Payout-Based Asset Pricing

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Abstract

Firms' payout decisions respond to expected returns: everything else equal, firms invest less and pay out more when their cost of capital increases. Given investors' demand for firm payout, market clearing implies that productivity and payout demand dynamics fully determine equilibrium asset prices and returns. Using this logic, we propose a payout-based asset pricing framework. To operationalize it, we introduce a quantitative model, calibrating the productivity and payout demand processes to match aggregate U.S. corporate output and payout moments. Model-implied payout yields and firm returns match key empirical moments, and model-implied expected returns predict future firm returns in the data.

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Keywords: Payout-Based Asset Pricing; Production-Based Asset Pricing; Investment-Based Asset Pricing; Market Returns; Return Predictability.

1 Introduction

This paper introduces a new framework within the production-based asset pricing paradigm, called payout-based asset pricing. In our framework, a firm's payout supply is derived from its optimality conditions, while payout demand is treated as exogenous. Equilibrium expected returns are, then, determined by the clearing of the payout market, without requiring the recovery of the economy's stochastic discount factor (SDF). Therefore, our approach differs from strands of the production-based literature that either derive the SDF from the firm's optimality conditions (e.g., Cochrane (1988), Jermann (2010), Belo (2010)) or assume that the firm optimizes its behavior taking into account an exogenous SDF (e.g., Zhang (2005)). Our approach also differs from the investment-based asset pricing strand of the production-based paradigm, which empirically examines the relationship between realized firm returns and realized investment returns, without deriving the SDF or equilibrium expected returns (e.g., Cochrane (1991)).

Our key insight is as follows. To pin down a firm's equilibrium expected return, we focus on supply and demand in the payout market: the firm's optimality conditions yield its payout supply policy, while we posit an exogenous process for payout demand, which reflects in reduced form the optimal payout demand of investors, without the need to explicitly specify their preferences. It follows that the firm's equilibrium expected return exhibits time variation both due to changes in the firm's desired payout, which arise from supply-side shocks (such as productivity shocks), and due to exogenous fluctuations in investors' payout demand, which reflect demand-side shocks (such as taste shocks) in reduced form. As we argue in our paper, if the exogenous payout demand process is correctly specified (i.e., if it reflects the true equilibrium payout process), then market clearing recovers the true equilibrium expected return.[1]

It can be argued that, alternatively, one could specify an exogenous process for investment (rather than payout) demand and back out equilibrium expected returns by imposing clearing in the investment market. However, that approach would lead to conceptual problems since both investment demand and investment supply arise from firms', rather than investors', optimizing behavior. Furthermore, from a practical perspective, defining and measuring investment is a difficult task. Whereas the early literature largely focuses on physical capital (the measurement of which poses non-trivial problems, see Bai, Li, Xue and Zhang (2024)), recent papers demonstrate the importance of other capital inputs, such as intangibles and working capital (e.g., Gonçalves, Xue and Zhang (2020) and Belo, Gala, Salomao and Vitorino (2022)), complicating the measurement issue even further. On the other hand, firm payout can be unambiguously defined and measured, facilitating the calibration and testing of payout-based asset pricing models. As we show below, those

[1] In a sense, our framework flips the logic of the consumption-based asset pricing framework, which uses the household's optimality conditions in order to retrieve the payout demand policy and posits an exogenous process for payout supply (which reflects in reduced form the optimal payout supply of firms, without explicitly specifying their production technology).

practical advantages yield important empirical benefits.

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

We solve for the model's equilibrium expected firm return numerically and show that it increases with the payout demand ratio, but is almost completely insensitive to firm productivity, indicating that most of the variation in the firm's expected return arises from variation in the payout demand ratio. Intuitively, exogenous fluctuations in the payout demand ratio necessitate corresponding shifts in the firm's payout supply for the payout market to clear, and those supply shifts are achieved by changes in the firm's equilibrium expected rate of return. Our model-implied expected returns strongly predict future aggregate firm returns, with a regression adjusted R^2 of 6.05%.[2] Panel A of Figure 1 illustrates the ability of our model to produce empirically plausible expected returns by plotting both the time series of our model-implied expected returns and the time series of empirically estimated expected returns, i.e., expected returns recovered by regressing one-year realized firm returns on lagged payout yields (payout over firm value), payout ratios (payout over output), and productivity (output over capital). As seen in the graph, the two expected return measures exhibit a very high degree of unconditional correlation (the correlation coefficient is 0.86), suggesting that our model is able to match empirical measures of expected returns very well.

We, then, simulate the model and show that it goes a long way in matching key asset pricing moments. Specifically, the model generates an average payout yield of 2.60% and payout yield volatility of 4.37%, which are very close to the respective empirical values of 1.59% and 2.47%. Furthermore, the model implies an average firm return of 5.46% and a firm return volatility of 12.78%, with the corresponding empirical moments being 7.86% and 14.88%. 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

[2] We also show that the expected firm returns generated by a model similar to ours, but with an exogenous investment (rather than payout) process, do not predict realized firm returns in the data using a range of investment measures, highlighting that payout-based and investment-based asset pricing models can yield very different expected returns.

moments. However, our main message is that even a simple payout-based asset pricing setup with a reasonable parametrization goes a long way in generating realistic asset pricing implications.

Part of the firm return volatility in the model arises from time-varying expected returns. To explore the properties of expected returns, we consider forecasting regressions of annual firm returns on lagged payout yields. In both the data and the model, there is a positive association between the two, with the model predictive coefficient (1.47) 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 the lagged payout ratio, which 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.

While our model's main mechanism for time-varying expected returns is supported by the data, we show that our model-implied expected equilibrium returns are overly sensitive to changes in the payout ratio compared to the data. That "excess sensitivity puzzle" is illustrated in Panel B of Figure 1, which plots the fitted values from regressions of one-year realized firm returns (in the model and the data) on lagged payout ratios. As seen in the graph, model-implied expected returns are far more sensitive to changes in the payout ratio than actual expected returns. We argue that the excess sensitivity likely stems from the fact that baseline models, such as ours, assume that raising external funding is frictionless. In richer models, the time variation in external financing costs incentivizes firms to time payouts in order to reduce frictions, potentially attenuating the sensitivity of firm payouts to expected returns. Hence, the excess sensitivity puzzle may be related to the "saving waves" documented in Eisfeldt and Muir (2016).

Since our approach does not recover the full set of state prices, one drawback of payout-based asset pricing is that, in the absence of additional information, it can only be used to price claims on a particular payout process. However, that drawback is not particularly restrictive: we can use our approach in order to price any claims, provided that we know the corresponding technologies and payout demand processes. To highlight that, we also introduce a more complex version of our model, which features a levered representative firm that is financed by equity and one-period safe debt. The joint optimization of the firm's investment and capital structure policies yields separate optimal supply schedules for equity and debt payouts. The firm faces exogenous payout demand ratios for debt and equity from investors, so equity and debt returns are endogenously determined by the clearing of the equity and debt payout markets, respectively. The model is able to match the properties of firm and equity returns quite well, replicating the good performance of the unlevered firm model, but is less successful in matching debt returns. Our model's limited success in replicating the empirical properties of debt returns partly stems from the assumption that the firm is able to only issue one-period safe debt, which implies that debt returns and risk-free rates are identical. Benchmarking our model-implied debt returns against empirical risk-free rates yields a more favorable assessment of our model.

Our payout-based asset pricing approach is analogous to the consumption-based asset pricing framework (Lucas (1978) and Breeden (1979)). In particular, while consumption-based asset pricing models solve for equilibrium expected returns by equating a postulated payout supply process to endogenous payout demand, in our payout-based asset pricing framework we solve for equilibrium expected returns by equating a postulated payout demand process to endogenous payout supply. Even though the consumption-based asset pricing setup is unrealistic, it generates the same expected return as a fully specified general equilibrium economy (i.e., an economy in which households and firms both optimize their behavior) as long as the postulated payout supply process coincides with the equilibrium payout process in the fully specified economy.[3] Similarly, our payout-based asset pricing framework generates the same expected return as a fully specified economy as long as the postulated payout demand process coincides with the equilibrium payout in that economy.

Our paper contributes to the production-based asset pricing literature, which aims to connect the production side of the economy with asset prices. Our key contribution lies in developing a framework which uses firms' optimality conditions and market clearing in order to retrieve equilibrium expected returns, without the need to recover the economy's SDF. Importantly, our approach shifts the focus from firms' investment processes to their payout processes. As discussed before, that shift has both conceptual and practical advantages. As a result, our approach produces expected returns that exhibit a tight connection with observed firm returns, consistent with the theory. We provide a detailed discussion of the relation of our approach with the rest of the production-based asset pricing literature in the next section.

The rest of this paper is organized as follows. Section 2 introduces our payout-based asset pricing model with an unlevered firm and discusses its qualitative properties, as well as its relation to the rest of the production-based asset pricing literature and to the consumption-based asset pricing paradigm. Section 3 reports the quantitative output of our model. Section 4 discusses a version of our model that includes a levered representative firm, which allows us to study the properties of equity and debt returns separately. Finally, Section 5 concludes. The Internet Appendix includes model derivations, as well as details on data sources and empirical measures, that are omitted from the main text.

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

2 Baseline Framework

In this section, we introduce our payout-based asset pricing framework. First, we describe our model and discuss its properties. Then, we compare our approach with investment-based asset pricing and consumption-based asset pricing and illustrate similarities and differences.

2.1 A payout-based asset pricing model

We start with the description of our payout-based asset pricing model, which features an optimizing equity-financed representative firm with an infinite horizon and an exogenous payout demand process. All derivations for the results in this section can be found in Internet Appendix A.

2.1.1 Setting

Consider an unlevered representative firm with operating profit

$$\Pi(K, Z) = \alpha \cdot Z \cdot K = \alpha \cdot Y, \tag{1}$$

where K is the firm's capital stock, Z is an exogenous productivity process, $Y = Z \cdot K$ is the firm's output, and $\alpha \in (0, 1)$ is the firm's operating profit margin.[4] The exogenous productivity process Z satisfies $Z_t = e^{z_t}$, where z is a stationary process that has law of motion

$$z_{t+1} = \mu_z + \phi_z(z_t - \mu_z) + \sigma_z \epsilon^z_{t+1}, \tag{2}$$

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

$$K_{t+1} = I_t + (1 - \delta)K_t, \tag{3}$$

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

$$\Phi(K, I) = \frac{a}{2} \cdot (I/K)^2 \cdot K. \tag{4}$$

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

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

$$D_t = (1 - \tau)\left(\Pi(K_t, Z_t) - \Phi(K_t, I_t)\right) - I_t + \tau\delta K_t, \tag{5}$$

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

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

$$V_t = \max_{\{I_{t+h}, D_{t+h}\}_{h=0}^{\infty}} \{D_t + \sum_{h=1}^{\infty} \mathbb{E}_t[M_{t,t+h} D_{t+h}]\}, \tag{6}$$

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

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

$$D^d(K, Z, d) = d \cdot Z \cdot K = d \cdot Y, \tag{7}$$

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

$$d_{t+1} = \mu_d + \phi_d \cdot (d_t - \mu_d) + \sigma_{d,t} \cdot \epsilon_{t+1}^d, \tag{8}$$

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

$$\sigma_{d,t} = \sigma_d \cdot \sqrt{d_t^{max} - d_t}, \tag{9}$$

where $\sigma_d > 0$ and d_t^{max} is the conditional upper bound of d, given by

$$d_t^{max} = (1 - \tau)\alpha + e^{-z_t}\left[\left(1 - \frac{(1 - \tau)a}{2} \cdot \varphi\right)\varphi + \tau\delta\right], \tag{10}$$

where $\varphi = \min\{1/(a(1 - \tau)), 1 - \delta\}$.

In our specification, the payout demand function D^d is linear in the firm's capital stock K. That assumption is necessary in order for the exogenous payout demand to be consistent with the firm's behavior: given its technology, the firm's optimal payout is always (i.e., for any SDF specification) proportional to its capital stock, so a postulated D^d process that violates that restriction cannot be consistent with any investor preferences. Similarly, as shown in Internet Appendix A, the assumption that the realizations of d have the conditional upper bound given by Equation 10 ensures that the model generates feasible firm payout and investment processes in equilibrium: in the absence of that bound, payout demand could have realizations too large to be satisfied by any feasible firm investment policy. Inter alia, as will be made clear when we derive the equilibrium properties of our model, that upper bound ensures that the equilibrium marginal q of the firm is always real-valued and non-negative.

2.1.2 Payout supply

The firm's problem can be rewritten recursively as

$$V(K_t, Z_t; \{f_t(M_{t,t+h})\}_{h=1}^{\infty}) = \max_{\{I_t\}} \{D_t + \mathbb{E}_t[M_{t,t+1} V(K_{t+1}, Z_{t+1}; \{f_{t+1}(M_{t+1,t+1+h})\}_{h=1}^{\infty})]\}, \quad (11)$$

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

The firm's first order condition is

$$\underbrace{\mathbb{E}_t[M_{t+1} \partial_K V(K_{t+1}, Z_{t+1}; \{f_{t+1}(M_{t+1,t+1+h})\}_{h=1}^{\infty})]}_{\equiv q_t} = 1 + (1-\tau)\partial_I \Phi(K_t, I_t), \quad (12)$$

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

$$I_t = I(K_t; q_t) = \frac{q_t - 1}{a(1-\tau)} K_t, \quad (13)$$

which specifies that the firm's optimal investment is proportional to its capital stock and increasing in the marginal q.[5] Therefore, the firm's payout supply satisfies

$$D_t = (1-\tau)\left(\Pi(K_t, Z_t) - \Phi(K_t, I(K_t; q_t))\right) - I(K_t; q_t) + \tau\delta K_t, \quad (14)$$

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

which, plugging in the investment function of Equation 13, yields the payout supply function

$$D_t = D(K_t, Z_t; q_t) = \left[(1-\tau)\alpha Z_t - \frac{q_t^2 - 1}{2a(1-\tau)} + \tau\delta\right] K_t. \tag{15}$$

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

Using the envelope condition, we obtain[6]

$$q_t = \mathbb{E}_t\left[M_{t+1}\left((1-\tau)(\partial_K \Pi(K_{t+1}, Z_{t+1}) - \partial_K \Phi(K_{t+1}, I_{t+1})) + \tau\delta + (1-\delta)q_{t+1}\right)\right]. \tag{17}$$

For any given set of conditional SDF distributions, Equation 17 implies a particular q_t process, which potentially depends on both the current state of the economy and the properties of future SDFs. Plugging that q_t into $I(K_t; q_t)$ and $D(K_t, Z_t; q_t)$ yields firm investment and payout policies. This is the approach taken by the subset of the production-based asset pricing literature that specifies exogenous SDFs (e.g., Zhang (2005)). We take a different approach: instead of specifying an exogenous SDF, we specify a payout demand process (Equation 8), which allows us to recover the equilibrium q process by imposing payout market clearing, as we detail next.

2.1.3 Equilibrium

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

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

[6] We can write Equation 17 as

$$\mathbb{E}_t\left[M_{t+1} \cdot R^I_{t+1}\right] = 1, \tag{16}$$

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

demand:

$$D(K_t, Z_t; q_t) = D^d(K_t, Z_t, d_t). \tag{18}$$

Using Equations 7 and 15, we can rewrite the payout market clearing condition as

$$\left[(1-\tau)\alpha Z_t - \frac{q_t^2 - 1}{2a(1-\tau)} + \tau\delta\right] K_t = d_t Z_t K_t, \tag{19}$$

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

$$q_t^* = q^*(z_t, d_t) = \sqrt{1 + 2a(1-\tau)\left[((1-\tau)\alpha - d_t)e^{z_t} + \tau\delta\right]}. \tag{20}$$

Notably, q_t^* does not depend on the firm's capital stock K_t. As discussed previously, our d specification (which imposes the restriction that $d_t \leq d_t^{max}$ for all t) ensures that q_t^* is always real-valued and increasing in productivity Z_t.

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

$$I_t^*/K_t^* = i^*(z_t, d_t) = \frac{\sqrt{1 + 2a(1-\tau)\left[((1-\tau)\alpha - d_t)e^{z_t} + \tau\delta\right]} - 1}{a(1-\tau)}, \tag{21}$$

and, trivially,

$$D_t^*/Y_t^* = d^*(z_t, d_t) = d_t, \tag{22}$$

respectively.

2.1.4 Equilibrium asset prices

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

$$V_t = D_t + q_t K_{t+1}, \tag{23}$$

so that

$$Q_t = q_t, \tag{24}$$

where the firm's average Tobin's q is defined as the ex-dividend value of the firm (P_t) per unit of capital: $Q_t \equiv \frac{P_t}{K_{t+1}} = \frac{V_t - D_t}{K_{t+1}}$. Furthermore, we show that the firm return is identical to the investment return:

$$R_{t+1} = R_{t+1}^I. \tag{25}$$

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

$$Q_t^* = Q^*(z_t, d_t) = \sqrt{1 + 2a(1-\tau)\left[((1-\tau)\alpha - d_t)e^{z_t} + \tau\delta\right]}, \tag{26}$$

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

$$\mathcal{R}^*(z_t, d_t) = \mathbb{E}\left[R_{t+1}^* \,\middle|\, z_t, d_t\right], \tag{27}$$

where

$$R_{t+1}^* = \frac{d_{t+1}e^{z_{t+1}} + Q^*(z_{t+1}, d_{t+1})\left(1 - \delta + \frac{Q^*(z_{t+1}, d_{t+1}) - 1}{a(1-\tau)}\right)}{Q^*(z_t, d_t)}. \tag{28}$$

We evaluate the functions $Q^*(z,d)$ and $\mathcal{R}^*(z,d)$ using Equations 26 and 27 and the laws of motion for the stationary state variables z and d (Equations 2 and 8, respectively). The integral needed for the evaluation of the $\mathcal{R}^*(z,d)$ function is computed using Gauss-Hermite quadrature, with 31 grid points per shock.

Figure 2 displays the equilibrium average q function, $Q^*(z,d)$, and the equilibrium expected return function, $\mathcal{R}^*(z,d)$, under the calibration described in Section 3.1. Panels A and B show the value of Q^* for different values of z and d, respectively, keeping the other state variable constant. We see that Q^* is increasing in z and decreasing in d. For a given level of d, the average price of a unit of installed capital is higher when firm productivity is higher. On the other hand, for a given level of z, the firm's Q^* is lower when the demanded payout is higher, suggesting a higher cash flow discount rate.

Panels C and D of Figure 2 show the value of $\mathcal{R}^*$ for different values of z and d, respectively, everything else constant. $\mathcal{R}^*$ is almost completely flat in z and strongly 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 desired payout, so payout market clearing requires a lower equilibrium expected return, given a fixed payout demand. On the other hand, due to the persistence of process z, higher current productivity implies higher future productivity, which entices the firm to increase current investment and lower current payout, pushing the equilibrium expected return higher. Under our parametrization, these two forces offset each other, producing an equilibrium expected return function that is effectively insensitive to z. As regards the payout demand process, an increase in d, other things equal, raises the payout demand from investors, without affecting the firm's operating profit, so payout market clearing requires an increase in the firm's cost of capital, which lowers investment and increases the firm's payout supply. Crucially, while the firm's expected return exhibits very moderate variation across different values of z, it is very sensitive with respect to d, underscoring the importance of payout demand as a driver of equilibrium expected returns. For the same reason, the firm's Q^* is much more sensitive to changes in d than to changes in z.

2.2 Relation to production-based asset pricing

Our payout-based asset pricing framework is part of the production-based asset pricing paradigm, which aims to connect the production side of the economy with asset prices (see Kogan and Papanikolaou (2012) and Zhang (2017) for literature reviews). This section details the similarities and differences between our framework and the main strands of the production-based asset pricing literature. Our key contribution lies in developing a framework which uses firms' optimality conditions and market clearing in order to retrieve equilibrium expected returns without the need to back out the economy's SDF. Furthermore, our framework shifts the focus from firms' investment processes to their payout processes, an approach that has considerable conceptual and practical benefits, as we detail below.

One strand of the production-based asset pricing literature consists of papers that retrieve the economy's SDF using firms' optimality conditions. A number of those papers (for instance, Cochrane (1988), Jermann (2010), and Jermann (2013)) consider standard production functions, which do not allow firms to shift resources across states of nature. In that case, recovering state prices requires the "complete technologies" assumption, i.e., that there are as many types of capital inputs as there are states of nature: for example, both Cochrane (1988) and Jermann (2010) assume two states of nature, consider two types of capital (each an input in a corresponding production technology) and recover state prices by positing exogenous investment growth processes. To avoid the "complete technologies" assumption, other papers (such as Belo (2010) and Cochrane (2021)) use non-standard production functions that allow producers to shift output across states of nature and generate firm optimality conditions that allow for the SDF to be recovered.[7]

The main difference of our payout-based asset pricing framework from that strand of the production-based asset pricing literature is that we do not need to recover the economy's SDF in order to characterize firms' expected returns; instead, we are able to back out a firm's equilibrium expected return process from its payout decisions by positing an exogenous payout demand process and imposing market clearing. The benefit of our approach is that it accommodates a continuum of states of nature while relying on a standard neoclassical model of firms (i.e., a standard production function with standard investment and financing structures). On the other hand, our approach has the obvious drawback that, in the absence of additional information, it can only be used to price claims on a particular payout process. However, this drawback is not as restrictive as it may appear: in principle, we can use the same approach in order to price other claims provided we know

[7] Relatedly, Steri (2023) considers standard production functions and recovers state prices within an optimal contracting framework in which firms transfer resources to lenders in a state-contingent way (which can be thought of as a "complete contracting" requirement).

the corresponding technologies and payout demand processes. As an example, Section 4 shows that our framework can be used to price debt and equity claims on a levered firm: given payout demand processes for equityholders and debtholders, we can jointly pin down the equilibrium expected equity and debt returns.

Another strand of the production-based asset pricing literature, often referred to as investment-based asset pricing, builds on the q-theory of investment.[8] Those papers do not attempt to back out the economy's SDF. Instead, they take the realizations of firms' investment and output, as well as equity and debt returns, as given and estimate firms' technological parameters by matching realized investment returns to realized firm returns, as dictated by the firms' optimality conditions. The closest paper to ours in that literature is Cochrane (1991), which, like ours, focuses on aggregate returns (other papers in this literature focus on the cross-section of returns). In particular, Cochrane (1991) postulates a firm production technology and uses aggregate U.S. investment data in order to retrieve the time-series of U.S. realized aggregate investment returns, statistically testing their similarity with the empirically observed realized aggregate equity returns.

The payout-based asset pricing framework is similar to investment-based asset pricing in one respect: neither approach relies on recovering the economy's SDF. However, our approach focuses on specifying an exogenous stochastic process for payout demand in order to retrieve equilibrium expected returns. On the other hand, the investment-based asset pricing literature has focused on testing the properties of realized returns, without specifying exogenous processes for investment demand that would allow for calculating expected returns. As a result, investment-based asset pricing papers have not explored the drivers of time variation in equilibrium expected returns, which is the focus of our paper. As we detail in Section 3, we use aggregate data on firm output and payout in order to calibrate exogenous processes for firm productivity and payout demand and we solve for equilibrium expected returns by imposing payout market clearing. Then, we simulate that economy and study the properties of equilibrium expected returns. Furthermore, in Section 4 we introduce a model that features a levered firm, which allows us to discuss expected equity returns and expected debt returns separately.

