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ABSTRACT

We develop a dynamic agency model where payout, investment and financing decisions are made by managers who attempt to maximize the rents they take from the firm, subject to a capital market constraint. Managers smooth payout in order to smooth their flow of rents. Total payout (dividends plus net repurchases) follows Lintner's (1956) target-adjustment model. Payout smooths out transitory shocks to current income and adjusts gradually to changes in permanent income. Smoothing is accomplished by borrowing or lending. Payout is not cut back to finance capital investment. Risk aversion causes managers to underinvest, but habit formation mitigates the degree of underinvestment.

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I. Introduction

THIS PAPER PRESENTS A THEORY OF PAYOUT by mature public corporations in a dynamic agency setting. The theory says that payout follows Lintner's (1956) target adjustment model. If payout is restricted to cash dividends, Lintner's model is:

$$\Delta\text{Dividend}_t = \kappa + SOA(\text{Target Dividend}_t - \text{Dividend}_{t-1}) + e_t \quad (1)$$

$\Delta\text{Dividend}_t$ is the change from the previous dividend at period $t - 1$, $SOA < 1$ is the speed of adjustment, κ is a constant and e_t is an error term. The target dividend is the product of a target payout ratio and net income at t . The target payout ratio and the coefficients κ and SOA are assumed constant over time, although they can vary across firms. Thus dividends are based on current net income, but smoothed.

Lintner did not derive his model. He came to it inductively, based on interviews with 28 large, public manufacturing firms. The model has been confirmed as a good fit to the time series of cash dividends, although the fit has degraded as repurchases have become more important. But Lintner's model has, as far as we can tell, never been derived formally. There has been no underlying theory. Thus it has been difficult to interpret coefficient estimates and empirical results. It has been difficult to know under what conditions or for what type of firms the Lintner model applies, or what forms of payout the model should explain.

Our paper addresses these issues. Our agency setting leads to the Lintner model exactly, with closed-form expressions for the coefficients κ and SOA . We note two key differences, however. First, our theory says that the Lintner model should not apply to cash dividends but to total payout, defined as cash dividends plus repurchases. Thus we have a fresh prediction, that the Lintner model should fit better to *total* payout than to cash dividends. This prediction is confirmed in Skinner (2008) for mature corporations that pay regular cash dividends. Second, our theory says that target payout depends on the firm's *permanent income*, not net income as reported. Permanent income is the annuity equivalent of the present value of all the firm's future income.

We also derive implications for debt policy. If payout is smoothed, something else has to absorb fluctuations in operating profitability and capital investment. Consider the budget constraint:

$$\Delta\text{Debt} + \text{Net income} = \text{CAPEX} + \text{Payout}$$

Lintner's formula says that changes in payout absorb only part of the changes in net income.

The remainder must be absorbed by changes in borrowing (ΔDebt) or by capital investment (CAPEX). If payout follows Lintner's model and CAPEX is nailed down by the firm's investment opportunities, then ΔDebt must be the shock absorber in the firm's budget constraint. First, ΔDebt must soak up most of the transitory noise in net income. Second, ΔDebt must accommodate the delayed adjustment of payout to changes in permanent income. With reasonable parameters, that adjustment takes several years.

Corporate finance theories tend to ignore the budget constraint. First, there are many separate theories of payout, debt and investment. But there can be no more than two independent theories. Given this period's net income, a theory of payout plus a theory of investment must imply a theory of debt. This paper presents a combined theory of payout, debt and investment. Second, most existing theories are static and do not explicitly recognize the inter-temporal budget constraint, which requires that the firm's sources and uses of cash match over the firm's lifetime. As we will show, the constraint is essential to understanding the dynamics of payout.

We assume that financial decisions are made by a coalition of managers, who maximize the present value of their utility from current and future rents that they will take from the firm. The managers in our model are entirely self-interested and have no loyalty to outside shareholders. We simplify by giving shareholders only the most basic property right, which is the ability to take over the firm and throw out the managers if sufficiently provoked. The managers therefore have to observe a capital-market constraint: they have to deliver an adequate return to investors in each period by paying out a sufficient amount. In equilibrium the managers do deliver adequate returns, and shareholders do not intervene.

Our model follows Fluck (1998, 1999), Myers (2000), Jin and Myers (2006) and Lambrecht and Myers (2007, 2008). But those papers assumed risk-neutral managers and did not analyze payout, debt and investment jointly. Here we assume a more realistic utility function, with risk aversion and habit formation. We do adopt those papers' view of managerial rents, however. We are *not* defining rents as psychological private benefits, such as the CEO's warm glow from leading a big public firm. We define rents as real resources appropriated by a broad coalition of managers and staff, including above-market salaries, job security, generous pensions and perks. Rich labor contracts can generate a flow of rents to blue-collar employees.

Rents follow naturally from agency issues and imperfect corporate governance. Rents can be efficient, however. They are necessary to reward managers' investment in firm-specific

human capital. Burkart, Gromb and Panunzi (1997) show that even when tight control by shareholders is ex post efficient, it creates an ex ante hold-up threat, which reduces managerial initiative and non-contractible investment. A dispersed ownership structure dilutes the hold-up threat.¹ This gain has to be weighed against the loss in control due to inadequate monitoring. Myers (2000) and Lambrecht and Myers (2008) show how rents can align managers' and shareholders' interests if the managers maximize the present value of rents subject to a capital-market constraint.

We assume perfect, frictionless financial markets. Investors in our model do not care whether payouts are stable or erratic. (There are clienteles of investors who want smooth dividends – see Baker, Nagel and Wurgler (2007), for example – but we do not invoke them to explain smoothing.) The market value of the firm does not depend on debt or payout policy, as in Modigliani-Miller (1958, 1961).

We now give a summary of the paper's insights and main results. A more comprehensive discussion of the empirical implications is deferred to section II.

1. Managers pay out cash to investors because they want to take out rents. Payout is smoothed because managers want to smooth their flow of rents. Rents and payouts move in lockstep. An attempt to smooth rents without smoothing payouts would violate the capital-market constraint. We believe that the idea that payout smoothing follows from rent smoothing is new.

2. Risk aversion means that rents depend on managers' *permanent* income, which is the annuity equivalent of the present value of all future net income. The response of rents and payouts to transitory changes in net income is an order of magnitude less than the response to changes in permanent income. Thus payouts smooth out transitory shocks to income.

3. Habit formation means that rents and payouts respond gradually to changes in managers' forecasts of permanent income. The managers' risk aversion and habit formation together lead to payout smoothing according to Lintner's target-adjustment model.

4. Changes in payout signal changes in managers' view of permanent income. Thus changes in payout can have "information content" for investors. The smaller the firm's *SOA*, the greater the stock-price response to an unanticipated payout change.

5. Managers do not maximize market value. They underinvest. Higher risk aversion and

¹Myers (2000) makes the same point with respect to venture-capital financing and IPOs.

profit volatility increase underinvestment. Habit formation mitigates underinvestment. As far as we know, this is the first paper to consider how habit formation affects investment in an agency model.

6. Given investment (CAPEX), changes in debt absorb all changes in income that are not soaked up by changes in payouts and rents. Once managers smooth rents and payouts, the change in debt is the only free variable in the budget constraint. Thus we arrive at a theory of debt dynamics, similar to the pecking order, but not by relying on asymmetric information and adverse selection, as in Myers and Majluf (1984) and Myers (1984). (Our model allows equity issues to finance part of CAPEX, however.) Debt does *not* follow a target-adjustment model. The sources = uses constraint rules out that payout and leverage simultaneously follow a target-adjustment model. If the capital stock is fixed, and payout adjusts smoothly to a permanent-income target, then debt cannot adjust smoothly to a target debt ratio. If debt does so adjust, then payout cannot be smoothed, and in addition the volatility of payout must amplify the volatility of net income.

7. Investment determines permanent income, which determines payout. Therefore managers decide on payout and investment simultaneously. Once investment is set, payout smoothing proceeds according to the Lintner model. Payout does not have to be cut back to finance CAPEX, however, because smoothing is effected by borrowing or lending. Cash outlays for CAPEX can increase payout simultaneously by increasing permanent income. Our theory is consistent with the survey evidence by Brav, Graham, Harvey and Michaely (2005) that the dividend and investment decisions are co-determined.

We are not attempting a Theory of Everything. Our model applies to mature, profitable, creditworthy public corporations that have access to debt and the ability to use borrowing and lending to balance their budget constraints. Such firms account for most of the aggregate payout to investors.²

Our model would not apply to zero-payout growth firms or to firms in financial distress. It would not apply to declining firms that should disinvest, as in Lambrecht and Myers (2007). Our goal is to understand payout policy and how payout interacts with borrowing and investment. Therefore we focus on mature companies that can make regular payouts to shareholders.

²Hsieh and Wang (2006) study payout by U.S. industrial firms. The top 100 (500) payers contributed about 64% (90%) of total payout in 1978 and 77% (97%) in 2003. Dividend payments have also become increasingly concentrated. See DeAngelo, DeAngelo and Skinner (2004).

Section I of the paper solves for the managers' optimal rents, payouts and debt policy. We prove that rent smoothing necessarily implies payout smoothing. We obtain Lintner's target-payout model and show how payout policy affects the firm's stock price. We derive the managers' optimal investment policy and its implications for payout and debt policy. We analyze the robustness of our results to the introduction of taxes, adjustment costs and growth options. Section II discusses empirical implications. Section III concludes and notes issues remaining for further research.

The rest of this introduction does two things. First, it explains why rent smoothing necessarily implies payout smoothing. The explanation will introduce the assumptions, setup and economic intuition of our model. Second, it reviews relevant literature in more detail.

A. Rent Smoothing and Payout Smoothing

The following example illustrates how payout smoothing follows from rent smoothing. Start with the following market-value balance sheet. The firm holds a capital stock K , which

$V_t(K)$	$(1 + \rho) D_{t-1}$	Interest on debt = ρD_{t-1}
	R_t	Annual rents = r_t
	S_t	Annual Payout = d_t
V_t	V_t	

generates income with present value $V_t(K)$. The capital stock includes plant and equipment, plus intellectual property that could be used efficiently by investors if they intervene and boot out managers.³ There are three claims on firm value: outstanding debt $((1 + \rho)D_{t-1})$, including one period's accrued interest at the constant interest rate ρ ; the present value of managerial rents (R_t) , and outside equity (S_t) , with $R_t + S_t = V_t(K) - (1 + \rho)D_{t-1}$. Debt service is senior to both rents and payouts. The flow of rents is r_t . (In practice the rents will often be received as job security, perks and future retirement benefits, but here we model

³Labor (or human capital) is not part of K . We do not model labor explicitly. One could, however, think of labor as varying optimally with the state of the economy (η_t) , so that optimal profits π_t explicitly depend on K and the state of the economy only.

rents as just a flow of cash to managers.) Payout is d_t . We assume that lenders and equity investors are risk-neutral.⁴

Managers maximize the present value of their lifetime utility from all future rents, subject to a capital-market constraint. They are constrained by the shareholders' property right to intervene and take over the company. If they do so, the managers get nothing ($R_t = 0$). But the shareholders face a cost of collective action. Their net payoff from intervening is $\alpha(V_t(K) - (1 + \rho)D_{t-1})$, with $\alpha < 1$. (Think of α as a governance parameter capturing the shareholders' practical property rights and the effectiveness of corporate governance.^{5 6}) In equilibrium the shareholders do not intervene, because it is in the managers' interest to deliver an adequate return of $\rho\alpha(V_t(K) - (1 + \rho)D_{t-1})$. The conditions for this equilibrium are described in Myers (2000) and in Section I.

