Payout-Based Asset Pricing

This Version: September 2023

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.
Keywords: Payout-based Asset Pricing; Consumption-based Asset Pricing; Investment-based Asset Pricing; Market Returns; Aggregate Return Predictability.

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.

To operationalize our approach, we propose a model that features a representative firm that optimally chooses its investment and payout policies, subject to capital adjustment costs. Crucially, we assume that investors' payout demand is 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 capital and 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, then, simulate the model and show that it goes a long way in matching key asset pricing moments.

Our payout-based asset pricing approach is analogous to the consumption-based asset pricing framework (Lucas (1978) and Breeden (1979) – see Breeden, Litzenberger and Jia (2015a) and Breeden, Litzenberger and Jia (2015b) for a review of the literature). 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 is useful as long as the postulated payout supply processes coincide with the actual equilibrium payout processes in the economy, in which case model-implied and actual expected returns are the same. Similarly, our payout-based asset pricing framework correctly identifies firms' expected returns as long as the postulated payout demand processes coincide with the actual equilibrium payout processes.

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 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 taste shifter, as well as firm capital and productivity. Then, we show that consumption-based asset pricing arises from imposing an exogenous payout supply process, which effectively replaces firm capital and productivity as drivers of payout supply: with that assumption, 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 preference shifter as a determinant of the household's payout demand. In that case, the equilibrium expected return of the firm is a function of firm capital and productivity, as well as the payout demand level.

To explore the asset pricing implications of our approach, we, then, introduce our quantitative model, which features a representative firm that optimizes its investment-payout decision while facing convex capital adjustment costs and an exogenous payout demand ratio. 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 and capital, 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.

Simulating our model, we find that the version of the model that features a representative firm with a constant returns to scale production function matches key asset pricing moments reasonably well. Specifically, the model generates an average payout yield (i.e., payout over firm value) of 1.6% with a payout yield volatility of 3.8%, which are very close to the respective empirical values of 1.6% and 2.5%. Furthermore, the model implies an average firm return of 5.1% and a firm return volatility of 10.2%, with the corresponding empirical moments being 7.9% and 14.9%. Using 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.

A large share 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.

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.

Another strand of the production-based asset pricing literature proposes partial equilibrium models with an exogenous pricing kernel (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).[1] 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. One 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

[1] That literature builds on the models developed in Berk, Green and Naik (1999) and Zhang (2005) and includes the models in Kogan and Papanikolaou (2010), Belo and Lin (2012), Belo and Yu (2013), Jones and Tuzel (2013), Belo, Lin and Bazdresch (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.

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.[2] 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 stock returns, as given and estimate firms' technological parameters from the firms' optimality condition. To do so, these papers require linear homogeneity, with the typical assumption being a constant returns to scale production function and a linearly homogeneous capital adjustment cost function: under linear homogeneity, the return that investors receive from buying a share of the firm and the return that the firm obtains on its investment projects are equalized, so the technology parameters are identified by moment conditions that equate average stock returns and implied investment returns. In contrast, our focus is on exploring the properties of model-implied 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. It is worth noting that our approach allows for differences between stock returns and investment returns and, hence, does not require linear homogeneity. Moreover, the investment-based asset pricing literature focuses on the cross-section of stock returns (with the notable exception of Cochrane (1991)), whereas our focus is on the time series of aggregate returns.

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 payout-based asset pricing model and discusses its properties. Finally, Section 4 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 introduce our payout-based asset pricing framework. Furthermore, we demonstrate that our framework is the flipside of consumption-based asset pricing: 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

[2] 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 Liu, Whited and Zhang (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).

endogenous payout supply with exogenous household payout demand. The detailed derivations of the results in this section can be found in Internet Appendix A.

2.1 Economic Setting

The economy has two periods (t and $t+1$) and consists of a representative 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. The only asset in the economy is the equity of the firm.

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 (which is equal to its operating profit) is given by function $\Pi_t = \Pi(K_t, Z_t)$. Furthermore, the firm's capital accumulation process is

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

where δ is the one-period capital depreciation rate. The firm faces capital adjustment costs, so the firm's payout process D satisfies the following one-period budget constraints:

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

where $\Phi_t = \Phi(K_t, I_t)$ is the capital adjustment cost function. 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 so as to maximize the (cum-payout) market value of the firm, V_t^c:

$$V_t^c = \max_{\{D_t, I_t\}} \left(D_t + \mathbb{E}_t \left[M_{t+1} D_{t+1} \right] \right), \tag{2}$$

subject to the two one-period budget constraints, where M_{t+1} is the stochastic discount factor (SDF) in the economy. Note that, since there is no debt market in our economy, and hence the representative firm is unlevered, the value of firm's equity is equal to the overall firm value.

Although the SDF is endogenous in our economy (as usual, it is the intertemporal marginal rate of substitution of the representative household, which is the sole owner of the firm), it is taken as given by the firm when optimizing.

Using the expression for capital accumulation (Equation 1), the two budget constraints can be rewritten as an intertemporal budget constraint, and, imposing that constraint, the firm's problem simplifies to

$$\underset{\{D_t\}}{Max} \; \left(D_t \; + \; \mathbb{E}_t \left[M_{t+1} \left(\Pi((1-\delta)K_t \; + \; I_t, Z_{t+1}) \; + \; (1-\delta)((1-\delta)K_t \; + \; I_t)\right)\right]\right), \tag{3}$$

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

$$1 \; = \; \mathbb{E}_t \left[M_{t+1} \cdot (-\partial_D I_t) \cdot (\partial_K \Pi((1-\delta)K_t \; + \; I_t, Z_{t+1}) + (1-\delta))\right], \tag{4}$$

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

$$1 \; = \; \mathbb{E}_t \left[M_{t+1} \cdot \frac{\partial_K \Pi((1-\delta)K_t + I_t, Z_{t+1}) + (1-\delta)}{1 + \partial_I \Phi(K_t, I_t)}\right], \tag{5}$$

which yields the payout supply function in the economy.

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).

Before moving on to the household, it is useful to introduce some notation regarding the return on the firm's equity, which is the only asset in our economy. The gross return from investing in the firm's equity from t to $t+1$ is given by

$$R_{t+1} \; \equiv \frac{D_{t+1}}{V_t} \; = \; \frac{D_{t+1}}{\mathbb{E}_t \left[M_{t+1} \cdot D_{t+1}\right]}, \tag{6}$$

where $V_t \equiv V_t^c - D_t$ denotes the ex-payout value of the firm. It follows that the firm's expected return is $\mathbb{E}_t[R_{t+1}] = \frac{\mathbb{E}_t[D_{t+1}]}{V_t} = \frac{\mathbb{E}_t[D_{t+1}]}{\mathbb{E}_t[M_{t+1} \cdot D_{t+1}]}$.

2.1.2 The household's problem and the payout demand function

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

$$\underset{\{C_t, S_t\}}{Max} \ \left(U(C_t, \theta_t) \ + \ \beta \cdot \mathbb{E}_t \left[U(C_{t+1}, \theta_{t+1})\right]\right) \tag{7}$$

where β is the subjective discount factor, and $U(C, \theta)$ 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's consumption satisfies the following one-period budget constraints:

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

The two budget constraints can be combined into an intertemporal budget constraint, $C_{t+1} = (W_t - C_t) \cdot R_{t+1}$, and imposing that constraint simplifies the household's problem to

$$\underset{\{C_t\}}{Max} \ \left(U(C_t) \ + \ \beta \cdot \mathbb{E}_t \left[U((W_t - C_t) \cdot R_{t+1})\right]\right). \tag{8}$$

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 the familiar Euler equation,

$$1 \ = \ \mathbb{E}_t \left[\beta \frac{\partial_C U((W_t - C_t) \cdot R_{t+1})}{\partial_C U(C_t)} \cdot R_{t+1}\right], \tag{9}$$

which yields the payout demand function in the economy.

2.1.3 Market clearing

In equilibrium, both the goods market and the asset market need to clear. At period t, the goods market clears when the firm's output, $\Pi(Z_t, K_t)$, equals consumption demand from the household, C_t, and investment demand from the firm I_t, adding the capital adjustment costs $\Phi(K_t, I_t)$: $\Pi(Z_t, K_t) = C_t + I_t + \Phi(K_t, I_t)$. 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, V_t) needs to equate period t asset demand (given by household savings S_t), so the *asset market clearing condition* is $V_t = S_t$.

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

2.2 Equilibrium

We can now characterize the equilibrium in our simple economy. For convenience, we assume that capital fully depreciates within one period (i.e., $\delta = 1$), so $K_{t+1} = I_t$ and $D_{t+1} = \Pi_{t+1}$. The firm's profit function is

$$\Pi_t \;=\; \Pi(K_t, Z_t) \;=\; \alpha \cdot Z_t \cdot K_t^{\eta}, \tag{10}$$

so parameter $\eta \in (0, 1]$ reflects returns to scale. The capital adjustment cost function is convex and has the familiar quadratic specification,

$$\Phi_t \;=\; \Phi(K_t, I_t) \;=\; \frac{a}{2} \cdot (I_t/K_t)^2 \cdot K_t. \tag{11}$$

Finally, 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 $\epsilon_{z,t+1} \sim N(-\sigma_z^2/2, \sigma_z^2)$.

The household's utility function is

$$U(C_t, \theta_t) \;=\; \theta_t \cdot \frac{C_t^{1-\gamma}}{1-\gamma}, \tag{12}$$

where the θ is an exogenous taste shifter process. 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.

2.2.1 Payout supply

Substituting the expressions for Π_t and Φ_t (Equations 10 and 11) into the firm's optimality condition (Equation 5), we derive the following expression for the firm's investment function $I_t = I(\mathbb{E}_t([R_{t+1}]; K_t, Z_t)$:

$$I_t - \frac{1}{a} \cdot \left(\frac{\alpha \cdot \eta \cdot Z_t^{\phi_z} \cdot I_t^{\eta-1}}{\mathbb{E}_t[R_{t+1}]} - 1 \right) \cdot K_t = 0. \tag{13}$$

Differentiating with respect to $\mathbb{E}_t[R_{t+1}]$, we can show that $\frac{\partial I_t}{\partial \mathbb{E}_t([R_{t+1}]} < 0$, i.e., that at any point of the state space $\{K_t, Z_t\}$, firm investment is decreasing in the expected return of the firm's equity. In the special case of constant returns to scale ($\eta = 1$), the firm's optimal investment is proportional to its capital stock: $I_t = \frac{1}{a} \cdot \left(\frac{\alpha \cdot \eta \cdot Z_t^{\phi_z}}{\mathbb{E}_t[R_{t+1}]} - 1 \right) \cdot K_t$.

Substituting the investment function into the firm's period t budget constraint yields the following expression for the payout supply function $D_t = D(\mathbb{E}_t[R_{t+1}]; K_t, Z_t)$:

$$D_t - \left(\alpha \cdot Z_t \cdot K_t^{\eta-1} - \frac{1}{2 \cdot a} \cdot \left(\frac{\alpha^2 \cdot \eta^2 \cdot Z_t^{2 \cdot \phi_z} \cdot I_t^{2 \cdot (\eta-1)}}{\mathbb{E}_t[R_{t+1}]^2} - 1 \right) \right) \cdot K_t = 0. \tag{14}$$

In the case of a constant returns to scale production function, the payout supply function has a closed form solution and payout is proportional to the firm's capital stock and, hence, its output: $D_t = \left(\alpha \cdot Z_t - \frac{1}{2 \cdot a} \cdot \left(\frac{\alpha^2 \cdot \eta^2 \cdot Z_t^{2 \cdot \phi_z}}{\mathbb{E}_t[R_{t+1}]^2} - 1 \right) \right) \cdot K_t = \left(1 - \frac{1}{2 \cdot a \cdot \alpha \cdot Z_t} \cdot \left(\frac{\alpha^2 \cdot \eta^2 \cdot Z_t^{2 \cdot \phi_z}}{\mathbb{E}_t[R_{t+1}]^2} - 1 \right) \right) \cdot Y_t$.

Finally, the firm's payout yield, $D_t/V_t^c = (D/V^c)(\mathbb{E}_t[R_{t+1}]\,;\, K_t, Z_t)$ is given by

$$D_t/V_t^c \;=\; \left(\frac{\alpha \cdot Z_t \cdot K_t^{\eta-1} \;-\; \frac{1}{2 \cdot a} \cdot \left(\alpha^2 \cdot \eta^2 \cdot \frac{Z_t^{2\phi_z} \cdot I_t^{2 \cdot (\eta-1)}}{\mathbb{E}_t[R_{t+1}]^2} - 1 \right)}{\alpha \cdot Z_t \cdot K_t^{\eta} - I_t - \frac{a}{2} \cdot (I_t/K_t)^2 \cdot K_t + (\alpha \cdot Z_t^{\phi_z} \cdot I_t^{\eta})/\mathbb{E}_t[R_{t+1}]} \right) \cdot K_t. \tag{15}$$

Figure 1 displays the firm's payout yield D/V^c for $\alpha = 1$, $a = 8$, $\phi_z = 1$, and two different choices for parameter η: $\eta = 1$ (constant returns to scale) and $\eta = 0.9$ (decreasing returns to scale). Panels A and B show the family of D_t/V_t^c curves for different values of K_t and Z_t, respectively, assuming $\eta = 1$. 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. As seen in Panel A, holding productivity Z_t constant, changes in the firm's capital stock K_t do not shift the D/V^c curve, as scale is irrelevant for firm decisions. On the other hand, changes in Z_t do move the D/V^c curve: Panel B shows that, keeping capital K_t constant, 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.