It is worth noting that, mathematically, a firm's expected return can also be recovered by assuming an exogenous process for investment demand and then imposing market clearing. While this is not what the investment-based asset pricing literature currently does, we could use that approach to recover expected returns in the context of a model that falls within the investment-based asset pricing framework. For example, we could replace Equations 7 and 8 with an expression for an

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

investment demand process,

$$I^d(K,i) = i \cdot K, \tag{29}$$

with the exogenous stochastic process i (investment demand per unit of capital) having law of motion

$$i_{t+1} = \mu_i + \phi_i \cdot (i_t - \mu_i) + \sigma_i \cdot \epsilon^i_{t+1}, \tag{30}$$

where $\phi_i \in (0,1)$, $\epsilon^i_{t+1} \sim N(0,1)$, $corr(\epsilon^z_{t+1}, \epsilon^i_{t+1}) = \rho_{z,i}$. Then, we could, in principle, impose market clearing by equating the exogenous investment demand with the firm's desired investment,

$$I(K_t; q_t) = I^d(K_t, i_t), \tag{31}$$

and get an expression for the firm's Q as a function of the exogenous state variables,

$$Q^*_t = Q^*(z_t, i_t) = 1 + a(1-\tau)i_t, \tag{32}$$

which would allow us to obtain the firm's expected return function:

$$\mathcal{R}^*(z_t, i_t) = \mathbb{E}\left[R^*_{t+1} \,\middle|\, z_t, i_t\right], \tag{33}$$

where

$$R^*_{t+1} = \frac{(1-\tau)(\alpha e^{z_{t+1}} + \frac{a}{2} i^2_{t+1}) + \tau\delta + (1-\delta)Q^*(z_{t+1}, i_{t+1})}{Q^*(z_t, i_t)}. \tag{34}$$

However, exogenously specifying investment demand is less preferable than exogenously specifying payout demand for two main reasons, one conceptual and the other more empirical in nature. Conceptually, both investment demand and investment supply arise from firms' optimizing behavior, as firms are both the buyers and the sellers of capital goods. Thus, in our representative firm economy, an exogenous investment demand process raises a fundamental issue: where does the exogenous investment demand process come from and what does it represent? By contrast, as we explain in detail in the next section, an exogenous payout demand process reflects household preferences in a reduced form manner, thereby providing the production-based counterpart to the consumption-based asset pricing framework.

From an empirical point of view, properly defining and measuring investment, which is essential for calibrating an exogenous investment process, is not easy. The early literature largely focuses on physical capital, the measurement of which can pose issues – see Bai et al. (2024). Furthermore, recent papers in the investment-based asset pricing literature demonstrate the importance of other capital inputs such as intangibles and working capital (e.g., Gonçalves et al. (2020) and Belo et al. (2022)), which complicates the definition and measurement of investment even more. In contrast, firm payout can be unambiguously defined and measured, making the calibration and testing of payout-based asset pricing models simpler and less subjective. As we show in Section 3, focusing on firm payout (rather than investment) has important quantitative benefits.

Finally, a number of production-based asset pricing papers propose partial equilibrium models that include an exogenous SDF (or exogenous risk neutral dynamics). In these models, firms' expected returns arise from their corporate policies, which determine the covariance of firms' returns with the SDF.[9] We take a different approach: instead of specifying an exogenous SDF, we assume an exogenous payout demand process and impose market clearing. The main benefit of our approach is that firm payout is observable: the payout demand processes can be calibrated to corporate payout data, ensuring that the model calibration is based on quantities, as opposed to prices. Thus, our approach sidesteps the problem of calibrating SDF parameters, which is often done by matching asset pricing moments (i.e., a subset of the moments the model is meant to explain).

2.3 Relation to consumption-based asset pricing

Our payout-based asset pricing framework is a direct analogue of the consumption-based approach. In particular, while consumption-based asset pricing focuses on household optimizing behavior and obtains equilibrium asset prices by equating the *endogenous payout demand* of households with an exogenous firm payout supply (i.e., cash flow), payout-based asset pricing relies on the optimal behavior of firms and retrieves equilibrium asset prices by equating the firm's *endogenous payout supply* with exogenous household payout demand.

We formalize that point through a simple two-period general equilibrium (GE) model. To conserve space, we relegate the two-period model details and all derivations to Internet Appendix B. The model features a representative (equity-financed) firm and a representative household. As is standard, the firm chooses its investment-payout policies by maximizing firm value while the household chooses its consumption-savings policies by maximizing lifetime utility. The firm's optimization problem yields a payout supply function, whereas the household's optimization problem yields a payout demand function. The equilibrium expected return of the firm is determined by the clearing of the payout market (i.e., it is the expected return that equalizes the desired payout supply of the firm with the desired payout demand of the household). Then, we show that the firm's equilibrium expected return in both the consumption-based model and our payout-based model retrieves its GE counterpart, *provided that the respective exogenous processes are correctly specified.* The difference

[9] That literature builds on the models developed in Berk, Green and Naik (1999) and Zhang (2005) and includes, inter alia, the models in Kogan and Papanikolaou (2010), Belo and Lin (2012), Belo and Yu (2013), Jones and Tuzel (2013), Belo, 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 closest to ours: 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.

between the two models is that each of them focuses on a different side of the payout market.

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. The payout market clears when the optimizing household's equilibrium consumption is equal to the firm's exogenous payout supply (i.e., the economy's endowment). This implies that the equilibrium expected return is pinned down by the household's optimality condition: it is the expected return that satisfies the household's Euler equation when the market clearing condition is imposed (i.e., the expected return for which the household optimally consumes the firm's exogenous payout supply). If the exogenously specified payout supply (i.e., endowment) process in the consumption-based model is equal to the endogenously determined equilibrium payout in the GE economy, then the expected return process in the consumption-based model retrieves the same equilibrium expected return process as the GE economy. It follows that the endowment shocks reflect, in reduced form, the supply-side shocks (for example, firm productivity shocks) of the GE economy.

Our payout-based asset pricing framework turns that logic around. In our model, we have an exogenous payout demand (which is equal to the household consumption demand in a simple model without labor income). The equilibrium expected return is pinned down by the equalization of the optimizing firm's endogenous payout supply with the exogenous payout demand: in equilibrium, the firm's payout needs to match the exogenous payout demand. So the equilibrium expected return is the expected return that satisfies the firm's Euler equation (i.e., the expected return for which the firm optimally supplies the household's exogenous payout demand). If the exogenously specified payout demand process in the payout-based model is equal to the endogenously determined equilibrium payout in the GE economy, then the payout-based model retrieves the same equilibrium expected return process as the GE economy. Thus, the payout demand shocks reflect, in reduced form, the demand-side shocks (e.g., household taste shocks) of the GE economy.[10]

3 Quantitative Results

This section provides the quantitative results from our payout-based asset pricing model. We start by describing our calibration process. Then, we provide a comparison between our model and an analogous investment-based asset pricing model. Finally, we simulate our payout-based asset pricing model and discuss its properties.

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

3.1 Calibration

We report our model calibration in Table 1. Tax and technological parameters are calibrated following the extant literature: we set $\tau = 0.35$ and $\delta = 0.15$, following DeAngelo, DeAngelo and Whited (2011). Since the capital adjustment cost specification in DeAngelo et al. (2011) is not comparable to ours, we set the adjustment cost parameter such that the adjustment cost annual expense is 10% of the firm's capital in the steady state (which corresponds to less than 5% of the firm's annual output in the steady state).[11] The resulting value of $a = 9.953$ is squarely within the range of values used in the prior quantitative literature, as documented by Li et al. (2023). Finally, we set the profit margin parameter to $a = 0.15$, which is the estimated value in Li et al. (2023) and also very close to the estimate obtained in Gonçalves et al. (2020).

The rest of the parameters are calibrated so as to match empirical moments. The data sample used to calculate those moments comprises annual observations of aggregate output Y and payout D from 1974 to 2017. We construct those measures using CRSP and COMPUSTAT data, as well as the dataset in Davydiuk, Richard, Shaliastovich and Yaron (2023), with D representing total payout of U.S. public firms to equity and debt investors (which includes dividends, interest payments, equity repurchases and issuances, and debt paydowns and issuances). The sample period is restricted by the Davydiuk et al. (2023) dataset, which is important for our analysis since it provides information on debt payouts as well as the market value of corporate debt. Internet Appendix D provides details on the data sources and empirical measurement for Y and D. It also discusses the methodology we use to generate the productivity (Z) time series, which relies on combining the Y and D data with the budget constraint and capital accumulation equation, in a fashion analogous to how the aggregate investment-to-capital ratio is calculated in Cochrane (1991).

The time series for the U.S. aggregate firm payout ratio (i.e., firm payout divided by firm output) from 1974 to 2017 is plotted in Figure 3. The figure also plots its two components, the aggregate equity payout ratio and the aggregate debt payout ratio. As seen in the figure, the firm payout ratio exhibits considerable time variation, taking both positive and negative values over the sample period. It is worth noting that the payout ratio turns sharply negative in the late 1990s and spikes up during the global financial crisis: since the former period is generally associated with low expected returns and the latter period with high expected returns in the asset pricing literature, there appears to be a positive relationship between firm payout ratios and firm expected returns, in line with the predictions of our model.

We set $\mu_z = 0.983$, $\phi_z = 0.745$, and $\sigma_z = 0.061$ to match the average log productivity level, the autocorrelation of the log productivity process, and the volatility of the log productivity autore-

[11]Mathematically, we set $\frac{a}{2}(1-\tau)i_{ss}^2 = 0.1$, which implies $a = 0.2/((1-\tau)i_{ss}^2)$. We, then, set the steady state investment-to-capital ratio to $i_{ss} = e^g - 1 + \delta$, as dictated by the capital accumulation equation, where $g = 0.025$ in order to match the average output growth in our dataset.

gressive shocks, respectively. The payout demand parameters are set to $\mu_d = 0.015$, $\phi_d = 0.595$, and $\sigma_d = 0.073$ in order to match, respectively, the mean and the autocorrelation of the empirical payout-to-output ratio d, as well as the volatility of the payout-to-output ratio autoregressive shocks normalized by lagged $\sqrt{d_t^{max} - d_t}$, in line with Equation 8.[12] Finally, we set $\rho_{d,z} = -0.125$ so as to match the unconditional correlation between the d and z autoregressive shocks.

3.2 Payout-based vs. investment-based returns

Before simulating our model, it is worth considering the properties of the model-implied realized and expected investment returns (which are equal to the model-implied realized and expected firm returns, respectively), taking the time series of aggregate firm productivity, Z, and payout, D, as given. In particular, for this exercise, we set all parameter values to the calibrated values of Table 1 and implicitly set the realizations of the productivity and payout demand shocks to the values needed so that our model generates exactly the U.S. aggregate productivity and payout realizations observed in the 1974-2017 period (calculated as discussed in the calibration section). Given the time series for Z and D, realized annual investment returns are calculated using Equation 28. To retrieve the time series of the expected annual returns, we use the laws of motion for z and d (Equations 2 and 8, respectively) and evaluate the resulting integrals of Equation 27 using Gauss-Hermite quadrature, with 31 grid points per shock. As pointed out in Cochrane (1991), production-based models in which investment return realizations and firm return realizations have to coincide every period can be trivially rejected. For that reason, the level of success of those models, including ours, needs to be evaluated on a more realistic standard: the degree of similarity between investment returns and firm returns.

Our findings are reported in the second column of Table 2. As seen in Panel A, our model generates investment returns that have unconditional moments that are quite close to the corresponding moments of U.S. aggregate firm returns. In particular, the model-implied investment returns have an unconditional mean of 5.63% and unconditional volatility of 14.82%, with the former being somewhat below the empirically observed U.S. aggregate return mean (7.86%) and the latter almost identical to the realized volatility of U.S. firm returns (14.88%). Furthermore, our model-implied investment returns are highly positively correlated with observed U.S. firm returns: the unconditional correlation coefficient is 0.57. Following the logic of Cochrane (1991) on the timing on investment expenditures, we also calculate the unconditional correlation between our model-implied investment returns and U.S. aggregate firm returns shifted by six months, denoted by R^s – for

[12] Note that we calibrate d to match *equilibrium* firm payout data, rather than data related to the household payout demand curve. This approach is analogous to how consumption growth is calibrated in consumption-based asset pricing models. It is also consistent with the theoretical implication of our 2-period model in Internet Appendix B: payout-based asset pricing yields the same asset pricing implications as a fully specified general equilibirum model if and only if the exogenous payout ratio reflects the properties of the *equilibrium* payout ratio in the general equilibrium economy.

example, the shifted return for the year 2000 is the return from July of 1999 to June of 2000.[13] However, shifting firm returns lowers their association with model-implied investment returns, as the correlation coefficient drops to 0.22, suggesting that our model better matches firm returns when the standard timing convention is used.

Panel B of Table 2 considers predictability regressions of annual U.S. aggregate firm returns on the lagged payout ratio D/Y. Consistent with our model, the slope coefficient is positive and statistically significant and the regression adjusted R^2 is 8.60%, suggesting that the payout ratio has forecasting ability for future returns. That finding is robust to controlling for lagged productivity z (Panel C), but the regression adjusted R^2 drops to 6.34%, indicating that including the productivity level does not add return forecasting power. Finally, as seen in Panel D, when we regress realized firm returns on model-implied expected investment returns, we get a slope coefficient of 0.55. Although that coefficient is below the model-implied value of one, it is statistically different from zero, suggesting that our model-implied expected returns are positively associated with future realized firm returns. Importantly, the regression adjusted R^2 is 6.05%, implying that the model-implied expected investment returns can account for a non-trivial amount of the variation in realized firm returns.

Figure 1 provides graphical evidence of the ability of the payout model-implied expected returns to match salient properties of aggregate U.S. expected returns. Panel A plots the 1974-2017 time series of both our model-implied aggregate expected returns (green solid line) and the corresponding empirically estimated expected returns (red dashed line). The latter are estimated by regressing realized annual U.S. aggregate firm returns on lagged payout yields (payout over firm value), payout ratios (payout over output), and productivity (output over capital). The two series track each other very well, exhibiting an unconditional correlation of 0.86. However, as discussed in the introduction of our paper, model-implied expected returns are too sensitive to changes in the payout ratio. To illustrate that point, we regress annual realized firm returns in the model and in the data on lagged payout ratios and plot the fitted values (green solid line and red dashed line, respectively) in Panel B of Figure 1. We see that model-implied expected returns are more sensitive to changes in the payout ratio than their empirically estimated counterparts, giving rise to an "excess sensitivity puzzle".

Finally, we compare the performance of our payout-based model against models in which investment is an exogenous process. In particular, we consider six different implementations of the investment-based approach, the details of which are discussed in Internet Appendix E and mainly differ on the measure of U.S. investment that is used to calculate (realized and expected) investment returns. In all cases, the exogenous investment-to-capital ratio is assumed to be a first-order autoregressive

[13] As detailed in Internet Appendix D, annual aggregate firm returns are obtained from the Davydiuk et al. (2023) dataset. To calculate the shifted annual aggregate firm returns, we use the quarterly aggregate firm returns available in that dataset.

process, as in Equation 30. To retrieve the time series of the realized U.S. aggregate I/K ratio, the first five implementations follow the approach in Cochrane (1991), whereas the last implementation directly measures the I/K ratio. We obtain realized investment returns from Equation 34 and expected investment returns from Equation 33, using the laws of motion for z and i (Equations 2 and 30, respectively) and evaluating the resulting integrals using Gauss-Hermite quadrature. All parameters are set to their Table 1 calibrated values, with the exception of the parameters for processes i and z, which are calibrated in a fashion identical to how we calibrate the parameters for processes d and z in our payout-based model.

Our findings appear in the last six columns of Table 2. The first three implementations of the investment-based approach use measures of aggregate investment from the NIPA tables: total investment, physical investment, and the sum of physical and intangible investment (columns three, four, and five, respectively). The last three implementations use COMPUSTAT data to retrieve the time series of U.S. aggregate investment: the first uses a measure of physical investment (column six), the second a measure of the sum of physical and intangible investment (column seven), and the third measures of physical investment and directly-measured physical capital (column eight). As seen in Panel A, all implementations generate both counterfactually low and counterfactually smooth investment returns – the exceptions are the two implementations that use COMPUSTAT data and focus on physical capital, which are able to generate reasonably volatile investment returns. Furthermore, the unconditional correlation between model-implied investment returns and observed firm returns is low across the board, both using the standard and the shifted timing of firm returns. As we see in Panels B and C of Table 2, firm returns are not forecastable by I/K ratios: none of the slope coefficients is statistically significant, and almost all regression adjusted R^2s are negative. Even worse, as documented in Panel D, there is complete disconnect between model-implied expected investment returns and observed firm returns, as the former appear to have no forecasting ability for the latter.

In summary, we find that aggregate firm returns are largely disconnected from aggregate investment returns, in contrast to the findings in Cochrane (1991). As we document in Internet Appendix E, that disparity is mainly due to the difference in the corresponding sample periods: we focus on the 1974-2017 period, whereas the analysis in Cochrane (1991) refers to the 1947-1987 period. A likely explanation for the deterioration in the performance of the investment-based approach in recent years is the increased importance of intangible capital (see, for example, Corrado, Haskel, Jona-Lasinio and Iommi (2022) and Crouzet, Eberly, Eisfeldt and Papanikolaou (2022)), which increases the difficulty of accurately measuring firm capital and investment.

Overall, we show that the payout-based approach generates realized and expected investment returns that are much more connected to observed firm returns than any implementation of the investment-based approach. Thus, apart from the conceptual reasons discussed in the previous section, shifting the focus from investment to payout, as our framework does, yields more realistic asset pricing implications. It should be stressed that our findings are not due to a particular calibration of the model parameters. To check the robustness of our results to alternative values of the model parameters, we redo our exercise by considering model-specific parameters (estimated using a Non-Linear Least Squares approach), which provide each model with its best chance to match firm returns. We find that, using model-specific parameters, the investment return volatility of all models declines substantially, but the superior performance of out payout-based approach is confirmed. The details are provided in Internet Appendix E.[14]

3.3 Model 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 order to match the size of our sample period. In our simulations, we update state variables according to their law of motion (with no state space discretization). Table 3 provides key asset pricing statistics in the data and in model simulations. Importantly, none of those statistics was used as a target moment for calibrating the model. For each simulation statistic, we report the median value across the 10,000 simulations, as well as the corresponding 1st and 99th percentiles.

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

Furthermore, the model captures payout yield dynamics quite well. In the data, the payout yield has an unconditional mean of 1.59%, an unconditional volatility of 2.47% and unconditional autocorrelation of 0.44. Our model is able to match the unconditional payout yield moments, with the caveat that model-implied payout yield volatility is somewhat elevated: the median values are $\mathbb{E}[D/P] = 2.60\%$, $\sigma[D/P] = 4.37\%$ and $\mathbb{AC}[D/P] = 0.52$. The model also yields empirically plausible return dynamics: the model-implied median values for the firm return mean and volatility ($\mathbb{E}[R] = 5.46\%$ and $\sigma[R] = 12.78\%$) are not far from the corresponding empirical values ($\mathbb{E}[R] = 7.86\%$ and $\sigma[R] = 14.88\%$). Despite that success, the model is not perfect: the U.S. firm return mean is above the 99th percentile of its simulated moment values, therefore, very unlikely to be generated in the model. Nonetheless, our payout-based asset pricing model goes a long way

[14]We obtain similar results when we assume that aggregate productivity Z is constant, as in Cochrane (1991).

in capturing the key moments of firm returns. It is worth noting that expected returns are very volatile in our model: the median unconditional volatility of $\mathbb{E}[R]$ is 5.79%. Due to the large discount rate fluctuations, the simulated realized returns exhibit negative autocorrelation: in the model, the median return autocorrelation is -0.20 (very close to the corresponding empirical value of -0.17).

Panel B reports the output of regressions of annual returns, R_{t+1}, on the lagged payout yield, D_t/P_t. Those forecasting regressions allow us to explore the properties of time variation in expected returns in a setting analogous to the one typically used in the evaluation of consumption-based asset pricing models. In the data, high payout yields forecast high future returns: the predictive coefficient is 1.81 (and significant at the 1% level) and the regression adjusted R^2 is 9.20%. The model yields a median predictive coefficient of 1.47 and a median regression adjusted R^2 of 23.66%, with the corresponding empirical values being well within the range of simulated outcomes.

Another important feature of return predictability is the underlying mechanism that generates it. In our model, return predictability arises from the payout decisions of the firm: when the payout demand is relatively high, the equilibrium expected return increases to induce the firm to cut investment and optimally supply the demanded payout level, which suggests a positive relationship between the firm's payout ratio, D/Y, and its future return. Notably, there is no mechanical relationship between the payout ratio and future returns, as the payout ratio (unlike the payout yield) is not scaled by firm value. Panel C of Table 3 reports the output of regressions of R_{t+1} on D_t/Y_t. Both in the data and in our model, the predictive coefficient is positive, confirming that the aggregate firm return predictability observed in the data is consistent with our model mechanism.

That said, our simulated expected results exhibit excess sensitivity to payout ratios, consistent with our findings in the previous section. In particular, the median model-implied forecast coefficient on D/Y is much higher than its empirical counterpart: 2.01 in the model, compared with 1.36 in the data. Furthermore, the model tends to generate excessive return predictability with respect to D/Y: the median adjusted R^2 is 21.84%, more than double the corresponding empirical value of 8.60%. Despite the fact that the empirical values of both the forecast coefficient and the regression R^2 are within the 98% simulation range, the disparity between the empirical values and the corresponding model median values is substantial and (as seen in Panel B of Figure 1, which refers to the 1974-2017 sample period) can be economically meaningful. The excess sensitivity puzzle is likely related to the fact that, in our model, firms are able to raise external capital costlessly. In the presence of time-varying external financing costs, the responsiveness of investment (and, hence, expected returns) to fluctuations in the investors' desired payout ratio may be attenuated, as firms are incentivized to accumulate internal cash in order to reduce their need for costly external financing. Hence, the excess sensitivity puzzle may be related to firms' "saving waves", explored in Eisfeldt and Muir (2016).

To examine the relationship between firm productivity and future returns, we regress R_{t+1} on both the lagged payout ratio D_t/Y_t and lagged productivity Z_t, and report our findings in Panel D of Table 3. We find that, both in simulated and actual data, the payout ratio is a strong predictor of subsequent firm returns, but productivity is not.[15] It follows that the model-implied mechanism for return predictability, which relies on variation in the investor payout demand ratio, rather than in productivity, is consistent with the data. However, as a result, controlling for productivity does not alleviate the aforementioned excess sensitivity problem.

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

4 Adding Firm Leverage

In this section, we retain all our previous assumptions, with the exception that we now allow for firm leverage. The assumption that the firm can finance itself using both equity and debt allows us to separately consider firm equity returns and firm debt returns. In the interests of simplicity, the only type of debt we consider is one-period risk-free debt. Following Hennessy and Whited (2005), we assume that the firm is subject to a collateral constraint which ensures that all the debt that it issues is riskless. Due to the deductability of interest payments, debt is beneficial to the firm, as it yields a tax shield. On the other hand, debt generates financial distress costs, which we model in reduced form as convex leverage costs.[16] It follows that the firm optimally chooses its capital structure by trading off the tax benefits of debt against the costs of leverage.

The firm determines its supply of debt and equity payouts by jointly optimizing its investment and capital structure decisions, taking the SDF as given. As we will show, determining the optimal debt

[15]The lack of return predictability of aggregate productivity is not a consequence of our methodology of measuring productivity without directly using profitability data. We obtain similar results in our predictability regressions when we replace aggregate productivity with aggregate profitability (measured as aggregate operating profits over assets).

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

and equity payouts for a given SDF is equivalent to determining those optimal payouts taking the firm's marginal q and the risk-free rate as given, respectively. Then, we pin down the equilibrium marginal q and the equilibrium risk-free rate by imposing market clearing in the debt and equity payout markets.

