^* = q_t^*. \tag{IA.34}$$

B.3 Equilibrium returns

We can now turn to equilibrium returns. The firm's equilibrium return is

$$R^*_{t+1} = \frac{V^*_{t+1}}{V^*_t - D^*_t} = \frac{D^*_{t+1} + q^*_{t+1}K^*_{t+2}}{q^*_t K^*_{t+1}}, \tag{IA.35}$$

which yields

$$R^*_{t+1} = \frac{d_{t+1}Z_{t+1} + q^*_{t+1}((1-\delta) + \frac{q^*_{t+1}-1}{a(1-\tau)})}{q^*_t}. \tag{IA.36}$$

The equilibrium investment return is

$$R^{I,*}_{t+1} = \frac{(1-\tau)\left(\partial_K \Pi(K^*_{t+1}, Z_{t+1}) - \partial_K \Phi(K^*_{t+1}, I^*_{t+1})\right) + \tau\delta + (1-\delta)q^*_{t+1}}{q^*_t}, \tag{IA.37}$$

which yields

$$R^{I,*}_{t+1} = \frac{\alpha(1-\tau)Z_{t+1} + \frac{(q^*_{t+1}-1)^2}{2a(1-\tau)} + \tau\delta + (1-\delta)q^*_{t+1}}{q^*_t}. \tag{IA.38}$$

We can rewrite the equilibrium investment return using the payout market clearing condition, which implies that

$$(1-\tau)\alpha Z_{t+1} - \frac{(q^*_{t+1})^2 - 1}{2a(1-\tau)} + \tau\delta = d_{t+1}Z_{t+1}, \tag{IA.39}$$

or, equivalently,

$$(1-\tau)\alpha Z_{t+1} = d_{t+1}Z_{t+1} + \frac{(q^*_{t+1})^2 - 1}{2a(1-\tau)} - \tau\delta. \tag{IA.40}$$

Plugging the expression of IA.40 in Equation IA.38, we get, after some algebra,

$$R^{I,*}_{t+1} = \frac{d_{t+1}Z_{t+1} + (1-\delta)q^*_{t+1} + \frac{(q^*_{t+1}-1)q^*_{t+1}}{a(1-\tau)}}{q^*_t}. \tag{IA.41}$$

From Equations IA.36 and IA.41, it is obvious that the firm's equilibrium return and the equilibrium investment return are equal state-by-state:

$$R^*_{t+1} = R^{I,*}_{t+1}. \tag{IA.42}$$

C Derivations for Payout-Based Asset Pricing Model with Firm Leverage

This section provides all derivations of the results related to our dynamic payout-based asset pricing model with firm leverage.

C.1 Equilibrium prices

As in case of the unlevered firm, we price the firm by following the approach outlined in Liu et al. (2009).

Since the operating profit function and the capital adjustment cost function are the same as in the case of the unlevered firm, Equations IA.22 and IA.23 are still satisfied. Furthermore, the leverage cost function $G(B,K) = \frac{\kappa}{2}\left(\frac{B}{K}\right)^2 K$ satisfies

$$G(B,K) = K \cdot \partial_K G(B,K) + B \cdot \partial_B G(B,K). \tag{IA.43}$$

Using Equations IA.22, IA.23, and IA.43 we can write the firm's optimal equity payout as

$$D_t^e = K_t \cdot \partial_K D_t - q_t I_t - (R_t^{b,a} + \partial_B G_t) B_t + B_{t+1}, \tag{IA.44}$$

so

$$\mathbb{E}_t[M_{t,t+1} D_{t+1}^e] = \mathbb{E}_t[M_{t,t+1}(K_{t+1} \cdot \partial_K D_{t+1} - q_{t+1} I_{t+1} - (R_{t+1}^{b,a} + \partial_B G_{t+1}) B_{t+1} + B_{t+2})]. \tag{IA.45}$$