Panels C and D of Figure 1 display the family of D/V^c curves for different values of K_t and Z_t, respectively, under the assumption of $\eta = 0.9$. As before, the firm's payout yield is increasing in the expected return. However, with decreasing returns to scale, the level of the firm's capital stock matters: as seen in Panel C, keeping Z_t fixed, an increase (decrease) in K_t shifts the payout supply curve up (down). Intuitively, an increase in K_t decreases the firm's expected profitability, which makes the firm invest less and pay more as a payout. Finally, changes in productivity Z_t, keeping K_t constant, shift the firm's payout yield curve in the same direction as in the constant returns to scale case (Panel D).

2.2.2 Payout demand

Substituting the expression for the utility function (Equation 12) into the household's optimality condition (Equation 9), we derive the household's payout demand function, which is nothing more than the optimal consumption specification

$$C_t \;=\; \frac{W_t}{1+\beta^{1/\gamma}\cdot\theta_t^{(\phi_\theta-1)/\gamma}\cdot\mathbb{E}_t[R_{t+1}]^{1/\gamma-1}\cdot e^{(\gamma-1)\cdot\sigma_z^2/2}} = \frac{D_t+\frac{\mathbb{E}_t[D_{t+1}]}{\mathbb{E}_t[R_{t+1}]}}{1+\beta^{1/\gamma}\cdot\theta_t^{(\phi_\theta-1)/\gamma}\cdot\mathbb{E}_t[R_{t+1}]^{1/\gamma-1}\cdot e^{(\gamma-1)\cdot\sigma_z^2/2}}, \tag{16}$$

where the second equality arises from the fact that initial household wealth is equal to the cum-payout firm value. We can rewrite Equation 16 as

$$C_t/W_t \;=\; (C/W)(\mathbb{E}_t[R_{t+1}]\,;\,\theta_t) \;=\; \frac{1}{1+\beta^{1/\gamma}\cdot\theta_t^{(\phi_\theta-1)/\gamma}\cdot\mathbb{E}_t[R_{t+1}]^{1/\gamma-1}\cdot e^{(\gamma-1)\cdot\sigma_z^2/2}}. \tag{17}$$

Notably, the magnitude of the risk aversion coefficient γ is crucial for the behavior of the household's consumption-wealth ratio. In particular, 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 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.

Figure 2 displays the consumption-wealth ratio C_t/W_t for $\beta = 0.9$, $\phi_\theta = 0.1$, $\sigma_z = 1$, and three different γ values. In particular, Panels A, B, and C show the family of C_t/W_t curves for different values of θ_t, assuming $\gamma = 1/5$, $\gamma = 1$, and $\gamma = 5$, respectively. As discussed above, the sign of the slope of the C/W curves depends critically on the value of parameter γ: it is negative for $\gamma = 1/5$ (Panel A), zero for $\gamma = 1$ (Panel B), and positive for $\gamma = 5$ (Panel C). Furthermore, an increase (decrease) in the current value 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.

2.2.3 General equilibrium

The market clearing condition is

$$(D/V^c)(\mathbb{E}_t[R_{t+1}]\,;\,K_t, Z_t) \;= (C/W)(\mathbb{E}_t[R_{t+1}]\,;\,\theta_t), \tag{18}$$

and yields the equilibrium expected return function $R^e(K_t, Z_t, \theta_t) \equiv \mathbb{E}^*_t[R_{t+1}]$.

Figure 3 graphically displays the equilibrium in the payout market and the dependence of the equilibrium expected return on each of the three state variables (K_t, Z_t, and θ_t). We assume $\eta = 0.9$ and $\gamma = 5$, with the rest of the parameters as in Figures 1 and 2. Panels A and B focus on the effect of changes in the firm's capital stock K_t. As seen in Panel A, an increase in K_t, other things equal, shifts the payout supply (D/V^c) curve up, as the firm wants to invest less and pay out more. However, the household is unwilling to consume that payout at the existing level of expected return, so the equilibrium expected return falls to clear the payout market. As a result, the equilibrium expected return R^e is decreasing in K_t (Panel B). Panels C and D consider changes in productivity Z_t. An increase in Z_t shifts the payout supply (D/V^c) curve down, as the firm wants to increase current investment and reduce current payout, in anticipation of higher future profitability. Payout market clearing requires an increase in the equilibrium expected return R^e (Panel C). It follows that R^e is increasing in Z_t (Panel D). Finally, Panels E and F present the impact of changes in the household taste shifter θ_t. Panel E 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 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 F).

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.

2.2.4 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. 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_t^s and D_{t+1}^s. Furthermore, we assume that the payout supply process satisfies $D_{t+1}^s = \mathbb{E}_t[D_{t+1}^s] \cdot e^{\epsilon_{d,t+1}}$, where $\epsilon_{d,t+1} \sim N(-\sigma_d^2/2, \sigma_d^2)$ and $\mathbb{E}_t[D_{t+1}^s] = f(D_t^s)$. Crucially, to retain the correspondence with the full economy, function f needs to be carefully chosen, so that it reflects the equilibrium path of the omitted state variables K and Z.[3]

Similar to the full economy, the household's optimality condition yields the payout demand function

$$C_t \;=\; \frac{D_t^s + \frac{\mathbb{E}_t[D_{t+1}^s]}{\mathbb{E}_t[R_{t+1}]}}{1 + \beta^{1/\gamma} \cdot \theta_t^{(\phi_\theta - 1)/\gamma} \cdot \mathbb{E}_t[R_{t+1}]^{1/\gamma - 1} \cdot e^{(\gamma-1)\cdot\sigma_d^2/2}}. \tag{19}$$

Imposing the market clearing condition $C_t = D_t^s$ and solving for the firm's expected return, we get

$$R^e(\theta_t, D_t^s) \;=\; \frac{\left(\mathbb{E}_t[D_{t+1}^s/D_t^s]\right)^\gamma}{\beta \cdot \theta_t^{\phi_\theta - 1} \cdot e^{\gamma\cdot(\gamma-1)\cdot\sigma_d^2/2}}. \tag{20}$$

Note that there are two state variables in the consumption-based model, both of them exogenous: the taste shifter θ and the payout supply D^s. Effectively, the payout supply D^s replaces capital K and productivity Z, the two state variables that appear in the firm's optimization problem in the full economy. As long as D^s exactly reflects the equilibrium behavior of the firm in the full model, then the consumption-based model has the same asset pricing implications as the full economy.

2.2.5 Payout-based asset pricing

In our payout-based asset pricing framework, the payout demand (i.e., the household consumption policy) is exogenous and the expected return is pinned down by the equalization of the firm's endogenous payout supply with the 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.

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_t^d and D_{t+1}^d. Importantly, for

[3]In the full economy, $D_t = \alpha \cdot Z_t \cdot K_t^\eta$ and $D_{t+1} = \alpha \cdot Z_t^{\phi_z} \cdot K_{t+1}^\eta \cdot e^{\epsilon_{z,t+1}}$, where $\epsilon_{z,t+1} \sim N(-\sigma_z^2/2, \sigma_z^2)$. Hence, the consumption-based asset pricing economy maps to the full economy if $D_t^s = \alpha \cdot Z_t \cdot K_t^\eta$, $\mathbb{E}_t[D_{t+1}^s] = \alpha \cdot Z_t^{\phi_z} \cdot K_{t+1}^\eta = g(K_t, Z_t) = f(D_t^s)$, and $\sigma_d = \sigma_z$.

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. Furthermore, for market clearing to be feasible, process D^d must be consistent with the firm's intertemporal budget constraint.

As in the full economy, payout supply arises from the firm's optimization problem and is given by Equation 14. Market clearing ($D_t = D_t^d$) yields the following expression for the equilibrium expected firm return:

$$R^e(K_t, Z_t, D_t^d) \;=\; \frac{\alpha \cdot \eta \cdot Z_t^{\phi_z} \cdot I(K_t, Z_t, D_t^d)^{\eta-1}}{1 + a \cdot I(K_t, Z_t, D_t^d)/K_t}, \tag{21}$$

where $I(K_t, Z_t, D_t^d) = \frac{1}{a} \cdot \left(\sqrt{1 - 2 \cdot a \cdot (D_t^d/K_t - \alpha \cdot Z_t \cdot K_t^{\eta-1})} - 1\right) \cdot K_t$. Thus, in the payout-based asset pricing framework the equilibrium expected return is a function of the firm's capital stock and productivity (K and Z, respectively) and the exogenous payout demand process D^d. In effect, the payout demand process replaces the taste shifter θ, which appears in the household's optimization problem in the full economy. As long as D^d 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.

3 Payout-Based Asset Pricing

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 Characterizing the firm's equilibrium return

Consider an all-equity financed representative firm with operating profit $\Pi(K, Z)$, where K is the firm's capital stock and Z is an exogenous Markov productivity process. Capital accumulation satisfies

$$K_{t+1} = I_t + (1 - \delta)K_t, \tag{22}$$

where I is the firm's investment. The firm faces capital adjustment costs given by $\Phi(K, I)$, with $\Phi(K, 0) = 0$. It follows that the firm's flow payout is given by

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

where τ is the corporate tax rate. Finally, the firm faces an exogenous payout demand $D_t^d = D^d(K_t, Z_t, d_t)$ from investors, where d is an exogenous Markov stochastic process.

The firm's manager chooses payout D in order to maximize the cum-payout firm value V_t^c,

$$V_t^c = \max_{\{D_{t+s}\}_{s=0}^{\infty}} \{D_t + \sum_{s=1}^{\infty} \mathbb{E}_t[M_{t+s} D_{t+s}]\}, \tag{24}$$

where M is the stochastic discount factor, which potentially depends on the two exogenous state variables Z and d.

Due to the fact that processes Z and d satisfy the Markov property, the economy has three state variables: two exogenous (Z and d) and one endogenous (K). It follows that the firm's problem can be rewritten recursively as

$$V^c(K_t, Z_t, d_t) = \max_{\{D_t\}} \{D_t + \mathbb{E}_t[M_{t+1} V^c(K_{t+1}, Z_{t+1}, d_{t+1})]\}. \tag{25}$$

3.1.1 Payout supply

The firm's first order condition is

$$\underbrace{\mathbb{E}_t[M_{t+1} \partial_K V^c(K_{t+1}, Z_{t+1}, d_{t+1})]}_{\equiv q_t} = 1 + (1-\tau)\partial_I \Phi(K_t, I_t), \tag{26}$$

where q is Tobin's marginal q. That condition yields an implicit investment function $I(K_t, q_t)$, and, therefore, an implicit *payout supply* function

$$D(K_t, Z_t, q_t) = (1-\tau)\left(\Pi(K_t, Z_t) - \Phi(K_t, I(K_t, q_t))\right) - I(K_t, q_t) + \tau\delta K_t. \tag{27}$$

It is evident that the firm's marginal q is a sufficient statistic for investor preferences as regards characterizing the firm's equilibrium payout behavior.

Using the envelope condition, we derive that the firm's optimal payout policy has to satisfy

$$\mathbb{E}_t\left[M_{t+1} \underbrace{\frac{(1-\tau)(\partial_K \Pi(K_{t+1}, Z_{t+1}) - \partial_K \Phi(K_{t+1}, I_{t+1})) + \tau\delta + (1-\delta) q_{t+1}}{q_t}}_{R_{t+1}^I}\right] = 1, \tag{28}$$

where R_{t+1}^I is the one-period investment return. If the stochastic discount factor M were known, this condition would pin down the firm's marginal q and, hence, its payout supply function. In what follows, we will exploit the property that q is a sufficient statistic for investor preferences in order to sidestep specifying M – rather, the exogenous payout demand process is all we need in order to characterize *equilibrium* returns.