The gross profits $\pi_t(K)$ generated over the period $(t - 1, t]$ are realized at time t . Net income (after interest but before rents) is $\pi_t(K) - \rho D_{t-1}$. Suppose that capital is sunk and constant at K . With no CAPEX, the budget constraint for period t is:

$$d_t + r_t = \pi_t(K) - \rho D_{t-1} + (D_t - D_{t-1}) \quad (2)$$

If debt is kept constant ($\Delta D = D_t - D_{t-1} = 0$), the equilibrium payout and rent policies simply split net income, $\alpha(\pi_t(K) - \rho D_{t-1})$ to payout and $(1 - \alpha)(\pi_t(K) - \rho D_{t-1})$ to rents. With these policies, payouts and rents follow net income, always in the ratio $\alpha/(1 - \alpha)$. Because all future income will also be split in this ratio, $S_t = \alpha(V_t(K) - (1 + \rho)D_{t-1})$ and $R_t = (1 - \alpha)(V_t(K) - (1 + \rho)D_{t-1})$. Managers would of course like to reduce payouts and take more rents, but cannot do so without violating the capital-market constraint. The managers pay out no more than necessary, so the capital-market constraint pins down payouts, rents and values exactly.

⁴If investors are assumed risk-averse, then cash flows should be interpreted as certainty equivalents to investors.

⁵Lambrecht and Myers (2007) show that collective action by raiders or hostile acquirers can act as a substitute for collective action by shareholders. Given that raiders or hostile acquirers are more organized and specialized in taking over a firm than outside shareholders, it is reasonable to assume that their cost of collective action is lower. This is the main reason why it is much more likely for management to get unseated by a hostile acquirer than by dispersed shareholders. To avoid being taken over, managers either have to pay out more or put in place anti-takeover protections.

⁶The cost of collective action could also reflect the loss in human capital, including managers' specialized knowledge and expertise, that shareholders suffer if they take over the firm. This cost could be captured by a smaller value of α .

Thus value is split between managers and shareholders. From the shareholders' viewpoint, the managers own the fraction $(1 - \alpha)$ of the equity. But the managers, unlike the investors, are assumed to be risk-averse. Their claims to future rents are not tradeable, for the usual reasons of moral hazard and non-verifiability. If the managers could trade their claims, their risk aversion and habit formation would not matter for the timing of rents and payout.

Now suppose that managers want to smooth rents, for example by taking more than $(1 - \alpha)(\pi_t(K) - \rho D_{t-1})$ when profitability declines. They cannot maintain rents by cutting payout. But they can maintain both rents and payout by taking on more corporate debt. If the firm borrows ΔD , they can keep $(1 - \alpha)\Delta D$ as additional rents, provided that they simultaneously increase payout by $\alpha\Delta D$. Thus rents can be smoothed by changes in debt, but payout must be smoothed along the same time pattern.

Suppose that $\alpha = .8$. For the managers to take \$1 in additional rents, the firm has to borrow $\Delta D = \$5$ and pay out \$4. The shareholders' claim is reduced by 80% of ΔD , so they have to be given \$4 extra. The managers' claim is reduced by 20% of ΔD , but they get \$1 in extra rents.

Smoothing also means gradual adjustment of rents when profitability increases. If growth in rents is held back, then payout growth has to be held back to exactly the same extent. Otherwise shareholders would get a free gift from the managers. The cash released by holding back rents and payouts has to be used to pay down debt, however. For example, reducing growth in rents by \$1 requires reducing growth in payout by \$4 and paying off \$5 of debt. (If paying down debt is inconvenient in the short run, the firm can invest the \$5 in money-market or other debt securities. Net debt is still reduced by \$5. Net debt is what matters in our model.)

When a corporation borrows, the debt is partly a claim against equity and partly a claim against the present value of managers' future rents (Lambrecht and Myers (2008)). If not invested, the proceeds of additional borrowing must be distributed to shareholders and managers in the ratio $\alpha/(1 - \alpha)$. If cash flow is used to pay down debt, rents and payout must be reduced in the same proportions. Thus rents and payouts have to move in lockstep. The shock absorber is corporate debt.

The managers in our model are using corporate borrowing and lending to shift rents forward or back in time. In a completely frictionless world, the managers could do this just as well on their own by managing their personal balance sheets. The managers would care about the present value of their future rents, but not about whether the rents are smoothed.

Thus by not considering managers' personal balance sheets, we may be missing something important. On the other hand, there are good reasons why wealth-constrained managers prefer smoothed rents to rents that are irregular or deferred. Consider a manager who wants to consume more today, but has not yet accumulated significant liquid wealth. The manager therefore wants to borrow against his or her future rents, but finds borrowing difficult and expensive because of personal moral hazard problems. This manager is better off if the firm borrows to increase current rents. The firm is in effect borrowing on the manager's behalf. The firm avoids the individual manager's moral-hazard problem, because its borrowing is backed by its assets, earnings and the aggregate rents paid to its managers collectively. The firm's borrowing is also backed up by shareholders' governance rights. These rights help assure lenders that the firm's assets and cash flows will not be tunneled out.

Our utility function will implicitly treat managers' rents as consumption. In other words, we will assume that managers do not borrow personally against future rents and do not save and invest current rents. This assumption is valid (and could indeed be obtained as a result) if managers can borrow or save more efficiently through the firm.

We have explained why corporate borrowing is efficient for managers who want to consume today out of the firm's permanent income. It is harder to claim that the firm can always invest "extra" rents at a higher rate than the managers. But some rents are difficult for the manager to save and invest. For example, the firm can easily defer award of perks. But the manager will have a hard time receiving a perk and then turning it back into investible cash.

Corporate rather than personal borrowing can also protect the manager against dismissal. The manager who is relieved of his or her job is also relieved from claims by the firm's creditors on the manager's future rents. There is no such relief if the manager borrows personally.⁷

Thus we expect a demand for rent smoothing from many managers, including those with limited liquid personal wealth. Senior managers with secure positions and plenty of liquid personal assets should not care about rent smoothing, but have no reason to resist it. Thus for purposes of this paper we assume that managers are wealth-constrained and depend on the firm to smooth rents and consumption.

⁷There is an opposite danger, that managers nearing retirement, or managers who fear dismissal or who have easy access to jobs elsewhere, will try to accelerate rents, at the expense of colleagues with longer horizons. Thus the equilibrium we describe may in practice require additional internal controls and discipline. See Acharya, Myers and Rajan (2011).

B. Prior Research

Most research on payout has focused on cash dividends, although in many theory papers “dividends” could just as well be interpreted as total payout. We start with the Miller and Modigliani (1961) proof that payout decisions do not affect market value in frictionless financial markets with complete information. Subsequent research has focused on the roles of taxes, information, agency costs and other imperfections. A full review of this literature is impossible here. We refer instead to excellent surveys by Allen and Michaely (2003), Kalay and Lemmon (2008), DeAngelo, DeAngelo and Skinner (2008), and also the survey evidence in Brav et al. (2005). Marsh and Merton (1987), who investigate aggregate dividends, also review research through the mid-1980s. Guttman, Kadan and Kandel (2010) and Leary and Michaely (2011) survey research on dividend smoothing. These surveys cite no derivations of the Lintner (1956) model.

Lintner’s paper was a breakthrough contribution to empirical corporate finance, but his target-adjustment specification does not fully explain cash dividends today. Brav et al. (2005) find that target dividend payout ratios are less important now than in Lintner’s day. They and Leary and Michaely (2011) find that the speed of adjustment has declined. Also the volume of repurchases has grown enormously. Skinner (2008, p. 584) concludes that repurchases have substituted for cash dividends and “are now the dominant form of payout.” Some mature, blue-chip firms – Exxon Mobil, for example – pay steady cash dividends and also repurchase shares year in and year out.

Casual explanations of dividend smoothing sometimes start with the “information content of dividends.” One might overhear the following: “Dividends have information content because investors expect managers to smooth dividends and to increase dividends only when they are confident about future income. Managers smooth dividends because they don’t want to send a false positive signal to investors.” Statements like this either assume some kind of smoothing or are close to circular.

The causes of dividend smoothing are not clear in prior theory. The dividend signaling models of Bhattacharya (1979), Miller and Rock (1985), and John and Williams (1985) explain why dividends can convey information, but do not explain smoothing. They are one-period exercises that explain dividend levels but not dividend changes.⁸ Some other papers suggest smoothing but not the Lintner model specifically. Kumar (1988) derives a

⁸Miller (1987) reviews conditions for a dividend signaling equilibrium, but finds no satisfactory explanation of Linter-style dividend smoothing or the information content of dividends.

coarse signaling equilibrium in which a firm's dividends are more stable than its performance and prospects. Guttman, Kadan and Kandel (2010) derive an equilibrium in a Miller-Rock (1985) setup in which dividends are constant over a range of earnings. Allen, Bernardo and Welch (2000) argue that well-managed firms pay dividends to attract institutional investors and to weed out tax-paying retail investors. The less well-managed firms turn to retail investors. This theory could accommodate smoothing if the dividing line between high- and low-dividend payers is stable.⁹

The surveys by Allen and Michaely (2003) and Leary and Michaely (2011) conclude that dividend policy is better explained by agency problems than by signalling. Roberts and Michaely (2007) show that private firms smooth dividends less than their public counterparts, suggesting that the scrutiny of public capital markets leads firms to pay and smooth dividends. Leary and Michaely (2011), who explore cross-sectional differences in the degree of dividend smoothing, conclude that smoothing is more prevalent when (proxies for) agency costs are high. Ours is an agency model, but with a capital-market constraint that forces managers to smooth payouts if they decide to smooth rents. La Porta et al. (2000) survey dividend policies worldwide and conclude that companies pay dividends because investors have (more or less imperfect) governance mechanisms that force payout.

Most agency models focus on the amount of payout in a given period, not on payout policy over time. We use a dynamic agency framework. Some recent papers also include payout within a dynamic model of the firm. DeMarzo and Fishman (2007) study the effect of agency problems on investment, payout and capital structure. Bolton, Chen and Wang (2011) focus on the role of investment and corporate risk management for a financially constrained firm. Korinek and Stiglitz (2009) analyze the effects of changes in tax policy using a dynamic, discrete-time life-cycle model of the firm. DeMarzo and Sannikov (2011) consider the contracting problem between a principal and risk-neutral agent. The agent and the firm start out with zero cash, but accumulate cash in order to build a buffer stock to absorb cash and avoid inefficient liquidation. Once sufficient cash is accumulated, dividends

⁹Fudenberg and Tirole (1995) develop a model in which managers smooth income in order to protect their jobs and private benefits. All reported income is paid out as dividends, which are thus also smoothed. Acharya and Lambrecht (2011) present a theory of income smoothing in which outside shareholders can observe sales but not costs. Sales can be used to create a noisy proxy of income. They show that reported income is a distributed lag model of sales. Payout to outside shareholders equals their share of reported income and is therefore smoothed relative to sales. But the Lintner model, backed up by ample facts, says that dividends are smoothed relative to income.

are paid, and the optimal dividends are smoother than earnings. None of these models generates the payout dynamics of the Lintner model.

Our paper uses insights and methods from theories of household consumption, starting with the permanent income hypothesis (PIH) of Friedman (1957). The PIH states that consumers' consumption choices are determined not by their current income but by their longer-term income expectations. Therefore transitory, short-term changes in income have little effect on consumer spending behavior. Hall (1978) formalizes the PIH by deriving a relation between income and consumption in an intertemporal stochastic optimization framework. The assumption of quadratic utility in Hall (1978) (and in many subsequent models) switches off consumers' motives for precautionary savings, however. Caballero (1990) shows that when marginal utility is convex, agents have an incentive to accumulate savings as a precautionary measure against income shocks.

The standard assumption in the household consumption literature is that agents' utility only depends on contemporaneous consumption. Research on asset pricing has, however, stressed the importance of habit formation and the links between today's consumption and the marginal utility of future consumption. We allow managers' utility to depend on previous as well as current rents. Our paper belongs to the strand of "internal habit" models such as Muellbauer (1988), Sundaresan (1989), Constantinides (1990) and Alessie and Lusardi (1997).