4.1 Setting

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

$$D^b_t = R^b_t B_t - B_{t+1}. \tag{35}$$

Since interest payments are tax deductible, debt yields a benefit to the firm in the form of a tax shield. In the absence of any countervailing leverage cost, the firm would choose to borrow up to its collateral constraint. Instead, we assume that leverage entails costs to the firm (such as potential costs of financial distress), which we model in reduced form by assuming that the firm pays a (non-deductible) cost $G_t = G(B_t, K_t)$ at period t.[17] In particular, we assume that

$$G(B_t, K_t) = \frac{\kappa}{2}\left(\frac{B_t}{K_t}\right)^2 K_t, \tag{36}$$

for $\kappa > 0$, so the leverage cost is increasing and convex in the firm's debt B_t.[18]

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

$$R^b_{t+1}B_{t+1} \le (1-\delta)K_{t+1} + (1-\tau)\alpha Z^{min}_{t+1}K_{t+1} + \tau\delta K_{t+1} + \tau(R^b_{t+1} - 1)B_{t+1} - \frac{\kappa}{2}\left(\frac{B_{t+1}}{K_{t+1}}\right)^2 K_{t+1}, \tag{37}$$

[17] The non-deductibility of the leverage cost does not impact our results. To see that, consider a model with tax-deductible leverage cost and leverage cost parameter κ'. We can easily show that, under the parametrization $\kappa = (1-\tau)\kappa'$, that model is identical to our model.

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

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

$$R_{t+1}^{b,a} b_{t+1} \leq (1-\delta) + (1-\tau)\alpha Z_{t+1}^{min} + \tau\delta - \frac{\kappa}{2} b_{t+1}^2, \tag{38}$$

where $b_{t+1} \equiv \frac{B_{t+1}}{K_{t+1}}$ is the firm's leverage ratio.[19]

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

$$V_t^e = \max_{\{I_{t+h}, D_{t+h}^e, B_{t+1+h}\}_{h=0}^{\infty}} \{D_t^e + \sum_{h=1}^{\infty} \mathbb{E}_t[M_{t,t+h} D_{t+h}^e]\}, \tag{39}$$

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

$$D_t^e = (1-\tau)(\Pi(K_t, Z_t) - \Phi(I_t, K_t)) + \tau\delta K_t - I_t - R_t^{b,a} B_t + B_{t+1} - G(B_t, K_t). \tag{40}$$

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

$$D^{e,d}(K, Z, d) = Z \cdot K \cdot d^e = Y \cdot d^e, \tag{41}$$

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

$$D^{b,d}(K, Z, d^b) = Z \cdot K \cdot d^b = Y \cdot d^b. \tag{42}$$

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

The law of motion for d is given by Equation 8, except that the conditional upper bound of d is

[19]Since the firm issues safe debt, its pre-tax cost of debt R_{t+1}^b is the (pre-tax) risk-free rate in the economy: $1 = \mathbb{E}_t[M_{t+1} R_{t+1}^b] = \mathbb{E}_t[M_{t+1}] R_{t+1}^b = \frac{R_{t+1}^b}{R_{t+1}^f} \implies R_{t+1}^b = R_{t+1}^f = \frac{1}{\mathbb{E}_t[M_{t+1}]}$. It follows that the firm's after-tax cost of debt, $R_{t+1}^{b,a} = R_{t+1}^b - \tau(R_{t+1}^b - 1)$, also depends solely on the SDF and, thus, is taken as given by the firm. Our derivation implicitly assumes that the investor tax rate, denoted by τ^i, is zero. If, instead, $\tau^i > 0$, then R_{t+1}^b is still the pre-tax gross risk-free rate, but the investor Euler equation is $1 = \mathbb{E}_t[M_{t+1}(R_{t+1}^b - \tau^i(R_{t+1}^b - 1))]$. In our paper, we assume $\tau > \tau^i = 0$. That assumption ensures that the firm optimally chooses positive debt (i.e., that $B_{t+1} \geq 0$) when the net risk-free rate is positive (i.e., when $R_{t+1}^b \geq 1$).

given by

$$d_t^{max} = (1-\tau)\alpha + e^{-z_t}\left[\left(1 - \frac{(1-\tau)a}{2}\cdot\varphi\right)\varphi + \tau\delta + \frac{\kappa}{2}b_t^2\right]. \tag{43}$$

As in the case of the unvelered firm, this upper bound for d ensures that the firm's equilibrium investment and payout processes are feasible and that the firm's marginal q is real-valued and non-negative (see Internet Appendix C). The debt payout ratio process, d^b, is stationary, with law of motion

$$d_{t+1}^b = \mu_b + \phi_b\cdot(d_t^b - \mu_b) + \sigma_b\cdot\epsilon_{t+1}^b, \tag{44}$$

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

4.2 Payout supply

The firm's problem can be rewritten recursively as

$$V^e(K_t, B_t, Z_t; \{f_t(M_{t,t+h})\}_{h=1}^{\infty}) = \max_{\{I_t, B_{t+1}\}}\{D_t^e + \mathbb{E}_t[M_{t,t+1}V^e(K_{t+1}, B_{t+1}, Z_{t+1}; \{f_{t+1}(M_{t+1,t+1+h})\}_{h=1}^{\infty})]\}, \tag{45}$$

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

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

$$1 + \mathbb{E}_t[M_{t+1}\partial_B V^e(K_{t+1}, B_{t+1}, Z_{t+1}; \{f_t(M_{t+1,t+1+h})\}_{h=1}^{\infty})] = 0, \tag{46}$$

and the envelope condition with respect to B_t is

$$\partial_B V^e(K_t, B_t, Z_t; \{f_t(M_{t,t+h})\}_{h=1}^{\infty}) = -R_t^{b,a} - \partial_B G_t. \tag{47}$$

Together, Equations 46 and 47 yield the Euler equation

$$\mathbb{E}_t\left[M_{t,t+1}\cdot(R_{t+1}^{b,a} + \partial_B G_{t+1})\right] = 1. \tag{48}$$

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

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

$$\tau(R^b_{t+1} - 1) = \kappa\left(\frac{B_{t+1}}{K_{t+1}}\right). \tag{49}$$

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

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

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

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

$$\underbrace{\mathbb{E}_t[M_{t+1}\partial_K V^e(K_{t+1}, B_{t+1}, Z_{t+1}; \{f_t(M_{t+1,t+1+h})\}_{h=1}^{\infty})]}_{\equiv q_t} = 1 + (1-\tau)\partial_I \Phi(K_t, I_t), \tag{51}$$

which yields the firm's investment function:

$$I_t = \frac{q_t - 1}{a(1-\tau)} K_t. \tag{52}$$

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

After solving for the firm's optimal investment and capital structure policies, we are ready to characterize the firm's optimal debt and equity payout policies. Substituting the firm's optimal

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

$$q_t = \mathbb{E}_t\left[M_{t,t+1}\left((1-\tau)\left(\partial_K \Pi(K_{t+1}, Z_{t+1}) - \partial_K \Phi(I_{t+1}, K_{t+1})\right) + \tau\delta - \partial_K G(B_{t+1}, K_{t+1}) + (1-\delta)q_{t+1}\right)\right]. \tag{53}$$

This condition is analogous to Equation 17 for the unlevered firm.

investment policy (Equation 52) and optimal debt policy (Equation 50) into Equation 35, we get the firm's debt payout function,

$$D_t^b = \left[R_t^b b_t - \left(\frac{\tau}{\kappa} (R_{t+1}^b - 1) \right) \left((1-\delta) + \frac{q_t - 1}{a(1-\tau)} \right) \right] K_t. \tag{54}$$

Similarly, substituting the firm's optimal investment and debt policy into Equation 40, we derive the firm's equity payout function,

$$D_t^e = \left[\alpha(1-\tau) Z_t + \tau\delta - \frac{q_t^2 - 1}{2a(1-\tau)} - R_t^{b,a} b_t + \left(\frac{\tau}{\kappa} (R_{t+1}^b - 1) \right) \left((1-\delta) + \frac{q_t - 1}{a(1-\tau)} \right) - \frac{\kappa}{2} b_t^2 \right] K_t. \tag{55}$$

In summary, the firm's optimality conditions determine the firm's optimal payout supply functions (Equations 54 and 55), for given SDF properties. Notably, the firm's period t optimal payouts are functions of one contemporaneous exogenous variable (productivity Z_t), two contemporaneous endogenous variables (the firm's marginal q_t and the risk-free rate R_{t+1}^b), and one pre-determined endogenous variable (R_t^b – note that b_t is a function of R_t^b through Equation 50). It is easy to see that the firm's marginal q and the risk-free rate are summary statistics for investor preferences regarding firm payout: keeping the exogenous productivity process Z the same, any SDFs that yield the same q and R^b processes also yield the same debt payout D^b and equity payout D^e processes. What remains is to pin down the *equilibrium* q_t and R_{t+1}^b at each period t. For that, we rely on the two market clearing conditions, one for debt payout and the other for equity payout.

4.3 Equilibrium

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

$$D_t^b = D_t^{b,d}. \tag{56}$$

Substituting for the firm's debt payout supply (Equation 54) and investors' debt payout demand (Equation 42), and using Equation 50 in order to write R_t^b as a function of b_t, we get an expression for the equilibrium risk-free rate:

$$R_{t+1}^{b,*} = \frac{\kappa}{\tau} \frac{\left(\frac{\kappa}{\tau} b_t^* + 1 \right) b_t^* - d_t^b e^{z_t}}{(1-\delta) + \frac{q_t^* - 1}{a(1-\tau)}} + 1. \tag{57}$$

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

$$D_t^e = D_t^{e,d}, \tag{58}$$

substituting for the firm's equity payout supply (Equation 55) and investors' equity payout demand (Equation 41), imposing the expression for the equilibrium risk-free rate (Equation 57) and rearranging, we get an expression for the firm's equilibrium marginal q:

$$q_t^* = \sqrt{1 + 2a(1-\tau)\left[(\alpha(1-\tau) - d_t)\, e^{z_t} + \tau\delta + \frac{\kappa}{2}(b_t^*)^2\right]}. \tag{59}$$

To summarize, payout market clearing yields Equations 57 and 59, which express $R_{t+1}^{b,*}$ and q_t^*, respectively, as functions of contemporaneous exogenous variables (z_t, d_t, and d_t^b) and an endogenous pre-determined variable (b_t^*). Moreover, Equation 35 and the firm's debt optimality condition (Equation 50) yield the following expression for the evolution of the firm's equilibrium leverage ratio:

$$b_{t+1}^* = \frac{\left(\frac{\kappa}{\tau} b_t^* + 1\right) b_t^* - d_t^b e^{z_t}}{(1-\delta) + \frac{q_t^* - 1}{a(1-\tau)}}. \tag{60}$$

4.4 Equilibrium asset prices

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

$$P_t^e = q_t K_{t+1} - B_{t+1} = (q_t - b_{t+1}) K_{t+1}. \tag{61}$$

As a result, the ex-payout firm value is

$$P_t = P_t^e + B_{t+1} = q_t K_{t+1}, \tag{62}$$

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

$$Q_t = q_t, \tag{63}$$

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

$$Q_t^* = Q^*(b_t^*, z_t, d_t) = \sqrt{1 + 2a(1-\tau)\left[(\alpha(1-\tau) - d_t)\, e^{z_t} + \tau\delta + \frac{\kappa}{2}(b_t^*)^2\right]}, \tag{64}$$

and the equilibrium expected firm return function is

$$\mathcal{R}^*(b_t^*, z_t, d_t, d_t^b) = \mathbb{E}\left[R_{t+1}^* \,\middle|\, b_t^*, z_t, d_t, d_t^b\right], \tag{65}$$

where

$$R_{t+1}^* = \frac{d_{t+1} e^{z_{t+1}} + Q^*(b_{t+1}^*, z_{t+1}, d_{t+1})\left(1 - \delta + \frac{Q^*(b_{t+1}^*, z_{t+1}, d_{t+1}) - 1}{a(1-\tau)}\right)}{Q^*(b_t^*, z_t, d_t)}. \tag{66}$$

We can also characterize the firm's equity and debt expected returns separately. As regards the equity return, $R_{t+1}^e = (P_{t+1}^e + D_{t+1}^e)/P_t^e$, Equations 61 and 63 imply the equilibrium expected equity return function

$$\mathcal{R}^{e,*}(b_t^*, z_t, d_t, d_t^b) = \mathbb{E}\left[R_{t+1}^{e,*} \mid b_t^*, z_t, d_t, d_t^b\right], \tag{67}$$

where

$$R_{t+1}^{e,*} = \frac{d_{t+1}Z_{t+1} + Q^*(b_{t+1}^*, z_{t+1}, d_{t+1})\left(1-\delta+\frac{Q^*(b_{t+1}^*, z_{t+1}, d_{t+1})-1}{a(1-\tau)}\right) - \left(\frac{\kappa}{\tau}b_{t+1}^*+1\right)b_{t+1}^*}{Q^*(b_t^*, z_t, d_t) - b_{t+1}^*}. \tag{68}$$

As regards debt, the equilibrium (expected and realized) debt return satisfies

$$R_{t+1}^{b,*} = \frac{\kappa}{\tau}b_{t+1}^* + 1, \tag{69}$$

which is nothing more than the equilibrium version of the firm's debt optimality condition (Equation 50). Intuitively, the risk-free rate needs to adjust so that, in equilibrium, the firm's leverage ratio b_{t+1}^*, which is pinned down by the payout market clearing conditions, is optimal for the firm. In other words, the equilibrium risk-free rate is the rate that clears the debt payout market, i.e., the rate that makes the firm *optimally* issue the amount of debt that is desired by investors.[21]

Substituting Equation 60 into Equation 69, taking conditional expectations, and using Equation 63, we get the equilibrium expected debt return,

$$\mathcal{R}^{b,*}(b_t^*, z_t, d_t, d_t^b) = \frac{\kappa}{\tau}\frac{\left(\frac{\kappa}{\tau}b_t^*+1\right)b_t^* - d_t^b e^{z_t}}{(1-\delta)+\frac{Q^*(b_t^*, z_t, d_t)-1}{a(1-\tau)}} + 1, \tag{70}$$

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

To solve for the expected firm, equity, and debt returns, we use Equations 65, 67, and 70, as well as the expression for the firm's equilibrium Q (Equation 64), the laws of motion of the exogenous processes z, d, and d^b, and the law of motion for the equilibrium leverage ratio, b^* (Equation 60).

Figures 5, 6, and 7 display the expected equilibrium firm return $\mathcal{R}^*$, the expected equilibrium equity return $\mathcal{R}^{e,*}$, and the expected equilibrium debt return $\mathcal{R}^{b,*}$, respectively, as functions of the four state variables: productivity z, demanded firm payout ratio d, demanded debt payout ratio d^b, and lagged leverage ratio b. For our calculations, we use the calibrated parameter values discussed in the next section and Gauss-Hermite quadrature (with 31 grid points per shock) to compute the

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

integrals needed for the evaluation of the $\mathcal{R}^*$ and $\mathcal{R}^{e,*}$ functions.

As seen in Figure 5, the firm's expected return is sharply increasing in total payout d, whereas it is essentially flat with respect to productivity z, debt payout d^b, and lagged leverage ratio b. Thus, as in the case of the unlevered firm, most of the variation in the firm's expected return arises from fluctuations in the investors' demanded total payout ratio d. As seen in Panel C (in which d is kept fixed, whereas the relative magnitudes of d^e and d^b change), it is just the size of the overall payout d that matters for the magnitude of the firm's expected return, but not its composition.

The composition of the firm's total demanded payout becomes important when we focus on the firm's expected equity and debt returns separately. As seen in Panel C of Figure 6, the firm's expected equity return is decreasing in the debt payout ratio d^b, holding everything else (including the total payout ratio d) fixed. This is because, for d to remain fixed, an increase in d^b has to be offset by an equivalent decline in the equity payout ratio d^e. To satisfy a lower demanded equity payout ratio, the firm has to cut its equity payout and increase investment, so the equity discount rate has to fall to incentivize the firm to do so. An increase in d^b, keeping d fixed, decreases not only the firm's cost of equity, but also its cost of debt: as seen in Panel C of Figure 7, the firm's debt return is negatively associated with d^b. Intuitively, a reduction of d^b, everything else equal, implies that investors desire to hold less newly-issued debt. Taking into account the positive relationship between the firm's debt supply and the risk-free rate in our model, the firm's cost of debt has to fall in order for the firm to want to supply the reduced amount of new debt that investors want to hold. On the other hand, the firm's debt return is strongly increasing in the lagged leverage ratio b (Panel D of Figure 7). This is because a higher b, keeping everything else (and, in particular d^b) the same, implies a stronger investor desire for holding newly-issued debt. To match the higher investor demand for debt, the equilibrium risk-free rate needs to rise, so that the firm is willing to issue more debt.

4.5 Quantitative results

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

[22] All common parameter values are identical across the two models, with the exception of the values of the productivity parameters, which change slightly because the implied productivity process changes slightly due to the different budget constraints in the two models.

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

whereas the debt payout parameters are calibrated to match the corresponding moments of the U.S. aggregate debt payout ratio.

Again, we run 10,000 model simulations, each of which consists of 44 annual observations (after an initial period of 1,000 years, to reduce the dependence on initial conditions). We report empirical and simulated moments for firm returns, equity returns, and debt returns in Tables 4, 5, and 6, respectively.[24]

As seen in Table 4, our model is able to capture many of the salient properties of U.S. aggregate firm returns. This is not surprising: the simulated moments in Table 4 are almost identical to the simulated moments of the unlevered firm discussed in the previous section (Table 3). The only new component of Table 4 is Panel E, which reports the output of return forecasting regressions that use equity and debt payout ratios as the predictive variables. In both the data and the model, both ratios have a positive forecasting coefficient, underscoring the ability of the model to accurately capture important return predictability attributes. Furthermore, Panel E shows that the excess sensitivity of the firm's return to its payout ratio is due to its excess sensitivity to the firm's equity payout ratio, whereas firm returns do not exhibit excess sensitivity to the firm's debt payout ratio.

When we consider equity and debt returns separately, the performance of the model gets more mixed. As seen in Panel A of Table 5, the model generates realistic correlations of equity returns with output growth rates, productivity shocks, equity payout shocks, and debt payout shocks. However, simulated equity payout yields are higher on average, and more volatile, than their empirical counterparts. On the other hand, the model is able to generate realistic equity return unconditional moments: the average equity return is 10.23% and the unconditional equity return volatility is 24.20%, both quite close to their empirical values (8.96% and 17.76%, respectively). Furthermore, the model is able to produce empirically plausible conditional expected returns, as evidenced by the fact that the output of the simulated return predictability regressions (Panels B–E of Table 5) is qualitatively similar to the output of the corresponding regressions that use U.S. aggregate firm data. Notably, as seen in Panels D and E, equity returns exhibit excess sensitivity to equity payout ratios.

When we turn to debt prices and returns (Table 6), we see that the model is able to generate realistic unconditional moments for debt payout yields, but not for debt returns: in the model, debt returns are low (mean of 1.02%) and almost constant (unconditional volatility of 0.12%), quite different from actual U.S. aggregate debt returns (which have a mean of 4.84% and an unconditional

[24]Under the law of motion for z shown in Equation 2, $Z_t^{min} = 0$ for all t, since normally distributed shocks have infinite support. As discussed in Internet Appendix C, a lower bound of $Z_t^{min} = 0$ sometimes leads to a binding collateral constraint. To ensure that the collateral constraint binds very infrequently (and, hence, can be ignored when solving the model), we introduce the following slight modification: we set the value of $Z_{t+1}^{\min}$ to be equal to the value that Z_{t+1} would take if the realization of the productivity shock at $t+1$ were equal to four standard deviations below zero. Since realizations below four standard deviations from zero are extremely rare for normally distributed shocks, our modification helps ensure that the collateral constraint almost never binds without substantially violating our distributional assumptions for z.

volatility of 7.47%). Given that the model generates essentially constant debt returns, it is unable to match the empirical debt return predictability properties: as seen in Panels B–E, all simulated forecasting coefficient estimates are extremely close to zero. It should be noted that a key reason for the inability of our model to match the empirical debt return properties is the fact that our representative firm is constrained to only issue one-period safe debt, so the debt return is always equal to the risk-free rate. If we compare the debt returns in our model with the empirical risk-free rate time series, then the performance of our model improves significantly: in the data, the average (real) risk-free rate has a mean of 0.82% and an unconditional volatility of 2.56%.

Finally, in order to quantify the contribution of each state variable to the overall volatility of key asset pricing measures, we run a single 100-year simulation of the model and report the paths of the firm's equilibrium Q, expected firm return, expected equity return, and expected debt return in Figure 8. As seen in Panels A, B, and C, fluctuations in the firm payout ratio d account for almost all of the variation in the firm's Q, firm expected returns, and equity expected returns. On the other hand, the volatility of the firm's expected debt returns is mainly due to changes in the lagged leverage ratio b.

5 Conclusion

In this paper, we propose a payout-based asset pricing framework within the production-based asset pricing paradigm. Our framework allows us to back out firms' equilibrium expected returns using the clearing of the payout market, without the need to recover the economy's SDF. Our model-implied equilibrium expected firm returns successfully predict subsequent realized firm returns in the data. Furthermore, simulations show that our model is able to closely match key asset pricing moments, producing empirically plausible payout yields, firm returns, and equity returns.

Our model is intentionally simple, as our goal is to highlight the baseline implications of the payout-based asset pricing approach. That simplicity leaves room for more sophisticated models that could better capture the key properties of asset prices and returns. For example, our model-implied equilibrium expected returns are too sensitive to changes in the payout ratio compared to the data. That excess sensitivity may arise because our baseline model does not incorporate external financing costs, underscoring the need for richer models. Furthermore, our framework opens the door to new potential research paths. For instance, future work could extend our payout-based asset pricing approach to the cross-section of firm returns, helping to better understand the relationship between firm returns and investors' payout demand and potentially addressing well-known anomalies.

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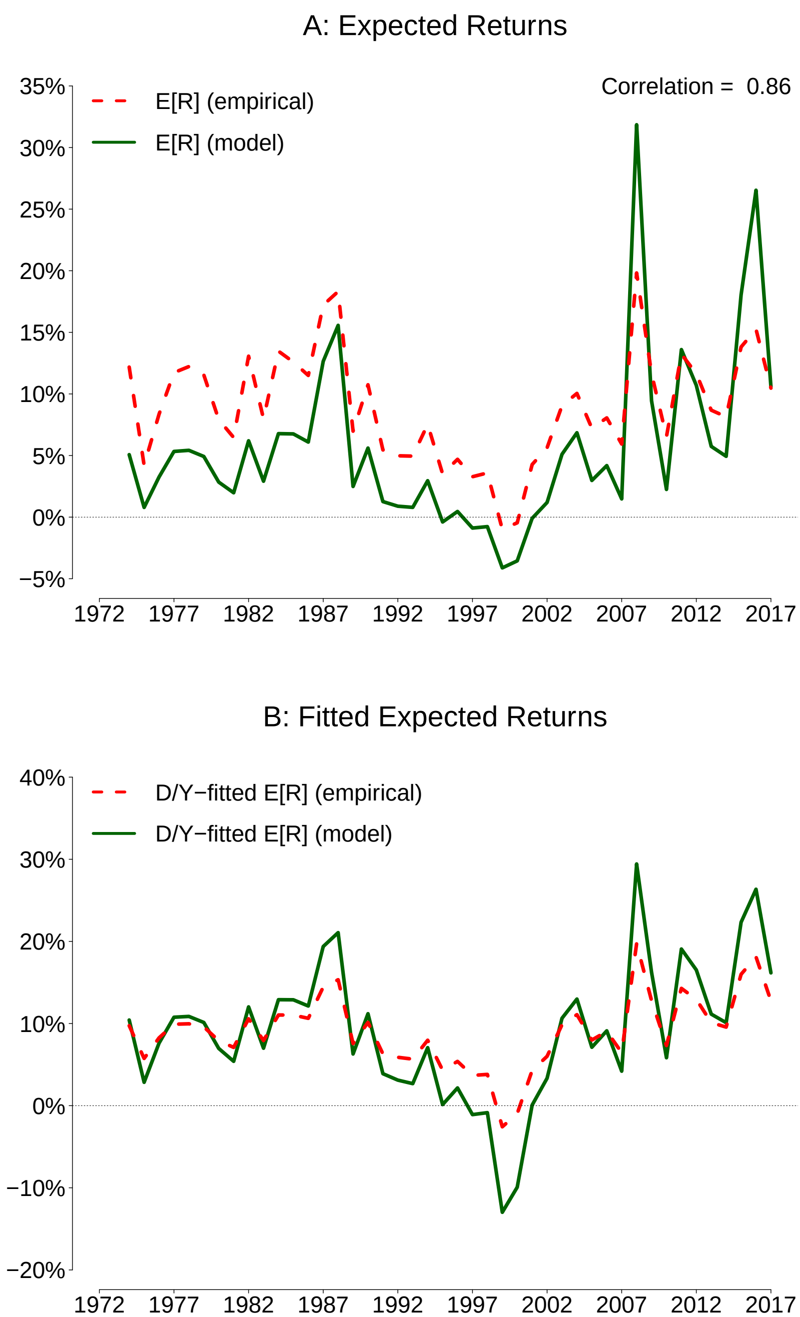


Fig. 1: Comparison of model-implied and empirically estimated expected returns

Panel A of this figure plots the time series of model-implied expected returns (solid green line) and the time series of empirically estimated expected returns (dashed red line). The latter are the fitted values from regressions of one-year realized aggregate firm returns on lagged payout yields (payout over firm value), lagged payout ratios (payout over output), and lagged productivity (output over capital). Panel B of this figure plots the time series of the fitted values from regressions of one-year realized returns, in the model and the data, on lagged payout ratios (solid green line and dashed red line, respectively).