3.1.2 Equilibrium

In equilibrium, the payout market clears, so the firm's endogenous payout supply needs to equal the exogenous payout demand:

$$D(K_t, Z_t, q_t) = D^d(K_t, Z_t, d_t). \tag{29}$$

Crucially, the equilibrium condition yields an implicit characterization of the firm's *equilibrium* marginal q, denoted by q^e. In particular, q^e is a function of the three state variables,

$$q_t^e = q^e(K_t, Z_t, d_t), \tag{30}$$

such that $D(K_t, Z_t, q^e(K_t, Z_t, d_t)) = D^d(K_t, Z_t, d_t)$. We can then use the firm's equilibrium marginal q in order to derive its equilibrium investment function, I_t^e, satisfying $I_t^e = I^e(K_t, Z_t, d_t) = I(K_t, q^e(K_t, Z_t, d_t))$.

We are now ready to characterize the firm's equilibrium expected return, $\mathbb{E}_t[R_{t+1}] = \frac{\mathbb{E}_t[V_{t+1}^c]}{V_t^c - D_t^d}$. In particular, as we show in Internet Appendix B, the equilibrium expected return satisfies

$$\mathbb{E}_t[R_{t+1}] = \mathbb{E}_t[R_{t+1}^I] - \frac{V_t^c - D_t^d}{(1-\tau)(\partial_K \Pi(K_t, Z_t) - \partial_K \Phi(K_t, I_t^e)) + \tau\delta - \partial_K D_t^d + (1-\delta) q_t^e} \frac{d\mathbb{E}_t[R_{t+1}]}{dK_t}. \tag{31}$$

In the special case that the expected return of the firm is independent of the level of the firm's capital stock, then it is equal to the expected investment return. Given the laws of motion for the state variables K, Z, and d, Equation 31, coupled with

$$V_t^c = D_t^d + \frac{\mathbb{E}_t[V_{t+1}^c]}{\mathbb{E}_t[R_{t+1}]}, \tag{32}$$

allow us to pin down the cum-payout firm value V^c and the firm expected return $\mathbb{E}_t[R_{t+1}]$. In order to jointly solve Equations 31 and 32 numerically, we need to specify the operating profit function Π and the capital adjustment cost function Φ, which we do next.

3.2 Model specification

The firm's operating profit function is

$$\Pi(K, Z) \;=\; \alpha \cdot Z \cdot K^\eta \;=\; \alpha \cdot Y, \tag{33}$$

where Y is the firm's output. Our operating profit specification is consistent with a Cobb-Douglas production function in which capital is the only costly adjustable input.[4]

The capital adjustment cost function is

$$\Phi(K, I) \;=\; \frac{a}{2} \cdot (I/K)^2 \cdot K. \tag{34}$$

Since the firm's capital stock has to be non-negative, investment needs to satisfy $I_t \geq -(1-\delta) \cdot K_t$ for all t. We further assume that capital adjustment costs are sufficiently large so that the firm always optimally picks an interior solution for investment (and, hence, payout). In particular, we assume that the adjustment cost parameter a satisfies $a > \frac{1}{(1-\tau)(1-\delta)}$.[5]

The exogenous productivity process Z is given by

$$Z_t \;= e^{g\cdot(1-\eta)\cdot t + z_t}, \tag{35}$$

where z is a stationary process satisfying

$$z_{t+1} \;= \mu_z \;+\; \phi_z \cdot (z_t - \mu_z) \;+\; \sigma_z \cdot \epsilon^z_{t+1}, \tag{36}$$

with $\epsilon^z_t \sim N(0,1)$, $0 < \phi_z < 1$, and $\sigma_z > 0$. Furthermore, we set the unconditional mean of z, μ_z, to a value that ensures that $\log(Y/K)$ is a stationary process. To see this, first consider the variable k, defined so that it satisfies $K_t = e^{g\cdot t + k_t}$. It follows that $\log(Y_t/K_t) = z_t + (\eta-1)k_t$. In the special case of constant returns to scale ($\eta = 1$), we have $\log(Y_t/K_t) = z_t$, and we have specified z to be a stationary process, so any value of μ_z yields a stationary $\log(Y/K)$ process. However, if $\eta < 1$, the stationarity of $\log(Y/K)$ requires the stationarity of k, which implies that $\mathbb{E}[\Delta \log(K_t)] = g$. To that end, when we calibrate the model, we set μ_z to a value that yields that condition.[6]

Finally, the payout demand process D^d is given by

$$D^d(K, Z, d) \;= Z \cdot K^\eta \cdot d = Y \cdot d. \tag{37}$$

[4] To see that, consider the Cobb-Douglas production function $Y_t = \hat{Z}_t \cdot K_t^{\eta_K} \cdot L_t^{\eta_L}$, where $\hat{Z}_t$ is exogenous productivity and L_t reflects intermediate inputs or costlessly adjustable labor. If one unit of L_t costs $p_{L,t}$, then the firm profit is $\Pi_t = Y_t - p_{L,t} \cdot L_t$, and intratemporal profit maximization results in $L_t = (\eta_L \cdot \hat{Z}_t / p_{L,t})^{1/(1-\eta_L)} \cdot K_t^{\eta_L/(1-\eta_L)}$. Substituting this expression into the production function yields $Y_t = Z_t \cdot K_t^\eta$, where $Z_t = (\eta_L/p_{L,t})^{\eta_L/\alpha} \cdot \hat{Z}_t^{1/\alpha}$, $\eta = \eta_K/(1-\eta_L)$, and $\alpha = 1 - \eta_L$. Therefore, our productivity process Z can also incorporate variation in the cost of other inputs in a model with a Cobb-Douglas production function.

[5] The firm's first order condition yields $I_t = \frac{q_t - 1}{a(1-\tau)} K_t$. Intuitively, the restriction $a > \frac{1}{(1-\tau)(1-\delta)}$ ensures the feasibility of the interior solution, given the non-negativity of the firm's marginal q: 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 $I_t \geq 0 \geq -(1-\delta)K_t$.

[6] It is worth noting that our specification is mathematically equivalent to the specification $Y_t = Z_t \cdot G_t^{1-\eta} \cdot K_t^\eta$ with $\log(G_t) = g \cdot t$ and $\log(Z_t) = z_t$, similar to Belo et al. (2018).

The exogenous stochastic process d has law of motion

$$d_{t+1} = \mu_d + \phi_d \cdot (d_t - \mu_d) + \sigma_{d,t} \cdot \epsilon^d_{t+1}, \tag{38}$$

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

$$\sigma_{d,t} = \sigma_d \cdot \sqrt{d^{max} - d_t}, \tag{39}$$

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

3.2.1 Equilibrium

Substituting the specifications for Π and Φ in Equation 23, the firm's period t payout is

$$D_t = (1-\tau)\left(\alpha Z_t K_t^{\eta} - \frac{a}{2}\left(\frac{I_t}{K_t}\right)^2 K_t\right) - I_t + \tau\delta K_t, \tag{40}$$

and the first order condition for the firm's payout (Equation 26) yields the familiar investment function

$$I(K_t, q_t) = \frac{q_t - 1}{a(1-\tau)} K_t. \tag{41}$$

The firm's optimal investment is proportional to its capital stock and increasing in the marginal q. Plugging Equation 41 into Equation 40, we derive the firm's payout supply function

$$D(K_t, Z_t, q_t) = \left[(1-\tau)\alpha Z_t K_t^{\eta-1} - \frac{q_t^2 - 1}{2a(1-\tau)} + \tau\delta\right] K_t. \tag{42}$$

We can now turn to equilibrium. Imposing the market clearing condition $D(K_t, Z_t, q_t) = D^d(K_t, Z_t, d_t)$ and solving for q_t, we derive an expression for the equilibrium marginal q,

$$q_t^e = \sqrt{1 + 2a(1-\tau)\left[(1-\tau)\alpha Z_t K_t^{\eta-1} + \tau\delta - \frac{D^d(K_t, Z_t, d_t)}{K_t}\right]}. \tag{43}$$

Note that the restriction $d_t \leq (1-\tau)\cdot\alpha$ implies a lower bound for q^e: $q_t^e \geq \sqrt{1 + 2a(1-\tau)\tau\delta}$.

3.2.2 Model solution

In order to numerically solve for the equilibrium firm value and expected return, we first need to rewrite all equilibrium expressions as function of the stationary variables k, z and d. In what follows, we use the notation $y_t \equiv Y_t^e/K_t = e^{z_t+(\eta-1)k_t}$ and $i_t^e \equiv I_t^e/K_t = \frac{q_t^e-1}{a(1-\tau)}$, where

$$q_t^e = q^e(k_t, z_t, d_t) = \sqrt{1 + 2a(1-\tau) \cdot (\tau\delta + (1-\tau)\alpha y_t - d_t y_t)}. \tag{44}$$

First, we need to pin down the appropriate value for μ_z. The law of motion for the equilibrium k is

$$k_{t+1} = k_t + \log(1 - \delta + i_t^e) - g, \tag{45}$$

so, for equilibrium k to be a stationary process, we need $g = \mathbb{E}[\log(1 - \delta + i_t^e)]$, which yields

$$g = \mathbb{E}\left[\log\left(1 - \delta + \frac{\sqrt{1 + 2a(1-\tau) \cdot (\tau\delta + (1-\tau)\alpha y_t - d_t y_t)} - 1}{a(1-\tau)}\right)\right]. \tag{46}$$

Thus, the value of μ_z is the value that satisfies Equation 46.

Next, denote the firm's average Tobin's q by $Q_t = \frac{V_t^c - D_t}{K_t}$. In equilibrium, the average Tobin's q satisfies the recursive expression

$$Q^e(k_t, z_t, d_t) = \frac{\mathbb{E}_t\left[(1 - \delta + i_{t+1}^e) \cdot Q(k_{t+1}, z_{t+1}, d_{t+1}) + d_{t+1} \cdot y_{t+1}\right]}{R^e(k_t, z_t, d_t)}, \tag{47}$$

where the firm's expected return satisfies the differential equation

$$\begin{aligned} R^e(k_t, z_t, d_t) = \mathbb{E}_t&\left[\frac{(1-\tau)(\eta\alpha y_{t+1} + \frac{a}{2}(i_{t+1}^e)^2) + \tau\delta + (1-\delta)q_{t+1}^e}{q_t^e}\right] \\ &- \frac{(1 - \delta + i_t^e)Q(k_t, z_t, d_t)}{(1-\tau)(\eta\alpha y_t + \frac{a}{2}(i_t^e)^2) + \tau\delta - \eta d_t y_t + (1-\delta)q_t^e} \cdot \frac{\partial R^e(k_t, z_t, d_t)}{\partial k_t}. \end{aligned} \tag{48}$$

We numerically obtain functions $Q^e(k_t, z_t, d_t)$ and $R^e(k_t, z_t, d_t)$ using Equations 47 and 48 and the laws of motion for the stationary state variables k, z, and d (Equations 45, 36, and 38, respectively). The details are provided in Internet Appendix B.

Figure 4 displays the equilibrium expected return function, $R^e(k_t, z_t, d_t)$, for $\eta = 0.9$. Panels A, B, and C show the value of R^e for different values of k, z, and d, respectively, keeping the other two variables constant. R^e is decreasing in k and z, and increasing in d. As regards z, there are two opposing 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 payout supply and lower the equilibrium expected return. 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 former effect slightly dominates. Crucially, the expected return exhibits very moderate variation across different values of k and z, but is very sensitive with respect to d, underscoring the importance of payout demand as a driver of equilibrium returns. Intuitively, 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 raises payout.

Our model becomes greatly simplified for $\eta = 1$, as the equilibrium expected return does not depend on k, due to the constant returns to scale production function. In particular, as shown in Internet Appendix B, for $\eta = 1$ we have $Q_t^e = q_t^e$, so the firm's average q can be expressed in closed form as

$$Q^e(z_t, d_t) \ = \sqrt{1 + 2a(1-\tau) \cdot (\tau\delta + (1-\tau)\alpha e^{z_t} - d_t e^{z_t})}. \tag{49}$$

Furthermore, we have $R_t = R_t^I$, which yields

$$R^e(z_t, d_t) \ = \mathbb{E}_t \left[\frac{(1-\tau)\alpha e^{z_{t+1}} + \frac{1}{2a(1-\tau)}(Q^e(z_{t+1}, d_{t+1}) - 1)^2 + \tau\delta + (1-\delta)Q^e(z_{t+1}, d_{t+1})}{Q^e(z_t, d_t)} \right]. \tag{50}$$

Figure 5 presents the $R^e(k_t, z_t, d_t)$ function for $\eta = 1$. As discussed above, R^e is flat in k (Panel A). Furthermore, the expected return is increasing in z and d (Panels B and C, respectively). Again, the firm's expected return varies little with z and is very sensitive to d.

3.3 Quantitative Results

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

3.3.1 Calibration

We consider two versions of the model, one with $\eta = 1$ (constant returns to scale, CRS model) and one with $\eta = 0.9$ (decreasing returns to scale, DRS model). Table 1 reports our model calibration.