Of course we are not modeling an individual CEO's utility function, but the combined utility of a coalition of managers.¹⁰ One can think of a "representative manager", like a representative agent in asset-pricing theory, or simply accept the idea of a coalition as a reduced-form description of how managers behave. (Acharya, Myers and Rajan (2011) show how a coalition of managers can form to invest and operate the firm, even with weak or no outside governance.) But it is clearly reasonable to assume that managers as a group are risk averse. Habit formation also comes naturally. Many forms of rents, including above-market wages, job security and pension benefits, are not normally changed on short notice. The assumption of a rent-seeking coalition of managers has proved fruitful in prior work, including Myers (2000), Jin and Myers (2006) and Lambrecht and Myers (2007, 2008).

¹⁰The notion that the CEO runs the firm on his or her own, like a puppet master who pulls all the strings, makes no sense for large firms. Nor can we assert that the CEO captures all the rents. But the compensation that goes to the CEO and other top managers is probably correlated with aggregate rents. Thus it may be interesting to explore the co-movement of payout and top-management compensation.

We assume that managers' compensation comes only from rents (plus their immediate opportunity wages). We could extend the model by allowing the managers to hold (restricted) stock, which gives them a fraction of payout in addition to rents. (The managers could pay for the stock by taking lower rents or with personal savings or sweat equity.) The managers' future compensation would come in part from payout by the firm. This would not affect rent and payout policies, however, because equilibrium rents and payout would vary proportionally. (Large block-holdings by managers could impede shareholders' property rights, however.)

Much of the research on corporate payout policy focuses on cash dividends, not on total payout. Thus we have referred to theories and empirical results about cash dividends. But our agency theory applies to total payout. In the next section we define payout as the net cash paid out to shareholders, that is, cash dividends plus repurchases minus stock issues.

II. How Managers Set Rents and Payout

We start with a coalition of managers, who undertake financing, rent and payout decisions in order to maximize the present value of their life-time utility. Investors are risk neutral, but managers are risk averse with a concave utility function. The managers are also subject to habit formation. We assume their utility of current rents is $u(r_t - hr_{t-1})$. The reference point hr_{t-1} is determined by last period's rents r_{t-1} and the habit persistence coefficient $h \in [0, 1)$. Habit formation means that utility is no longer time-separable.

At each time t the infinitely-lived managers choose payout and rent policies (d_t, r_t) that maximize the objective function:

$$\max E_t \left[\sum_{j=0}^{\infty} \omega^j u(r_{t+j} - hr_{t+j-1}) \right] \quad (3)$$

where ω is the managers' subjective discount factor and $\frac{1}{\omega}$ measures "impatience." The market discount factor is $\beta \equiv \frac{1}{1+\rho}$ where ρ is the risk-free rate of return. We assume $\omega \leq \beta$, so that managers can be more impatient than investors.¹¹

Managers maximize their life-time utility subject to the following constraints that must

¹¹Managers will also be more impatient if they face a probability of termination (e.g. due to dismissal, illness or death) in each future period. In that case $\omega = \beta\zeta$, where ζ is managers' constant survival probability.

be satisfied at all times:

$$S_t \equiv d_t + \beta E_t [S_{t+1}] \geq \alpha [V_t - (1 + \rho)D_{t-1}] \quad (4)$$

$$D_t = D_{t-1}(1 + \rho) + d_t + r_t - K^\phi \pi_t(\eta_t) \quad (5)$$

$$\lim_{j \rightarrow \infty} \frac{D_{t+j}}{(1 + \rho)^j} = 0 \quad (6)$$

$$\text{where } V_t \equiv \sum_{j=0}^{\infty} \beta^j K^\phi E_t[\pi_{t+j}(\eta_{t+j})]$$

$K^\phi \pi_t$ is the operating profit at time t . For now we take the capital stock K as fixed and constant. (Later in this section we will allow the managers to set capital stock and payout simultaneously.) The amount of output produced each period is K^ϕ , with decreasing returns to scale ($\phi < 1$). $\pi_t(\eta_t)$ is the operating profit per unit of output, which depends on the realization of a demand shock η_t . The demand shock is exogenous and not affected by rents and payout at time t . Payout and rents are paid at the end of each period, after operating profit is realized and interest is paid on start-of-period debt.

D_t is *net* debt. If $D_t > 0$, the firm is a net borrower. If $D_t < 0$, the firm holds a surplus in liquid assets and is a net lender. The rate of interest ρ is the same for financial assets and liabilities. For simplicity we ignore default risk, and assume that the firm can borrow and lend at the risk-free rate ρ .¹²

Eq. (4) is the capital market constraint, which requires that payout policy always supports an equity value S_t that at least equals what shareholders can get from taking over. The net payoff to shareholders from taking over is $\alpha (V_t - (1 + \rho)D_{t-1})$, with $0 < \alpha < 1$.¹³

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Eq. (5) is the firm's budget constraint. The operating profit $K^\phi \pi_t$ is used for interest (ρD_{t-1}), for net cash paid out to shareholders (d_t) and for rents (r_t). Any surplus or deficit leads to a reduction or increase in debt. Debt is therefore a balancing variable that follows

¹²Default risk should be second-order for mature corporations that make regular payouts and have ample debt capacity. Modeling a default put would add a heavy layer of complication. See Lambrecht and Myers (2008), who analyze the effect of default risk on rents, payout, debt and investment.

¹³For $\alpha = 0$ shareholders have no stake in the firm and the capital market constraint disappears. For $\alpha = 1$ managers can no longer capture rents and their objective function is no longer defined. Therefore $\alpha \in (0, 1)$.

¹⁴The alternative is to assume a net payoff from collective action of $\alpha V_t - (1 + \rho)D_{t-1}$. But then managers' claims on the firm would be senior to debt, and debt could not discipline managers. This is not a realistic case, so we do not consider it. See also Lambrecht and Myers (2008).

from the rent and payout policies (r_t, d_t) (and from investment policy, as will become clear later). The optimal debt policy allows the managers to take their optimal rents. The accounting equality between sources and uses of cash pins down debt once rents and payout have been chosen.

Eq. (6) is a constraint that prevents the managers from running a Ponzi scheme in which they borrow to achieve an immediate increase in rents and then borrow forever after to pay the interest on the debt. The constraint prevents debt from growing faster than the interest rate ρ , so that claim values are bounded.

Since the budget constraint needs to be satisfied for *all* future times t , repeated forward substitution of the budget constraint Eq. (5), combined with the no-Ponzi constraint Eq. (6) gives the following intertemporal budget constraint (IBC):

$$\sum_{j=0}^{\infty} \beta^j [K^\phi \pi_{t+j} - d_t - r_t] = (1 + \rho)D_{t-1} \quad (7)$$

The IBC gives a condition that a feasible rent and payout plan $\{r_{t+j}, d_{t+j}\}$ ($j = 0, 1, 2, \dots$) must satisfy. The condition essentially states that the sum of the managers', lenders' and shareholders' claims must add up to the present value of all future operating profits. Since K is fixed and the profit process π_{t+j} is exogenous (and not affected by rent and payout policy), the IBC requires that any increases in rents and payout at time t must be compensated for by future decreases. After taking expectations and simplifying, the IBC becomes:

$$R_t \equiv \sum_{j=0}^{\infty} \beta^j E_t(r_{t+j}) = V_t - S_t - (1 + \rho)D_{t-1} \quad (8)$$

Note that R_t equals the market value of the managers' present and future rents, which is not the same as the private value of rents that is being optimized.

The following proposition describes the linkage between total payout and managers' rents.

PROPOSITION 1 : *Total payout d_t is proportional to managers' rents r_t , with $d_t = \left(\frac{\alpha}{1-\alpha}\right) r_t \equiv \gamma r_t$.*

Thus payout and rents are locked together in the ratio $\frac{d_t}{r_t} = \frac{\alpha}{1-\alpha} \equiv \gamma$. We show in the appendix that this result is a direct consequence of the collective action constraint and does *not* depend on managers' utility function nor on the stochastic process π_t . The payout d_t is set by managers so that shareholders are indifferent between taking collective action at

time t and letting managers carry on for another period. As managers raise the rent level r_t , this increases net debt and therefore reduces the payoffs shareholders can expect from taking collective action at time $t + 1$, so shareholders require a higher payout d_t . Payout therefore moves in lockstep with rents.

Next we consider how managers set rents and therefore payout. Their decision problem is sequential. At time t they decide on the optimal level for r_t and d_t , given the values for $r_{t-1}, d_{t-1}, D_{t-1}$, the exogenous demand shock η_t and managers' expectations about future shocks η_{t+j} ($j > t$). To solve their optimization problem explicitly, we need to make assumptions about the managers' utility function $u(\cdot)$ and the stochastic process $\pi_t(\eta_t)$. We assume that managers have exponential utility $u(x) = 1 - \frac{1}{\theta}e^{-\theta x}$. This utility function has been used extensively in the household consumption literature because of its tractability. The empirical workhorse model for earnings and cash flows is the first-order autoregressive process (see Dichev and Tang (2009) and Frankel and Litov (2009), among others). We assume therefore that π_t follows the AR(1) process $\pi_t = \mu\pi_{t-1} + \eta_t$ with $\mu \in [0, 1]$. The shocks η_{t+j} ($j = 0, 1, \dots$) are independently and identically normally distributed with zero mean and volatility σ_η .¹⁵ Thus $E_t(\eta_{t+j}) = 0$, $E_t(\eta_{t+j}^2) = \sigma_\eta^2$ and $E_t(\eta_{t+j}\eta_{t+j+1}) = 0$ for all j .

The following proposition gives the solution to the managers' dynamic optimization problem.

PROPOSITION 2 : *The managers' optimal rent policy r_t at time t is:*

$$r_t = \beta h r_{t-1} + (1 - h\beta)(1 - \alpha)Y_t + c \quad (9)$$

$$\text{where } c \equiv \left(\frac{\beta}{(1 - \beta)\theta} \right) \ln \left(\frac{\beta}{\omega} \right) - \frac{(1 - \alpha)^2 \beta (1 - \beta) (1 - h\beta)^2 \theta}{(1 - \beta\mu)^2} \frac{K^{2\phi} \sigma_\eta^2}{2} \quad (10)$$

Y_t is the firm's permanent income:

$$Y_t = \rho\beta \sum_{j=0}^{\infty} \beta^j E_t [K^\phi \pi_{t+j}(\eta_{t+j})] - \rho D_{t-1} \quad (11)$$

¹⁵Our assumption of exponential utility and normally distributed shocks can lead to negative rents and payouts, which we would interpret as the managers' sweat equity and stock issues, respectively. These assumptions could also lead to negative stock prices, which are impossible with limited liability. But default risk is remote for the mature and stable firms that our model is designed for. Therefore we ignore default risk for simplicity.

Permanent income Y_t is the rate of return on the sum of current and the present value of all future net income, net of debt service, but before rents. It is an annuity payment that, given expectations at time t , could be sustained forever.

Proposition 2 contains the paper's core results, which allow us to analyze (1) optimal payout policy, (2) how it influences stock prices, (3) how payout policy interacts with debt policy and (4) how much managers decide to invest.

A. Optimal Payout Policy

Eq. (9) implies that in the presence of habit formation ($h > 0$) payouts follow Lintner's target-adjustment model. Subtracting r_{t-1} from both sides of Eq. (9) and expressing rents r_t in terms of payout (using $d_t = \gamma r_t$) gives the following corollary:

COROLLARY 1 : *The firm's payout policy is given by the following target-adjustment model:*

$$d_t - d_{t-1} = (1 - \beta h)(\alpha Y_t - d_{t-1}) + \kappa \quad \text{where } \kappa \equiv \frac{\alpha c}{1 - \alpha} = \gamma c \quad (12)$$

This is Lintner's model. The speed of adjustment $SOA \equiv (1 - \beta h)$ depends on the market discount factor β and managers' habit persistence parameter h . Absent habit formation ($h = 0$), the gap between the target payout and previous period's actual payout would be fully adjusted for each period, that is, $d_t - d_{t-1} = (\alpha Y_t + \kappa - d_{t-1})$. The target payout $\alpha Y_t + \kappa / (1 - \beta h)$ depends on permanent income Y_t . A higher level of investor protection α reduces rents and increases target payout.