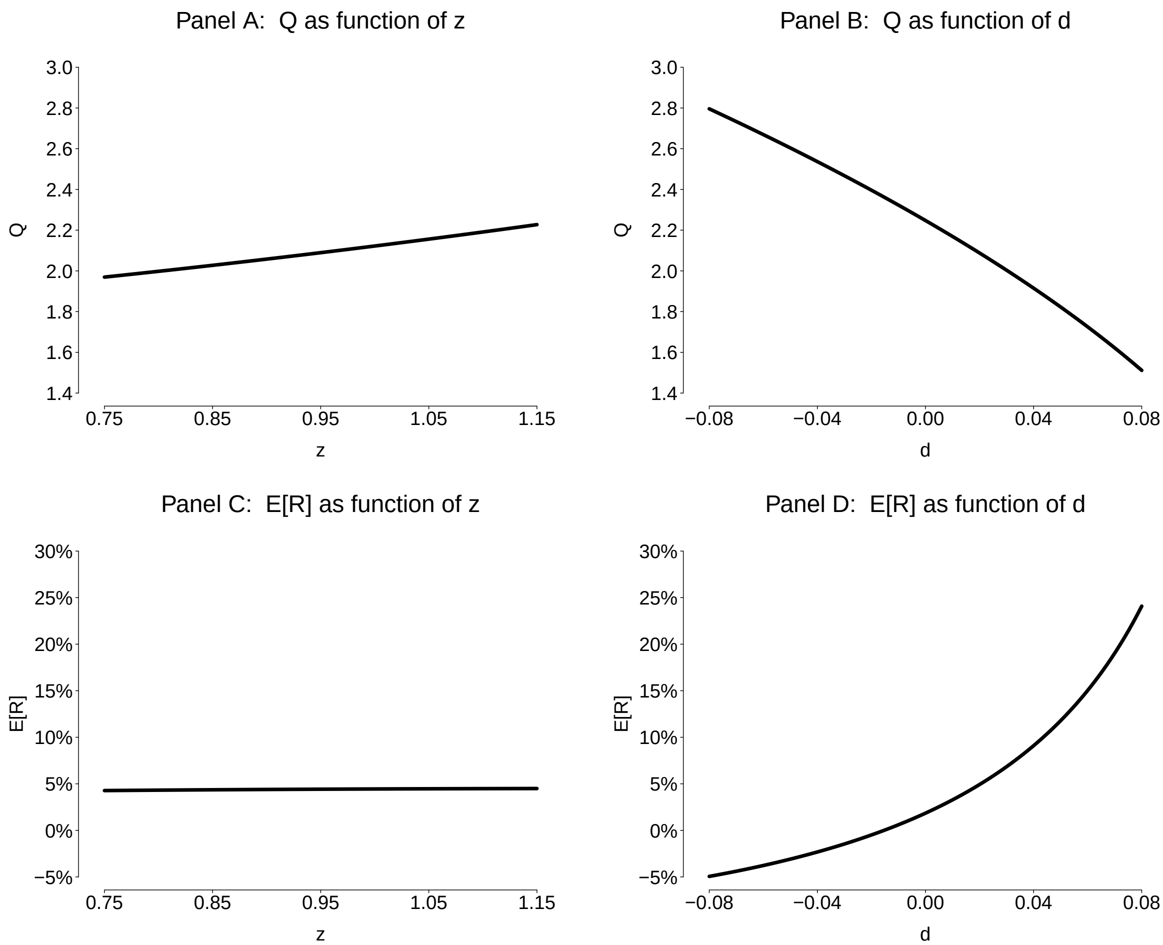


Fig. 2: Equilibrium Q and expected firm return as functions of the state variables

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

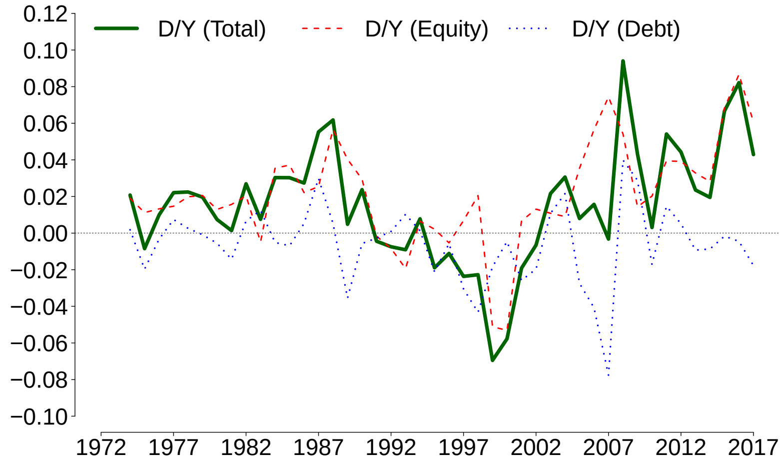


Fig. 3: U.S. aggregate payout ratio

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

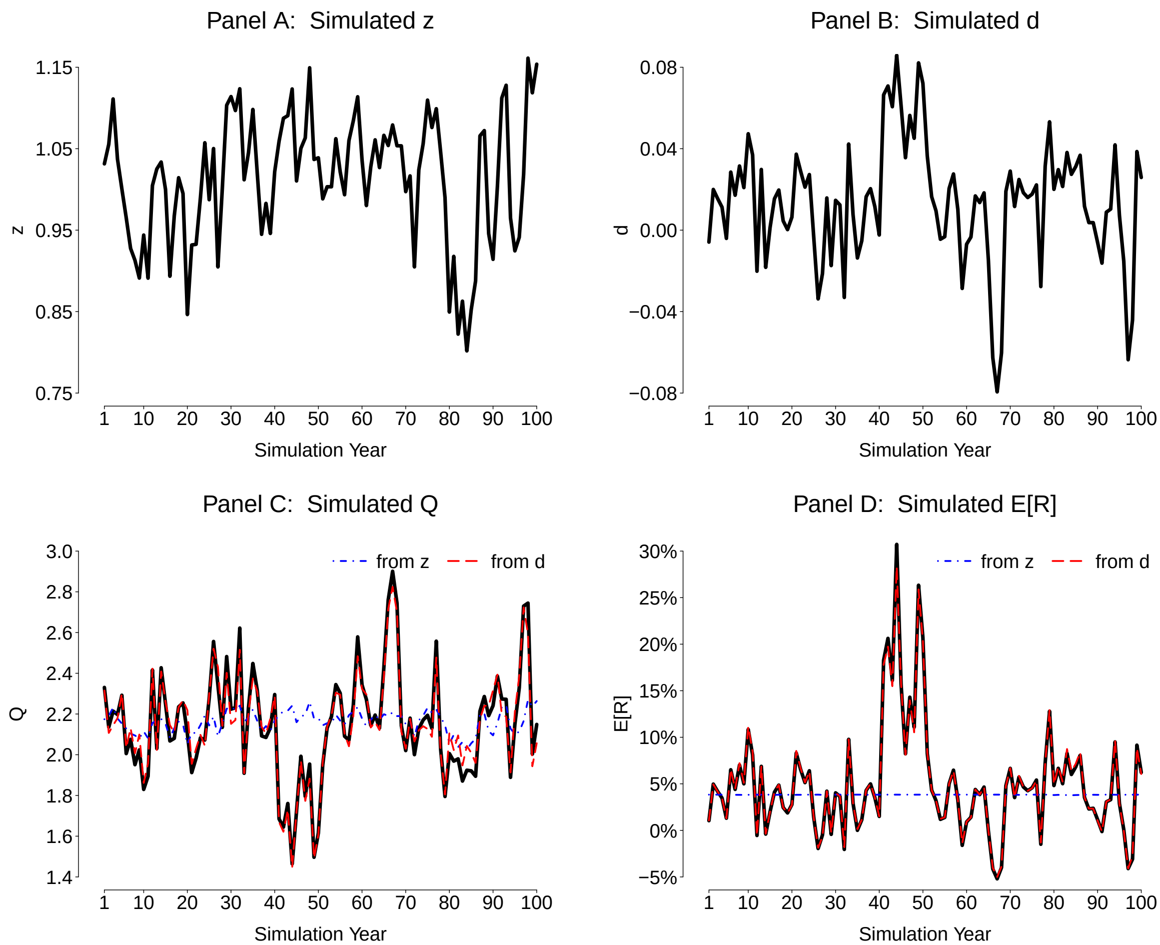


Fig. 4: Simulated paths: model with unlevered firm

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

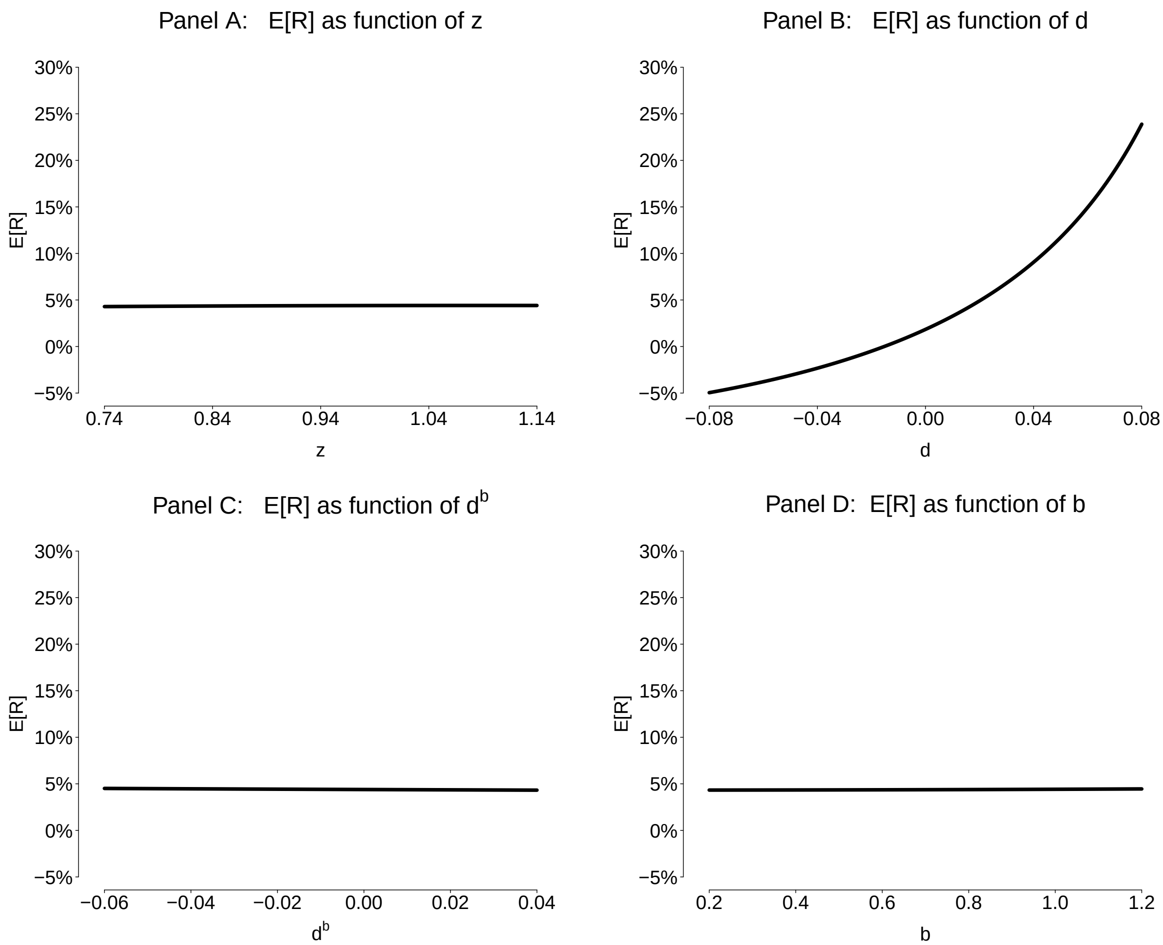


Fig. 5: Expected return of the levered firm as a function of the state variables

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

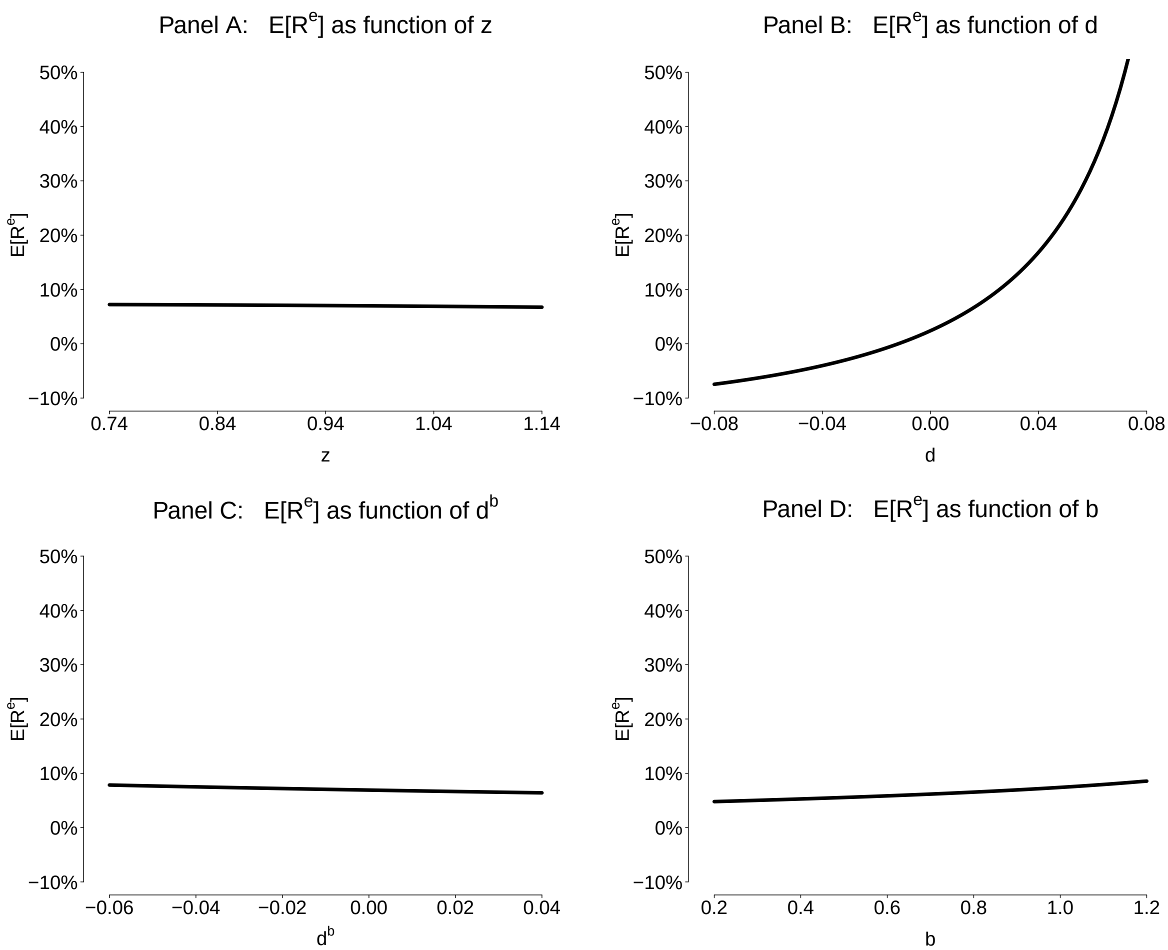


Fig. 6: Equity expected return of the levered firm as a function of the state variables

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

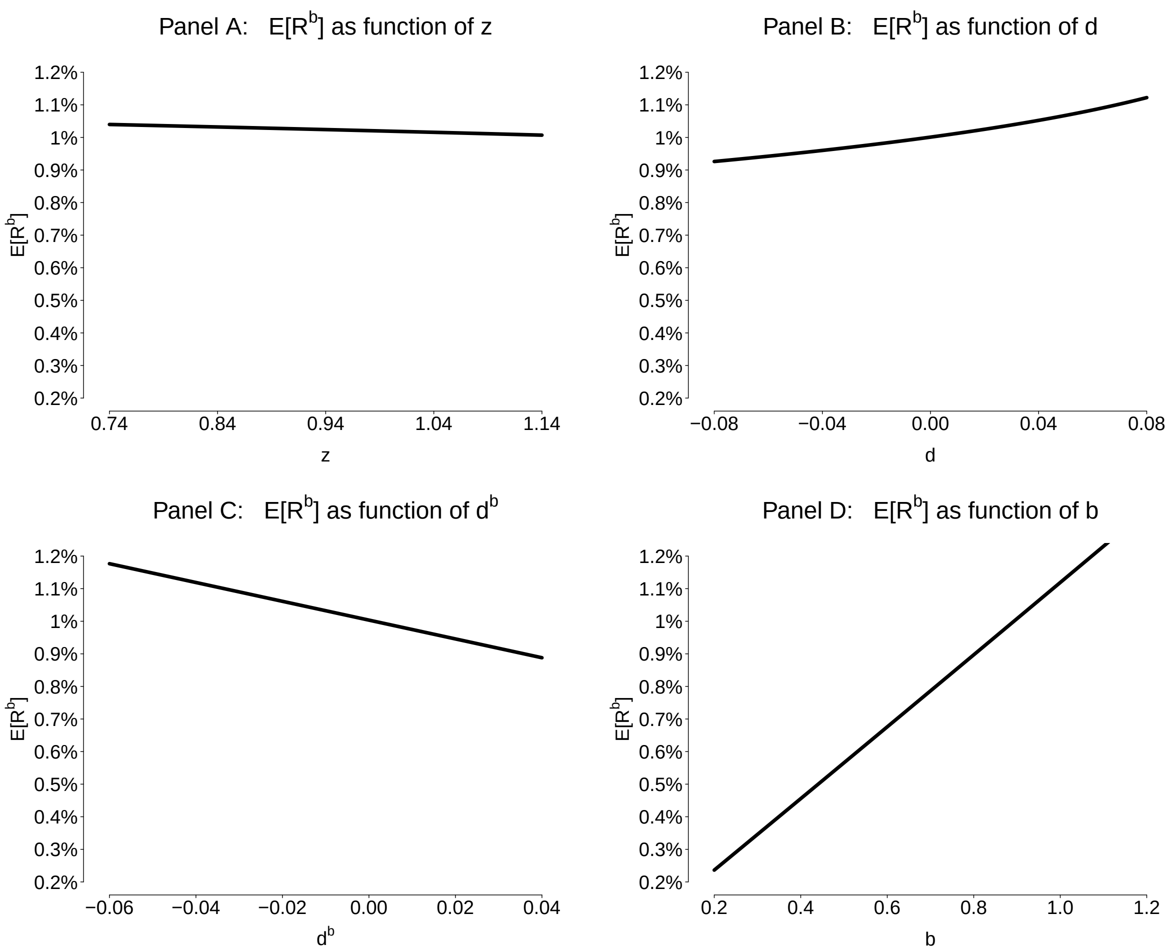


Fig. 7: Debt expected return of the levered firm as a function of the state variables

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

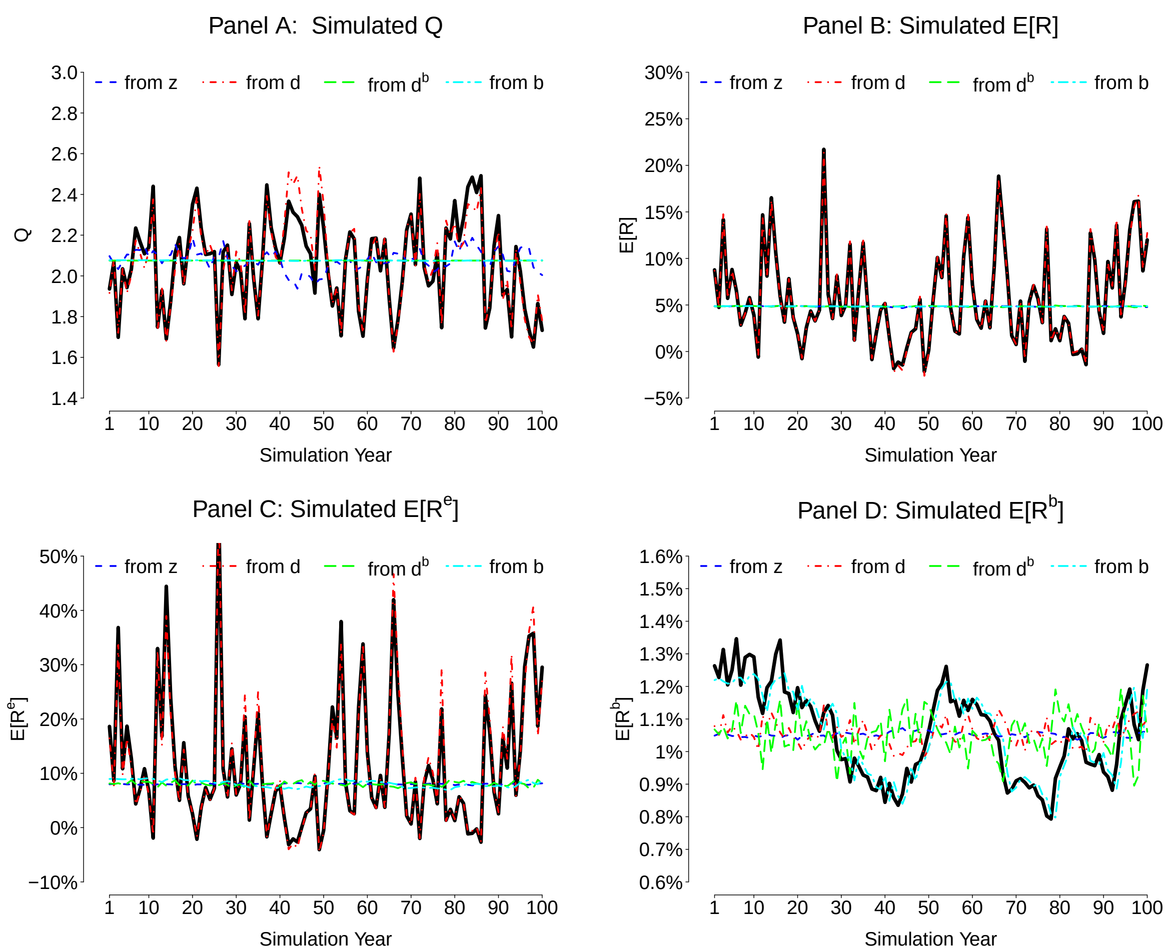


Fig. 8: Simulated paths: model with levered firm

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

Table 1: Model calibration

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

		Calibrated Value	
Parameter Description	**Symbol**	**Unlevered Firm**	**Levered Firm**
Adjustment Cost Parameter	a	9.953	9.953
Depreciation Rate	δ	0.150	0.150
Corporate Tax Rate	τ	0.350	0.350
Profit Margin	α	0.150	0.150
Leverage cost parameter	κ	–	0.003
Average z	μ_z	0.983	0.979
Autocorrelation of z	ϕ_z	0.745	0.743
Volatility Parameter of z	σ_z	0.061	0.061
Average d	μ_d	0.015	0.015
Autocorrelation of d	ϕ_d	0.595	0.595
Volatility Parameter of d	σ_d	0.073	0.073
Average d^b	μ_b	–	-0.006
Autocorrelation of d^b	ϕ_b	–	0.167
Volatility Parameter of d^b	σ_b	–	0.021
Correlation(z , d)	$\rho_{z,d}$	-0.125	-0.125
Correlation(z , d^b)	$\rho_{z,b}$	–	-0.057
Correlation(d , d^b)	$\rho_{d,b}$	–	0.568

Table 2: Payout-based vs. investment-based returns

This table reports the properties of model-implied realized and expected investment returns for seven different models. In particular, Panel A reports the unconditional moments of realized and expected investment returns, whereas Panels B, C, and D report the output of regressions of observed firm returns on different forecasting signals. The seven models are, in order, the payout-based model (column two) and six implementations of the investment-based model (columns three to eight). We report Newey and West (1987) standard errors, with lag selection as in Newey and West (1994).