We calibrate δ, τ, and a relying on the extant literature. In particular, we set $\delta = 0.15$ and $\tau = 0.35$, following DeAngelo, DeAngelo and Whited (2011). Since the investment adjustment cost specification in DeAngelo et al. (2011) is not comparable to ours, we set $a = 8$ as in Favilukis, Lin and Zhao (2020).

The other parameters are calibrated to match empirical moments. The data sample used to construct those moments includes annual observations of aggregate profit Π, output Y, sales-to-capital ratio y, and payout ratio d from 1974 to 2017. We construct those measures using CRSP data, COMPUSTAT data, and the dataset in Davydiuk, Richard, Shaliastovich and Yaron (2023). 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 C provides details on the data sources and the empirical measure construction calculations.

We set $\alpha = 0.164$ to match the average profit-to-output ratio in the data. Furthermore, we set $g = 0.025$ and $\mu_z = 0.802$ to match the average log output growth rate in the data and to ensure that the average log growth rate of output and capital are the same, respectively. As regards the payout demand parameters, we set $\mu_d = 0.015$, $\phi_d = 0.595$, and $\sigma_d = 0.087$ in order to match the mean and the autocorrelation of d, as well as the unconditional volatility of d autoregressive shocks. Finally, we calibrate ϕ_z, σ_z, $\rho_{d,z}$ to match the autocorrelation of y, the volatility of y autoregressive shocks, and the correlation between d and y autoregressive shocks. For the CRS model, matching these last three moments yields $\phi_z = 0.795$, $\sigma_z = 0.059$, and $\rho_{d,z} = -0.106$. On the other hand, for the DRS model, we need to set $\phi_z = 0.662$, $\sigma_z = 0.057$, and $\rho_{d,z} = -0.101$ in order to match the same three target moments.

3.3.2 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) and apply linear interpolation to evaluate the $Q^e(k, z, d)$ and $R^e(k, z, d)$ functions outside of the state vector grid points. 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 payout yield and the return of the representative firm. Our results suggest that the CRS model is much better at capturing payout yield dynamics than the DRS model. In the data, the payout yield has an unconditional mean of 1.6% and an unconditional volatility of 2.5%. Those moments are well-matched by the CRS model (the median values are $\mathbb{E}[D/V] = 1.6\%$ and $\sigma[D/V] = 3.8\%$), but not by the DRS model (median values of $\mathbb{E}[D/V] = 0.2\%$ and $\sigma[D/V] = 0.3\%$). The CRS model also yields empirically plausible return dynamics. Specifically, the CRS model median values for the firm return mean and volatility ($\mathbb{E}[R] = 5.1\%$ and $\sigma[R] = 10.2\%$) are not far from the corresponding empirical values ($\mathbb{E}[R] = 7.9\%$ and $\sigma[R] = 14.9\%$). Despite that success, the CRS 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 CRS 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 a large share of the unconditional firm return volatility in the CRS model arises from variation in the expected return: as seen in the last row of Panel A, the median unconditional volatility of $\mathbb{E}[R]$ in the CRS model is 4.5%.

Panel B reports the output of regressions of annual returns, R_{t+1}, on the lagged payout yield, D_t/V_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 the regression adjusted R^2 is 9.2%. The CRS model yields a median predictive coefficient of 1.30 and a median regression adjusted R^2 of 21.6%. However, there is substantial variation in both those measures across simulations, so the empirical values are well within the range of simulated outcomes. On the other hand, the DRS model is not successful in capturing the empirical attributes of return predictability: although it generates a median predictive adjusted R^2 that is very close to the empirical value, the counterfactually low $\sigma[D/V]$ in the model results in a predictive coefficient of 20.14, an order of magnitude higher than the empirical value.

While the association between payout yield and future returns is strong in the model, it is well-known that asset pricing models with time-varying expected returns mechanically generate such predictability due to the present value identity linking future returns and firm value (Larrain and Yogo (2008)). To explore whether the documented return predictability arises from the payout decisions of the firm, as our model suggests, we regress annual returns R_{t+1} on the lagged payout ratio D_t/Y_t, which is a state variable in our model and does not require the use of firm value for its construction. Panel C of Table 2 reports the output of those regressions. Both in the data and in our model, the predictive coefficient is positive. Intuitively, 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. In the data, the predictive regression adjusted R^2 is 8.6%, indicating that the payout ratio D_t/Y_t and the payout yield D_t/V_t have a quantitatively similar predictive ability for future returns. Generally, the CRS model generates much stronger return predictability: the median predictive adjusted R^2 is 20.7%. However, due to substantial variation in that measure across simulations, the empirical value of R^2=8.6% is much higher than the 1th percentile of model simulations, and, thus, firmly within the range of simulated outcomes.

In our model, the main source of expected return variation is payout demand variation. To illustrate that point, we run a single 100-year simulation of the CRS model and report the paths for key variables in Figure 6 (in unreported results, the DRS model generates very similar paths). Panels A, B, and C show the simulated paths of state variables k, z, and d, respectively. While k is extremely persistent (and, thus, unlikely to generate strong return predictability at the annual horizon), both z and d exhibit substantial variation across time. To disentangle the effect of different state variables on expected returns, Panel D plots the simulated path of the firm's expected return, as well as three counterfactual paths, each allowing for time variation in only one state variable. As seen in the plot, almost all of the variation in the expected return is due to variation in d. It follows that the strong model-generated return predictability we document in the regressions of Panels B and C of Table 2 arises mainly from time variation in payout demand.

4 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 and 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.

____ **, Robert H. Litzenberger, and Tingyan Jia**, "Consumption-Based Asset Pricing, Part 1: Classic Theoryand Tests, Measurement Issues, and Limited Participation," *Annual Reviews of Financial Economics*, 2015, *7*, 35–83.

———, ———, and ———, "Consumption-Based AssetPricing, Part 2: HabitFormation, Conditional Risks,Long-Run Risks, and RareDisasters," *Annual Review of Financial Economics*, 2015, *7*, 85–131.

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.

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.

Larrain, Borja and Motohiro Yogo, "Does firm value move too much to be justified by subsequent changes in cash flow?," *Journal of Financial Economics*, 2008, *87* (1), 200–226.

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.

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.

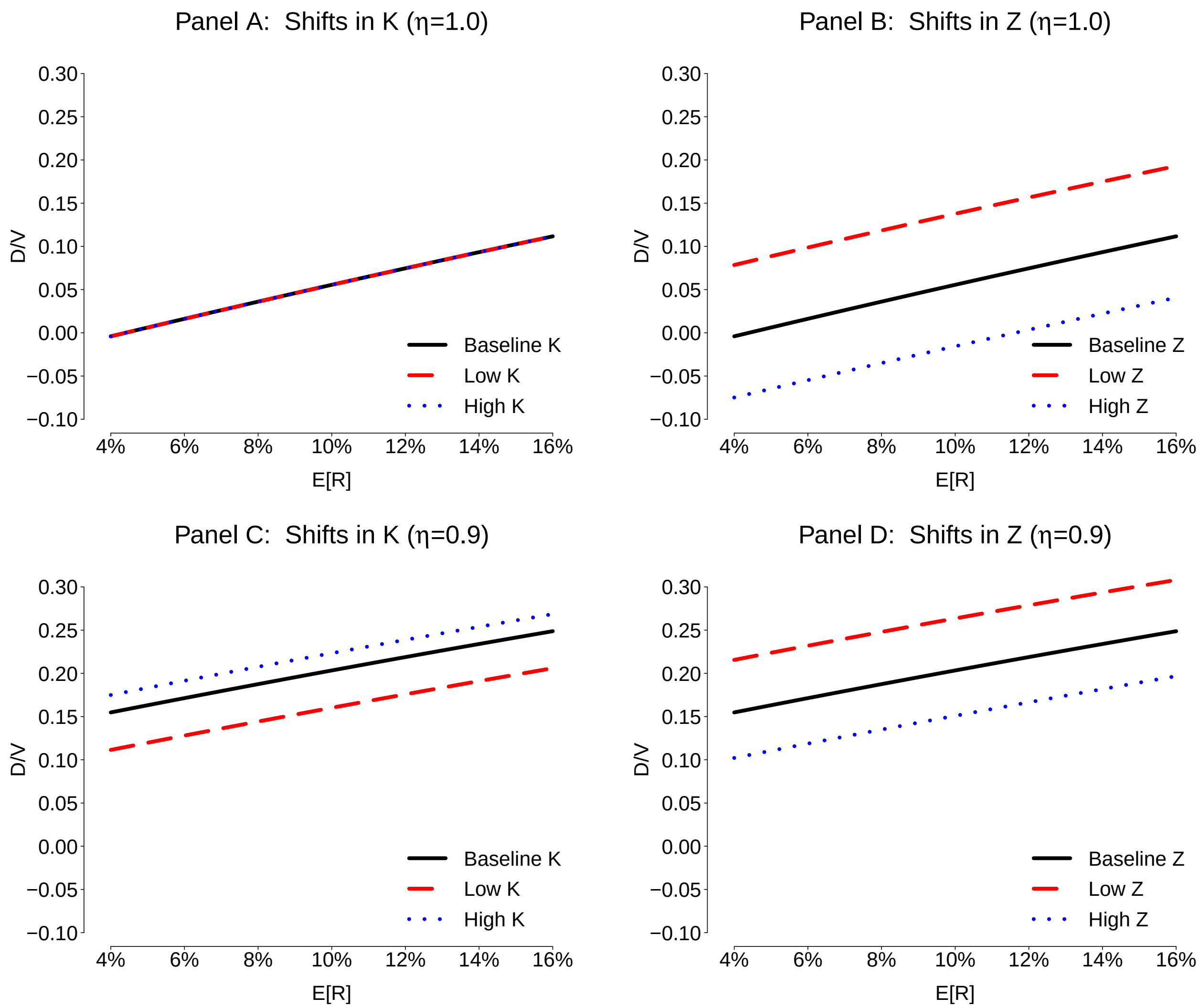

Fig. 1: Payout yield in the two-period model

This figure presents the payout yield of the representative firm in the two-period model as a function of the firm's expected return. Panel A presents the payout yield curve for different values of the firm's capital stock K, holding firm productivity Z constant, under the parametrization $\eta = 1$. Panel B presents the payout yield curve for different values of the firm's productivity Z, holding firm's capital stock K constant, under the parametrization $\eta = 1$. Panel C presents the payout yield curve for different values of the firm's capital stock K, holding firm productivity Z constant, under the parametrization $\eta = 0.9$. Panel D presents the payout yield curve for different values of the firm's productivity Z, holding firm's capital stock K constant, under the parametrization $\eta = 0.9$. Section 2.2.1 provides more details.

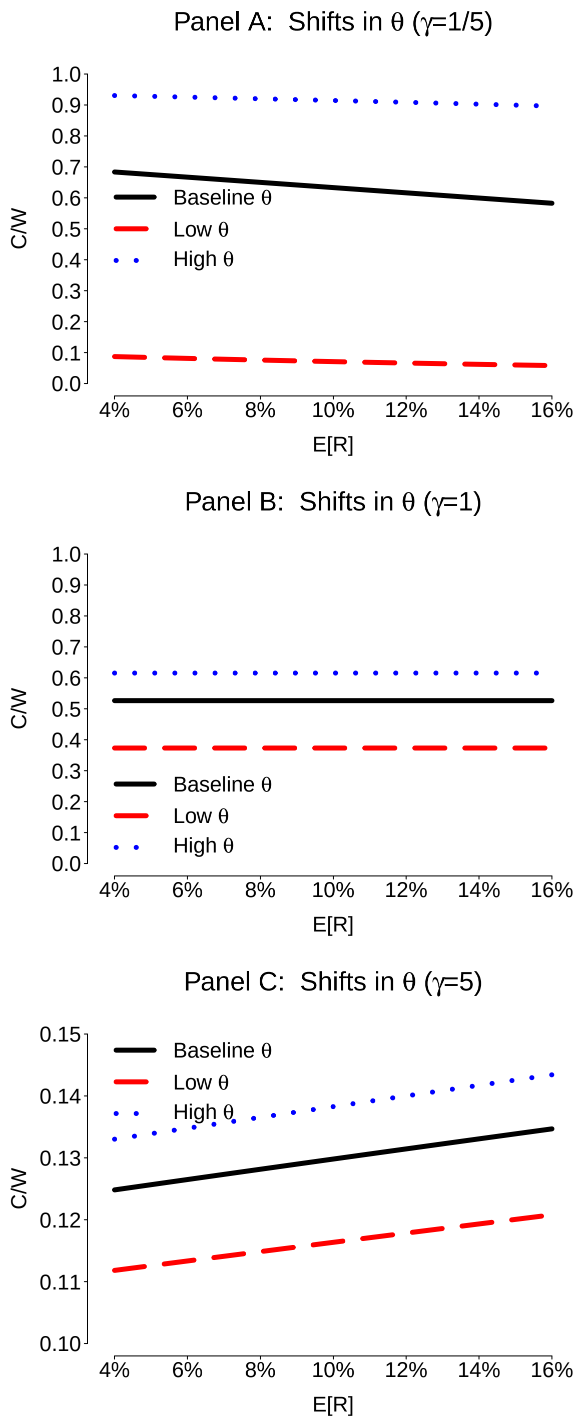

Fig. 2: Consumption-wealth ratio in the two-period model

This figure presents the consumption-wealth ratio of the representative household in the two-period model as a function of the firm's expected return. Panels A, B, and C present the consumption-wealth ratio curve for different values of the taste shifter θ, under the parametrization $\gamma = 1/5$, $\gamma = 1$, and $\gamma = 5$, respectively. Section 2.2.2 provides more details.