The constant κ in the partial-adjustment model can be expressed as the difference between acceleration of rents due to managers' impatience and their precautionary savings due to risk-aversion. The first term is positive (zero) for $\omega < \beta$ ($\omega = \beta$). Increased impatience (i.e. higher $\frac{\beta}{\omega}$) raises current payout at the expense of future payout. This property follows directly from the first order condition (see appendix), which requires that the expected marginal utility from rents grows by a factor $\frac{\beta}{\omega}$ along the optimal path. Increased investor protection (higher α) raises the dissavings term.

The second, negative term in the formula for the constant κ corresponds to the standard precautionary savings term from the household consumption literature (see Caballero (1990)). A higher risk aversion coefficient (θ) or autoregressive coefficient (μ) each increase

the amount of precautionary savings and therefore reduce payout. The higher the earnings volatility $K^\phi \sigma_\eta$, the more managers cut rents in order to save for a rainy day. More uncertainty therefore leads to higher planned payout growth. Precautionary savings decrease with habit formation (h). Since habit formation by itself induces cautious payout behavior, it reduces the need for additional precautionary savings.

The following corollary summarizes how our model's parameters affect the Lintner constant κ .

COROLLARY 2 : *If managers have exponential utility, then the constant term in the Lintner model increases with managers' impatience and habit formation but decreases with risk aversion and earnings volatility. The constant is a U-shaped function of investor protection.*¹⁶

The speed of adjustment SOA is determined by the risk-free rate ρ and the managers' habit persistence coefficient h . As h increases, managers' cost of adjusting towards a new target rent level goes up, so payout becomes "stickier" and less responsive to changes in permanent income.

The market discount factor β does not enter directly into the managers' utility function, but β matters because of the IBC. The discount rate ρ sets the terms at which managers can move cash through time by changes in corporate borrowing. When ρ is high and β is low, it costs more to borrow against future cash flows, so managers smooth less and adjust more quickly to shocks ($\frac{\partial SOA}{\partial \beta} < 0$). The overall effect of the market discount rate ρ on payout is more complicated, however, because ρ affects not only the speed of adjustment SOA , but also permanent income Y_t .

A dollar increase in the firm's permanent income leads to an immediate increase in payout of only $SOA\alpha$. The lagged incremental effects in subsequent periods are given by $SOA\alpha\beta h$, $SOA\alpha(\beta h)^2$, $SOA\alpha(\beta h)^3$, The long-run effect of a dollar increase in permanent income on payout equals $SOA\alpha \sum_{j=0}^{\infty} (\beta h)^j = \alpha$.¹⁷ Our derivation of the Lintner model can therefore be expressed as a distributed lag model in which current payout is a function of current and past permanent income. Repeated backward substitution of (12) gives:

$$d_t = (1 - h\beta) \alpha \sum_{j=0}^{\infty} (\beta h)^j Y_{t-j} + \frac{\kappa}{1 - \beta h} \quad (13)$$

¹⁶The constant term approaches zero from below as $\alpha \rightarrow 0$ and goes towards positive infinity as $\alpha \rightarrow 1$.

¹⁷Recall that permanent income is defined before rents. In the long-run, shareholders get the fraction α of permanent income. They get 100% of permanent income after rents.

Now we turn to permanent income Y_t and its effect on payout. Using the IBC it is straightforward to prove the following property.

PROPERTY 1 : *The following property results directly from the IBC and is valid for all utility functions:*

$$E_t[Y_{t+1}] = Y_t + \rho(Y_t - (1 + \gamma)r_t) \quad (14)$$

Therefore permanent income follows a martingale process if and only if shareholders' plus managers' payout $((1 + \gamma)r_t)$ equals Y_t . Proposition 2 gives this result if and only if both $\omega = \beta$ and $h = \sigma_\eta = 0$. The martingale property no longer holds in all other cases. For example, if current payout is above (below) the target payout, then permanent income is expected to go down (up) next period.

The IBC implies that the long run payout target is proportional to permanent income Y_t . Proposition 2 implies that a lower level of expected permanent income $E_t[Y_{t+1}]$ reduces expected payout:

$$E_t[d_{t+1}] - d_t = \beta h(d_t - d_{t-1}) + (1 - \beta h)\alpha[E_t[Y_{t+1}] - Y_t] \quad (15)$$

Substituting property 1 of permanent income for expected payout changes gives:

$$E_t[d_{t+1}] - d_t = \beta h(d_t - d_{t-1}) + (1 - \beta h)\rho[\alpha Y_t - d_t] \quad (16)$$

Expected payout changes are therefore a weighted average of lagged payout changes and the deviation of the long run payout target αY_t from current payout.

If there is no habit formation and uncertainty ($h = \sigma_\eta = 0$), and if $\omega = \beta$, then payout is always on target with $E_t[d_{t+1}] = d_t$. Payout is still smoothed, however, because the firm gears payout to permanent income (Y_t) rather than current net income $\pi_t - \rho D_{t-1}$.

B. Payout and Stock Prices

The managers' optimal rent and payout policies give the following valuation for the firm's stock:

COROLLARY 3 : *Ex-dividend market capitalization S_t^{ex} is independent of payout policy and given by:*

$$S_t^{ex} = \sum_{j=1}^{\infty} E_t[d_{t+j}]\beta^j = \alpha \left[\sum_{j=1}^{\infty} \beta^j K^\phi E_t[\pi_{t+j}] - D_t \right] = \alpha [E_t[\beta V_{t+1}] - D_t] \quad (17)$$

$$= \frac{\alpha Y_t}{\rho\beta} - d_t \equiv S_t - d_t \quad (18)$$

The corollary shows that the firm's share price and overall market capitalization depend on the firm's permanent income Y_t but not on payout policy. A dollar of extra payout reduces the equity value by the same amount, which is the standard Miller and Modigliani (1961) result.

The corollary also shows that an extra dollar of debt reduces the firm's market capitalization by α , which is equity's share of income after interest. The rest of debt is covered by managers, who pay the fraction $1 - \alpha$ of debt service by reducing rents. The Modigliani-Miller (1958) leverage irrelevance result still holds, however, because total firm value includes the present value of rents.

C. Permanent and Transitory Income Shocks

The earnings shock η_t affects not only current earnings but also the expected value of all future earnings. But earnings will also include transitory gains and losses. We introduce transitory shocks by assuming that $\pi_t = p_t + \tau_t$ with $p_t = \mu p_{t-1} + \eta_t$, where η_t and τ_t are iid shocks. Set $K = 1$, so that a \$1 transitory shock τ_t increases operating profits at time t by exactly \$1. Therefore:

$$\frac{\partial \pi_t}{\partial \tau_t} = 1 \quad \text{and} \quad \frac{\partial \pi_{t+j}}{\partial \eta_t} = \mu^j \quad \text{with } \mu > 0 \text{ for } j = 0, 1, 2, \dots$$

Thus transitory shocks have a smaller effect on permanent income than persistent shocks:

$$\begin{aligned} \frac{\partial Y_t}{\partial \tau_t} &= \rho\beta \frac{\partial \pi_t}{\partial \tau_t} = \rho\beta \\ \frac{\partial Y_t}{\partial \eta_t} &= \rho\beta \left[\frac{\partial \pi_t}{\partial \eta_t} + \beta \frac{\partial \pi_{t+1}}{\partial \eta_t} + \beta^2 \frac{\partial \pi_{t+2}}{\partial \eta_t} + \dots \right] = \frac{\rho\beta}{1 - \mu\beta} \end{aligned}$$

The transitory effect is of order $\rho\beta$ and the permanent effect is of order $\frac{\rho\beta}{1 - \mu\beta}$. The transitory effect $\rho\beta$ is probably less than 0.05 for reasonable discount rates. The effect of a permanent

shock is much larger. For example, for a random walk ($\mu = 1$) a permanent shock contributes dollar for dollar to permanent income.

Habit formation means that payout responds gradually to changes in permanent income from temporary and permanent earnings shocks. Proposition 2 gives:

$$\frac{\partial d_t}{\partial \tau_t} = (1 - \beta h) \alpha \rho \beta \quad \text{and} \quad \frac{\partial d_t}{\partial \eta_t} = (1 - \beta h) \alpha \left(\frac{\rho \beta}{1 - \beta \mu} \right) \quad (19)$$

The increase in payout and rents from a \$1 transitory income shock is very small, about 1 cent for typical values of SOA and α . Almost all of that \$1 is used to pay down debt. The reduction in debt interest increases permanent income by ρ times the debt repayment. The increase in permanent income then allows an increase in rents and payout. The increase in payout from a permanent income shock is much larger. Assuming a random walk ($\mu = 1$), a \$1 persistent income shock raises payout by about 30 cents for typical values of SOA and α .

Thus total payouts are smoothed in two ways. First, payouts are linked to permanent income, not to contemporaneous income. Payouts do not respond much to transitory earnings. This type of smoothing is a result of managers' risk aversion. Second, payouts adjust gradually to changes in permanent income. This type of smoothing or "stickiness" results from habit formation.

D. Payout and Debt Policy

Proposition 2 shows how payout policy drives debt policy once investment is fixed. Repeated substitution of the optimal policy for r_{t-j} and d_{t-j} gives the following corollary.

COROLLARY 4 : *The dynamics of the firm's debt (assuming the capital stock K is fixed) are:*

$$\begin{aligned} D_t - D_{t-1} &= \rho D_{t-1} + d_t + r_t - K^\phi \pi_t \\ &= \left[Y_t + \frac{\kappa}{\alpha} - (K^\phi \pi_t - \rho D_{t-1}) \right] + \beta h [d_{t-1} + r_{t-1} - Y_t] \end{aligned} \quad (20)$$

$$= \rho D_{t-1} - K^\phi \pi_t + \sum_{j=0}^{t-1} (\beta h)^j \left[(1 - \beta h) Y_{t-j} + \frac{\kappa}{\alpha} \right] + (\beta h)^t (d_0 + r_0) \quad (21)$$

The corollary has interesting implications. First, the change in debt is a residual determined by the constraint that sources equal uses of cash in each period. Debt follows a pecking order, as in Myers and Majluf (1984) and Myers (1984), but not because of asymmetric information and adverse selection.

Second, the change in debt includes a *fixed* component that is proportional to κ/α , where κ is defined in corollary 1. Whether this change is positive or negative depends on whether dissavings from managerial impatience or precautionary savings dominates. For example, more impatient managers derive more utility from today's rents and are therefore prepared to incur additional borrowing. Of course, extra borrowing raises rents and payouts now, but reduces expected future permanent income, which in turn tightens the intertemporal budget constraint (IBC) on future rents and payouts. The IBC means that borrowing cannot sustain rents that exceed managers' share of permanent income. Borrowing by the firm smooths rents and tailors them to managers' preferences. Strict enforcement of the IBC also means that debt policy can never spiral out of control.¹⁸

Third, changes in debt depend on the complete history of permanent income (Y_{t-j}), the firm's current operating profits ($K^\phi \pi_t$) and the initial level of payout plus rents ($d_0 + r_0$). If there is no habit formation ($h = 0$) then Eq. (20) shows that the debt level goes up (down) if the total – i.e. rents plus payout – target payout, $Y_t + \kappa/\alpha$, exceeds (is below) current income. With habit formation ($h > 0$), a second term is added, which reflects the difference between the firm's payout plus rents in last period ($d_{t-1} + r_{t-1}$) and current permanent income (Y_t). If last period's payout and rents are above (below) current permanent income, debt increases (decreases). The increase or decrease is not completed immediately, however, because $\beta h < 1$. Since last period's rents and payout themselves depend on last period's permanent income, changes in debt can be expressed as a distributed lag model of current and past levels of permanent income as illustrated by Eq. (21).

¹⁸The IBC does not rule out financial distress if the firm's operating earnings fall so far that managers and shareholders decide to default. See Lambrecht and Myers (2008) for an analysis of default with risk-neutral, rent-seeking managers. In this paper we have assumed mature, blue-chip corporations and ignored default for simplicity.