We use the firm's investment and debt optimality conditions, $q_t = \mathbb{E}_t\left[M_{t,t+1}\left(\partial_K D_{t+1} + (1-\delta) q_{t+1}\right)\right]$ and $1 = \mathbb{E}_t\left[M_{t,t+1}(R_{t+1}^{b,a} + \partial_B G_{t+1})\right]$, respectively, to rewrite Equation IA.45 as follows:

$$\mathbb{E}_t[M_{t,t+1} D_{t+1}^e] = \left(q_t - \mathbb{E}_t[M_{t,t+1}(1-\delta) q_{t+1}]\right) K_{t+1} - \mathbb{E}_t[M_{t,t+1} q_{t+1} I_{t+1}] - B_{t+1} + \mathbb{E}_t[M_{t,t+1} B_{t+2}], \tag{IA.46}$$

which yields

$$\mathbb{E}_t[M_{t,t+1} D_{t+1}^e] = (q_t K_{t+1} - B_{t+1}) - \mathbb{E}_t[M_{t,t+1}(q_{t+1} K_{t+2} - B_{t+2})]. \tag{IA.47}$$

Iterating, using the fact that $M_{t,t+2} = M_{t,t+1} M_{t+1,t+2}$, and applying the law of iterated expectations, we get

$$\mathbb{E}_t[M_{t,t+1} D_{t+1}^e] = (q_t K_{t+1} - B_{t+1}) - \mathbb{E}_t[M_{t,t+2}(D_{t+2}^e + q_{t+2} K_{t+3} - B_{t+3})], \tag{IA.48}$$

which yields

$$\mathbb{E}_t[M_{t,t+1}D^e_{t+1}] + \mathbb{E}_t[M_{t,t+2}D^e_{t+2}] = (q_t K_{t+1} - B_{t+1}) - \mathbb{E}_t[M_{t,t+2}(q_{t+2}K_{t+3} - B_{t+3})]. \tag{IA.49}$$

Finally, iterating forward and imposing the transversality condition $\lim_{n\to\infty}\mathbb{E}_t[M_{t,t+n}(q_{t+n}K_{t+n+1} - B_{t+n+1})] = 0$, we get

$$q_t K_{t+1} - B_{t+1} = \mathbb{E}_t\left[\sum_{s=1}^{\infty} M_{t,t+s}D^e_{t+s}\right] = P^e_t, \tag{IA.50}$$

so the market value of (ex-payout) equity is given by

$$P^e_t = q_t K_{t+1} - B_{t+1} = (q_t - b_{t+1})K_{t+1}. \tag{IA.51}$$

C.2 Equilibrium returns

The firm's equilibrium equity return is

$$R^{e,*}_{t+1} = \frac{D^{e,*}_{t+1} + P^{e,*}_{t+1}}{P^{e,*}_t} = \frac{d^e_{t+1}Z_{t+1}K^*_{t+1} + (q^*_{t+1} - b^*_{t+2})K^*_{t+2}}{(q^*_t - b^*_{t+1})K^*_{t+1}}, \tag{IA.52}$$

which yields

$$R^{e,*}_{t+1} = \frac{d^e_{t+1}Z_{t+1} + (q^*_{t+1} - b^*_{t+2})\left((1-\delta) + \frac{q^*_{t+1}-1}{a(1-\tau)}\right)}{q^*_t - b^*_{t+1}}. \tag{IA.53}$$

Note that Equation 37 implies that, in equilibrium,

$$b^*_{t+2} = \frac{R^{b,*}_{t+1}b^*_{t+1} - d^b_{t+1}Z_{t+1}}{(1-\delta) + \frac{q^*_{t+1}-1}{a(1-\tau)}}, \tag{IA.54}$$

so we can rewrite the expression above as

$$R^{e,*}_{t+1} = \frac{d_{t+1}Z_{t+1} + q^*_{t+1}\left((1-\delta) + \frac{q^*_{t+1}-1}{a(1-\tau)}\right) - R^{b,*}_{t+1}b^*_{t+1}}{q^*_t - b^*_{t+1}}. \tag{IA.55}$$

Finally, using Equation 70, the expression above can be rewritten as

$$R^{e,*}_{t+1} = \frac{d_{t+1}Z_{t+1} + q^*_{t+1}\left((1-\delta) + \frac{q^*_{t+1}-1}{a(1-\tau)}\right) - \left(\frac{\kappa}{\tau}b^*_{t+1} + 1\right)b^*_{t+1}}{q^*_t - b^*_{t+1}}. \tag{IA.56}$$

D Data sources and empirical measures

We map profit Π_t, output Y_t, and payout D_t to the corresponding measures for the aggregate public corporate sector in the United States. To do so, we rely on annual data from CRSP and COMPUSTAT, obtained from WRDS, as well as the dataset in Davydiuk et al. (2023) – henceforth, the DRSY dataset – obtained directly from the article's Journal of Finance webpage. The sample period for our analysis is determined by the DRSY dataset, which contains annual data from 1974 to 2017, so we collect data only for those sample years from all sources.