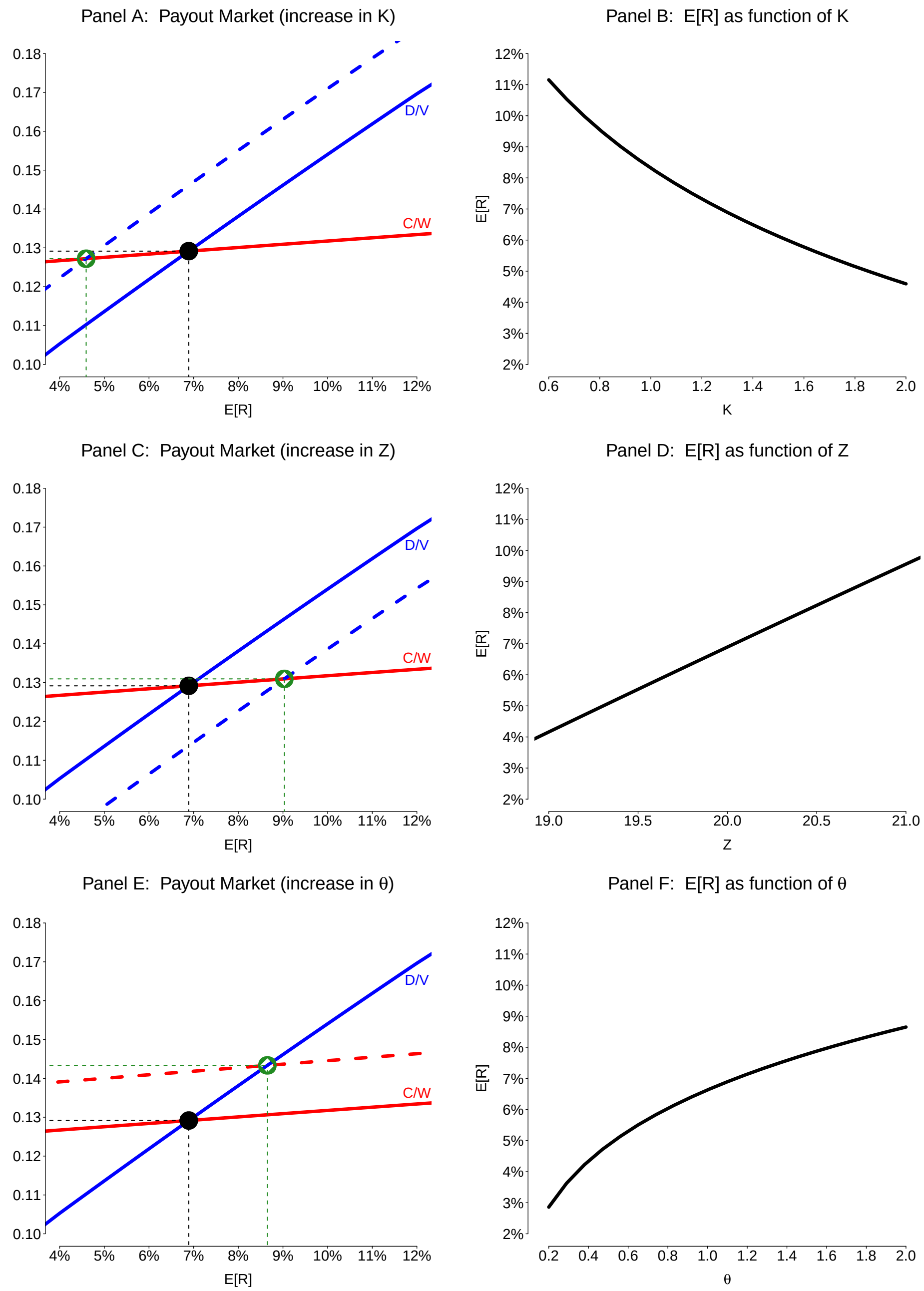

Fig. 3: Payout market equilibrium in the two-period model

Panels A, C, and E of 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 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 capital stock K increases, Panel C shows the impact of a shift of the firm's payout yield curve when the firm's productivity Z increases, and Panel E shows the impact of a shift of the household's consumption-wealth ratio curve when the taste shifter θ increases. Panels B, D, and F of this figure plot the equilibrium expected return as a function of firm capital stock K, firm productivity Z, and the taste shifter θ, respectively, keeping the rest of the state variables constant. Section 2.2.3 provides more details.

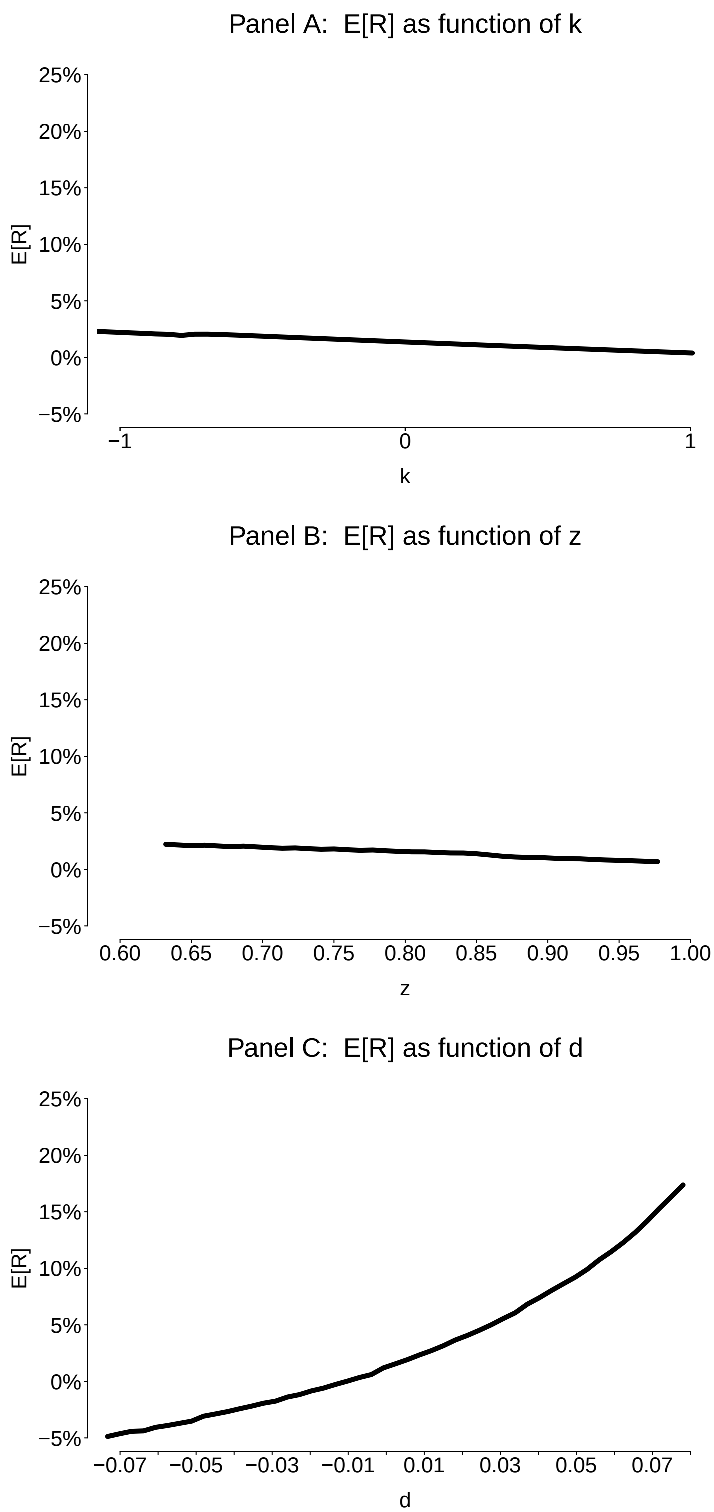

Fig. 4: Expected return as function of the state variables ($\eta = 0.9$)

This figure presents the equilibrium expected return of the representative firm in the quantitative model, under the parametrization $\eta = 0.9$. Panels A, B, and C of this figure plot the firm's equilibrium expected return as a function of the state variable k, z and d, respectively, keeping the rest of the state variables constant. Section 3.2.2 provides more details.

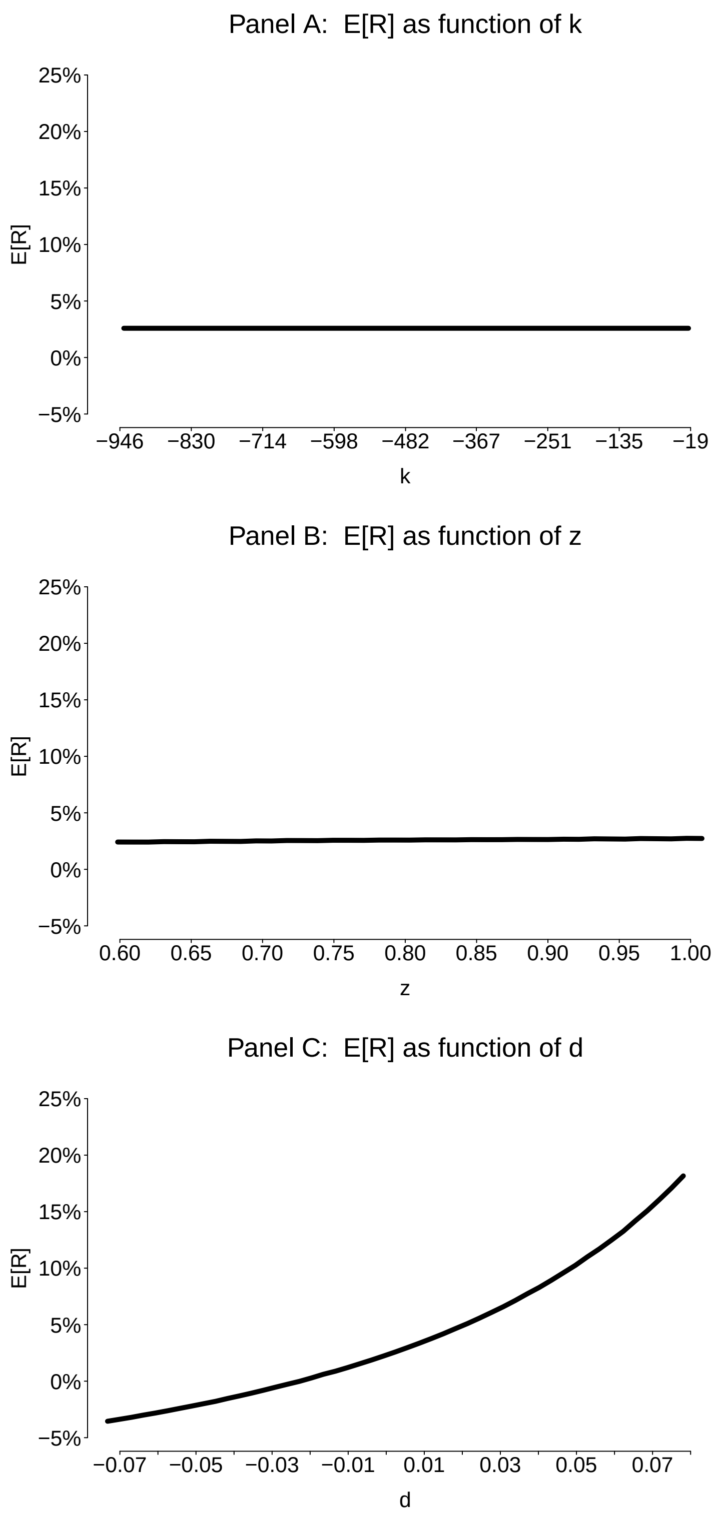

Fig. 5: Expected return as function of the state variables ($\eta = 1$)

This figure presents the equilibrium expected return of the representative firm in the quantitative model, under the parametrization $\eta = 1$. Panels A, B, and C of this figure plot the firm's equilibrium expected return as a function of the state variable k, z and d, respectively, keeping the rest of the state variables constant. Section 3.2.2 provides more details.