The evolution of debt will clearly be path dependent. The path dependence is caused by earnings shocks, which lead to revisions in expectations about future income and therefore permanent income. A shock in earnings is also propagated over time through its effect on payouts and rents. If the firm's payout is off target, then adjustment to the target must occur over time because of the IBC. Debt policy acts as a shock absorber that allows the firm gradually to adjust towards the new targets for rents and payouts.

We can distinguish the effects on debt of a transitory shock τ_t and a persistent shock η_t . Using our earlier expressions for $\frac{\partial Y_t}{\partial \tau_t}$ and $\frac{\partial Y_t}{\partial \eta_t}$ (and assuming again that $K = 1$), the marginal effects are:

$$\frac{\partial [D_t - D_{t-1}]}{\partial \tau_t} = (1 - \beta h)\rho\beta - 1 < 0 \quad (22)$$

$$\frac{\partial [D_t - D_{t-1}]}{\partial \eta_t} = \frac{(1 - \beta h)\rho\beta}{1 - \beta\mu} - 1 < 0 \quad (23)$$

A dollar of transitory earnings decreases debt by almost a full dollar, because only a small fraction $(1 - \beta h)\rho\beta$ of the windfall cash flows is immediately paid out to stockholders or managers. An extra dollar of permanent earnings decreases debt by a much smaller amount because a larger fraction $(1 - \beta h)$ is paid out.

E. Investment

Now we consider managers' optimal investment policy. At time t the firm makes an irreversible investment K that generates a future stream of operating profits of $K^\phi \pi_{t+j}$, where π_{t+j} is the autoregressive process $\pi_{t+1+j} = \mu\pi_{t+j} + \eta_{t+1+j}$.¹⁹ Managers first decide on K and then set rents and payouts r_t and d_t . Of course managers take into account how investment will affect current and future rents.

Since managers are wealth constrained (we assume they do not borrow or save on their own behalf) the investment has to be paid for by issuing debt and equity, so $K = \Delta D + \Delta S$. The capital market constraint implies that the proceeds from an equity issue are $\Delta S =$

¹⁹It's easiest to think of the firm starting from scratch, with no capital stock or debt. If the firm has pre-existing capital, then think of old capital as rolled over costlessly into new capital. Any old debt would likewise be carried forward and rolled into new debt.

$\alpha(\Delta V - \Delta D)$. The additional debt required to finance the investment K is $\Delta D(K) \equiv (K - \alpha\Delta V)/(1 - \alpha) = \left[K - \alpha K^\phi \sum_{j=1}^{\infty} \beta^j E_t(\pi_{t+j}) \right] / (1 - \alpha)$.^{20 21}

The budget constraints at the time of investment t and later times $t + j$ are:

$$D_t = (1 + \gamma) r_t + \Delta D(K) \quad (24)$$

$$D_{t+j} = (1 + \gamma) r_{t+j} + (1 + \rho) D_{t+j-1} - K^\phi \pi_{t+j} \quad j = 1, 2, \dots \quad (25)$$

Investing the amount K has two effects. First, it increases the outstanding debt at t by an amount $\Delta D(K)$. Second, it scales all future operating profits by a factor K^ϕ . Repeated substitution of the budget constraint leads to the following intertemporal budget constraint:

$$(1 + \gamma) \sum_{j=0}^{\infty} \beta^j r_{t+j} = \Pi_t + K^\phi \sum_{j=1}^{\infty} \beta^j \pi_{t+j} - (1 + \rho) (D_{t-1} + \beta \Delta D(K)) \quad (26)$$

where Π_t is the operating income at t . If the risk-neutral shareholders were in charge, they would simply maximize the present value of expected payout over the firm's infinite life. Optimizing the right hand of this equality with respect to K and taking expectations, we get the shareholders' first-best investment policy:

PROPOSITION 3 : *The investment policy K^* that maximizes shareholder value is the solution to:*

$$\phi K^{\phi-1} \sum_{j=1}^{\infty} \beta^j E_t[\pi_{t+j}] - 1 = 0 \quad (27)$$

The efficient investment policy K^ is given by:*

$$K^* = \left[\frac{\beta \phi E_t[\pi_{t+1}]}{1 - \beta \mu} \right]^{\frac{1}{1-\phi}} \quad (28)$$

Consider next the managers' investment decision. We have derived managers' optimal rent policy r_t for any given constant level of investment and for any level of debt. Once the

²⁰If the investment has a high NPV then ΔD could be negative. The firm could use the proceeds of the equity issue to pay down existing debt or pile up cash.

²¹If managers were for some reason unable to issue any new equity and had to rely exclusively on debt ($\Delta D(K) = K$), then managers' optimal investment is the same as Eq. (33) below, except that $(1 - \alpha)^2$ is replaced by $1 - \alpha$. Financing 100% by debt therefore increases the degree of underinvestment and reduces rents and payout.

investment K is sunk, the managers' optimal rent policy is described in proposition 2, that is:²²

$$r_t = \beta h r_{t-1} + (1 - \beta h)(1 - \alpha)Y_t[K] + c \quad (29)$$

$$\text{where } Y_t[K] \equiv \rho\beta \left[\Pi_t + \sum_{j=1}^{\infty} K^\phi \beta^j E_t[\pi_{t+j}] \right] - \rho(D_{t-1} + \beta\Delta D(K)) \quad (30)$$

Payout still moves in lockstep with rents and follows the same process.²³ Managers choose K in order to maximize:²⁴

$$\max_K \sum_{j=0}^{\infty} \omega^j E_t[u(\hat{r}_{t+j})] \quad \text{where } \hat{r}_{t+j} \equiv r_{t+j} - h r_{t+j-1} \quad (31)$$

The first-order condition is:

$$\sum_{j=0}^{\infty} \omega^j E_t \left[u'(\hat{r}_{t+j}) \frac{\partial \hat{r}_{t+j}}{\partial K} \right] = 0 \quad (32)$$

After lengthy calculations (see appendix) this first-order condition simplifies to:

$$\sum_{j=0}^{\infty} \omega^j E_t \left[u'(\hat{r}_{t+j}) \frac{\partial \hat{r}_{t+j}}{\partial K} \right] = e^{-\theta \hat{r}_t} \frac{\partial \hat{r}_t}{\partial K} \sum_{j=0}^{\infty} \omega^j \left(\frac{\beta}{\omega} \right)^j = \frac{e^{-\theta \hat{r}_t} \frac{\partial \hat{r}_t}{\partial K}}{1 - \beta} = 0$$

which ultimately leads to the following proposition.²⁵

PROPOSITION 4 : *The managers' optimal investment policy K is the solution to:*

$$\phi K^{\phi-1} \sum_{j=1}^{\infty} \beta^j E_t[\pi_{t+j}] - 1 = \frac{\theta \sigma_\eta^2 (1 - \alpha)^2 \beta (1 - h\beta) \phi K^{2\phi-1}}{(1 - \beta\mu)^2} \quad (33)$$

Managers underinvest if they are risk-averse ($\theta > 0$) and if profits are uncertain ($\sigma_\eta > 0$).

²²If there is no rent history prior to time t , then a benchmark value for r_{t-1} can be picked as an initial starting value.

²³But note that investment may be partly financed by issuing shares. In practice the firm could cut back payout, rather than issuing the extra shares necessary to maintain payout.

²⁴Managers do not invest directly, but they can co-invest by keeping current rents r_t as low as possible. The budget constraint Eq. (24) shows that a dollar cutback in r_t reduces debt D_t by $1 + \gamma$ dollars. When managers set K , they take account of its effect on immediate and future rents (see the first-order condition Eq. (32)).

²⁵Calculating $\frac{\partial \hat{r}_{t+j}}{\partial K}$ may seem like a daunting task. However, the optimal rent policy can be expressed as $\hat{r}_{t+j} = \hat{r}_t + j\Gamma + K^\phi \sum_{i=1}^j \delta \eta_{t+i}$ (where Γ and δ are constants defined in the proof of proposition 2). Therefore, under the optimal policy, habit-adjusted rents \hat{r}_t follow a random walk with drift. This allows us to express $\frac{\partial \hat{r}_{t+j}}{\partial K}$ as a simple function of $\frac{\partial \hat{r}_t}{\partial K}$ (see Eq. (A31)).

The proposition has several interesting implications. First, investment is efficient only if the right side of Eq. (33) is zero. But this expression is positive, so risk-averse managers underinvest. Comparing Eqs. (33) and (10) reveals that the term on the right is proportional to the precautionary savings term. Risk aversion causes managers to save for a rainy day, which leads to underinvestment.

Consider next the role of risk-aversion and profit volatility. All outcomes in the first-order condition Eq. (32) are weighed by $u'(r_{t+j})$, the managers' marginal utility of rents at $t + j$. Since rents increase with the realization of the economic shock η , and since marginal utility is declining exponentially in rents, the managers' first order condition puts relatively more weight on bad outcomes than on good outcomes. Therefore the degree of under-investment increases with managers' risk-aversion coefficient (θ) and with profit volatility (σ_η).

Habit formation mitigates underinvestment. The managers' optimal investment decreases with the speed of adjustment $(1 - \beta h)$, because habit formation reduces the managers' need for precautionary savings. Habit formation and the resulting partial adjustment of rents smooths the rent stream and dampens the effect of volatility.

A higher level of investor protection makes investment policy more efficient. Notice how the squared factor $(1 - \alpha)^2$ pushes the right side of Eq. (33) rapidly towards zero as α increases. As investor protection approaches perfection ($\alpha \rightarrow 1$), the risks borne by managers approach zero, and their investment policy approaches the shareholders' first best. This result is fragile and misleading near the limit of $\alpha = 1$, however, because the managers' rents also go to zero at this limit. "Perfect" investor protection gives managers no hope of future rents and no reason to invest in firm-specific human capital.²⁶ The managers do not care how much the firm invests.

Our prediction of underinvestment is opposite to the free-cash-flow theory, which proposes that managers of mature firms always want to invest if there is cash lying around.²⁷ Of course

²⁶Firms that depend on firm-specific human capital go public (Myers (2000)) or adopt a dispersed ownership structure (Burkart, Gromb and Panunzi (1997)) in order to *reduce* investors' bargaining power and to create space for managerial rents.

²⁷The free cash flow theory starts with Jensen (1986). Note also Shleifer and Vishny's (1989) theory of entrenching investment, which we would interpret as an attempt by managers to reduce α .

the managers in our model would be happy to increase K if they could invest only the shareholders' money, for example by cutting payouts while maintaining rents. The capital-market constraint prevents this, however. Managers might be tempted to overinvest and finance the investment by borrowing (or by drawing down cash reserves, which reduces net borrowing), but on second thought would not do so, because this strategy would reduce the present value of their rents.

Payout depends on investment, because investment determines permanent income. Once investment is set, payout follows the Lintner model. Payout is not cut back to finance CAPEX, because smoothing is effected by borrowing or lending. CAPEX and payout can increase simultaneously.

We assume that investment takes place only once. A more general model would endow the firm with opportunities for future investment. This would complicate the analysis, especially if current investment preserves or expands future growth options. We discuss growth and growth options below.

Our model does not rely on psychological private benefits, but this is one place where such benefits may enhance efficiency by offsetting risk aversion and mitigating underinvestment. Suppose that managers get private benefits bK from investment ($b > 0$), and that these benefits do not impose a financial drain on the firm. Then there is a level for b that is just right and leads to value-maximizing investment. Of course a b that is too high would lead to overinvestment. We see no good way of gauging the actual or optimal magnitude of private benefits for the managers of large, public corporations. This is a problem for theories that rely on private benefits to motivate managers.

F. Extensions and Robustness

Our model and its results have been derived under simplifying assumptions. Before turning to empirical implications, it's useful to consider how our results could be affected by the introduction of adjustment costs, taxes and growth. For this discussion we take capital stock as fixed.

F.1. Adjustment Costs

Some papers on dividend behavior argue that there are costs of adjusting dividends. For example, Garrett and Priestley (2000) propose an econometric model that assumes managers minimize the costs of adjustment associated with being away from their target dividend payout. These type of adjustment costs have sometimes been invoked as a rationale for the stickiness of payout and managerial compensation.