Model	d	i_{NIPA}	i^{p}_{NIPA}	$i^{p\&i}_{NIPA}$	i^{p}_{CS}	$i^{p\&i}_{CS}$	$i^{p,K}_{CS}$
Panel A: Unconditional moments							
Average Firm Return	7.86%	7.86%	7.86%	7.86%	7.86%	7.86%	7.86%
Volatility of Firm Return	14.88%	14.88%	14.88%	14.88%	14.88%	14.88%	14.88%
Average Investment Return	5.63%	-2.53%	1.12%	-1.70%	1.86%	-1.69%	2.54%
Volatility of Investment Return	14.82%	5.27%	4.70%	3.93%	13.30%	8.37%	13.73%
Volatility of $\mathbb{E}[R^I]$	7.02%	1.78%	1.37%	1.14%	6.29%	3.63%	5.69%
Corr(R^I,R)	0.57	-0.08	-0.10	-0.08	0.18	0.20	0.14
Corr(R^I, R^s)	0.22	0.21	0.09	0.09	0.07	0.08	0.07
Panel B: Regressions of R_{t+1} on D_t/Y_t or I_t/K_t							
Predictive Coefficient	1.36	-0.25	-1.02	-1.15	-0.46	-0.56	-0.78
s.e.	[0.40]	[0.86]	[1.15]	[1.32]	[0.50]	[0.68]	[0.49]
Adjusted R^2	8.60%	-2.29%	-0.61%	-0.55%	-0.86%	-1.30%	3.82%
Panel C: Regressions of R_{t+1} on D_t/Y_t or I_t/K_t, controlling for z_t							
Predictive Coefficient	1.37	-0.31	-0.60	-1.15	-0.76	-1.02	-0.45
s.e.	[0.49]	[0.90]	[1.39]	[1.50]	[0.68]	[1.08]	[0.56]
Adjusted R^2	6.34%	-4.66%	-2.20%	-3.06%	-2.59%	-3.14%	2.12%
Panel D: Regressions of R_{t+1} on $\mathbb{E}[R^I_{t+1}]$							
Predictive Coefficient	0.55	0.35	0.44	1.05	0.27	0.42	0.44
s.e.	[0.20]	[1.06]	[1.49]	[2.20]	[0.26]	[0.46]	[0.31]
Adjusted R^2	6.05%	-2.21%	-2.22%	-1.63%	-0.78%	-1.12%	1.28%

Table 3: Empirical and simulated moments: unlevered firm

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

			Model		
Description	**Notation**	**Data**	**Median**	**Q(1%)**	**Q(99%)**
Panel A: Unconditional moments					
Average Output Growth	$\mathbb{E}[(Y'-Y)/Y]$	2.75%	2.39%	-0.52%	5.63%
Volatility of Output Growth	$\sigma[(Y'-Y)/Y]$	5.95%	7.49%	5.60%	9.63%
Correlation of Return with Output Growth	$corr(R,(Y'-Y)/Y)$	0.02	0.01	-0.32	0.35
Correlation of Return with Productivity Shock	$corr(R, z-\mathbb{E}[z])$	0.24	0.32	-0.04	0.60
Correlation of Return with Payout Shock	$corr(R, d-\mathbb{E}[d])$	-0.54	-0.85	-0.93	-0.71
Average Payout Yield	$\mathbb{E}[D/P]$	1.59%	2.60%	-0.45%	5.75%
Volatility of Payout Yield	$\sigma[D/P]$	2.47%	4.37%	2.89%	6.72%
Autocorrelation of Payout Yield	$\mathbb{AC}[D/P]$	0.44	0.52	0.16	0.76
Average Return	$\mathbb{E}[R]$	7.86%	5.46%	3.94%	7.13%
Volatility of Return	$\sigma[R]$	14.88%	12.78%	9.31%	17.61%
Reward-to-Risk	$\mathbb{E}[R]/\sigma[R]$	0.53	0.43	0.31	0.58
Autocorrelation of Return	$\mathbb{AC}[R]$	-0.17	-0.20	-0.49	0.12
Volatility of $\mathbb{E}[R]$	$\sigma[\mathbb{E}[R]]$	–	5.79%	3.56%	10.10%
Panel B: Regressions of R_{t+1} on D_t/P_t					
Predictive Coefficient	b	1.81***	1.47	0.72	2.55
Adjusted R^2	R^2_{adj}	9.20%	23.66%	7.77%	45.96%
Panel C: Regressions of R_{t+1} on D_t/Y_t					
Predictive Coefficient	b	1.36***	2.01	0.84	3.90
Adjusted R^2	R^2_{adj}	8.60%	21.84%	6.58%	42.29%
Panel D: Regressions of R_{t+1} on D_t/Y_t and Z_t					
D_t/Y_t Predictive Coefficient	b_d	1.38***	2.09	0.82	4.04
Z_t Predictive Coefficient	b_z	-0.02	-0.01	-0.23	0.21
Adjusted R^2	R^2_{adj}	6.38%	22.06%	5.56%	43.79%

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

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

			Model		
Description	**Notation**	**Data**	**Median**	**Q(1%)**	**Q(99%)**
Panel A: Unconditional moments					
Average Output Growth	$\mathbb{E}[(Y'-Y)/Y]$	2.75%	2.38%	-0.58%	5.54%
Volatility of Output Growth	$\sigma[(Y'-Y)/Y]$	5.95%	7.44%	5.62%	9.50%
Correlation of Firm Return with Output Growth	$corr(R,(Y'-Y)/Y)$	0.02	0.02	-0.32	0.35
Correlation of Firm Return with Productivity Shock	$corr(R,z-\mathbb{E}[z])$	0.23	0.32	-0.04	0.61
Correlation of Firm Return with Payout Shock	$corr(R,d-\mathbb{E}[d])$	-0.54	-0.85	-0.93	-0.72
Average Firm Payout Yield	$\mathbb{E}[D/P]$	1.59%	2.55%	-0.35%	5.74%
Volatility of Firm Payout Yield	$\sigma[D/P]$	2.47%	4.34%	2.87%	6.72%
Autocorrelation of Firm Payout Yield	$\mathbb{AC}[D/P]$	0.44	0.51	0.15	0.76
Average Firm Return	$\mathbb{E}[R]$	7.86%	5.42%	3.95%	7.06%
Volatility of Firm Return	$\sigma[R]$	14.88%	12.68%	9.31%	17.25%
Reward-to-Risk	$\mathbb{E}[R]/\sigma[R]$	0.53	0.42	0.31	0.58
Autocorrelation of Firm Return	$\mathbb{AC}[R]$	-0.17	-0.20	-0.49	0.12
Volatility of $\mathbb{E}[R]$	$\sigma[\mathbb{E}[R]]$	–	5.74%	3.55%	9.99%
Panel B: Regressions of R_{t+1} on D_t/P_t					
Predictive Coefficient	b	1.81***	1.48	0.73	2.57
Adjusted R^2	R^2_{adj}	9.20%	23.83%	8.11%	45.47%
Panel C: Regressions of R_{t+1} on D_t/Y_t					
Predictive Coefficient	b	1.36***	2.00	0.84	3.76
Adjusted R^2	R^2_{adj}	8.60%	21.98%	6.63%	42.03%
Panel D: Regressions of R_{t+1} on D_t/Y_t and Z_t					
D_t/Y_t Predictive Coefficient	b_d	1.38***	2.07	0.82	3.91
Z_t Predictive Coefficient	b_z	-0.02	-0.01	-0.24	0.20
Adjusted R^2	R^2_{adj}	6.39%	22.26%	5.72%	43.54%
Panel E: Regressions of R_{t+1} on D^e_t/Y_t and D^b_t/Y_t					
D^e_t/Y_t Predictive Coefficient	b_e	0.86**	2.02	0.65	4.06
D^b_t/Y_t Predictive Coefficient	b_b	2.29**	2.02	0.00	4.38
Adjusted R^2	R^2_{adj}	10.07%	22.03%	5.55%	43.37%

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

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

			Model		
Description	**Notation**	**Data**	**Median**	**Q(1%)**	**Q(99%)**
Panel A: Unconditional moments					
Correlation of Equity Return with Output Growth	$corr(R^e, (Y'-Y)/Y)$	0.02	-0.02	-0.37	0.33
Correlation of Equity Return with Productivity Shock	$corr(R^e, z-\mathbb{E}[z])$	0.27	0.30	-0.08	0.60
Correlation of Equity Return with Equity Payout Shock	$corr(R^e, d^e-\mathbb{E}[d^e])$	-0.27	-0.50	-0.72	-0.13
Correlation of Equity Return with Debt Payout Shock	$corr(R^e, d^b-\mathbb{E}[d^b])$	-0.26	-0.45	-0.69	-0.08
Average Equity Payout Yield	$\mathbb{E}[D^e/P^e]$	2.49%	6.20%	0.82%	16.47%
Volatility of Equity Payout Yield	$\sigma[D^e/P^e]$	2.54%	7.98%	3.80%	34.22%
Autocorrelation of Equity Payout Yield	$\mathbb{AC}[D^e/P^e]$	0.54	0.48	0.05	0.74
Average Equity Return	$\mathbb{E}[R^e]$	8.96%	10.23%	5.31%	21.53%
Volatility of Equity Return	$\sigma[R^e]$	17.76%	24.20%	13.05%	81.93%
Reward-to-Risk	$\mathbb{E}[R^e]/\sigma[R^e]$	0.50	0.42	0.26	0.56
Autocorrelation of Equity Return	$\mathbb{AC}[R^e]$	-0.17	-0.19	-0.48	0.16
Volatility of $\mathbb{E}[R^e]$	$\sigma[\mathbb{E}[R^e]]$	–	12.28%	5.32%	81.09%
Panel B: Regressions of R^e_{t+1} on D^e_t/P^e_t					
Predictive Coefficient	b	1.64*	1.49	0.61	2.98
Adjusted R^2	R^2_{adj}	4.40%	22.79%	2.58%	84.38%
Panel C: Regressions of R^e_{t+1} on D_t/Y_t					
Predictive Coefficient	b	1.91***	4.06	1.26	12.67
Adjusted R^2	R^2_{adj}	12.20%	24.90%	7.58%	45.83%
Panel D: Regressions of R^e_{t+1} on D^e_t/Y_t and D^b_t/Y_t					
D^e_t/Y_t Predictive Coefficient	b_e	1.25***	4.11	1.05	12.46
D^b_t/Y_t Predictive Coefficient	b_b	3.13***	4.00	-0.12	13.88
Adjusted R^2	R^2_{adj}	14.46%	24.98%	6.72%	46.65%
Panel E: Regressions of R^e_{t+1} on D^e_t/Y_t, D^b_t/Y_t, and Z_t					
D^e_t/Y_t Predictive Coefficient	b_e	1.21	4.23	1.04	12.81
D^b_t/Y_t Predictive Coefficient	b_b	3.14**	4.11	-0.15	14.19
Z_t Predictive Coefficient	b_z	0.02	-0.03	-0.57	0.44
Adjusted R^2	R^2_{adj}	12.37%	25.14%	5.81%	47.67%

Table 6: Empirical and simulated moments: debt returns of levered firm

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

			Model		
Description	**Notation**	**Data**	**Median**	**Q(1%)**	**Q(99%)**
Panel A: Unconditional moments					
Correlation of Debt Return with Output Growth	$corr(R^b, (Y'-Y)/Y)$	-0.04	0.05	-0.37	0.45
Correlation of Debt Return with Productivity Shock	$corr(R^b, z-\mathbb{E}[z])$	-0.14	0.04	-0.32	0.38
Correlation of Debt Return with Equity Payout Shock	$corr(R^b, d^e-\mathbb{E}[d^e])$	-0.21	-0.15	-0.45	0.21
Correlation of Debt Return with Debt Payout Shock	$corr(R^b, d^b-\mathbb{E}[d^b])$	-0.15	0.09	-0.27	0.41
Average Debt Payout Yield	$\mathbb{E}[D^b/B]$	-1.69%	-1.54%	-4.21%	2.50%
Volatility of Debt Payout Yield	$\sigma[D^b/B]$	7.13%	6.21%	4.12%	22.88%
Autocorrelation of Debt Payout Yield	$\mathbb{AC}[D^b/B]$	0.14	0.13	-0.25	0.47
Average Debt Return	$\mathbb{E}[R^b]$	4.84%	1.02%	0.29%	1.19%
Volatility of Debt Return	$\sigma[R^b]$	7.47%	0.12%	0.03%	0.30%
Reward-to-Risk	$\mathbb{E}[R]/\sigma[R^b]$	0.65	7.90	1.47	36.23
Autocorrelation of Debt Return	$\mathbb{AC}[R^b]$	-0.04	0.91	0.52	0.99
Volatility of $\mathbb{E}[R^b]$	$\sigma[\mathbb{E}[R^b]]$	–	0.13%	0.05%	0.31%
Panel B: Regressions of R^b_{t+1} on D^b_t/B_{t+1}					
Predictive Coefficient	b	-0.01	0.00	-0.01	0.00
Adjusted R^2	R^2_{adj}	-2.44%	4.72%	-2.38%	38.57%
Panel C: Regressions of R^b_{t+1} on D_t/Y_t					
Predictive Coefficient	b	-0.23	0.00	-0.04	0.03
Adjusted R^2	R^2_{adj}	-1.26%	1.21%	-2.38%	37.82%
Panel D: Regressions of R^b_{t+1} on D^e_t/Y_t and D^b_t/Y_t					
D^e_t/Y_t Predictive Coefficient	b_e	-0.46*	0.01	-0.03	0.04
D^b_t/Y_t Predictive Coefficient	b_b	0.19	-0.01	-0.05	0.02
Adjusted R^2	R^2_{adj}	-0.93%	12.85%	-3.75%	48.79%
Panel E: Regressions of R^b_{t+1} on D^e_t/Y_t, D^b_t/Y_t, and Z_t					
D^e_t/Y_t Predictive Coefficient	b_e	-0.35	0.01	-0.03	0.04
D^b_t/Y_t Predictive Coefficient	b_b	0.16	-0.01	-0.05	0.01
Z_t Predictive Coefficient	b_z	-0.07*	0.00	-0.01	0.01
Adjusted R^2	R^2_{adj}	1.02%	19.96%	-3.87%	60.03%

Internet Appendix

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

A Derivations for the Payout-Based Model

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

A.1 Payout supply

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

The firm's first order condition is

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

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

$$q_t = 1 + (1-\tau)\partial_I \Phi(K_t, I_t). \tag{IA.2}$$

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

The envelope condition (with respect to K_t) is

$$\partial_K V(K_t, Z_t) = (1-\tau)(\partial_K \Pi(K_t, Z_t) - \partial_K \Phi(K_t, I_t)) + \tau\delta + (1-\delta)\mathbb{E}_t[M_{t+1}\partial_K V(K_{t+1}, Z_{t+1})], \tag{IA.3}$$

so, using the definition for q_t, we can write

$$\partial_K V(K_t, Z_t) = (1-\tau)(\partial_K \Pi(K_t, Z_t) - \partial_K \Phi(K_t, I_t)) + \tau\delta + (1-\delta)q_t. \tag{IA.4}$$

Finally, the investment return is

$$R^I_{t+1} = \frac{(1-\tau)(\partial_K \Pi(K_{t+1}, Z_{t+1}) - \partial_K \Phi(K_{t+1}, I_{t+1})) + \tau\delta + (1-\delta)q_{t+1}}{q_t}, \tag{IA.5}$$

so, using Equation IA.4, the equilibrium investment return satisfies

$$R^I_{t+1} = \frac{\partial_K V(K_{t+1}, Z_{t+1})}{q_t}. \tag{IA.6}$$

Plugging in Equation IA.6 into IA.1, we get

$$\mathbb{E}_t[M_{t+1} R^I_{t+1} q_t] = q_t, \tag{IA.7}$$

which yields Equation 17.

A.2 Equilibrium prices

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

$$\Pi(Z, K) = K \cdot \partial_K \Pi(Z, K), \tag{IA.8}$$

and

$$\Phi(K, I) = K \cdot \partial_K \Phi(K, I) + I \cdot \partial_I \Phi(K, I), \tag{IA.9}$$

respectively.

Using Equation IA.9, the firm's investment optimality condition can be written as follows:

$$q_t = 1 + \partial_I \Phi(K_t, I_t) = 1 + (1-\tau)(\Phi(K_t, I_t) - K_t \partial_K \Phi(K_t, I_t))/I_t. \tag{IA.10}$$

Recall that the firm payout is given by

$$D_t = (1-\tau)(\Pi(Z_t, K_t) - \Phi(I_t, K_t)) - I_t + \tau\delta K_t, \tag{IA.11}$$

so, using Equations IA.8 and IA.10, the firm's optimal payout satisfies

$$D_t = (1-\tau)\left(\partial_K \Pi(Z_t, K_t) - \partial_K \Phi(K_t, I_t)\right) \cdot K_t - q_t I_t + \tau\delta K_t = \partial_K D_t \cdot K_t - q_t I_t. \tag{IA.12}$$

Equation IA.12 implies that

$$\mathbb{E}_t[M_{t+1}D_{t+1}] = \mathbb{E}_t[M_{t+1}(\partial_K D_{t+1} \cdot K_{t+1} - q_{t+1}I_{t+1})]. \tag{IA.13}$$

We can now use the optimality condition $q_t = \mathbb{E}_t\left[M_{t+1}\left(\partial_K D_{t+1} + (1-\delta)q_{t+1}\right)\right]$ to rewrite Equation IA.13 as follows:

$$\mathbb{E}_t[M_{t+1}D_{t+1}] = \left(q_t - \mathbb{E}_t[M_{t+1}(1-\delta)q_{t+1}]\right)K_{t+1} - \mathbb{E}_t[M_{t+1}q_{t+1}I_{t+1}] = q_tK_{t+1} - \mathbb{E}_t[M_{t+1}q_{t+1}K_{t+2}]. \tag{IA.14}$$

Iterating and applying the law of iterated expectations, we get

$$\mathbb{E}_t[M_{t+1}D_{t+1}] = q_tK_{t+1} - \mathbb{E}_t[M_{t+2}(D_{t+2} + q_{t+2}K_{t+3})], \tag{IA.15}$$

which yields

$$\mathbb{E}_t[M_{t+1}D_{t+1}] + \mathbb{E}_t[M_{t+2}D_{t+2}] = q_tK_{t+1} - \mathbb{E}_t[M_{t+2}q_{t+2}K_{t+3}]. \tag{IA.16}$$

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

$$q_tK_{t+1} = \mathbb{E}_t\left[\sum_{s=1}^{\infty} M_{t+s}D_{t+s}\right] = V_t - D_t, \tag{IA.17}$$

or, equivalently,

$$V_t = D_t + q_tK_{t+1}. \tag{IA.18}$$

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

$$Q_t = q_t. \tag{IA.19}$$

It is important to note that we only use the firm's optimality conditions, but not the market clearing condition, for the above derivation. In other words, Equation IA.18 holds for any conditional SDF distributions that the firm takes as given. Of course, different assumptions about the conditional SDF distributions lead to a different q process (and, hence, a different firm value process), but the message of Equation IA.18 is simple: due to the linear homogeneity conditions (Equations IA.8 and IA.9), the only information regarding conditional SDF distributions that is needed to price the firm is q. All the market clearing condition (Equation 18) is needed for is to pin down the equilibrium q, denoted by q^*. By pinning down q^*, the market clearing condition is providing all the information regarding investor preferences that is needed in order to price the firm. Thus, in equilibrium we have

$$V_t^* = D_t^* + q_t^* K_{t+1}^*, \quad Q_t^* = q_t^*. \tag{IA.20}$$

A.3 Equilibrium returns

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

$$R_{t+1}^* = \frac{V_{t+1}^*}{V_t^* - D_t^*} = \frac{D_{t+1}^* + q_{t+1}^* K_{t+2}^*}{q_t^* K_{t+1}^*}, \tag{IA.21}$$

which yields

$$R_{t+1}^* = \frac{d_{t+1} Z_{t+1} + q_{t+1}^*((1-\delta) + \frac{q_{t+1}^*-1}{a(1-\tau)})}{q_t^*}. \tag{IA.22}$$

The equilibrium investment return is

$$R_{t+1}^{I,*} = \frac{(1-\tau)\left(\partial_K \Pi(K_{t+1}^*, Z_{t+1}) - \partial_K \Phi(K_{t+1}^*, I_{t+1}^*)\right) + \tau\delta + (1-\delta) q_{t+1}^*}{q_t^*}, \tag{IA.23}$$

which yields

$$R_{t+1}^{I,*} = \frac{\alpha(1-\tau) Z_{t+1} + \frac{(q_{t+1}^*-1)^2}{2a(1-\tau)} + \tau\delta + (1-\delta) q_{t+1}^*}{q_t^*}. \tag{IA.24}$$

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

$$(1-\tau)\alpha Z_{t+1} - \frac{(q_{t+1}^*)^2 - 1}{2a(1-\tau)} + \tau\delta = d_{t+1} Z_{t+1}, \tag{IA.25}$$

or, equivalently,

$$(1-\tau)\alpha Z_{t+1} = d_{t+1} Z_{t+1} + \frac{(q_{t+1}^*)^2 - 1}{2a(1-\tau)} - \tau\delta. \tag{IA.26}$$

Plugging the expression of IA.26 in Equation IA.24, we get, after some algebra,

$$R_{t+1}^{I,*} = \frac{d_{t+1} Z_{t+1} + (1-\delta) q_{t+1}^* + \frac{(q_{t+1}^*-1) q_{t+1}^*}{a(1-\tau)}}{q_t^*}. \tag{IA.27}$$

From Equations IA.22 and IA.27, it is obvious that the firm's equilibrium return and the equilibrium investment return are equal state-by-state:

$$R_{t+1}^{*} = R_{t+1}^{I,*}. \tag{IA.28}$$

A.4 Payout ratio upper bound

We show that the upper bound specification for the demanded payout ratio d, given by Equation 10, leads to feasible equilibrium investment and payout processes for the firm.