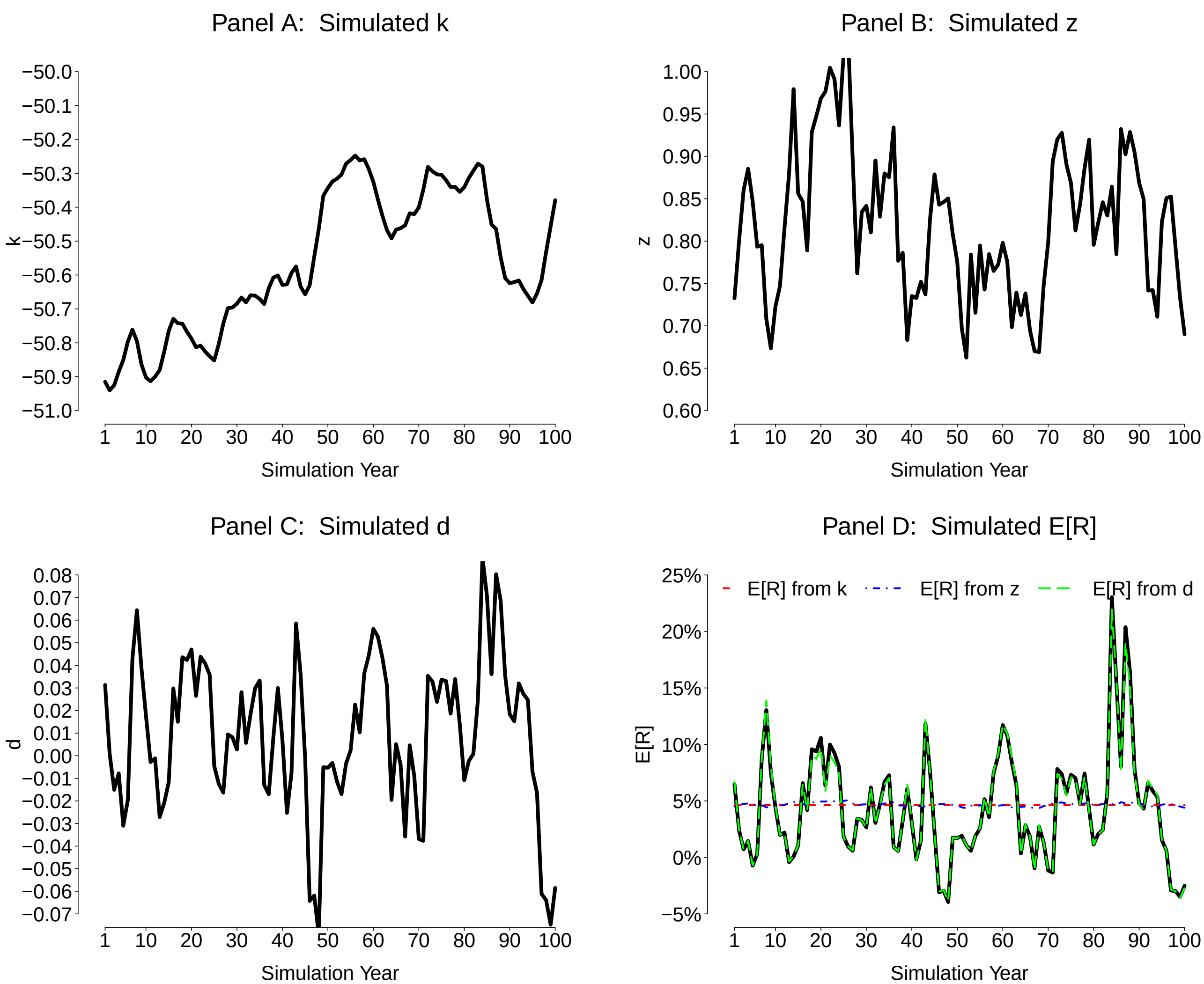

Fig. 6: Simulated paths

This figure reports the output of a 100-year simulation of the CRS (constant returns to scale) quantitative model. Panels A, B, and C plot the simulated paths of the state variables k, z, and d, respectively. Panel D plots the simulated path of the firm's equilibrium expected return (in black), as well as the equilibrium expected return path when k, z, and d varies (in red, blue, and green, respectively) and the other two state variables are kept constant. Section 3.3.2 provides more details.

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, the third column reports its calibrated value in the CRS (constant returns to scale) model, and the fourth column reports its calibrated value in the DRS (decreasing returns to scale) model. Section 3.3.1 provides more details.

Parameter Description	**Symbol**	**CRS model ($\eta = 1$)**	**DRS model ($\eta = 0.9$)**
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
Average Economy Growth	g	0.025	0.025
Average z_t	μ_z	0.802	0.802
Autocorrelation of z_t	ϕ_z	0.759	0.662
Volatility of z_t Shocks	σ_z	0.059	0.057
Average d_t	μ_d	0.015	0.015
Autocorrelation of d_t	ϕ_d	0.595	0.595
Volatility Parameter for d_t Process	σ_d	0.087	0.087
Correlation(d_t , z_t)	$\rho_{d,z}$	-0.106	-0.101

Table 2: Empirical and simulated moments

This table reports empirical and simulated asset pricing moments. For each moment, it shows its description, its notation, its empirical value, its median and 1st and 99th percentile values across 10,000 simulations of the CRS model, and its median and 1st and 99th percentile values across 10,000 simulations of the DRS model. Panel A reports unconditional moments. Panel B reports the slope coefficient and the adjusted R^2 of regressions of returns on lagged payout yields. Panel C reports the slope coefficient and the adjusted R^2 of regressions of returns on lagged payout ratios. Section 3.3.2 provides more details.

			CRS Model ($\eta = 1$)			DRS Model ($\eta = 0.9$)		
Description	**Notation**	**Data**	**Q(1%)**	**Median**	**Q(99%)**	**Q(1%)**	**Median**	**Q(99%)**
Panel A: Unconditional moments								
Average Payout Yield	$\mathbb{E}[D/V]$	1.6%	-0.9%	1.6%	3.5%	-0.0%	0.2%	0.4%
Volatility of Payout Yield	$\sigma[D/V]$	2.5%	2.7%	3.8%	5.4%	0.2%	0.3%	0.4%
Average Return	$\mathbb{E}[R]$	7.9%	3.8%	5.1%	6.5%	1.5%	4.1%	7.1%
Volatility of Return	$\sigma[R]$	14.9%	7.6%	10.2%	13.3%	12.6%	16.8%	21.8%
Reward-to-Risk	$\mathbb{E}[R]/\sigma[R]$	0.53	0.36	0.50	0.69	0.10	0.25	0.41
Volatility of $\mathbb{E}[R]$	$\sigma[\mathbb{E}[R]]$	–	3.0%	4.5%	6.5%	3.0%	4.6%	6.7%
Panel B: Regressions of R_{t+1} on D_t/V_t								
Predictive Coefficient	b	1.81	0.59	1.30	2.28	3.54	20.14	44.37
Adjusted R-squared	R^2_{adj}	9.2%	5.9%	21.6%	42.3%	-1.9%	8.3%	29.7%
Panel C: Regressions of R_{t+1} on D_t/Y_t								
Predictive Coefficient	b	1.36	0.62	1.58	3.06	0.22	1.77	4.24
Adjusted R-squared	R^2_{adj}	8.6%	4.9%	20.7%	42.2%	-2.1%	8.2%	29.7%

Internet Appendix

This Internet Appendix is organized as follows. Section A provides the derivations for the two-period model, Section B reports the derivations for the infinite horizon payout-based asset pricing model, and Section C 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

To derive Equation 13, first note that the Equations 10 and 11 can be used to write the firm's optimality condition (Equation 5) as

$$1 = \mathbb{E}_t\left[M_{t+1}\cdot\frac{\alpha\cdot\eta\cdot Z_{t+1}\cdot I_t^{\eta-1}}{1+a\cdot I_t/K_t}\right] = \mathbb{E}_t\left[M_{t+1}\cdot\frac{\eta\cdot D_{t+1}\cdot I_t^{-1}}{1+a\cdot I_t/K_t}\right] = \frac{\eta\cdot I_t^{-1}\cdot\mathbb{E}_t\left[M_{t+1}\cdot D_{t+1}\right]}{1+a\cdot I_t/K_t}. \tag{IA.1}$$

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

$$1 = \frac{\eta\cdot I_t^{-1}\cdot\mathbb{E}_t[D_{t+1}]/\mathbb{E}_t[R_{t+1}]}{1+a\cdot I_t/K_t} = \frac{(\alpha\cdot\eta\cdot Z_t^{\phi_z}\cdot I_t^{\eta-1})/\mathbb{E}_t[R_{t+1}]}{1+a\cdot I_t/K_t}. \tag{IA.2}$$

Rearranging terms yields Equation 13.

Finally, Equation 15 follows from dividing the expression for payout supply (Equation 14) by the expression for the firm's cum-payout value,

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

A.2 Payout demand

First, note that our specification implies that

$$D_{t+1} = \Pi_{t+1} = \alpha\cdot Z_{t+1}\cdot I_t^{\eta} = \alpha\cdot Z_t^{\phi_z}\cdot I_t^{\eta}\cdot e^{\epsilon_{z,t+1}}, \tag{IA.3}$$

which implies that

$$\mathbb{E}_t[D_{t+1}^{1-\gamma}] \;=\; (\alpha \cdot Z_t^{\rho_z} \cdot I_t^{\eta})^{1-\gamma} \cdot e^{\gamma\cdot(\gamma-1)\cdot\sigma_z^2/2} \;=\; \mathbb{E}_t[D_{t+1}]^{1-\gamma} \cdot e^{\gamma\cdot(\gamma-1)\cdot\sigma_z^2/2}. \tag{IA.4}$$

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

$$\mathbb{E}_t[R_{t+1}^{1-\gamma}] \;=\; \frac{\mathbb{E}_t[D_{t+1}^{1-\gamma}]}{V_t^{1-\gamma}} \;=\; \frac{\mathbb{E}_t[D_{t+1}]^{1-\gamma}}{V_t^{1-\gamma}} \cdot e^{\gamma\cdot(\gamma-1)\cdot\sigma_z^2/2} \;=\; \mathbb{E}_t[R_{t+1}]^{1-\gamma} \cdot e^{\gamma\cdot(\gamma-1)\cdot\sigma_z^2/2}. \tag{IA.5}$$

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

$$C_t \;=\; \frac{W_t}{1 + \left(\beta \cdot \theta_t^{(\phi_\theta-1)}\right)^{1/\gamma} \cdot \mathbb{E}_t[R_{t+1}^{1-\gamma}]^{1/\gamma}}, \tag{IA.6}$$

which, using Equation IA.5, yields Equation 16.

A.3 Consumption-based asset pricing

To derive Equation 19, we substitute

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

into the household's optimality condition. Then, plugging the market clearing condition $C_t = D_t^s$ into Equation 19, we get

$$D_t^s \;=\; \frac{D_t^s + \frac{\mathbb{E}_t[D_{t+1}^s]}{\mathbb{E}_t[R_{t+1}]}}{1 + \beta^{1/\gamma} \cdot \theta_t^{(\phi_\theta-1)/\gamma} \cdot \mathbb{E}_t[R_{t+1}]^{1/\gamma - 1} \cdot e^{(\gamma-1)\cdot\sigma_d^2/2}}, \tag{IA.7}$$

which, after some algebra, yields

$$D_t^s \;=\; \frac{\mathbb{E}_t[D_{t+1}^s]}{\beta^{1/\gamma} \cdot \theta_t^{(\phi_\theta-1)/\gamma} \cdot \mathbb{E}_t[R_{t+1}]^{1/\gamma} \cdot e^{(\gamma-1)\cdot\sigma_d^2/2}}. \tag{IA.8}$$

Solving for $\mathbb{E}_t[R_{t+1}]$, we get Equation 20.

A.4 Payout-based asset pricing

First, we derive the equilibrium investment function $I(K_t, Z_t, D_t^d)$. To do so, we first substitute the market clearing condition $D_t = D_t^d$ into the firm's period t budget constraint, and get

$$\frac{a}{2} \cdot (I_t/K_t)^2 \; + \; I_t/K_t \; + \; (D_t^d/K_t - \alpha \cdot Z_t \cdot K_t^{\eta-1}) \; = 0.$$

Then, we solve this quadratic equation for I_t/K_t, and get

$$I_t \; = I(K_t, Z_t, D_t^d) \; = \; \frac{1}{a} \cdot \left(\sqrt{1 - 2 \cdot a \cdot (D_t^d/K_t - \alpha \cdot Z_t \cdot K_t^{\eta-1})} - 1 \right) \cdot K_t. \tag{IA.9}$$

Finally, we plug in the equilibrium investment function into Equation 13, and, solving for $\mathbb{E}_t[R_{t+1}]$, we derive Equation 21.