We could add adjustment costs to our model, for example by adding an adjustment cost parameter a to the managers' optimization problem:

$$\max E_t \left[\sum_{j=0}^{\infty} \beta^j \left[u(r_{t+j} - hr_{t+j-1}) - \frac{a}{2} (r_{t+j} - r_{t+j-1})^2 \right] \right] \quad (34)$$

subject to the previous constraints Eqs. (4), (5) and (6). (The adjustment costs would affect payout as well as rents, because rents and payout are proportional.) As this objective function shows, adjustment costs and habit formation affect managers' total utility in very different ways. Managers' direct utility $u(r_t, r_{t-1})$ is monotonically increasing in r_t in the presence of habit formation, but the disutility of adjustment, $\frac{a}{2} (r_t - r_{t-1})^2$ is a U-shaped function of r_t that reaches a minimum at $r_t = r_{t-1}$.

Note that this objective forces managers to pay for the costs of adjusting rents. Shareholders will not pay, because they do not care whether payout is volatile or smooth. We do not include adjustment costs for payout, because such costs should be at most second-order for maturing firms that repurchase shares regularly.

The adjustment costs for rents could include financing frictions. Changes in rents are "financed" at the margin by corporate borrowing or lending. Adjustment costs for rents could represent transaction costs of issuing or retiring debt. These transaction costs would have to be paid for by the managers as reduced rents. (Stockholders in our model do not care about smoothing and would not pay for debt transactions that they would not execute if they were in control.)²⁸

²⁸But if *investors* want smooth payout and are willing to pay for it, then the value impact of smoothing would show up in the constraints, which would probably make the optimization problem intractable. We leave this as a possible topic for future research.

For tractability we adopt for this example the quadratic utility function $u(r_t, r_{t-1}) = -\frac{1}{2}(b - r_t + hr_{t-1})^2$ and we assume that managers have the same discount factor as the market ($\omega = \beta$). We get the following rent policy:²⁹

$$r_t = \beta\epsilon r_{t-1} + (1 - \beta\epsilon)Y_t \quad \text{where :} \quad (35)$$

$$\epsilon = \frac{m - \sqrt{m^2 - \frac{4}{\beta}}}{2} \quad \text{and} \quad m \equiv \frac{1 + a(1 + \beta) + \beta h^2}{(h + a)\beta} \quad \text{and} \quad 0 \leq \epsilon < 1 \quad (36)$$

This solution indicates that habit formation and adjustment costs would reinforce each other and increase rent and payout smoothing. Also habit formation is not strictly necessary to a Lintner model. With no habit formation ($h = 0$) but a positive adjustment cost ($a > 0$), we still obtain a partial adjustment model with $SOA \equiv 1 - \beta\epsilon < 1$.

Adjustment costs for rents may matter, but we believe our habit-formation setup is more tractable, more interesting and more easily interpreted. For example, we can see how the SOA depends on both habit formation and the interest rate. Also, the SOA is highly sensitive to the habit formation coefficient ($SOA = 1 - \beta h$ for $h > a = 0$), but large changes in adjustment costs have relatively small impact. Increasing the adjustment cost parameter from $a = 0.1$ to $a = 1$ pushes the SOA down from 0.92 to 0.64. It seems that very high adjustment costs would be required to get $SOAs$ in the ballpark of empirical estimates.³⁰

F.2. Taxes

Introducing taxes could complicate our model massively, not by changing our analysis of payout smoothing, but by making debt policy value-relevant. If interest tax shields contribute to firm value, then we would need to introduce (at least) default and costs of financial distress as an offset. We would have to consider managers' and shareholders' optimal default strategies, moral hazard and debt overhang issues, etc. Lambrecht and Myers (2008) consider

²⁹The absence of a Lintner constant in Eq. (35) follows from our assumption here that $\omega = \beta$. If $\omega < \beta$ then the solution includes a positive Lintner constant.

³⁰Garrett and Priestley (2000, p. 174) report that their adjustment-cost "model yields a substantially higher speed of adjustment toward the target dividend payout than other models, suggesting that managers adjust toward their target much quicker than previously thought."

some of these issues, but with simplifying assumptions, including the assumption of risk-neutral managers. We cannot attempt to unite that and this paper here. But we can show how taxes affect our payout results when debt policy is *not* value-relevant, as in Miller (1977).

Assume that corporate profits are taxed at the rate τ_c and that rents r_t are taxed at a personal rate τ_p . Thus rents and interest on debt are both tax-deductible at the corporate level.³¹ Corporate taxes paid at time t are $\tau_c (K^\phi \pi_t - \rho D_{t-1} - r_t)$.

The managers' optimization problem is now given by:

$$\max E_t \left[\sum_{j=0}^{\infty} \omega^j \left[1 - \frac{1}{\theta} e^{-\theta(1-\tau_p)(r_{t+j} - hr_{t+j-1})} \right] \right]$$

subject to the constraints:

$$\begin{aligned} \sum_{j=0}^{\infty} \beta^j E_t [d_{t+j}] = \alpha E_t \left[\sum_{j=0}^{\infty} \beta^j (1 - \tau_c) K^\phi \pi_{t+j} - (1 + \rho(1 - \tau_c)) D_{t-1} \right. \\ \left. + \sum_{j=0}^{\infty} \beta^j D_{t+j} (1 - \beta [1 + \rho(1 - \tau_c)]) \right] \end{aligned} \quad (37)$$

$$D_t = D_{t-1}(1 + \rho(1 - \tau_c)) + d_t + (1 - \tau_c)r_t - (1 - \tau_c)K^\phi \pi_t(\eta_t) \quad (38)$$

$$\lim_{j \rightarrow \infty} \beta^j D_{t+j} = 0 \quad (39)$$

When $\beta = 1/(1+\rho)$, the third term in brackets in the capital-market constraint (37) simplifies to the present value of interest tax shields, i.e. $\sum_{j=0}^{\infty} \beta^j \tau_c \rho D_{t+j}$.

Corporate taxes change the capital market constraint Eq. (37) and the budget constraint Eq. (38). Both constraints now depend on the after-tax cost of debt $\rho(1 - \tau_c)$, the after-tax cost of managerial rents $(1 - \tau_c)r_t$ and after-tax operating profits $(1 - \tau_c)K^\phi \pi_t$. The capital market constraint Eq. (37) states that the firm's stock market capitalization equals the present value of all free cash-flows after corporate taxes, multiplied by the governance parameter $\alpha < 1$. Using a derivation similar to the one for Eq. (A13) (see appendix), the

³¹ Rents that the company pays for are tax-deductible expenses. Such rents include above-market salaries, perks, generous retirement packages and the excess costs of empire building. Intangible private benefits, for example the psychological value of power and prestige, may not require cash outlays and thus may not be tax-deductible. Intangible benefits are possible, but we do not invoke them in this paper.

IBC with taxes is now given by:

$$\begin{aligned} \sum_{j=0}^{\infty} \beta^j (r_{t+j}(1 - \tau_c) + d_{t+j}) &= \sum_{j=0}^{\infty} \beta^j K^\phi \pi_{t+j}(1 - \tau_c) - (1 + \rho(1 - \tau_c)) D_{t-1} \\ &+ \sum_{j=0}^{\infty} \beta^j D_{t+j} (1 - \beta(1 + \rho(1 - \tau_c))) \end{aligned} \quad (40)$$

With corporate taxes the IBC (and therefore permanent income) and the capital market constraint depend on the entire future path of net debt. With valuable interest tax shields, increasing the net debt level at any point in time loosens the IBC and increases permanent income. Solving for the value of interest tax shields is beyond the scope of this paper.

But suppose we cancel out the value of interest tax shields, as in a Miller (1977) equilibrium. In that equilibrium, the risk-free rate for valuing equity claims is after-tax, and the marginal investors' tax rate equals the corporate rate. Thus we use the after-tax rate $\rho(1 - \tau_c)$ and an after-tax discount factor $\beta^* = 1/(1 + \rho(1 - \tau_c))$. Then the capital market constraint only depends on D_{t-1} and not on the future levels of debt. We focus on this case to see how taxes affect payout in our model.

Using a similar derivation as for proposition 1, we now find that:

$$d_t = \left(\frac{\alpha}{1 - \alpha} \right) (1 - \tau_c) r_t \equiv \gamma(1 - \tau_c) r_t \quad (41)$$

Because rents are tax-deductible by the firm, only their after-tax cost, $(1 - \tau_c)r_t$, matters to outside shareholders. Payout and rents still move in lockstep, but payout is now a smaller multiple of rents. Corporate taxes therefore squeeze payout relative to managerial compensation.

Substituting $\beta^* = 1/(1 + \rho(1 - \tau_c))$ and Eq. (41) into Eq. (40) gives the following after-tax IBC:

$$(1 + \gamma)(1 - \tau_c) \sum_{j=0}^{\infty} \beta^{*j} r_{t+j} = \sum_{j=0}^{\infty} \beta^{*j} (1 - \tau_c) K^\phi \pi_{t+j} - (1 + \rho(1 - \tau_c)) D_{t-1} \quad (42)$$

Comparing the current optimization problem with the one without taxes, one can show that both problems are equivalent if we make the following substitutions in the original problem: $\beta \rightarrow \beta^*$, $\rho \rightarrow \rho(1 - \tau_c)$, $\omega \rightarrow \omega^*$, $\theta \rightarrow \theta(1 - \tau_p)$, $K^\phi \rightarrow (1 - \tau_c)K^\phi$ and $(1 + \gamma) \rightarrow (1 + \gamma)(1 - \tau_c)$.³²

³²One might question how personal taxes should affect managers' *subjective* discount factor ω . This is a further complication that could be explored.

Implementing those substitutions gives the following rent and payout policies:

$$r_t - r_{t-1} = (1 - \beta^* h) \left[\left(\frac{1 - \alpha}{1 - \tau_c} \right) Y_t^* - r_{t-1} \right] + c^* \quad (43)$$

$$d_t - d_{t-1} = (1 - \beta^* h) [\alpha Y_t^* - d_{t-1}] + \frac{\alpha(1 - \tau_c)}{1 - \alpha} c^* \quad (44)$$

where Y_t^* and c^* are the after-tax versions of Y_t and c as defined in proposition 2.

We still obtain a Lintner model for payout. The main effect of corporate taxes is that the payout and rent policy now depend on the after-tax permanent income Y_t^* , which in turn depends on the after-tax cost of debt $\rho(1 - \tau_c)$ and after-tax profits $((1 - \tau_c)K^\phi \pi_t)$. The ratio of shareholders' target payout to managers' target rents now equals $\alpha(1 - \tau_c)/(1 - \alpha)$. The sum of shareholders' target payout and managers' target rents exceed Y_t^* because managers' rents are levied before taxes. This allows rents to be scaled up by a factor $1/(1 - \tau_c)$. The after-tax cost to shareholders of managers' target rents equals $(1 - \alpha)Y_t^*$.

Personal taxes do not affect the IBC nor the capital market constraint because they are not levied at the firm level. Personal taxes do enter into the managers' objective function, however, and by recalculating the Euler equation, one can show that the effect of personal taxes is to scale down the risk aversion coefficient by a factor $1 - \tau_p$.

All else equal, a higher personal tax rate decreases the net payout to managers. This causes the firm to reduce precautionary savings (by increasing net debt) and to increase dissaving due to managers' impatience. We do assume, however, that rents are paid in cash and show up on managers' personal tax returns. There may be more tax-efficient ways of paying rents, for example as untaxed perks. Of course, it may also be tax-efficient to distribute payout as repurchases rather than cash dividends. Our model does not predict the form of payout, only the total amount.³³

To summarize: We have shown that a Lintner model of payout still holds, with a closed-form solution, when corporate taxes are introduced. Our qualitative predictions are unchanged.³⁴ The main effect of corporate taxes is to expand rents, which are tax-deductible,

³³Korinek and Stiglitz (2009) analyze the effects of changes in dividend tax policy using a life-cycle model of the firm. They show that anticipated dividend tax changes create incentives for firms to engage in inter-temporal tax arbitrage so as to reduce investors' tax burden.