At each period t, the firm needs to choose investment and payout policies that satisfy its budget constraint, given Z_t (which is exogenous) and K_t (which is predetermined). If the investors' demanded payout is large enough, then the firm needs to disinvest in order to provide the demanded payout. However, since the firm has limited resources and faces capital adjustment costs, there is a maximal amount of payout that the firm is able to provide. Furthermore, since the firm's capital stock has to be always non-negative, the capital accumulation equation $K_{t+1} = (1-\delta)K_t + I_t$ implies that firm investment needs to satisfy $I_t \geq -(1-\delta)K_t$ for all t, which further constrains the maximal firm payout.[IA.2]

In particular, the maximum payout that the firm is able to provide at period t, denoted by D_t^{max}, is given by the solution of the following static problem:

$$D_t^{max} = \max_{\{I_t\}} \{(1-\tau)\left(\alpha Z_t K_t - \frac{a}{2}\left(I_t/K_t\right)^2 K_t\right) - I_t + \tau\delta K_t\}, \tag{IA.29}$$

such that $I_t \geq -(1-\delta)K_t$. It can be easily shown that the investment level that maximizes resources is $I_t = -\varphi K_t$, where $\varphi \equiv \min\{1/(a(1-\tau)), 1-\delta\}$, which yields a maximum payout level of

$$D_t^{max} = (1-\tau)\alpha Z_t K_t - (1-\tau)\frac{a}{2}\varphi^2 K_t + \varphi K_t + \tau\delta K_t. \tag{IA.30}$$

It follows that the maximum payout per unit of output is

$$\frac{D_t^{max}}{Y_t} = (1-\tau)\alpha + e^{-z_t}\left[\left(1 - \frac{(1-\tau)a}{2}\varphi\right)\varphi + \tau\delta\right], \tag{IA.31}$$

which is identical to the expression for the conditional upper bound of the demanded payout ratio, d_t^{max}, in our model (Equation 10).

Next, we show that our specification for d ensures that the capital non-negativity constraint never binds and, hence, the firm always optimally picks an interior solution for investment, given by the firm's first order condition: $I_t = \frac{q_t - 1}{a(1-\tau)} K_t$.

Fix t and assume that $K_t \geq 0$. The interior optimal investment satisfies the capital non-negativity

[IA.2] By assumption, the firm has initial capital stock $K_0 > 0$, so the capital non-negativity constraint is trivially satisfied at the initial period.

constraint if (and only if) $\frac{q_t-1}{a(1-\tau)}K_t \geq -(1-\delta)K_t$. This condition is trivially satisfied for $K_t = 0$. For $K_t > 0$, the expression is equivalent to $q_t \geq 1-a(1-\tau)(1-\delta)$. Since economic logic suggests that the firm's marginal q is always non-negative, ensuring that the firm's interior optimality condition satisfies the capital non-negativity constraint implies ensuring the following lower bound for the firm's marginal q: $q_t \geq max\{0, 1-a(1-\tau)(1-\delta)\}$. If that lower bound is satisfied, then the firm's investment policy at t is given by its interior optimality condition and K_{t+1} is non-negative. Iterating from $K_0 > 0$, it follows that we need to ensure that the model's exogenous processes are such that the firm's marginal q satisfies $q_t \geq max\{0, 1-a(1-\tau)(1-\delta)\}$ for all t.

All left to do is to confirm that our specification for the demanded payout ratio d, which imposes a conditional upper bound on that process, leads to an equilibrium q process that satisfies the condition above. First, consider the case that $a \geq \frac{1}{(1-\tau)(1-\delta)}$. Then, we need to show that our d process leads to an equilibrium q process that satisfies $q_t \geq 0$ for all t. Indeed, for any $d_t \leq d_t^{max} = (1-\tau)\alpha + e^{-z_t}\left[\frac{1}{2a(1-\tau)} + \tau\delta\right]$, Equation 20 yields a real-valued (and non-negative) q_t^*. Now, consider the case that $a < \frac{1}{(1-\tau)(1-\delta)}$. We need to show that our d process leads to an equilibrium q process that satisfies $q_t \geq 1-a(1-\tau)(1-\delta)$ for all t. Indeed, for any $d_t \leq d_t^{max} = (1-\tau)\alpha + e^{-z_t}\left[\left(1-\frac{(1-\tau)a}{2}\cdot(1-\delta)\right)(1-\delta)+\tau\delta\right]$, Equation 20 yields a real-valued q_t^* that satisfies $q_t^* \geq 1-a(1-\tau)(1-\delta) > 0$.

B The Two-Period General Equilibrium Model

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

B.1 The general equilibrium model

The economy has two periods (denoted by t and $t+1$) and consists of a representative equity-financed firm and a representative household. There is a single good that can be either consumed or used as a capital input in the firm's production, and all quantities are expressed in units of that good. The optimizing behavior of the firm generates the payout supply function, while the payout demand function arises from the household's optimal consumption-saving decision.[IA.3]

[IA.3] In our simple economy, the only asset that exists is the equity of the firm, so the household's equity payout demand is equal to the household's consumption demand: simply put, there is no other available source of income for the household, so the entirety of its consumption has to be financed by the equity payout of the firm. However, it is important to stress that in a richer model (that would include, for example, labor income, multiple assets, or a government sector) the household's payout demand for any particular asset would be determined by the solution to the household's optimization problem and would generally differ from its consumption demand. For example, in a model where the household can invest only in a single firm's equity, but earns labor income, its equity payout demand would be equal to the difference between its consumption demand and its (optimally chosen) labor income. In such a model, our payout-based asset pricing approach would entail specifying an exogenous process for the household's equity payout demand, rather than for the household's consumption demand.

B.2 The firm's problem and the payout supply function

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

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

$$V_t = \max_{\{D_t, I_t\}} \left(D_t + \mathbb{E}_t \left[M_{t+1} D_{t+1}\right]\right), \tag{IA.32}$$

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

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

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

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

$$\max_{\{D_t\}} \left(D_t + \mathbb{E}_t \left[M_{t+1} \left(\Pi((1-\delta)K_t \; + \; I_t, Z_{t+1}) \; + \; (1-\delta)((1-\delta)K_t \; + \; I_t)\right)\right]\right), \tag{IA.33}$$

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

$$1 = \mathbb{E}_t \left[M_{t+1} \cdot (-\partial_D I_t) \cdot (\partial_K \Pi((1-\delta)K_t \; + \; I_t, Z_{t+1}) + (1-\delta))\right], \tag{IA.34}$$

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

$$1 = \mathbb{E}_t \left[M_{t+1} \cdot \frac{\partial_K \Pi((1-\delta)K_t + I_t, Z_{t+1}) + (1-\delta)}{1 + \partial_I \Phi(K_t, I_t)} \right]. \qquad \text{(IA.35)}$$

The intuition is simple: taking M_{t+1} as given, the firm adjusts its investment I_t (and, hence, its payout D_t) so that its optimality condition is satisfied. As a result, the firm's optimality condition yields a payout supply function: conditional on state variables K_t and Z_t, for any given M_{t+1}, the firm chooses the particular investment (and, thus, payout) level that is consistent with its optimization objective.[IA.4]

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

$$R_{t+1} = \frac{D_{t+1}}{P_t} = \frac{D_{t+1}}{\mathbb{E}_t \left[M_{t+1} \cdot D_{t+1} \right]}. \qquad \text{(IA.36)}$$

In what follows, we assume that the productivity process satisfies $Z_{t+1} = Z_t^{\phi_z} \cdot e^{\epsilon_{z,t+1}}$, where $\phi_z \in [0,1]$ and $\epsilon_{z,t+1} \sim N(-\sigma_z^2/2, \sigma_z^2)$, and that capital fully depreciates within one period (i.e., $\delta = 1$). Substituting the expressions for Π_t and Φ_t into the firm's optimality condition (Equation IA.35), we get

$$1 = \mathbb{E}_t \left[M_{t+1} \cdot \frac{Z_{t+1}}{1 + a(I_t/K_t)} \right] = \mathbb{E}_t \left[M_{t+1} \cdot \frac{D_{t+1} \cdot I_t^{-1}}{1 + a(I_t/K_t)} \right] = \frac{I_t^{-1} \cdot \mathbb{E}_t \left[M_{t+1} \cdot D_{t+1} \right]}{1 + a(I_t/K_t)}. \qquad \text{(IA.37)}$$

Then, using the expression for the firm's expected return, $\mathbb{E}_t[R_{t+1}] = \frac{\mathbb{E}_t[D_{t+1}]}{P_t} = \frac{\mathbb{E}_t[D_{t+1}]}{\mathbb{E}_t[M_{t+1} \cdot D_{t+1}]}$, and the expression for the firm's expected payout, $\mathbb{E}_t[D_{t+1}] = Z_t^{\phi_z} I_t$, and rearranging terms yields the following expression for the firm's investment function:

$$I_t = I(K_t, Z_t; \mathbb{E}_t([R_{t+1}]) = \frac{1}{a} \left[\frac{Z_t^{\phi_z}}{\mathbb{E}_t[R_{t+1}]} - 1 \right] K_t. \qquad \text{(IA.38)}$$

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

[IA.4] It is worth noting that we can express the firm's optimality condition in more familiar terms by considering the investment return, R^I, defined as the gross return of an extra unit of firm capital

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

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

supply function:

$$D_t = D(K_t, Z_t; \mathbb{E}_t[R_{t+1}]) = \left[Z_t - \frac{1}{2a} \left(\left(\frac{Z_t^{\phi_z}}{\mathbb{E}_t[R_{t+1}]} \right)^2 - 1 \right) \right] K_t. \tag{IA.39}$$

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

Finally, the firm's cum-payout value satisfies

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

so firm's payout yield is given by

$$D_t/V_t = (D/V)(Z_t; \mathbb{E}_t[R_{t+1}]) = \frac{Z_t - \frac{1}{2a} \left[\left(\frac{Z_t^{\phi_z}}{\mathbb{E}_t[R_{t+1}]} \right)^2 - 1 \right]}{Z_t + \frac{1}{2a} \left(\frac{Z_t^{\phi_z}}{\mathbb{E}_t[R_{t+1}]} - 1 \right)^2}. \tag{IA.40}$$

Note that, due to the assumption of constant-returns-to-scale technology, the firm's payout yield does not directly depend on its stock of capital K_t.

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

B.3 The household's problem and the payout demand function

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

$$\max_{\{C_t, S_t\}} \left(U(C_t, \theta_t) \; + \; \beta \cdot \mathbb{E}_t \left[U(C_{t+1}, \theta_{t+1}) \right] \right) \tag{IA.41}$$

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

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

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

$$C_{t+1} = (C_t - W_t) \cdot R_{t+1}. \tag{IA.42}$$

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

$$\max_{\{C_t\}} \left(U(C_t) \ + \ \beta \cdot \mathbb{E}_t \left[U((W_t - C_t) \cdot R_{t+1})\right]\right). \tag{IA.43}$$

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 optimality condition is the familiar Euler equation,

$$1 = \mathbb{E}_t \left[\beta \frac{\partial_C U((W_t - C_t) \cdot R_{t+1}, \theta_{t+1})}{\partial_C U(C_t, \theta_t)} \cdot R_{t+1}\right]. \tag{IA.44}$$

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

In what follows, we assume that process θ has law of motion $\theta_{t+1} = \theta_t^{\phi_\theta} e^{\epsilon_{\theta,t+1}}$, where $\phi_\theta \in [0, 1]$ and $\epsilon_{\theta,t+1} \sim N(-\sigma_\theta^2/2, \sigma_\theta^2)$. Furthermore, we assume that shocks $\epsilon_{\theta,t+1}$ and $\epsilon_{z,t+1}$ are independent of each other. The household's payout demand function (i.e., its consumption-wealth ratio) is[IA.5]

$$C_t/W_t \;=\; (C/W)(\theta_t; \mathbb{E}_t[R_{t+1}]) \;=\; \frac{1}{1+\beta^{1/\gamma}\cdot\theta_t^{(\phi_\theta-1)/\gamma}\cdot\mathbb{E}_t[R_{t+1}]^{1/\gamma-1}\cdot e^{(\gamma-1)\sigma_z^2/2}}. \qquad \text{(IA.48)}$$

Panel B of Figure IA.1 shows the family of the household's C_t/W_t curves for different values of θ_t, setting $\gamma = 5$, $\beta = 0.9$, $\phi_\theta = 0.1$, $\sigma_z = 1$. Since $\gamma > 1$, the household's wealth-consumption ratio is increasing in the firm's expected return.[IA.6] 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.

B.4 Equilibrium

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

[IA.5] In order to derive Equation IA.48, we work as follows. First, we note that our specification implies that

$$\mathbb{E}_t[D_{t+1}^{1-\gamma}] \;=\; (Z_t^{\phi_z}\cdot I_t)^{1-\gamma}\cdot e^{\gamma\cdot(\gamma-1)\cdot\sigma_z^2/2} \;=\; \mathbb{E}_t[D_{t+1}]^{1-\gamma}\cdot e^{\gamma\cdot(\gamma-1)\cdot\sigma_z^2/2}. \qquad \text{(IA.45)}$$

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

$$\mathbb{E}_t[R_{t+1}^{1-\gamma}] \;=\; \frac{\mathbb{E}_t[D_{t+1}^{1-\gamma}]}{V_t^{1-\gamma}} \;=\; \frac{\mathbb{E}_t[D_{t+1}]^{1-\gamma}}{V_t^{1-\gamma}}\cdot e^{\gamma\cdot(\gamma-1)\cdot\sigma_z^2/2} \;=\; \mathbb{E}_t[R_{t+1}]^{1-\gamma}\cdot e^{\gamma\cdot(\gamma-1)\cdot\sigma_z^2/2}. \qquad \text{(IA.46)}$$

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

$$C_t \;=\; \frac{W_t}{1+\left(\beta\cdot\theta_t^{(\phi_\theta-1)}\right)^{1/\gamma}\cdot\mathbb{E}_t[R_{t+1}^{1-\gamma}]^{1/\gamma}}. \qquad \text{(IA.47)}$$

Using Equation IA.46, we get Equation IA.48.

[IA.6] 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.

S_t), so the *asset market clearing condition* is $P_t = S_t$.

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

$$(D/V)(Z_t; \mathbb{E}_t[R^*_{t+1}]) \; = (C/W)(\theta_t; \mathbb{E}_t[R^*_{t+1}]), \tag{IA.49}$$

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

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

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

B.5 Consumption-based asset pricing

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

K and Z.[IA.7]

As in the full economy, the household's payout demand is given by Equation IA.48, which is nothing more than the household's optimality condition. The market clearing condition is now $C_t = D_t^s$, which implies $\frac{C_t}{W_t} = \frac{D_t^s}{D_t^s + \frac{\mathbb{E}_t[D_{t+1}^s]}{\mathbb{E}_t[R_{t+1}]}}$, so plugging that condition in the household's optimality condition and solving for the expected return of the firm, we get

$$\mathbb{E}_t[R_{t+1}^*] = \mathcal{R}^*(\theta_t, \mathbb{E}_t[D_{t+1}^s/D_t^s]) = \frac{\left(\mathbb{E}_t[D_{t+1}^s/D_t^s]\right)^\gamma}{\beta \cdot \theta_t^{\phi_\theta - 1} \cdot e^{\gamma(\gamma-1)\sigma_d^2/2}}. \tag{IA.50}$$

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

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

B.6 Payout-based asset pricing

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 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.[IA.8]

Payout supply arises from the firm's optimization problem and is given by Equation IA.39. Plugging

[IA.7] In the full economy, $D_t = Z_t K_t - I_t^* - \frac{a}{2}\left(I_t^*/K_t\right)^2 K_t$ and $D_{t+1} = Z_t^{\phi_z} I_t^* e^{\epsilon_{z,t+1}}$, where I_t^* is the equilibrium investment level and $\epsilon_{z,t+1} \sim N(-\sigma_z^2/2, \sigma_z^2)$. Hence, the consumption-based asset pricing economy maps to the full economy if $D_t^s = Z_t K_t - I_t^* - \frac{a}{2}\left(I_t^*/K_t\right)^2 K_t$, $\mathbb{E}_t[D_{t+1}^s] = Z_t^{\phi_z} I_t^*$, and $\sigma_d = \sigma_z$.

[IA.8] To do so, a necessary (but not sufficient) condition is feasibility of market clearing: the exogenous process D^d must be consistent with the firm's intertemporal budget constraint. Inter alia, that requires that D_t^d and $\mathbb{E}_t[D_{t+1}^d]$ satisfy $D_t^d = Z_t K_t - \frac{\mathbb{E}_t[D_{t+1}^d]}{Z_t^{\phi_z}} - \frac{a}{2}\left(\frac{\mathbb{E}_t[D_{t+1}^d]}{Z_t^{\phi_z}}\right)^2 \frac{1}{K_t}$.

in the market clearing condition ($D_t = D_t^d$, which implies $\frac{D_t}{V_t} = \frac{D_t^d}{D_t^d + \frac{\mathbb{E}_t[D_{t+1}^d]}{\mathbb{E}_t[R_{t+1}]}}$) yields the following expression for the equilibrium expected return of the firm:

$$\mathbb{E}_t[R_{t+1}^*] = \mathcal{R}^*(Z_t, D_t^d/Y_t) = \frac{Z_t^{\phi_z}}{\sqrt{1 + 2a(1 - D_t^d/Y_t)Z_t}}, \tag{IA.51}$$

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

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

C Derivations for the Payout-Based Model with Firm Leverage

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

C.1 Equilibrium prices

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

Since the operating profit function and the capital adjustment cost function are the same as in the case of the unlevered firm, Equations IA.8 and IA.9 are still satisfied. Furthermore, the leverage cost function $G(B, K) = \frac{\kappa}{2}\left(\frac{B}{K}\right)^2 K$ satisfies

$$G(B, K) = K \cdot \partial_K G(B, K) + B \cdot \partial_B G(B, K). \tag{IA.52}$$

Using Equations IA.8, IA.9, and IA.52 we can write the firm's optimal equity payout as

$$D_t^e = K_t \cdot \partial_K D_t - q_t I_t - (R_t^{b,a} + \partial_B G_t)B_t + B_{t+1}, \tag{IA.53}$$

so

$$\mathbb{E}_t[M_{t,t+1}D^e_{t+1}] = \mathbb{E}_t[M_{t,t+1}(K_{t+1}\cdot\partial_K D_{t+1} - q_{t+1}I_{t+1} - (R^{b,a}_{t+1} + \partial_B G_{t+1})B_{t+1} + B_{t+2})]. \quad \text{(IA.54)}$$

We use the firm's investment and debt optimality conditions, $q_t = \mathbb{E}_t\left[M_{t,t+1}\left(\partial_K D_{t+1} + (1-\delta)q_{t+1}\right)\right]$ and $1 = \mathbb{E}_t\left[M_{t,t+1}(R^{b,a}_{t+1} + \partial_B G_{t+1})\right]$, respectively, to rewrite Equation IA.54 as follows:

$$\mathbb{E}_t[M_{t,t+1}D^e_{t+1}] = \left(q_t - \mathbb{E}_t[M_{t,t+1}(1-\delta)q_{t+1}]\right)K_{t+1} - \mathbb{E}_t[M_{t,t+1}q_{t+1}I_{t+1}] - B_{t+1} + \mathbb{E}_t[M_{t,t+1}B_{t+2}], \quad \text{(IA.55)}$$

which yields

$$\mathbb{E}_t[M_{t,t+1}D^e_{t+1}] = (q_t K_{t+1} - B_{t+1}) - \mathbb{E}_t[M_{t,t+1}(q_{t+1}K_{t+2} - B_{t+2})]. \quad \text{(IA.56)}$$

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

$$\mathbb{E}_t[M_{t,t+1}D^e_{t+1}] = (q_t K_{t+1} - B_{t+1}) - \mathbb{E}_t[M_{t,t+2}(D^e_{t+2} + q_{t+2}K_{t+3} - B_{t+3})], \quad \text{(IA.57)}$$

which yields

$$\mathbb{E}_t[M_{t,t+1}D^e_{t+1}] + \mathbb{E}_t[M_{t,t+2}D^e_{t+2}] = (q_t K_{t+1} - B_{t+1}) - \mathbb{E}_t[M_{t,t+2}(q_{t+2}K_{t+3} - B_{t+3})]. \quad \text{(IA.58)}$$

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

$$q_t K_{t+1} - B_{t+1} = \mathbb{E}_t\left[\sum_{s=1}^{\infty} M_{t,t+s}D^e_{t+s}\right] = P^e_t, \quad \text{(IA.59)}$$

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

$$P^e_t = q_t K_{t+1} - B_{t+1} = (q_t - b_{t+1})K_{t+1}. \quad \text{(IA.60)}$$

C.2 Equilibrium returns

The firm's equilibrium equity return is

$$R^{e,*}_{t+1} = \frac{D^{e,*}_{t+1} + P^{e,*}_{t+1}}{P^{e,*}_t} = \frac{d^e_{t+1}Z_{t+1}K^*_{t+1} + (q^*_{t+1} - b^*_{t+2})K^*_{t+2}}{(q^*_t - b^*_{t+1})K^*_{t+1}}, \quad \text{(IA.61)}$$

which yields

$$R^{e,*}_{t+1} = \frac{d^e_{t+1} Z_{t+1} + (q^*_{t+1} - b^*_{t+2}) \left((1-\delta) + \frac{q^*_{t+1}-1}{a(1-\tau)} \right)}{q^*_t - b^*_{t+1}}. \tag{IA.62}$$

Note that Equation 35 implies that, in equilibrium,

$$b^*_{t+2} = \frac{R^{b,*}_{t+1} b^*_{t+1} - d^b_{t+1} Z_{t+1}}{(1-\delta) + \frac{q^*_{t+1}-1}{a(1-\tau)}}, \tag{IA.63}$$

so we can rewrite the expression above as

$$R^{e,*}_{t+1} = \frac{d_{t+1} Z_{t+1} + q^*_{t+1} \left((1-\delta) + \frac{q^*_{t+1}-1}{a(1-\tau)} \right) - R^{b,*}_{t+1} b^*_{t+1}}{q^*_t - b^*_{t+1}}. \tag{IA.64}$$

Finally, using Equation 69, the expression above can be rewritten as

$$R^{e,*}_{t+1} = \frac{d_{t+1} Z_{t+1} + q^*_{t+1} \left((1-\delta) + \frac{q^*_{t+1}-1}{a(1-\tau)} \right) - \left(\frac{\kappa}{\tau} b^*_{t+1} + 1 \right) b^*_{t+1}}{q^*_t - b^*_{t+1}}. \tag{IA.65}$$

C.3 Payout ratio upper bound

We show that the specification for the upper bound of the demanded payout ratio d, given by Equation 43, generates feasible equilibrium investment and payout processes for the levered firm. The logic of our derivation follows the logic of the corresponding derivation for the unlevered firm.

At each period t, the firm needs to choose policies that satisfy its budget constraint, given Z_t (which is exogenous) and K_t and B_t (which are predetermined). The choice of B_{t+1} does not affect the total resources that the firm has available to pay out to all claimholders, D, as any choice of B_{t+1} leads to offsetting changes in the firm's debt and equity payout (see Equations 35 and 40, respectively). Hence, the maximum total payout that the firm is able to provide at period t, denoted by D^{max}_t, is given by the solution of the following static problem:

$$D^{max}_t = \max_{\{I_t\}} \{ (1-\tau) \left(\alpha Z_t K_t - \frac{a}{2} (I_t/K_t)^2 K_t \right) - I_t + \tau\delta K_t + \tau (R^b_t - 1) B_t - \frac{\kappa}{2} (B_t/K_t)^2 K_t \}, \tag{IA.66}$$

such that $I_t \geq -(1-\delta)K_t$. As in the case of the unlevered firm, the investment level that maximizes resources is $I_t = -\varphi K_t$, where $\varphi \equiv \min\{1/(a(1-\tau)), 1-\delta\}$, which yields a maximum total payout level of

$$D^{max}_t = (1-\tau)\alpha Z_t K_t - (1-\tau)\frac{a}{2}\varphi^2 K_t + \varphi K_t + \tau\delta K_t + \tau(R^b_t - 1)B_t - \frac{\kappa}{2} (B_t/K_t)^2 K_t. \tag{IA.67}$$

It follows that the firm's maximum total payout per unit of output is

$$\frac{D_t^{max}}{Y_t} = (1-\tau)\alpha + e^{-z_t}\left[\left(1 - \frac{(1-\tau)a}{2}\varphi\right)\varphi + \tau\delta + \tau(R_t^b - 1)b_t - \frac{\kappa}{2}b_t^2\right], \tag{IA.68}$$

and, since the equilibrium risk-free rate satisfies $R_t^b = \frac{\kappa}{\tau}b_t + 1$ (see Equation 69), the expression above can be simplified to

$$\frac{D_t^{max}}{Y_t} = (1-\tau)\alpha + e^{-z_t}\left[\left(1 - \frac{(1-\tau)a}{2}\varphi\right)\varphi + \tau\delta + \frac{\kappa}{2}b_t^2\right], \tag{IA.69}$$

which is identical to the expression for the conditional upper bound of the demanded total payout ratio, d_t^{max} (Equation 43).