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

The firm's first order condition is

$$\mathbb{E}_t[M_{t+1}\partial_K V^c(K_{t+1}, Z_{t+1}, d_{t+1})] = 1 + (1-\tau)\partial_I \Phi(K_t, I_t). \tag{IA.10}$$

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

$$q_t = 1 + (1-\tau)\partial_I \Phi(K_t, I_t). \tag{IA.11}$$

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

The envelope condition (with respect to K_t) is

$$\partial_K V^c(K_t, Z_t, d_t) = (1-\tau)(\partial_K \Pi(K_t, Z_t) - \partial_K \Phi(K_t, I_t)) + \tau\delta + (1-\delta)\mathbb{E}_t[M_{t+1}\partial_K V^c(K_{t+1}, Z_{t+1}, d_{t+1})], \tag{IA.12}$$

so, using the definition for q_t, we can write

$$\partial_K V^c(K_t, Z_t, d_t) = (1-\tau)(\partial_K \Pi(K_t, Z_t) - \partial_K \Phi(K_t, I_t)) + \tau\delta + (1-\delta)q_t. \tag{IA.13}$$

Finally, the investment return is

$$R^I_{t+1} = \frac{(1-\tau)(\partial_K \Pi(K_{t+1}, Z_{t+1}) - \partial_K \Phi(K_{t+1}, I_{t+1})) + \tau\delta + (1-\delta)q_{t+1}}{q_t}, \tag{IA.14}$$

so, using Equation IA.13, the equilibrium investment return satisfies

$$R^I_{t+1} = \frac{\partial_K V^c(K_{t+1}, Z_{t+1}, d_{t+1})}{q_t}. \tag{IA.15}$$

Plugging in Equation IA.15 into IA.10, we get

$$\mathbb{E}_t[M_{t+1} R^I_{t+1} q_t] = q_t, \tag{IA.16}$$

which yields Equation 28.

B.2 Equilibrium return

The equilibrium firm return is given by

$$R_{t+1} = \frac{V^c((1-\delta)K_t + I^e(K_t, Z_t, d_t), Z_{t+1}, d_{t+1})}{V^c(K_t, Z_t, d_t) - D^d(K_t, Z_t, d_t)}, \tag{IA.17}$$

which can be rewritten as

$$(V^c(K_t, Z_t, d_t) - D^d(K_t, Z_t, d_t))R_{t+1} = V^c((1-\delta)K_t + I^e(K_t, Z_t, d_t), Z_{t+1}, d_{t+1}). \tag{IA.18}$$

Differentiating Equation IA.18 with respect to K_t yields

$$(\partial_K V^c_t - \partial_K D^d_t)R_{t+1} + (V^c_t - D^d_t)\frac{dR_{t+1}}{dK_t} = \left((1-\delta) + \frac{dI^e_t}{dK_t}\right)\partial_K V^c_{t+1}. \tag{IA.19}$$

Note that the equilibrium condition $D(K_t, Z_t, q^e(K_t, Z_t, d_t)) = D^d(K_t, Z_t, d_t)$ yields

$$(1-\tau)(\Pi(K_t, Z_t) - \Phi(K_t, I^e(K_t, Z_t, d_t))) - I^e(K_t, Z_t, d_t) + \tau\delta K_t = D^d(K_t, Z_t, d_t). \tag{IA.20}$$

Differentiating Equation IA.20 with respect to K_t, we get

$$(1-\tau)(\partial_K \Pi_t - \partial_K \Phi_t) + \tau\delta - ((1-\tau)\partial_I \Phi_t + 1) \cdot \frac{dI^e_t}{dK_t} = \partial_K D^d_t, \tag{IA.21}$$

In equilibrium, Equation IA.11 yields

$$q_t^e = 1 + (1-\tau)\partial_I \Phi(K_t, I_t^e), \tag{IA.22}$$

so Equation IA.21 yields

$$(1-\tau)(\partial_K \Pi_t - \partial_K \Phi_t) + \tau\delta - q_t^e \cdot \frac{dI_t^e}{dK_t} = \partial_K D_t^d. \tag{IA.23}$$

Using the expression in Equation IA.13, we can rewrite Equation IA.23 as follows:

$$\partial_K V_t^c - \left((1-\delta) + \frac{dI_t^e}{dK_t}\right) q_t^e = \partial_K D_t^d. \tag{IA.24}$$

Finally, plugging in the expressions in Equations IA.15 and IA.24 in Equation IA.19, we get

$$\left((1-\delta) + \frac{dI_t^e}{dK_t}\right) q_t^e R_{t+1} + (V_t^c - D_t^d)\frac{dR_{t+1}}{dK_t} = \left((1-\delta) + \frac{dI_t^e}{dK_t}\right) q_t^e R_{t+1}^I, \tag{IA.25}$$

which yields

$$R_{t+1} = R_{t+1}^I - \frac{V_t^c - D_t^d}{\left((1-\delta) + \frac{dI_t^e}{dK_t}\right) q_t^e} \frac{dR_{t+1}}{dK_t}. \tag{IA.26}$$

Applying conditional expectations to both sides of Equation IA.26, we get

$$\mathbb{E}_t[R_{t+1}] = \mathbb{E}_t[R_{t+1}^I] - \frac{V_t^c - D_t^d}{\left((1-\delta) + \frac{dI_t^e}{dK_t}\right) q_t^e} \mathbb{E}_t\left[\frac{dR_{t+1}}{dK_t}\right], \tag{IA.27}$$

which, assuming that R satisfies the usual regularity conditions, yields

$$\mathbb{E}_t[R_{t+1}] = \mathbb{E}_t[R_{t+1}^I] - \frac{V_t^c - D_t^d}{\left((1-\delta) + \frac{dI_t^e}{dK_t}\right) q_t^e} \frac{d\mathbb{E}_t[R_{t+1}]}{dK_t}. \tag{IA.28}$$

Finally, solving IA.23 for $\frac{dI_t^e}{dK_t}$ and plugging in the solution into Equation IA.28, we get Equation 31.[IA.2]

[IA.2] We can also derive $\frac{dI_t^e}{dK_t}$ directly. First, note that for the equilibrium investment function $I_t^e = I(K_t, q_t^e)$ it holds that $\frac{dI_t^e}{dK_t} = \partial_K I_t + \partial_q I_t \frac{dq_t^e}{dK_t}$. From payout market clearing, $D_t^d = D_t$, we have (by differentiating both sides with respect to K_t), $\partial_K D_t^d = \partial_K D_t + \partial_I D_t \frac{dI_t^e}{dK_t} = \partial_K D_t - ((1-\tau)\partial_I \Phi_t + 1)\frac{dI_t^e}{dK_t} = \partial_K D_t - q_t^e \frac{dI_t^e}{dK_t}$, so we get

$$\frac{dI_t^e}{dK_t} = \frac{\partial_K D_t - \partial_K D_t^d}{q_t^e} = \frac{(1-\tau)(\partial_K \Pi(K_t, Z_t) - \partial_K \Phi(K_t, I_t^e)) + \tau\delta - \partial_K D_t^d}{q_t^e}.$$

B.3 Model solution

We start with the equilibrium average Tobin's q. In equilibrium, we have

$$Q_t^e = \frac{V_t^c - D_t^d}{K_{t+1}} = \frac{1}{K_{t+1}} \frac{\mathbb{E}_t[V_{t+1}^c]}{\mathbb{E}_t[R_{t+1}]} = \frac{\mathbb{E}_t[K_{t+2} \cdot Q_{t+1}^e + D_{t+1}^d]}{K_{t+1} \cdot \mathbb{E}_t[R_{t+1}]}. \tag{IA.29}$$

Finally, recalling that the law of motion for capital yields $\frac{K_{t+2}}{K_{t+1}} = 1 - \delta + i_{t+1}^e$, we get

$$Q_t^e = \frac{\mathbb{E}_t[(1-\delta+i_{t+1}^e) \cdot Q_{t+1}^e + d_{t+1} y_{t+1}]}{\mathbb{E}_t[R_{t+1}]}. \tag{IA.30}$$

We can now turn to the firm's expected return. Note that, by application of the chain rule,

$$\frac{d\mathbb{E}_t[R_{t+1}]}{dK_t} = \frac{d\mathbb{E}_t[R_{t+1}]}{dk_t} \frac{dk_t}{dK_t} = \frac{1}{K_t} \frac{d\mathbb{E}_t[R_{t+1}]}{dk_t}. \tag{IA.31}$$

Furthermore, Equation IA.23 yields

$$\frac{dI_t^e}{dK_t} = \frac{(1-\tau)\left(\eta\alpha Z_t K_t^{\eta-1} + \frac{a}{2}(i_t^e)^2\right) + \tau\delta - \eta Z_t K_t^{\eta-1} d_t}{q_t^e}. \tag{IA.32}$$

Plugging the expressions of Equations IA.31 and IA.32 into Equation IA.28, we get

$$\mathbb{E}_t[R_{t+1}] = \mathbb{E}_t[R_{t+1}^I] - \frac{V_t^c - D_t^d}{(1-\delta)q_t^e + (1-\tau)\left(\eta\alpha Z_t K_t^{\eta-1} + \frac{a}{2}(i_t^e)^2\right) + \tau\delta - \eta Z_t K_t^{\eta-1} d_t} \frac{1}{K_t} \frac{d\mathbb{E}_t[R_{t+1}]}{dk_t}, \tag{IA.33}$$

which yields

$$\mathbb{E}_t[R_{t+1}] = \mathbb{E}_t[R_{t+1}^I] - \frac{\frac{K_{t+1}}{K_t} Q_t^e}{(1-\delta)q_t^e + (1-\tau)\left(\eta\alpha Z_t K_t^{\eta-1} + \frac{a}{2}(i_t^e)^2\right) + \tau\delta - \eta Z_t K_t^{\eta-1} d_t} \frac{d\mathbb{E}_t[R_{t+1}]}{dk_t}. \tag{IA.34}$$

Finally, we can rewrite Equation IA.34 in terms of stationary variables, as follows:

$$\mathbb{E}_t[R_{t+1}] = \mathbb{E}_t[R_{t+1}^I] - \frac{(1-\delta+i_t^e)Q_t^e}{(1-\delta)q_t^e + (1-\tau)\left(\eta\alpha y_t + \frac{a}{2}(i_t^e)^2\right) + \tau\delta - \eta y_t d_t} \frac{d\mathbb{E}_t[R_{t+1}]}{dk_t}. \tag{IA.35}$$

The equilibrium investment return is given by

$$R_{t+1}^I = \frac{(1-\tau)\left(\eta\alpha Z_{t+1} K_{t+1}^{\eta-1} + \frac{a}{2}(i_{t+1}^e)^2\right) + \tau\delta + (1-\delta)q_{t+1}^e}{q_t^e} = \frac{(1-\tau)\left(\eta\alpha y_{t+1} + \frac{a}{2}(i_{t+1}^e)^2\right) + \tau\delta + (1-\delta)q_{t+1}^e}{q_t^e}. \tag{IA.36}$$

Plugging the expression of Equation IA.36 into Equation IA.35, we get

$$\mathbb{E}_t[R_{t+1}] = \mathbb{E}_t\left[\frac{(1-\tau)\left(\eta\alpha y_{t+1} + \frac{a}{2}(i_{t+1}^e)^2\right) + \tau\delta + (1-\delta)q_{t+1}^e}{q_t^e}\right] - \frac{(1-\delta+i_t^e)Q_t^e}{(1-\delta)q_t^e + (1-\tau)\left(\eta\alpha y_t + \frac{a}{2}(i_t^e)^2\right) + \tau\delta - \eta y_t d_t}\frac{d\mathbb{E}_t[R_{t+1}]}{dk_t}, \quad \text{(IA.37)}$$

so, denoting $R^e(k_t, z_t, d_t) \equiv \mathbb{E}_t[R_{t+1}]$, we get Equation 48 in the main text.

We jointly solve for functions $Q^e(k_t, z_t, d_t)$ and $R^e(k_t, z_t, d_t)$ using Equations 47 and 48 and the laws of motion for k, z, and d (Equations 45, 36, and 38, respectively). For our numerical computations, we use a grid of 100 equally spaced points for k, z, and d. The grid points are selected so that they cover all possible values that the state variables take during our simulations. In particular, we first simulate the state variables k, z, and d (a process that does not require solving for Q and R^e) over 440,000 years, and we then, for each state variable, we set the minimum (maximum) grid point slightly below (above) the lowest (highest) simulated value for the state variable. To avoid interpolation in the model solution (when computing expectations), we transform the bivariate stochastic process $[z_t,\ d_t]$ into a bivariate discrete state space Markov chain with $100 \times 100 =$ 10,000 states, covering all grid points selected for $[z_t,\ d_t]$ using a Gaussian quadrature to determine the transition probabilities. Similarly, we approximate Equation 45 by setting k_{t+1} to the closest corresponding point in the k grid. Finally, we use the central finite difference method to approximate $\frac{\partial R^e(k_t,z_t,d_t)}{\partial k_t}$.