³⁴Thus it is useful to "take the model to the data" on payout, even in the absence of a combined theory

relative to payout, which is not. But we have not tackled the next challenge, which is to introduce valuable interest tax shields (rather than the Miller (1977) equilibrium), costs of financial distress, or other factors emphasized in models of capital structure.

There are obvious conflicts between a Lintner model of payout smoothing and standard models of capital structure. Suppose we hold capital stock constant, and introduce a target debt ratio representing the value-maximizing tradeoff of valuable interest tax shields and costs of financial distress. This tradeoff suggests a target-adjustment model of capital structure. But if the firm follows a target-adjustment model of capital structure, then it cannot implement a target-adjustment model of payout. The two target-adjustment models cannot coexist.

For example, suppose the firm's payout in the prior period was exactly on target, with rents and payout accounting for 100% of permanent income of \$100. By chance the firm is also exactly at its target debt ratio. Now there is an unexpected downward shock to permanent income from \$100 to \$80. If the firm smooths rents and payout, they must decrease by less than 20%, say to \$95. But that leaves a cash deficit of \$15, which must be covered by additional borrowing. Thus the firm ends up borrowing *more* when a target-adjustment model of debt says it should be *paying down* debt.

Suppose instead that the firm implements a target-adjustment model of capital structure. It pays down \$20 of debt to get part way to the target debt level at the firm's new, lower value. That leaves only \$60 for rents and payout, which fall by 40%. Thus the volatility of rents and payout is not smoothed but amplified.

A target-adjustment model of debt implies that changes in debt are smoothed and have lower volatility than permanent income and value. Then the volatility of rents and payout must be *higher* than the volatility of permanent income and value. If one believes on the contrary that rents and payout are smoothed, then changes in debt cannot be smoothed, leaving no space to also believe in a target-adjustment model of capital structure.

These points follow from the firm's sources-uses constraint. There can be no more than

of payout and debt policy. We discuss empirical implications and results below.

two independent theories of capital investment, payout and borrowing. Given CAPEX, there can only be one. We present a joint theory of payout and borrowing, but under the simplifying and restricting assumption that corporate borrowing is not value-relevant. Introducing value-relevant debt policy is a challenge for future work.

F.3. Growth

We focus on stable, mature firms and hold capital stock K constant. Therefore we assume an autoregressive profit process with no drift. Introducing growth as positive drift is relatively easy. One can show (see for example Wang (2003)) that introducing a non-zero drift μ_0 (i.e. $\pi_t = \mu_0 + \mu\pi_{t-1} + \eta_t$) adds an additional term in μ_0 to the expression for the Lintner constant κ . A higher (lower) drift μ_0 increases (reduces) the constant κ .

Therefore managerial impatience ($\omega < \beta$) is not strictly necessary to generate a positive Lintner constant, provided that the drift term μ_0 is sufficiently high. For example, Japanese firms are said to be more long-term oriented and to offer more job security and less turnover. This may translate in more managerial patience and a higher value for ω . This should shift current payout and rents to the of future. All else equal, this leads to a lower value of the Lintner constant. But this negative effect on current payout and rents could be offset by a positive drift in profits, leaving the Lintner constant still positive.

We model a one-time investment decision and do not consider future investment. Future investment opportunities are real options. Even the mature firms that we consider have some growth options. Thus we have another challenge for future research: How would the introduction of growth options affect current payout?

If growth options contribute to current firm value, in addition to the value of assets in place, then permanent income should increase. This suggests that valuable growth options should increase current rents and payout. Perhaps so, but the conclusion rests on the premise that managers can and will borrow against the growth options to pay for the increase in current rents and payout. But it seems that growth firms are also low-payout firms. It may be that managers of growth firms are reducing rents and payout (thus retaining earnings) in

order to co-invest and grow. Borrowing to increase rents and payout could also generate the classic debt-overhang problem described by Myers (1977). In our agency setup, the moral hazard caused by debt overhang would apply to managers as well as shareholders. But these or other possibilities must be left to another paper.

III. Empirical Implications

This section discusses the model’s empirical implications. First we summarize the empirical specifications that our model calls for and note problems that arise when the Lintner model is fit to reported net income rather than permanent income. Second, we interpret the Lintner constant and *SOA*. We summarize our model’s main predictions about payout and relate them to existing empirical evidence. Third, we cover “the information content of dividends” and other empirical implications. We close this section with a brief comment on “the *new* dividend puzzle.”

A. Estimation

Corollary 1 gives a partial-adjustment model that connects current payouts to lagged payouts and permanent income. The model would be estimated as:

$$d_t = a_0 + a_1 d_{t-1} + a_2 Y_t + e_t \quad (45)$$

where a_0 , a_1 and a_2 are the regression coefficients and e_t the error term. Our model says that $a_0 = \kappa$, $a_1 = \beta h$ and $a_2 = (1 - \beta h) \alpha$. Permanent income Y_t is not observable, but could be estimated from current operating profit and the market’s expectation of future profits. If the profit margin π_t follows the autoregressive process $\pi_t = \mu \pi_{t-1} + \eta_t$, then permanent income is $Y_t = \frac{\rho}{1+\rho-\mu} (K^\phi \pi_t - (1 + \rho - \mu) D_{t-1})$. In the limiting case where π_t follows a random walk ($\mu = 1$), permanent income equals $K^\phi \pi_t - \rho D_{t-1}$, that is, current net income, measured before rents but after interest.

Writing the target-adjustment model (45) in first differences gives:

$$\Delta d_t = a_1 \Delta d_{t-1} + a_2 \Delta Y_t + \Delta e_t \quad (46)$$

Here we need an expression for ΔY_t , the change in permanent income. But in principle it is possible to identify the habit coefficient and *SOA* without knowing Y_t or ΔY_t . After lengthy derivations (see appendix) we obtain the following proposition:

PROPOSITION 5 : *If managers have negative exponential utility then the changes in payouts and rents are:*

$$\Delta d_t = h\Delta d_{t-1} - \frac{\alpha\rho c}{1-\alpha} + \alpha(1-\beta h)\nu_t \quad (47)$$

$$\Delta r_t = h\Delta r_{t-1} - \rho c + (1-\alpha)(1-\beta h)\nu_t \quad (48)$$

Payouts and rents are smoothed relative to income:

$$\text{var}(\Delta d_t) = \Lambda^2\alpha^2 [K^{2\phi}\sigma_\eta^2] \quad \text{and} \quad \text{var}(\Delta r_t) = \Lambda^2(1-\alpha)^2 [K^{2\phi}\sigma_\eta^2] \quad (49)$$

where $\Lambda = \frac{(1-\beta h)(1-\beta)}{1-\beta\mu} < 1$ and ν_t is white noise given by $\nu_t = \frac{\rho\beta K^\phi \eta_t}{1-\beta\mu}$.

Since ν_t is white noise, h can be estimated from the vector autoregression (47), which allows us to calculate the speed of adjustment $1-\beta h$. The advantage of this regression is that we do not need to know permanent income. In fact, our estimate for h allows us to calculate the permanent income that is implied by a payout series as:

$$Y_t = \frac{(d_t - \beta h d_{t-1}) - \alpha c}{\alpha(1-\beta h)} \quad (50)$$

The variance of payout changes is a fraction $\Lambda^2\alpha^2$ of the variance of operating income ($K^{2\phi}\sigma_\eta^2$). This confirms that payouts are smoothed relative to income.

Our model also says that transitory income shocks have a much smaller effect on payout than persistent income shocks. This result highlights the perils of an econometric model for payout that lumps earnings all in one basket. Ideally, the econometrician should distinguish transitory and persistent earnings.³⁵ This can be illustrated as follows. Assume as before that $K=1$ and that $\pi_t = p_t + \tau_t$. Then permanent income is given by:

$$Y_t = \frac{\rho\beta}{1-\beta\mu} p_t + \rho\beta\tau_t - \rho D_{t-1} \quad (51)$$

$$= \frac{\rho\beta}{1-\beta\mu} E_t - \frac{\rho\beta(1-\mu)}{1-\beta\mu} D_{t-1} - \frac{\rho\beta^2\mu\tau_t}{1-\beta\mu} \quad (52)$$

³⁵The accounting literature may provide further guidance on these topics. For example, see Ohlson (1999) and Barth et al. (1999).

where the current reported earnings is $E_t \equiv p_t + \tau_t - \rho D_{t-1}$. The Lintner model as traditionally estimated is:

$$\Delta d_t = b_0 + b_1 E_t + b_2 d_{t-1} + u_t \quad (53)$$

The coefficient b_2 on lagged payouts is interpreted as (the negative of) the *SOA* and the coefficient b_1 on earnings as the product of the payout ratio and the *SOA*.

According to our theory, the true model is:

$$\Delta d_t = \kappa + \frac{\rho\beta\alpha SOA}{1 - \beta\mu} E_t - SOA d_{t-1} - \frac{\rho\beta^2\mu\alpha SOA}{1 - \beta\mu} \tau_t - \frac{\rho\beta(1 - \mu)\alpha SOA}{1 - \beta\mu} D_{t-1} + e_t \quad (54)$$

The estimates for the coefficients b_0 , b_1 and b_2 from Eq. (53) will be biased and inconsistent, unless the omitted variables D_{t-1} and τ_t are orthogonal to the included variables (Greene (1993), p. 246). The omitted variables are likely to be correlated with the included variables, given the definition of the earnings variable E_t , and because d_{t-1} is linked with D_{t-1} through the budget constraint. The variance of the estimates and of the error term are also biased. Thus the usual confidence interval and hypothesis testing procedures can give misleading conclusions about statistical significance.

In practice, however, the misspecification of the traditional Lintner model in Eq. (53) may not be all that severe. First, corporate earnings or cash-flows are highly persistent for mature, stable companies with low earnings volatility (see Dichev and Tang (2009) and Frankel and Litov (2009)).³⁶ As $\mu \rightarrow 1$ the term in D_{t-1} in Eq. (54) vanishes and the omitted variable problem with respect to D_{t-1} disappears. Second, the transitory income component τ_t may account for only a small part of the total earnings E_t of a mature company. Thus the correlation between τ_t and E_t may be small too. In other words, current earnings E_t may be highly correlated with permanent income when transitory income is small. Of course E_t becomes a noisy measure of permanent income when transitory income is volatile

³⁶Dichev and Tang (2009) run an AR(1) earnings model for quintiles formed on earnings volatility. They find a strong, monotonic, negative relationship between volatility and earnings persistence. The persistence coefficient declines from 0.93 in the lowest volatility quintile to 0.51 in the highest. Frankel and Litov (2009) find similar results when the AR(1) model is run on cash flows rather than earnings, with coefficients of 0.85 in the lowest volatility quintile and 0.51 in the highest.

and important. Then the traditional Lintner regression Eq. (53) may give quite different results from the model specified in Eq. (54).

While our paper presents the first formal model linking payout to permanent earnings, some empirical papers have already tested the link between dividends and permanent income. Marsh and Merton (1987) use common-stock price changes to measure changes in permanent income. Garrett and Priestley (2000) propose a method for extracting an estimate of permanent earnings from an observed earnings series. Their results show, at least at the aggregate level, that information about expected permanent earnings is captured by lagged stock prices. In our model, stock-market capitalization is proportional to permanent income. In an efficient market, unanticipated changes in market value would reveal unanticipated changes in permanent income. One could estimate a version of Eq. (13) in first differences, with a distributed lag on past stock market returns instead of on past changes in permanent income. Of course there could be complications, for example if managers, who set rents and payouts, have a better fix on permanent income than investors. In that case stock prices do not anticipate changes in payouts; they react to them. We discuss this “information content” in section *C*.