We now proceed to demonstrate that our specification for d ensures that the capital non-negativity constraint never binds and, hence, the firm always optimally picks an interior solution for investment.

The interior investment condition of the levered firm, given by Equation 52, is identical to the interior investment condition of the unlevered firm. Thus, following the same steps as for the unlevered firm, we can show that we need to ensure that the model's exogenous processes are such that the firm's marginal q satisfies $q_t \geq max\{0, 1 - a(1-\tau)(1-\delta)\}$ for all t.

We conclude by showing that our specification for the demanded payout ratio d leads to an equilibrium q process that satisfies the condition above. First, assume that $a \geq \frac{1}{(1-\tau)(1-\delta)}$. In that case, we need to show that our d process leads to an equilibrium q process that satisfies $q_t \geq 0$ for all t. We can easily see that, for any $d_t \leq d_t^{max} = (1-\tau)\alpha + e^{-z_t}\left[\frac{1}{2a(1-\tau)} + \tau\delta + \frac{\kappa}{2}b_t^2\right]$, Equation 59 yields a real-valued (and non-negative) q_t^*. Now, assume that $a < \frac{1}{(1-\tau)(1-\delta)}$. In that case, we need to show that our d process generates an equilibrium q process that satisfies $q_t \geq 1 - a(1-\tau)(1-\delta)$ for all t. Indeed, for any $d_t \leq d_t^{max} = (1-\tau)\alpha + e^{-z_t}\left[\left(1 - \frac{(1-\tau)a}{2} \cdot (1-\delta)\right)(1-\delta) + \tau\delta + \frac{\kappa}{2}b_t^2\right]$, Equation 59 yields a real-valued q_t^* that satisfies $q_t^* \geq 1 - a(1-\tau)(1-\delta) > 0$.

C.4 Collateral constraint

First, we need to ensure that the firm's optimal interior leverage ratio, given by Equation 50, always satisfies the firm's collateral constraint (Equation 38) and, hence, the collateral constraint never binds. We start by rewriting the collateral constraint as a quadratic inequality:

$$\frac{\kappa}{2}b_{t+1}^2 + R_{t+1}^{b,a}b_{t+1} - \left((1-\delta) + (1-\tau)\alpha Z_{t+1}^{min} + \tau\delta\right) \leq 0. \tag{IA.70}$$

Due to its nature, the firm's collateral constraint applies only when the firm borrows, i.e., when $b_{t+1} \geq 0$, whereas there is no constraint when the firm holds cash, i.e., when $b_{t+1} < 0$. It follows that the firm's collateral constraint is satisfied if and only if

$$b_{t+1} \leq \frac{\sqrt{(R_{t+1}^{b,a})^2 + 2\kappa[(1-\delta) + (1-\tau)\alpha Z_{t+1}^{min} + \tau\delta]} - R_{t+1}^{b,a}}{\kappa}. \tag{IA.71}$$

Consider the firm's optimal interior leverage ratio, given by $b_{t+1} = \frac{\tau}{\kappa}(R_{t+1}^{b} - 1)$. The interior optimum satisfies the collateral constraint if

$$\frac{\tau}{\kappa}(R_{t+1}^{b} - 1) \leq \frac{\sqrt{(R_{t+1}^{b,a})^2 + 2\kappa[(1-\delta) + (1-\tau)\alpha Z_{t+1}^{min} + \tau\delta]} - R_{t+1}^{b,a}}{\kappa}. \tag{IA.72}$$

We can easily show that the condition above is satisfied for all $R_{t+1}^{b} \leq \bar{R}_{t+1}^{b}$, where $\bar{R}_{t+1}^{b}$ is an upper bound that depends on the value of Z_{t+1}^{min}. For our derivations, we assume that Z_{t+1}^{min} is always high enough so that the firm's collateral constraint never binds and the firm's optimal leverage ratio is always given by Equation 50.

Since Equation 50 (and, hence, Equation 69) always holds, we can derive an expression for the upper bound of b_{t+1} as a function of exogenous variables. We start by using the expression for the equilibrium pre-tax cost of debt (Equation 69), to derive the following expression for the equilibrium after-tax cost of debt:

$$R_{t+1}^{b,a} = R_{t+1}^{b} - \tau(R_{t+1}^{b} - 1) = 1 + \frac{\kappa}{\tau}b_{t+1} - \kappa b_{t+1} = 1 + \left(\frac{1}{\tau} - 1\right)\kappa b_{t+1}. \tag{IA.73}$$

Plugging the expression above into the firm's collateral constraint (Equation 38), we get

$$\left(1 + \left(\frac{1}{\tau} - 1\right)\kappa b_{t+1}\right) b_{t+1} \leq (1-\delta) + (1-\tau)\alpha Z_{t+1}^{min} + \tau\delta - \frac{\kappa}{2} b_{t+1}^2, \tag{IA.74}$$

which yields the following quadratic inequality:

$$\left(\frac{1}{\tau} - \frac{1}{2}\right)\kappa b_{t+1}^2 + b_{t+1} - \left((1-\delta) + (1-\tau)\alpha Z_{t+1}^{min} + \tau\delta\right) \leq 0. \tag{IA.75}$$

Since the firm's collateral constraint applies only when the firm borrows (i.e., when $b_{t+1} \geq 0$), it follows that the firm's collateral constraint is satisfied if and only if

$$b_{t+1} \leq \frac{\sqrt{1 + 2\kappa\left(\frac{2}{\tau} - 1\right)\left((1-\delta) + (1-\tau)\alpha Z_{t+1}^{min} + \tau\delta\right)} - 1}{\kappa\left(\frac{2}{\tau} - 1\right)}. \tag{IA.76}$$

D Data Sources and Empirical Measures

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

We measure aggregate corporate payout as

$$D_t = P_t \cdot \left(\frac{P_t^e}{P_t} \cdot \frac{D_t^e}{P_t^e} + \frac{P_t^b}{P_t} \cdot \frac{D_t^b}{P_t^b} \right) \tag{IA.77}$$

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

We use the DRSY dataset for data on the market value of equity (P_t^e) and debt (P_t^b) aggregated across all U.S. public companies and accounting for equity cross-holdings (i.e., excluding the fraction of the aggregate market equity held by public corporations). We also rely on the DRSY dataset for aggregate debt payout (D_t^b) data. Hence, in Equation IA.77, the measures for P_t, P_t^e/P_t, P_t^b/P_t and D_t^b/P_t^b are constructed using the DRSY dataset. However, we calculate D_t^e/P_t^e using data from CRSP, which is the original data source for D_t^e/P_t^e in the DRSY dataset, as follows.[IA.9] First, we retrieve the subset of the CRSP dataset which includes public firms incorporated in the United States (SHRCD = 10 or 11) trading on NYSE, Amex, or Nasdaq (EXCHCD = 1,2, or 3). Then, we measure the market value of equity monthly for each PERMNO (as |PRCC|·SHROUT) and carry it forward when there are missing observations. We measure net payout at the PERMNO level as $D_t^e = P_{t-1}^e \cdot (1 + R_t^e) - P_t^e$ (where R_t^e is based on the RET variable in CRSP) – recall that P_t^e refers to the market value of equity (rather than price per share), so D_t^e retrieves the entirety of the firm's net equity payout (dividends plus equity repurchases, minus equity issuances), rather than just dividends. We assume that the first month of non-missing market equity is the firm's entry month in the public market portfolio so that $P_{t-1}^e = 0$ and $D_t^e = -P_t^e$ for the firm at that month. Moreover, in the delisting month we set $P_t^e = 0$ and $D_t^e = P_{t-1}^e \cdot (1 + R_t^e)$, where R_t^e is

[IA.9] We do not use the D_t^e/P_t^e values from the DRSY dataset for two reasons. First, the average DRSY D_t^e/P_t^e ratio is 1.7%, which implies a very high cash flow duration for the equity market. In contrast, our average D_t^e/P_t^e ratio is 2.5%. Second, to account for equity cross-holdings, DRSY assume that the return that corporations get on their equity portfolio is the same as the return that other investors get on their equity portfolio. While this assumption is reasonable, it has the effect that their D_t^e measure partially reflects the market value of firms, mixing cash flows with asset prices. Specifically, let D_t^e be the equity payout measured directly from CRSP, $\hat{D}_t^e$ the payout from the portfolio that accounts for equity cross-holdings, and γ_t the fraction of the equity market held by public firms. DRSY assume $(D_t^e + P_t^e)/P_{t-1}^e = (\hat{D}_t^e + \gamma_t \cdot P_t^e)/(\gamma_{t-1} \cdot P_{t-1}^e)$, which allows them to measure their equity payout as

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

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

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 $R_t^e = -1$ so that $D_t^e = 0$ over that month). After measuring P_t^e and D_t^e monthly at the PERMNO level, we aggregate over time (from January to December) to obtain annual D_t^e for each PERMNO and then aggregate across PERMNOs to obtain aggregate annual D_t^e values. Similarly, we aggregate P_t^e across PERMNOs at the end of each December to obtain the aggregate P_t^e. Finally, we compute the aggregate D_t^e/P_t^e and use it in Equation IA.77.

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

Finally, we measure productivity $Z_t = Y_t/K_t$ in a way that allows us to not take a stand on how to measure investment or capital, which is advantageous given that measuring physical capital is prone to non-trivial measurement errors (see, e.g., Bai et al. (2024)) 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, set the initial value for Z_t in 1974 (the first year in our sample) to its steady-state value and update the Z_t series as follows (consistent with our model)[IA.10]:

$$Z_t = Y_t/K_t, \tag{IA.78}$$

$$q_t = \sqrt{1 + 2a(1-\tau)\left(\tau\delta + [\alpha(1-\tau) - d_t]Z_t\right)}, \tag{IA.79}$$

$$i_t = \frac{q_t - 1}{a(1-\tau)}, \tag{IA.80}$$

$$K_{t+1} = (1 - \delta + i_t) \cdot K_t. \tag{IA.81}$$

[IA.10] It should be stressed that our methodology for backing out aggregate productivity Z does not impose our asset pricing model into the data, but follows directly from the firm's budget constraint and the capital accumulation equation, similar in spirit to the methodology used in Cochrane (1991). To see that, note that Equations IA.79 and IA.80 can be combined into one equation that reflects the firm's budget constraint.

In the expressions above, i denotes the investment-to-capital ratio. We follow an analogous procedure for the model with firm leverage, except that we also use the expression for the evolution of b (Equation 60), since q also depends on b.

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

$$R_{t+1} = \frac{P_{t+1} + D_{t+1}}{P_t}, \tag{IA.82}$$

where P_t is measured as described previously and D_t is measured as in Equation IA.77. The returns in the DRSY dataset differ from ours because we do not use their D_t^e measure (as discussed in Footnote IA.9). However, the differences are not large: the correlation between the two firm return measures is 0.995. Moreover, our return measure makes it somewhat harder for the model to match the data, as the DRSY measure implies higher average and more volatile aggregate returns. In particular, the DRSY measure implies $\mathbb{E}[R] = 7.0\%$ and $\sigma[R] = 14.2\%$, whereas our measure implies $\mathbb{E}[R] = 7.9\%$ and $\sigma[R] = 14.9\%$. Similarly, the equity and debt returns are given by

$$R_{t+1}^e = \frac{P_{t+1}^e + D_{t+1}^e}{P_t^e}, \tag{IA.83}$$

and

$$R_{t+1}^b = \frac{P_{t+1}^b + D_{t+1}^b}{P_t^b}, \tag{IA.84}$$

respectively.

E Investment-Based Approach Implementation

This section provides the details for the measurement of aggregate investment and the selection of model parameters for our implementations of the investment-based approach, and shows that the disparity between our findings and the findings in Cochrane (1991) is mainly due to focusing on different sample periods.

E.1 Investment measurement and parameter selection

The first three implementations of the investment-based approach use three different measures of U.S. real aggregate domestic investment from the NIPA tables as a proxy for the model investment process. The first implementation, denoted by "i_{NIPA}", uses total investment ("Gross Private Domestic Investment", line 4 in NIPA Table 5.2.6), the second implementation ("i_{NIPA}^p") uses aggregate physical investment (defined as the sum of the gross private domestic investment in "Structures" and "Equipment", i.e., lines 13 and 16, respectively, in NIPA Table 5.2.6), and the third implementation ("$i_{NIPA}^{p\&i}$") uses the sum of aggregate physical and intangible investment (where the latter is defined as gross domestic private investment in "Intellectual property products", i.e., line 19 in NIPA Table 5.2.6). Note that the investment measure used in the first implementation is almost identical to the measure used in the analysis of Cochrane (1991).[IA.11]

For the last three implementations ("i^{p}_{CS}", "$i^{p\&i}_{CS}$", and "$i^{p,K}_{CS}$"), we measure U.S. aggregate investment using COMPUSTAT data: i^{p}_{CS} and $i^{p,K}_{CS}$ use physical investment, whereas $i^{p\&i}_{CS}$ uses the sum of physical and intangible investment. To calculate firm-level physical investment, we follow Gonçalves et al. (2020): we use the law of motion $I_t = K_{t+1} - K_t + Depr_t$, and define firm-level depreciation as variable DP and firm-level physical capital as variable PPENT (net property, plant, and equipment). To calculate firm-level intangible investment, we follow the methodology of Peters and Taylor (2017). In particular, we set the missing values of XRD and XSGA (which reflect R&D and SG&A) to zero when total assets is available. We also set to zero all missing values of RDIP, which reflects the portion of R&D that does not enter the SG&A variable in COMPUSTAT. Then, we calculate Pure SG&A as XSGA - (XRD-RDIP) and replace these values with XSGA if either XRD > XSGA or if XRD < COGS. Intangible investment is, then, equal to 0.3*Pure SG&A + XRD. For each measure, aggregate investment is calculated by aggregating the corresponding firm-level investment measure across firms. When we compute ratios of aggregate measures derived from COMPUSTAT data, we make sure that we account for the fact that different firms may have different types of missing information. In particular, analogously to our approach in Section D of the Internet Appendix, each aggregate variable is divided by the fraction of aggregate market equity that corresponds to the firms for which the variable of interest is not missing. Finally, in order to align the timing of accounting data across firms, we calculate all firm measures for a given year using December COMPUSTAT data. For the firms with fiscal years not ending in December (for which we cannot use the annual COMPUSTAT database), we use quarterly COMPUSTAT data (in which case flow variables reflect the sum of the corresponding quarterly variables within the year).

In the first five implementations, the U.S. aggregate I/K ratio is calculated using the time series of U.S. aggregate investment by applying the methodology in Cochrane (1991). After retrieving the time series of the I/K ratio, we can back out the time series of U.S. aggregate capital K, which allows us to back out the time series of U.S. aggregate productivity Z (since aggregate U.S. output Y is observable).[IA.12] In the last implementation, the U.S. aggregate I/K ratio is directly calculated by dividing the physical investment measure by the physical capital measure (with both measures calculated using COMPUSTAT data).

[IA.11] We provide detailed comparison of our results with the results in Cochrane (1991) in Tables IA.2 and IA.3, to be discussed below.

[IA.12] In the case of investment measures constructed using NIPA data, output Y and capital K do not correspond to the same sample of firms. In particular, Y reflects the aggregate output of COMPUSTAT firms, whereas K corresponds to the aggregate capital of the all firms. To address that issue, we multiply the NIPA-implied capital measure K (i.e., the measure implied from the I/K ratio calculated using NIPA investment data) by the average of the ratio of the corresponding investment measure from COMPUSTAT relative to the given investment measure from NIPA. This multiplication by a constant has no effect on our estimation of the profit margin parameter α.

To check the robustness of our findings in Table 2 to alternative values of the firm's technological parameters, we repeat the exercise by considering model-specific estimated parameters, which provide each model with its best chance to match firm returns. In particular, in both parts of Table IA.1, parameters a and α are estimated by Non-Linear Least Squares (NLS) estimation. In particular, the parameter values used in Part I are estimated by regressing realized firm returns on model-implied realized investment returns, whereas the parameter values in Part II are estimated by regressing realized firm returns on model-implied expected investment returns. Both realized and expected investment returns are non-linear functions of parameters a and α. In all cases, all other model parameters are fixed at the calibrated values reported in Table 1.

As we see in Part I of Table IA.1, all models are able to generate empirically plausible average returns, but they severely undershoot return volatility. The best-performing model is the payout-based one, which manages to generate unconditional return volatility of 8.08%, which is about half the magnitude of the observed firm return volatility (14.88%). The six investment-based model implementations do much worse, with unconditional return volatility ranging from 1.45% to 3.85%. As regards the unconditional correlation between observed firm returns and model-implied investment returns, our payout-based approach does much better than all the investment-based model implementations: our model generates an unconditional correlation coefficient of 0.57, compared with coefficients ranging from -0.12 to 0.11 for the investment-based models. Shifting the timing of the firm returns somewhat improves the performance of the investment-based model, but the maximum attained unconditional correlation is still quite low (0.20). Importantly, the payout-based model clearly overperforms all the investment-based model implementations regarding the connection between firm returns and expected investment returns. When we regress realized firm returns on our model-implied expected investment returns, we get a statistically significant slope coefficient and a regression adjusted R^2 of 5.80%. In contrast, all the implementations of the investment-based approach generate slope coefficients that are statistically indistinguishable from zero and negative regression adjusted R^2s.

When we consider parameters estimated using expected investment returns (Part II of Table IA.1), our findings do not change much. The payout-based model is still able to generate investment returns that are highly correlated with observed firm returns, and model-implied expected investment returns have forecasting power for realized firm returns. In contrast, all six implementations of the investment-based model continue to perform poorly on both those metrics.

E.2 Sample period comparison

As mentioned above, the first implementation of the investment-based approach ("i_{NIPA}") uses almost the same investment measure as Cochrane (1991). Yet, some of our empirical findings for that implementation, reported in Table 2, differ from the corresponding results reported in Cochrane

(1991). In particular, Cochrane (1991) reports a correlation of 0.39 between aggregate investment returns and (shifted) aggregate stock returns, as well as strong predictability of aggregate stock returns and aggregate investment returns (but not their difference) by aggregate I/K ratios. In contrast, as we report in Table 2, we find that the correlation between aggregate investment returns and (shifted) aggregate firm returns is 0.21, and that aggregate firm returns are not forecastable by aggregate I/K ratios.

Our analysis differs from that of Cochrane (1991) in several respects. First, our sample period is 1974-2017, whereas Cochrane (1991) focuses on the 1947-1987 sample period. Second, our model features a somewhat different specification than Cochrane (1991) as regards the representative firm's capital accumulation expression (which includes the impact of capital adjustment costs) and the taxability of firm profits (we set the firm tax rate to $\tau = 0.35$, whereas Cochrane (1991) assumes $\tau = 0$). Third, the values of key parameters differ. Fourth, in Cochrane (1991) annual investment returns are calculated by compounding quarterly investment returns (which are, in turn, calculated using quarterly I/K ratios), whereas we directly calculate annual returns using annual I/K ratios. Fifth, we consider aggregate firm returns (which are a weighted average of stock and debt returns), whereas Cochrane (1991) focuses on aggregate stock returns. Finally, the analysis in Cochrane (1991) assumes constant firm productivity, whereas we use a stochastic productivity process for our analysis. Since our results do not materially change when we assume that firm productivity is constant, in what follows we assume that firm productivity is constant at level $\bar{Z}$. Furthermore, to match the analysis in Cochrane (1991), we consider aggregate stock returns (from CRSP) instead of aggregate firm returns. Hence, in order to explain why our results deviate from those in Cochrane (1991), we focus on the first four differences. In all exercises, we use the NIPA seasonally adjusted real gross private domestic investment series as our aggregate investment measure. In contrast, the analysis in Cochrane (1991) uses the seasonally adjusted real gross private domestic investment series from Citibase (series GIF82), a difference that accounts for some of the disparity between our results and the findings in Cochrane (1991).

Table IA.2 reports our findings for the 1947-1987 period, exactly matching the sample period in Cochrane (1991). Each column corresponds to a different implementation of the investment-based approach, with the first three columns focusing on implementations that use the Cochrane (1991) specification and the last four columns reporting the results of implementations that use our ("GS") specification. The details of each implementation are provided when discussing each column. For each implementation, Panel A reports the value of the depreciation parameter δ, of the marginal product of capital $\alpha\bar{Z}$, and of the capital adjustment cost parameter a. Panel B reports the mean and volatility of aggregate stock and investment returns, as well as the correlation between aggregate investment returns and aggregate stock returns (with the latter calculated both using the standard timing and the six-month timing shift). Panel C (Panel D) reports the output of a forecasting regression of annual aggregate stock returns on the lagged quarterly (annual) aggregate I/K ratio.

For those regressions, both aggregate stock returns and aggregate investment returns for year $t+1$ are calculated using the standard timing convention (i.e., from the end of December of year t to the end of December of year $t+1$) and lagged I/K ratios are either quarterly (in Panel C) or annual (in Panel D) I/K ratios measured at the end of December of year t. Panel E (Panel F) reports the output of a forecasting regression of annual aggregate stock returns on the lagged quarterly (annual) aggregate I/K ratio, as before, with the difference being that the timing of aggregate stock returns is shifted, consistent with Cochrane (1991): for those regressions, aggregate investment returns are calculated using the standard timing convention, but aggregate stock returns are shifted, with the magnitude of the shift depending on whether, in a given implementation, annual investment returns are calculated by compounding quarterly returns, or are directly calculated from annual investment data. In particular, for implementations that compound quarterly investment returns to calculate annual investment returns, aggregate annual stock returns for year $t+1$ are shifted back by two months, i.e. they are calculated from the end of October of year t to the end of October of year $t+1$, and the forecasting variable (quarterly or annual I/K ratio) is measured at the end of September of year $t-1$, whereas for implementations that directly calculate annual investment returns, aggregate annual stock returns for year $t+1$ are shifted six months back, i.e., they are calculated from the end of June of year t to the end of June of year $t+1$, and the forecasting variable (annual I/K ratio) is measured at the end of December of year $t-1$. In Table IA.2, shifted stock returns are denoted by R^s, to distinguish them from the standard (non-shifted) stock returns, denoted by R. Finally, Panel E (Panel F) reports the output of a forecasting regression of the difference between annual aggregate shifted stock returns and annual aggregate investment returns on the lagged quarterly (annual) aggregate I/K ratio. In all cases, we report Newey-West standard errors, with 8 lags in the case of compounded quarterly investment returns (as in Cochrane (1991)) and with 2 lags in the case of directly measured annual investment returns.

We start with the first three implementations, which adopt the specification in Cochrane (1991). For the results reported in the first column (implementation [1]), we use both the specification and parameter calibration in Cochrane (1991) and we calculate annual investment returns by compounding quarterly investment returns. We find that the mean of average investment returns matches the mean of average stock returns almost perfectly. However, investment returns are substantially more volatile than stock returns, in contrast to the findings in Cochrane (1991). The correlation between investment and stock returns is 0.20 when the standard timing convention is used, rising to 0.26 when the timing of stock returns is shifted. As seen in Panels C and D, when the standard return timing is used, quarterly I/K ratios forecast subsequent annual stock returns, but annual I/K ratios do not. Furthermore, those results continue to hold when we consider shifted stock returns (Panels E and F). Finally, as seen in Panels G and H, both quarterly and annual I/K ratios forecast the differences between annual stock returns and annual investment returns, at odds with the lack of predictability that Cochrane (1991) finds.