We measure aggregate corporate payout as

$$D_t = P_t \cdot \left(\frac{P_t^e}{P_t} \cdot \frac{D_t^e}{P_t^e} + \frac{P_t^b}{P_t} \cdot \frac{D_t^b}{P_t^b} \right) \tag{IA.57}$$

where P_t^e and P_t^b are the aggregate market value of equity and debt, respectively, $P_t = P_t^e + P_t^b$ is the aggregate market value of U.S. public corporations, D_t^e is their aggregate equity payout, and D_t^b is their aggregate debt payout.

We use the DRSY dataset for data on the market value of equity (P_t^e) and debt (P_t^b) aggregated across all U.S. public companies and accounting for equity cross-holdings (i.e., excluding the fraction of the aggregate market equity held by public corporations). We also rely on the DRSY dataset for aggregate debt payout (D_t^b) data. Hence, in Equation IA.57, the measures for P_t, P_t^e/P_t, P_t^b/P_t and D_t^b/P_t^b are constructed using the DRSY dataset. However, we calculate D_t^e/P_t^e using data from CRSP, which is the original data source for D_t^e/P_t^e in the DRSY dataset, as follows.[IA.2] First, we retrieve the subset of the CRSP dataset which includes public firms incorporated in the United States (SHRCD = 10 or 11) trading on NYSE, Amex, or Nasdaq (EXCHCD = 1,2, or 3). Then, we measure the market value of equity monthly for each PERMNO (as |PRCC|·SHROUT) and carry it forward when there are missing observations. We measure net payout at the PERMNO level as $D_t^e = P_{t-1}^e \cdot (1 + R_t^e) - P_t^e$ (where R_t^e is based on the RET variable in CRSP) – recall that P_t^e refers to the market value of equity (rather than price per share), so D_t^e retrieves the entirety

[IA.2] We do not use the D_t^e/P_t^e values from the DRSY dataset for two reasons. First, the average DRSY D_t^e/P_t^e ratio is 1.7%, which implies a very high cash flow duration for the equity market. In contrast, our average D_t^e/P_t^e ratio is 2.5%. Second, to account for equity cross-holdings, DRSY assume that the return that corporations get on their equity portfolio is the same as the return that other investors get on their equity portfolio. While this assumption is reasonable, it has the effect that their D_t^e measure partially reflects the market value of firms, mixing cash flows with asset prices. Specifically, let D_t^e be the equity payout measured directly from CRSP, $\hat{D}_t^e$ the payout from the portfolio that accounts for equity cross-holdings, and γ_t the fraction of the equity market held by public firms. DRSY assume $(D_t^e + P_t^e)/P_{t-1}^e = (\hat{D}_t^e + \gamma_t \cdot P_t^e)/(\gamma_{t-1} \cdot P_{t-1}^e)$, which allows them to measure their equity payout as

$$\hat{D}_t^e = \gamma_{t-1} \cdot D_t^e - \Delta\gamma_t \cdot P_t^e$$

so P_t^e affects the DRSY D_t^e. Instead, our assumption is that the payout yield that public corporations get on their equity portfolio is the same as the payout yield that other investors get on their equity portfolio. Using the notation above, our assumption implies $\hat{D}_t^e = (\gamma_t \cdot P_t^e) \cdot (D_t^e/P_t^e) = \gamma_t \cdot D_t^e$, which does not include any asset pricing effect. Nonetheless, the correlation between the DRSY D/P measure and our measure is above 0.90, so the two measures have very similar dynamics, with the main difference being that our measure has a higher mean.

of the firm's net equity payout (dividends plus equity repurchases, minus equity issuances), rather than just dividends. We assume that the first month of non-missing market equity is the firm's entry month in the public market portfolio so that $P^e_{t-1} = 0$ and $D^e_t = -P^e_t$ for the firm at that month. Moreover, in the delisting month we set $P^e_t = 0$ and $D^e_t = P^e_{t-1} \cdot (1 + R^e_t)$, where R^e_t is measured from the actual return or the delisting return depending on availability (when the return and delisting return are not available on the delisting month, we set $R^e_t = -1$ so that $D^e_t = 0$ over that month). After measuring P^e_t and D^e_t monthly at the PERMNO level, we aggregate over time (from January to December) to obtain annual D^e_t for each PERMNO and then aggregate across PERMNOs to obtain aggregate annual D^e_t values. Similarly, we aggregate P^e_t across PERMNOs at the end of each December to obtain the aggregate P^e_t. Finally, we compute the aggregate D^e_t/P^e_t and use it in Equation IA.57.