B.4 The linear homogeneous case

In the case of linear homogeneity, we can use the properties

$$\Pi(Z_t, K_t) = K_t \cdot \partial_K \Pi(Z_t, K_t), \quad \text{(IA.38)}$$

and

$$\Phi(K_t, I_t) = K_t \cdot \partial_K \Phi(K_t, I_t) + I_t \cdot \partial_I \Phi(K_t, I_t). \quad \text{(IA.39)}$$

Then, the investment optimality condition becomes

$$q_t = 1 + \partial_I \Phi(K_t, I_t) = 1 + (\Phi(K_t, I_t) - K_t \partial_K \Phi(K_t, I_t))/I_t, \quad \text{(IA.40)}$$

and we can rewrite the firm payout as follows:

$$D_t = (1-\tau)\left(\partial_K \Pi(Z_t, K_t) - \partial_K \Phi(K_t, I_t)\right) K_t - q_t I_t + \tau\delta K_t = \partial_K D(Z_t, K_t, I_t) K_t - q_t I_t. \quad \text{(IA.41)}$$

Equation IA.41 implies that, in equilibrium,

$$\mathbb{E}_t[M_{t+1}D_{t+1}] = \mathbb{E}_t[M_{t+1}(\partial_K D(Z_{t+1}, K_{t+1}, I^e_{t+1})K_{t+1} - q^e_{t+1}I^e_{t+1})]. \tag{IA.42}$$

We can now use the property $q^e_t = \mathbb{E}_t\left[M_{t+1}\left(\partial_K D(K_{t+1}, Z_{t+1}, I^e_{t+1}) + (1-\delta)q^e_{t+1}\right)\right]$ to rewrite Equation IA.42 as follows:

$$\mathbb{E}_t[M_{t+1}D_{t+1}] = \left(q^e_t - \mathbb{E}_t[M_{t+1}(1-\delta)q^e_{t+1}]\right)K_{t+1} - \mathbb{E}_t[M_{t+1}q^e_{t+1}I^e_{t+1}] = q^e_t K_{t+1} - \mathbb{E}_t[M_{t+1}q^e_{t+1}K_{t+2}]. \tag{IA.43}$$

Iterating and applying the law of iterated expectations, we get

$$\mathbb{E}_t[M_{t+1}D_{t+1}] = q^e_t K_{t+1} - \mathbb{E}_t[M_{t+2}(D_{t+2} + q^e_{t+2}K_{t+3})], \tag{IA.44}$$

which yields

$$\mathbb{E}_t[M_{t+1}D_{t+1}] + \mathbb{E}_t[M_{t+2}D_{t+2}] = q^e_t K_{t+1} - \mathbb{E}_t[M_{t+2}q^e_{t+2}K_{t+3}]. \tag{IA.45}$$

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

$$q^e_t K_{t+1} = \mathbb{E}_t\left[\sum_{s=1}^{\infty} M_{t+s}D_{t+s}\right] = V^c_t - D_t, \tag{IA.46}$$

which implies that, in equilibrium, the firm's average Tobin's q, $Q^e_t = \frac{V^c_t - D^d_t}{K_{t+1}}$, is equal to the its marginal Tobin's q:

$$Q^e_t = q^e_t. \tag{IA.47}$$

It is important to note that the transversality condition imposes restrictions on the admissible exogenous payout processes. In particular, recall that, in equilibrium, we have

$$\mathbb{E}_t[M_{t+1}V^c(K_{t+1}, Z_{t+1}, d_{t+1})] = V^c(K_t, Z_t, \varphi_t) - D^d(K_t, Z_t, d_t). \tag{IA.48}$$

Differentiating both sides of Equation IA.48 with respect to K_t and recalling the definition of q, we get

$$\frac{dK_{t+1}}{dK_t}q^e_t = \partial_K V^c(K_t, Z_t, d_t) - \partial_K D^d(K_t, Z_t, d_t). \tag{IA.49}$$

In equilibrium, we have

$$\frac{dK_{t+1}}{dK_t} = (1-\delta) + \frac{dI_t^e}{dK_t} = (1-\delta) + \frac{q_t^e - 1}{a(1-\tau)} + \frac{1}{a(1-\tau)}\frac{dq_t^e}{dK_t}K_t. \tag{IA.50}$$

Furthermore, we know that

$$V^c(K_t, Z_t, d_t) - D^d(K_t, Z_t, d_t) = q_t^e K_{t+1} = q_t^e\left((1-\delta) + \frac{q_t^e - 1}{a(1-\tau)}\right)K_t, \tag{IA.51}$$

so, differentiating both sides of Equation IA.51 with respect to K_t, we get

$$\partial_K V^c(K_t, Z_t, d_t) - \partial_K D^d(K_t, Z_t, d_t) = \left((1-\delta) + \frac{2q_t^e - 1}{a(1-\tau)}\right)\frac{dq_t^e}{dK_t}K_t + q_t^e\left((1-\delta) + \frac{q_t^e - 1}{a(1-\tau)}\right). \tag{IA.52}$$

Plugging the expressions of Equations IA.50 and IA.52 into Equation IA.49, we get, after some algebra,

$$\left((1-\delta) + \frac{q_t^e - 1}{a(1-\tau)}\right)\frac{dq_t^e}{dK_t}K_t = 0. \tag{IA.53}$$

This holds across the state space only if

$$\frac{dq_t^e}{dK_t} = 0, \tag{IA.54}$$

which, given Equation 43, is equivalent to

$$\partial_K(D^d(K_t, Z_t, d_t)/K_t) = 0. \tag{IA.55}$$

Therefore, the transversality condition imposes the restriction that payout demand $D^d(K_t, Z_t, d_t)$ has to be linear in K_t. Our main text specification is consistent with that restriction.

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

$$R_{t+1} = \frac{V_{t+1}^c}{V_t^c - D_t^d} = \frac{D_{t+1}^d + q_{t+1}^e K_{t+2}}{q_t^e K_{t+1}} = \frac{\frac{D_{t+1}^d}{K_{t+1}} + q_{t+1}^e\left((1-\delta) + \frac{q_{t+1}^e - 1}{a(1-\tau)}\right)}{q_t^e}. \tag{IA.56}$$

The equilibrium investment return is

$$R_{t+1}^I = \frac{(1-\tau)\left(\partial_K \Pi(K_{t+1}, Z_{t+1}) - \partial_K \Phi(K_{t+1}, I_{t+1}^e)\right) + \tau\delta + (1-\delta)q_{t+1}^e}{q_t^e}, \tag{IA.57}$$

which yields, using Equations IA.38, IA.39 and IA.40,

$$R^I_{t+1} = \frac{\frac{D(K_{t+1},Z_{t+1},q^e_{t+1})}{K_{t+1}} + \frac{I^e_{t+1}}{K_{t+1}}q^e_{t+1} + (1-\delta)q^e_{t+1}}{q^e_t} = \frac{\frac{D(K_{t+1},Z_{t+1},q^e_{t+1})}{K_{t+1}} + q^e_{t+1}\left((1-\delta) + \frac{q^e_{t+1}-1}{a(1-\tau)}\right)}{q^e_t}. \tag{IA.58}$$

Given the equilibrium condition $D(K_{t+1}, Z_{t+1}, q^e_{t+1}) = D^d_{t+1}$, we conclude that

$$R_{t+1} = R^I_{t+1}. \tag{IA.59}$$

This result is consistent with Equation IA.26. Indeed, since D^d/K and q^e are independent of K, differentiating both sides of Equation IA.56 with respect to K_t yields $\frac{dR_{t+1}}{dK_t} = 0$. Finally, applying conditional expectations to both sides of Equation IA.59, we get

$$\mathbb{E}_t[R_{t+1}] = \mathbb{E}_t[R^I_{t+1}]. \tag{IA.60}$$

C Data sources and empirical measures

We map profit Π_t, sales Y_t, sales-to-capital ratios $y_t = Y_t/K_t$, and payout ratios $d_t = D_t/Y_t$ 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

$$D_t = V_t \cdot \left(\frac{V_{e,t}}{V_t} \cdot \frac{D_{e,t}}{V_{e,t}} + \frac{V_{b,t}}{V_t} \cdot \frac{D_{b,t}}{V_{b,t}}\right) \tag{IA.61}$$

where $V_{e,t}$ and $V_{b,t}$ are the aggregate market value of equity and debt, respectively, $V_t = V_{e,t} + V_{b,t}$ is the aggregate market value of U.S. public corporations, $D_{e,t}$ is their aggregate equity payout, and $D_{b,t}$ is their aggregate debt payout.

We use the DRSY dataset for data on the market value of equity ($V_{e,t}$) and debt ($V_{b,t}$) 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 ($D_{b,t}$) data. Hence, in Equation IA.61, the measures for V_t, $V_{e,t}/V_t$, $V_{b,t}/V_t$ and $D_{b,t}/V_{b,t}$ are constructed using the DRSY dataset. However, we calculate $D_{e,t}/V_{e,t}$ using data from CRSP, which is the original data source for $D_{e,t}/V_{e,t}$ in the DRSY dataset, as follows.[IA.3] 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 $D_{e,t} = V_{e,t-1} \cdot (1 + R_{e,t}) - V_{e,t}$ (where $R_{e,t}$ is based on the RET variable in CRSP). We assume that the first month of non-missing market equity is the firm's entry month in the public market portfolio so that $V_{e,t-1} = 0$ and $D_{e,t} = -V_{e,t}$ for the firm at that month. Moreover, in the delisting month we set $V_{e,t} = 0$ and $D_{e,t} = V_{e,t-1} \cdot (1+R_{e,t})$, 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 $V_{e,t}$ 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 $V_{e,t}$ across PERMNOs at the end of each December to obtain the aggregate $V_{e,t}$. Finally, we compute the aggregate $D_{e,t}/V_{e,t}$ and use it in Equation IA.61.

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

Similarly, we measure profit as $\Pi_t = V_{e,t} \cdot (\Pi_t/V_{e,t})$, with $V_{e,t}$ from the DRSY dataset and $\Pi_t/V_{e,t}$

[IA.3] We do not use the $D_{e,t}/V_{e,t}$ values from the DRSY dataset for two reasons. First, the average DRSY $D_{e,t}/V_{e,t}$ ratio is 1.7%, which implies a very high cash flow duration for the equity market, sometimes leading to infinite firm value in our model with $\eta < 1$. In contrast, our average $D_{e,t}/V_{e,t}$ 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 $D_{e,t}$ measure partially reflects the market value of firms, mixing cash flows with asset prices. Specifically, let $D_{e,t}$ be the equity payout measured directly from CRSP, $D^*_{e,t}$ the payout from the portfolio that accounts for equity cross-holdings, and κ_t the fraction of the equity market held by public firms. DRSY assume $(D_{e,t} + V_{e,t})/V_{e,t-1} = (D^*_{e,t} + \kappa_t \cdot V_{e,t})/(\kappa_{t-1} \cdot V_{e,t-1})$, which allows them to measure their equity payout as

$$D^*_{e,t} = \kappa_{t-1} \cdot D_{e,t} - \Delta\kappa_t \cdot V_{e,t}$$

so $V_{e,t}$ affects the DRSY $D_{e,t}$. 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 $D^*_{e,t} = (\kappa_t \cdot V_{e,t}) \cdot (D_{e,t}/V_{e,t}) = \kappa_t \cdot D_{e,t}$, which does not include any asset pricing effect. Nonetheless, the correlation between the DRSY D/V 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.

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 the sales-to-capital ratio $y_t = Y_t/K_t$ 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 y_t series as follows (consistent with our model):

$$y_t = Y_t/K_t, \tag{IA.62}$$

$$q_t = \sqrt{1 + 2 \cdot a \cdot (1-\tau) \cdot (\tau \cdot \delta + (1-\tau) \cdot \alpha \cdot y_t - d_t \cdot y_t)}, \tag{IA.63}$$

$$i_t = \frac{q_t - 1}{a \cdot (1-\tau)}, \tag{IA.64}$$

$$K_{t+1} = (1 - \delta + i_t) \cdot K_t. \tag{IA.65}$$

We iterate on this process until our initial arbitrary K_t value leads to an initial y_t that matches the average y_t over the sample.

We can now turn to returns. We have

$$R_{t+1} = \frac{V_{t+1} + D_{t+1}}{V_t}, \tag{IA.66}$$

where V_t is measured as described previously and D_t is measured as in Equation IA.61. The returns in the DRSY dataset differ from ours because we do not use their $D_{e,t}$ measure (as discussed in Footnote IA.3). 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 $\sigma[R] = 14.9\%$.