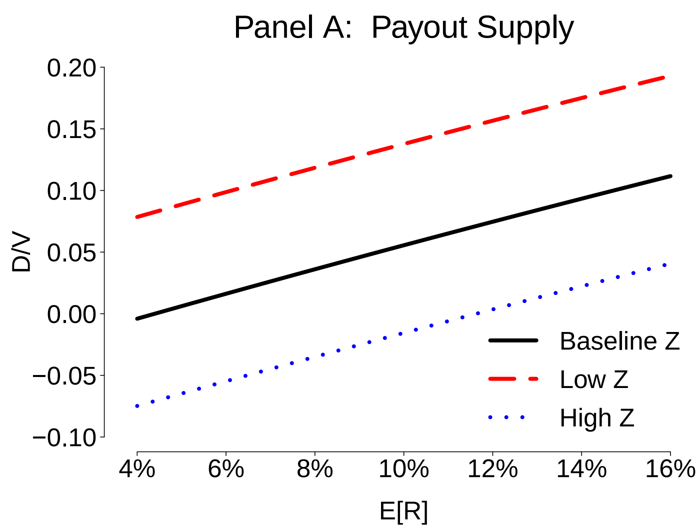
Since our aggregate investment measure differs from that in Cochrane (1991), the discrepancies may be due to the fact that the parameter values are not properly calibrated. To address that issue, in implementation [2] we continue to adopt the Cochrane (1991) specification and to compound quarterly investment returns, but we set the value of key parameters to estimates that match the same moments as in Cochrane (1991): the value of the marginal product of capital $\alpha\bar{Z}$ does not change much (it is now 0.145, compared to 0.150 before), but the value of the capital adjustment cost parameter a is now significantly lower (8.552, compared to 13.040 before). Under that parametrization, we are able to replicate the main findings of Cochrane (1991): aggregate investment returns are smoother than aggregate stock returns, and quarterly I/K ratios forecast subsequent annual stock returns, but not the differences between annual stock returns and annual investment returns. In addition, we find that annual I/K ratios have no forecasting ability either for stock returns or for the difference between stock and investment returns. Finally, the third implementation corresponds to a model that adopts the Cochrane (1991) specification, but in which annual investment returns are directly calculated using annual investment data, the values of parameters $\alpha\bar{Z}$ and a are set to match the same moments as in Cochrane (1991), and annual depreciation is set to $\delta = 0.15$, as in Table 1. Aggregate investment returns are still too smooth compared to stock returns and the unconditional correlation between the two series (when we shift the timing of stock returns) remains at 0.29. For this implementation, the only forecasting signal consistent with the model is the annual I/K ratio, but (as before) annual I/K ratios have no forecasting power either for stock returns or stock and investment return differentials.

The last four implementations use our specification, rather than the one in Cochrane (1991), allowing us to check the robustness of the findings in Cochrane (1991) to a somewhat different characterization of investment returns. In particular, the fourth and fifth columns (implementations [4] and [5], respectively) report results that mirror to the analysis in the second and third columns, respectively, but using our specification. Interestingly, changing the specification does not meaningfully change the crux of our findings: investment returns are smoother than stock returns and highly correlated with them (when the latter are shifted), and quarterly I/K ratios predict subsequent annual stock returns (but not their differences with investment returns), with annual I/K ratios exhibiting no forecasting power. Finally, the sixth and seventh columns (implementations [6] and [7], respectively) repeat the analysis in the fourth and fifth columns, but using parameter values estimated using a Non-Linear Least Squares estimation procedure (as in Part I of Table IA.1). Despite the change in the parameter values, our findings do not materially change.

In sum, when we use either the Cochrane (1991) specification or our specification, we are able to replicate the key findings of Cochrane (1991) as regards the properties of aggregate investment returns in the 1947-1987 sample period, but we find that annual I/K ratios have no forecasting ability for aggregate stock returns.

To check the robustness of the Cochrane (1991) findings, Table IA.3 repeats the analysis in Table

IA.2 for the 1974-2017 period, which is the focus of the main text of our paper. Across implementations, the unconditional moments of aggregate stock and investment returns are not very different from the corresponding moments in the 1947-1987 sample period. However, the conditional return properties differ substantially between the two sample periods. In particular, as seen in Panels C–F, neither quarterly nor annual I/K ratios are able to forecast aggregate stock returns, a finding that is robust across implementations. On the other hand, Panels G and H report that quarterly (and, in some cases, annual) I/K ratios have predictive power for differences between stock and investment returns, implying that the conditional means of investment returns differ from those of stock returns. The lack of predictability of stock returns and the predictability of investment and stock return differences stands in sharp constant to the findings in Cochrane (1991), with both findings suggesting that the investment-based approach does not generate conditional aggregate returns that match the properties of the observed aggregate stock returns.



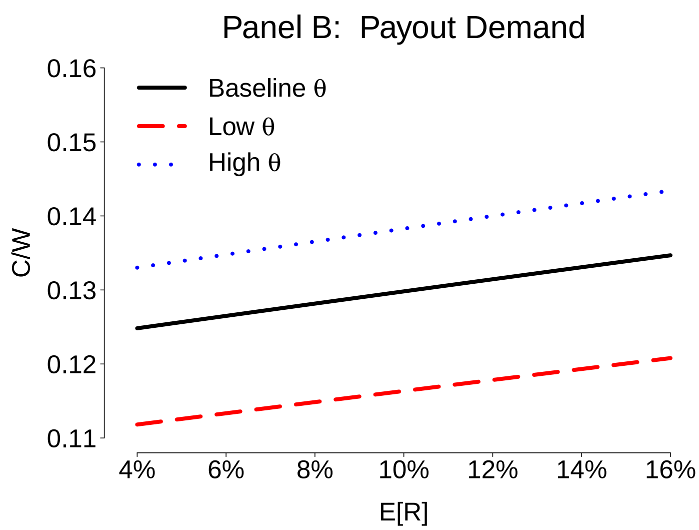


Fig. IA.1: Payout yield and consumption-wealth ratio in the two-period model

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

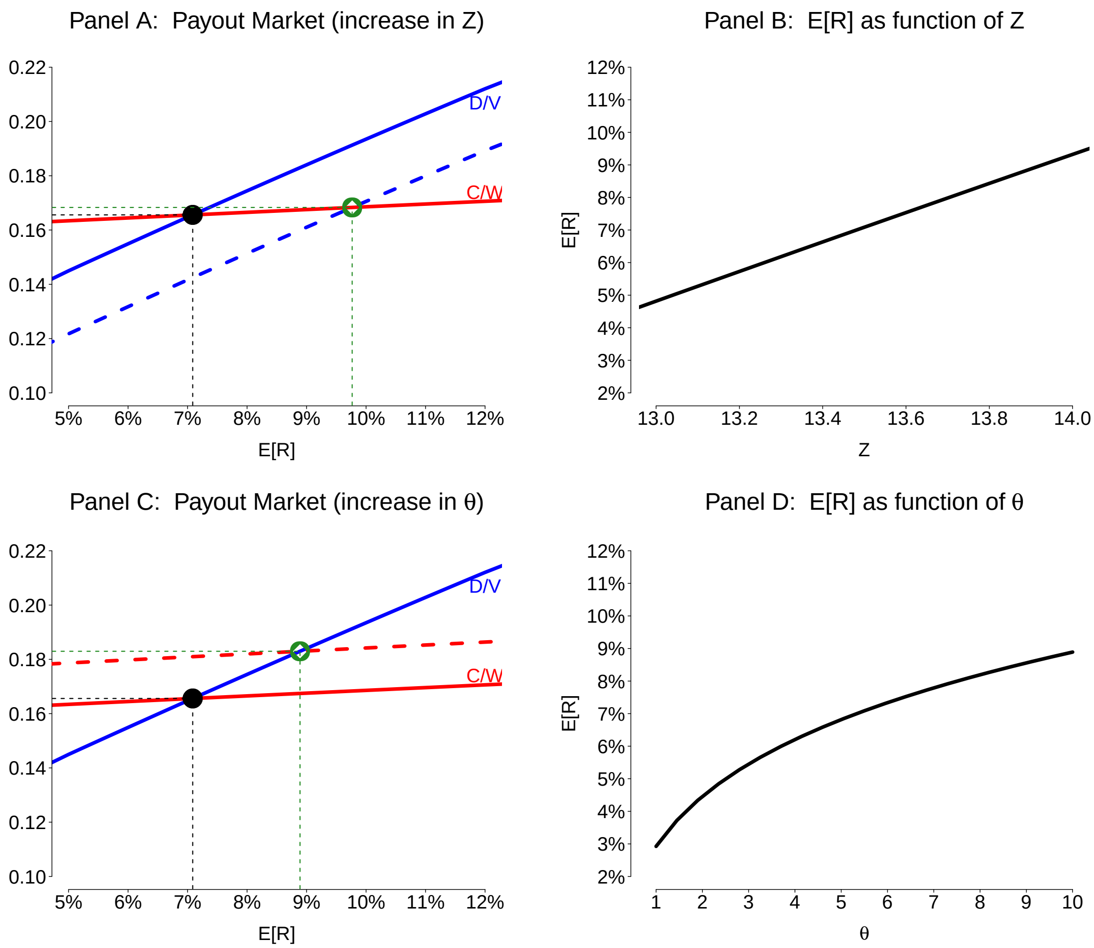


Fig. IA.2: Payout market equilibrium in the two-period model

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

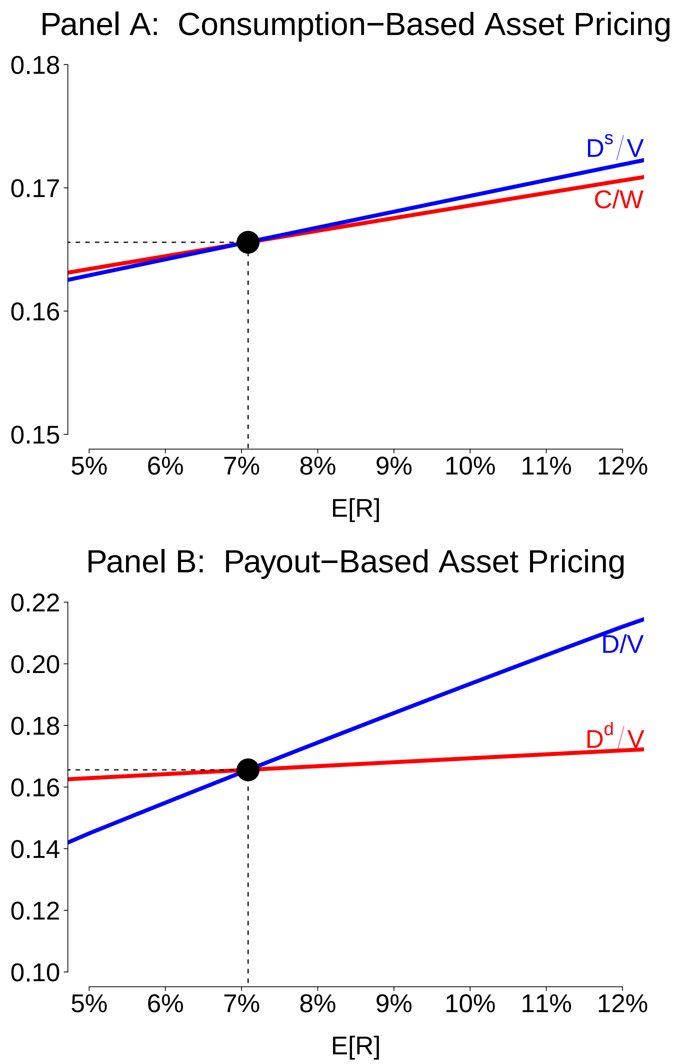


Fig. IA.3: Consumption-based and payout-based asset pricing in the two period model

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

Table IA.1: Payout-based vs. investment-based returns: estimated parameters

This table reports the properties of model-implied realized and expected investment returns for seven different models. Part I uses parameters estimated by regressing realized firm returns on model-implied realized investment returns, whereas Part II uses parameters estimated by regressing realized firm returns on model-implied expected investment returns. In each part, Panel A reports parameter values, Panel B reports unconditional moments of realized and expected investment returns, and Panel C reports the output of regressions of observed firm returns on expected investment returns. The seven models are, in order, the payout-based model and six implementations of the investment-based model. We report Newey and West (1987) standard errors, with lag selection as in Newey and West (1994).

Model	d	i_{NIPA}	i^{p}_{NIPA}	$i^{p\&i}_{NIPA}$	i^{p}_{CS}	$i^{p\&i}_{CS}$	$i^{p,K}_{CS}$
Part I: Estimated parameters using realized investment returns							
Panel A: Parameter values							
Profit Margin α	0.107	0.301	0.150	0.224	0.141	0.222	0.142
Adjustment Cost Parameter a	1.859	2.629	1.021	0.998	0.114	0.347	0.439
Panel B: Unconditional moments							
Average Investment Return	6.01%	7.56%	7.55%	7.56%	7.81%	7.85%	8.69%
Volatility of Investment Return	8.08%	3.85%	2.40%	2.69%	1.66%	1.45%	2.35%
Volatility of $\mathbb{E}[R^I]$	4.03%	2.52%	1.42%	2.01%	1.03%	0.56%	1.11%
Corr(R^I,R)	0.57	-0.03	-0.12	-0.04	0.08	0.11	-0.10
Corr($R^I, R^{shifted}$)	0.28	0.20	0.03	0.07	0.12	0.15	-0.06
Panel C: Regressions of R_{t+1} on $\mathbb{E}[R^I_{t+1}]$							
Predictive Coefficient	0.98	0.20	-1.27	-0.25	0.05	0.73	-2.71
s.e.	[0.49]	[0.76]	[0.70]	[0.66]	[1.73]	[2.83]	[1.32]
Adjusted R^2	5.80%	-2.30%	-0.56%	-2.29%	-2.44%	-2.35%	2.51%
Part II: Estimated parameters using expected investment returns							
Panel A: Parameter values							
Profit Margin α	0.090	0.338	0.341	0.721	0.173	0.283	0.181
Adjustment Cost Parameter a	1.445	3.578	14.665	25.162	1.937	2.660	3.698
Panel B: Unconditional moments							
Average Investment Return	7.06%	8.40%	8.66%	8.57%	8.86%	8.86%	8.68%
Volatility of Investment Return	9.07%	4.37%	6.08%	6.16%	4.89%	4.09%	7.89%
Volatility of $\mathbb{E}[R^I]$	5.01%	2.67%	2.05%	2.39%	1.83%	1.53%	2.89%
Corr(R^I,R)	0.54	-0.03	-0.09	-0.07	0.17	0.19	0.11
Corr($R^I, R^{shifted}$)	0.26	0.20	0.08	0.09	0.09	0.10	0.05
Panel C: Regressions of R_{t+1} on $\mathbb{E}[R^I_{t+1}]$							
Predictive Coefficient	0.77	0.20	0.15	0.37	1.10	1.12	0.81
s.e.	[0.42]	[0.73]	[1.01]	[1.00]	[0.99]	[1.15]	[0.63]
Adjusted R^2	4.84%	-2.28%	-2.38%	-2.00%	-0.15%	-0.77%	0.76%

Table IA.2: Investment return comparison: 1947-1987

This table reports the properties of model-implied realized and expected investment returns for seven different implementations of the investment-based model. Panel A reports parameter values, Panel B reports unconditional moments of realized and expected investment returns, and Panels C–H report the output of regressions of observed firm returns (calculated either using the standard timing convention and denoted by R, or using a shifted timing convention and denoted by R^s) on lagged investment-to-capital ratios. The sample period is 1947-1987. We report Newey and West (1987) standard errors, with lag selection as in Newey and West (1994).

Implementation	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**
Specification	**Cochrane**	**Cochrane**	**Cochrane**	**GS**	**GS**	**GS**	**GS**
Investment return calculation	**Quarterly**	**Quarterly**	**Annual**	**Quarterly**	**Annual**	**Quarterly**	**Annual**
Calibration	**Original**	**GMM**	**GMM**	**GMM**	**GMM**	**NLS**	**NLS**
Panel A: Parameter values							
Depreciation Parameter δ	0.100	0.100	0.150	0.100	0.150	0.100	0.150
Marginal Product of Capital $\alpha\bar{Z}$	0.150	0.145	0.323	0.266	0.755	0.188	0.477
Adjustment Cost Parameter a	13.040	8.552	2.672	19.527	16.672	8.298	6.505
Panel B: Unconditional moments							
Average Stock Return	8.58%	8.58%	9.43%	8.58%	9.43%	8.58%	9.43%
Volatility of Stock Return	16.57%	16.57%	19.20%	16.57%	19.20%	16.57%	19.20%
Average Investment Return	8.85%	8.15%	9.43%	8.10%	9.43%	8.07%	9.43%
Volatility of Investment Return	27.04%	9.88%	9.67%	9.03%	9.34%	5.72%	6.20%
Corr(R^I,R)	0.20	0.21	-0.11	0.26	-0.12	0.25	-0.12
Corr(R^I, R^s)	0.26	0.29	0.29	0.34	0.32	0.33	0.32
Panel C: Regressions of annual R_{t+1} on quarterly I_t/K_t							
Predictive Coefficient	-3.81	-4.13	–	-5.08	–	-5.08	–
s.e.	[1.49]	[1.59]	–	[1.91]	–	[1.91]	–
Adjusted R^2	8.00%	8.05%	–	8.16%	–	8.16%	–
Panel D: Regressions of annual R_{t+1} on annual I_t/K_t							
Predictive Coefficient	-0.39	-0.41	-0.94	-0.49	-1.27	-0.49	-1.27
s.e.	[0.43]	[0.47]	[1.02]	[0.57]	[1.33]	[0.57]	[1.33]
Adjusted R^2	0.58%	0.55%	-0.78%	0.54%	-0.62%	0.54%	-0.62%
Panel E: Regressions of annual R^s_{t+1} on quarterly I_t/K_t							
Predictive Coefficient	-2.95	-3.17	–	-3.89	–	-3.89	–
s.e.	[1.38]	[1.48]	–	[1.79]	–	[1.79]	–
Adjusted R^2	5.40%	5.37%	–	5.39%	–	5.39%	–
Panel F: Regressions of annual R^s_{t+1} on annual I_t/K_t							
Predictive Coefficient	-0.30	-0.31	0.67	-0.37	0.88	-0.37	0.88
s.e.	[0.40]	[0.43]	[0.74]	[0.53]	[0.97]	[0.53]	[0.97]
Adjusted R^2	0.22%	0.17%	-1.91%	0.13%	-1.88%	0.13%	-1.88%
Panel G: Regressions of annual $R_{t+1} - R^I_{t+1}$ on quarterly I_t/K_t							
Predictive Coefficient	7.02	1.58	–	1.90	–	-0.21	–
s.e.	[2.17]	[1.60]	–	[1.81]	–	[1.78]	–
Adjusted R^2	17.14%	0.95%	–	1.00%	–	-0.62%	–
Panel H: Regressions of annual $R_{t+1} - R^I_{t+1}$ on annual I_t/K_t							
Predictive Coefficient	1.21	0.40	1.13	0.48	1.63	0.17	1.39
s.e.	[0.40]	[0.40]	[0.83]	[0.49]	[1.07]	[0.50]	[0.93]
Adjusted R^2	7.31%	0.84%	-0.28%	0.90%	0.41%	-0.45%	-0.40%

Table IA.3: Investment return comparison: 1974-2017

This table reports the properties of model-implied realized and expected investment returns for seven different implementations of the investment-based model. Panel A reports parameter values, Panel B reports unconditional moments of realized and expected investment returns, and Panels C–H report the output of regressions of observed firm returns (calculated either using the standard timing convention and denoted by R, or using a shifted timing convention and denoted by R^s) on lagged investment-to-capital ratios. The sample period is 1974-2017. We report Newey and West (1987) standard errors, with lag selection as in Newey and West (1994).

Implementation	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**
Specification	**Cochrane**	**Cochrane**	**Cochrane**	**GS**	**GS**	**GS**	**GS**
Investment return calculation	**Quarterly**	**Quarterly**	**Annual**	**Quarterly**	**Annual**	**Quarterly**	**Annual**
Calibration	**Original**	**GMM**	**GMM**	**GMM**	**GMM**	**NLS**	**NLS**
Panel A: Parameter values							
Depreciation Parameter δ	0.100	0.100	0.150	0.100	0.150	0.100	0.150
Marginal Product of Capital $\alpha\bar{Z}$	0.150	0.152	0.322	0.822	1.437	0.225	0.505
Adjustment Cost Parameter a	13.040	12.063	3.480	100.000	45.571	13.724	8.743
Panel B: Unconditional moments							
Average Stock Return	8.97%	8.97%	8.44%	8.97%	8.44%	8.97%	8.44%
Volatility of Stock Return	14.93%	14.93%	16.32%	14.93%	16.32%	14.93%	16.32%
Average Investment Return	7.23%	8.19%	8.44%	8.16%	8.44%	8.06%	8.44%
Volatility of Investment Return	10.10%	8.59%	8.42%	8.11%	8.43%	4.41%	5.01%
Corr(R^I,R)	0.13	0.13	-0.01	0.17	-0.05	0.17	-0.04
Corr(R^I, R^s)	0.24	0.25	0.26	0.29	0.31	0.29	0.31
Panel C: Regressions of annual R_{t+1} on quarterly I_t/K_t							
Predictive Coefficient	-0.83	-0.80	–	-0.79	–	-0.79	–
s.e.	[1.41]	[1.44]	–	[1.88]	–	[1.88]	–
Adjusted R^2	-0.15%	-0.19%	–	-0.38%	–	-0.38%	–
Panel D: Regressions of annual R_{t+1} on annual I_t/K_t							
Predictive Coefficient	-0.04	-0.02	-0.57	0.10	-0.53	0.10	-0.53
s.e.	[0.36]	[0.37]	[0.78]	[0.46]	[1.03]	[0.46]	[1.03]
Adjusted R^2	-0.58%	-0.59%	-1.44%	-0.54%	-1.96%	-0.54%	-1.96%
Panel E: Regressions of annual R^s_{t+1} on quarterly I_t/K_t							
Predictive Coefficient	-0.44	-0.40	–	-0.20	–	-0.20	–
s.e.	[1.41]	[1.44]	–	[1.89]	–	[1.89]	–
Adjusted R^2	-0.44%	-0.48%	–	-0.58%	–	-0.58%	–
Panel F: Regressions of annual R^s_{t+1} on annual I_t/K_t							
Predictive Coefficient	-0.04	-0.02	-0.64	0.11	-0.61	0.11	-0.61
s.e.	[0.37]	[0.37]	[0.90]	[0.47]	[1.25]	[0.47]	[1.25]
Adjusted R^2	-0.58%	-0.60%	-1.29%	-0.52%	-1.90%	-0.52%	-1.90%
Panel G: Regressions of annual $R^s_{t+1} - R^I_{t+1}$ on quarterly I_t/K_t							
Predictive Coefficient	4.05	3.60	–	5.34	–	2.75	–
s.e.	[1.65]	[1.58]	–	[1.69]	–	[1.76]	–
Adjusted R^2	10.11%	8.15%	–	11.35%	–	2.77%	–
Panel H: Regressions of annual $R^s_{t+1} - R^I_{t+1}$ on annual I_t/K_t							
Predictive Coefficient	1.02	0.91	0.81	1.28	1.33	0.74	0.54
s.e.	[0.43]	[0.41]	[0.99]	[0.46]	[1.31]	[0.45]	[1.27]
Adjusted R^2	11.11%	9.10%	-0.52%	11.74%	0.57%	3.77%	-1.97%