We measure annual output as $Y_t = P^e_t \cdot (Y_t/P^e_t)$, with P^e_t from the DRSY dataset and Y_t/P^e_t from COMPUSTAT. Specifically, we start by aggregating firm-level Y_t (measured as REVT) and P^e_t (measured as CSHO·PRCC_F) for all firms with Y_t and P^e_t available and fiscal year ending in December in the annual COMPUSTAT dataset. We then aggregate firm-level Y_t (measured as REVTQ) and P^e_t (measured as CSHOQ·PRCCQ) for all firms not included in our annual COMPUSTAT aggregation and with Y_t and P^e_t available as of December of each year in the quarterly COMPUSTAT dataset. Finally, we measure Y_t/P^e_t as the sum of the aggregate Y_t from the annual and quarterly COMPUSTAT datasets payout by the sum of the P^e_t from the annual and quarterly COMPUSTAT datasets.

Similarly, we measure profit as $\Pi_t = P^e_t \cdot (\Pi_t/P^e_t)$, with P^e_t from the DRSY dataset and Π_t/P^e_t from COMPUSTAT. Firm-level Π_t from the COMPUSTAT is given by REVT $-$ COGS $-$ XSGA for the annual dataset and by REVTY $-$ COGSY $-$ XSGAY for the quarterly dataset.

Finally, we measure productivity $Z_t = Y_t/K_t$ in a way that allows us to not take a stand on how to measure investment or capital, which is advantageous given that measuring physical capital is prone to non-trivial measurement errors (see, e.g., Bai, Li, Xue and Zhang (2022)) and that firms can have different sources of capital beyond physical capital (see for example Gonçalves et al. (2020) and Belo et al. (2022)). Specifically, we start by taking our calibrated δ, τ, a, and α values as given, together with the Y_t and D_t series (and thus the d_t series) described above. We, then, consider an initial arbitrary value for K_t in 1974 (the first year in our sample) and update the Z_t series as follows (consistent with our model):

$$Z_t = Y_t/K_t, \tag{IA.58}$$

$$q_t = \sqrt{1 + 2a(1-\tau)\,(\tau\delta + [\alpha(1-\tau) - d_t]Z_t)}, \tag{IA.59}$$

$$i_t = \frac{q_t - 1}{a(1-\tau)}, \tag{IA.60}$$

$$K_{t+1} = (1 - \delta + i_t) \cdot K_t. \tag{IA.61}$$

In the expressions above, i denotes the investment-to-capital ratio. We iterate this process until our initial arbitrary K value leads to an initial Z that matches the average Z over the sample. We follow an analogous procedure for the model with firm leverage, except that we also use the expression for the evolution of b (Equation 61), since q also depends on b.

We can now turn to returns. The firm return is given

$$R_{t+1} = \frac{P_{t+1} + D_{t+1}}{P_t}, \tag{IA.62}$$

where P_t is measured as described previously and D_t is measured as in Equation IA.57. The returns in the DRSY dataset differ from ours because we do not use their D_t^e measure (as discussed in Footnote IA.2). However, the differences are not large: the correlation between the two firm return measures is 0.995. Moreover, our return measure makes it somewhat harder for the model to match the data, as the DRSY measure implies higher average and more volatile aggregate returns. In particular, the DRSY measure implies $\mathbb{E}[R] = 7.0\%$ and $\sigma[R] = 14.2\%$, whereas our measure implies $\mathbb{E}[R] = 7.9\%$ and $\sigma[R] = 14.9\%$. Similarly, the equity and debt returns are given by

$$R^e_{t+1} = \frac{P^e_{t+1} + D^e_{t+1}}{P^e_t}, \tag{IA.63}$$

and

$$R^b_{t+1} = \frac{P^b_{t+1} + D^b_{t+1}}{P^b_t}, \tag{IA.64}$$

respectively.