B. The Lintner Constant and SOA

Lintner (1956) said that “The constant will be zero for some companies but will generally be positive to reflect the greater reluctance to reduce than to raise dividends ... as well as the influence of the specific desire for a gradual growth in dividend payments found in about a third of the companies visited.” Fama and Babiak (1968) found that the constant in the Lintner model was positive but small, with a sample mean and median of 0.109 and 0.028, although for most firms the constant was not significantly different from zero. A small positive constant suggests that dissavings due to impatience marginally outweighed managers’ precautionary savings. This might come as a surprise if one believes that the subjective discount rate approximately equals the market discount rate, and therefore that dissavings due to impatience are small. Habit formation dramatically reduces the amount of precautionary savings, however. Note that the precautionary savings term in Eq. (12)

includes the squared speed of adjustment $(1 - \beta h)^2$. For a typical Lintner *SOA* of, say, 0.3 this implies that habit formation reduces precautionary savings by over 90%! Therefore, even if dissavings due to managerial impatience are small, they could still outweigh precautionary savings and generate a positive constant. A positive drift term in profits also increases the Lintner constant, as we showed in section *F.3*.

The speed of adjustment *SOA* is determined by the risk-free rate ρ and the managers' habit persistence coefficient h . As h increases, managers' cost of adjusting towards a new target rent level goes up, so payout becomes "stickier" and less responsive to changes in permanent income. The *SOA* implies a half-life for adjustment of payout to changes in permanent income. Half-life is the time needed to close the gap between the actual and target payout by 50%, after a one-unit shock to the error term in the Lintner model Eq. (1). When payout follows an AR(1) process) half-life is $\log(0.5)/\log(1 - SOA)$. If the *SOA* equals, say, 0.3 then the half-life is about 2 years, and it would take the firm about 6.5 years to close the gap between the actual payout and the target by 90%. Thus payout is history-dependent, and for reasonable parameters the history extends back several years.

Lintner (1956) found a *SOA* of about 0.3 using aggregate data on corporate earnings and dividends. Fama and Babiak (1968) tested Lintner's model for individual firms over a 20-year period and reported a mean *SOA* of 0.32 and a mean target payout ratio of 0.52. Skinner (2008) found a speed of adjustment for total payout of 0.4 and 0.55 for the periods 1980-1994 and 1995-2005.

These estimates of *SOA* allow some inferences about underlying parameters. Assume a market discount factor of $\beta = 0.95$. Since $h = (1 - SOA)/\beta$, Skinner's estimates imply habit persistence coefficients of 0.63 for 1980-1994 and 0.47 for 1995-2005. The habit coefficient in Lintner's (and Fama and Babiak's) days is about $h = 0.74$. It appears that managers' habit persistence has declined substantially over time. Declining habit persistence coincided with (and might be one possible explanation for) the rising popularity of share repurchases.

Our agency theory of payout predicts that the Lintner model should *not* apply to cash dividends, but to net *total* payout, defined as dividends plus repurchases minus equity issues. Our theory should be tested on mature firms with free cash flow available for payout, good

credit and unimpeded access to debt. Skinner (2008, Table 6) has fit the Lintner model to total payout and dividends by a sample of 345 firms that paid regular dividends in at least 16 years and repurchased shares in at least 11 years from 1980 to 2005. These firms should qualify as mature.³⁷ As we predict, the Lintner target-adjustment model works better for total payout than for dividends, at least in the last decade of the Skinner sample (1995-2005). In this period, the average *SOA* for the dividend regression was .29 and insignificant ($t = 1.48$). The average *SOA* for the total-payout regression was .55 and highly significant ($t = 8.93$).³⁸ The Lintner constant was significantly negative for the dividend regression but positive and insignificant in the total-payout regression.

Skinner's (2008) results for total payout may seem to contradict other recent tests of Lintner's model that generally report lower *SOAs* than Lintner (1956) or Fama and Babiak (1968). (See Choe (1990), Brav et al. (2005), DeAngelo et al. (2008) and Leary and Michaely (2011), for example). However, the comparison is misleading. First, recent studies have focused on cash dividends, not total payout. Second, transitory payouts were almost always packaged as specially designated dividends (SDDs) during the 1950s and 1960s. Lintner and Fama and Babiak included SDDs in the dividends used to fit the target-adjustment model. But now stock repurchases account for most transitory payouts and SDDs are rare. Thus most transitory payouts are now excluded from dividends, pushing estimated *SOAs* for dividends downward. It appears that share repurchases have given financial managers an extra degree of freedom, allowing them to make cash dividends more stable while maintaining payout according to Lintner's model.

Skinner (2008) finds that the *SOA* coefficients in his total-payout regressions are larger and more significant when a period is defined as two years rather than one. It appears that firms time repurchases based on stock prices and other tactical considerations, and that the timing shifts total payout from one year to another. That result is OK in our model, which

³⁷Nothing in our theory requires mature firms to pay cash dividends. In future work it would be better to drop cash dividends as a requirement for sample selection.

³⁸Leary and Michaely (2011) estimate *SOAs* based on total payout by a larger sample of 1,200 firms from 1985 to 2005. The median *SOA* is .38, vs. .11 for cash dividends alone. Leary and Michaely are mostly concerned with cross-sectional differences in the degree of dividend smoothing, not with whether the Lintner model is a better fit to cash dividends or to net total payout.

does not specify the length of period t . But our model does not explain why repurchases are timed tactically and dividends are not. Nor can we distinguish between the information content of changes in dividends and changes in repurchases. Here we are in good company with the literature on payout policy, however.

Skinner (2008) also fits the Lintner target-adjustment model for 351 firms that repurchase regularly but do not pay cash dividends. The estimated coefficients of the Lintner target-adjustment model are much higher than for the mature-firm sample. For example, the average SOA for two-year periods from 1995-2005 was .92 ($t = 5.79$) and the implied target payout ratio was 81% of reported earnings. These coefficients seem unusually high, although some of these firms may have smoothed less because they did not have easy access to debt markets. More empirical work is clearly in order.

We do not say that Skinner (2008) has proved our model. For example, we say that target payout and the firm's stock price are determined by *permanent* income. Skinner's tests used reported net income. Net income may be a good proxy for permanent income if earnings are highly persistent and transitory income is a small part of total income. Further empirical work should check that these conditions hold. If they do not hold, coefficients and standard errors from fitting the Lintner model to reported net income will be biased, and a better empirical proxy for permanent income will be necessary. Past changes in stock price are a leading candidate.

C. Information Content

The "information content of dividends" refers to the good news conveyed to investors by dividend increases and the bad news conveyed by dividend cuts. We say "the information content of payout." The good and bad news conveyed by changes in payout is obvious in our model, because payout is proportional to rents, and managers set rents depending on their view of the firm's permanent income. Thus an unanticipated increase in payout signals an unanticipated increase in permanent income. Whether changes in payout actually predict

changes in permanent income is an open empirical issue.³⁹

The effects of changes in payout on stock price are clear in Eq. (45), where d_t depends on permanent income Y_t and the previous payout d_{t-1} , and in Eq. (18), which states that cum-dividend stock-market value is proportional to permanent income. If investors only observe payouts, then Eqs. (50) and (18) say that an unanticipated payout increase of Δd_t should increase cum-dividend and ex-dividend stock-market value by $\Delta S_t = \Delta d_t / [(1 - \beta h)\rho\beta]$ and $\Delta S_t^{ex} = \Delta d_t [1 + \rho\beta h] / [(1 - \beta h)\rho]$. The higher the habit parameter h , the more good news is conveyed by a given payout change Δd_t . A change in payouts means more to investors when they know that managers are averse to changes in rents.

The information content of dividends is clear from the reaction of stock prices to initiation or changes in dividends.⁴⁰ Testing our predictions about the information content of total payout will be more challenging. Dividend announcements are suitable for event studies. Payout evolves over months and years.

Also shareholders may learn about payout through different information channels. Note that shareholders can't protect their property rights if they observe *only* payout. They must also observe or infer rents – otherwise they would have no clue about when to intervene, and the capital-market constraint would not work. Hiring accountants to report net income is a partial remedy, but net income is calculated after rents, and rents are mixed in with other business expenses. So accounting (and other monitoring and governance mechanisms) also have to provide sufficient detail about expenses so that shareholders can estimate rents with tolerable accuracy. The mechanisms have to prevent the managers from actively concealing

³⁹But there is extensive research on whether cash dividends send a signal about permanent income. Brickley (1983), Healy and Palepu (1988) and Aharony and Dotan (1994) find that an increase in dividends leads to an increase in future accounting earnings. Marsh and Merton (1987) specify the target dividend as a function of permanent earnings, which they measure by lagged stock prices. Kao and Wu (1994) find a positive relation between unexpected changes in dividends and permanent earnings. Garrett and Priestley (2000) find evidence that dividends convey information about current unexpected earnings. In contrast, Watts (1973) and Gonedes (1978) find no relation between current dividends and future earnings, and Benartzi, Michaely and Thaler (1997) suggest that dividend changes provide information about current and past earnings.

⁴⁰See DeAngelo, DeAngelo and Skinner (2008, Ch. 8) for a review of evidence on stock price reactions to dividend announcements.

rents or from suddenly tunneling out massive rents and leaving shareholders with an empty shell.

The information about rents does not have to be verifiable or contractible. The shareholders in our model are not relying on legal enforcement, but on their ability to take over (at a cost) and toss out the incumbent managers.

D. More Empirical Implications

1. We predict that total payout by mature firms should follow the Lintner model. We do not have a theory of how payout is split between repurchases and cash dividends, but we do predict that these two payout channels are managed jointly. For example, if cash dividends are more or less locked in for the short- or medium-term, then repurchases cannot be random or erratic. Repurchases must be managed over time in order for total payout to follow the Lintner model. In other words, repurchases must have a history and predictable future. Future empirical work should try to unpack total payout and understand, at least descriptively, how dividends and repurchases evolve jointly.

2. Payout can change not only with permanent income, but also as a result of shifts in the characteristics of the firm or its managers, including profit volatility or the managers' risk aversion or impatience. Changes in managers' characteristics cannot be observed directly, but changes in earnings volatility should be measurable. Our model predicts that higher volatility increases precautionary savings, retards payout and increases cash holdings or decreases debt.⁴¹ Payout should also respond to new investment, because profitable investment increases permanent income. But the response of payout to investment depends on the investment's future profitability, which is also not directly observable. Investors' profit forecasts will be picked up in stock prices, however.

3. We predict that target payout increases with stronger corporate governance, as in

⁴¹Increased profit volatility in conjunction with precautionary savings could help explain why U.S. corporations have increased average cash holdings over the past two decades (see Bates, Kahle and Stulz (2009)) and why firms start paying out later and later (Fama and French (2001)).

La Porta et al. (2002), who find higher average payout in countries with better protection of investors. Their several measures of investor protection can be regarded as proxies or instruments for our governance parameter α . In our model payout is proportional to α . It is worth running the Lintner model on international data, because α should vary more across than within countries. α may also be influenced by internal as well as external governance mechanisms, such as board composition or anti-takeover provisions.

4. To our knowledge there is little or no empirical research on the link between payout and management compensation. Our theory predicts that payout moves in lockstep with rents. We have interpreted rents not as top-management compensation, but as value extracted by a broad coalition of top and middle managers. Nevertheless, it is worth trying top-management compensation as a proxy for rents overall. If the proxy works, then increases in payout by mature firms should coincide with increases in compensation. Increased variability in payout (possibly by a shift from cash dividends to share repurchases) should translate into higher variability in compensation, for example through a shift from salaries and bonuses to stock-based compensation.

5. Consistent with the findings of Brav et al. (2005), we show that payout is set on par with investment policy. CAPEX should not upset payout smoothing, provided that the firm can borrow efficiently against the future cash flows that investment projects generate. Debt and cash are the shock absorbers that enable firms to implement the optimal payout and investment policies. Again we stress, however, that our predictions apply to mature firms, not growth firms, especially not to growth firms that have limited access to debt financing.

6. Our theory of payout also generates a theory of corporate debt. If the capital stock is fixed, smoothing of payout requires that changes in debt are the shock-absorber or residual. We do not present a complete theory of capital structure, because we have not included interest tax shields, costs of financial distress or other costs or frictions that can make capital structure value-relevant. Nevertheless our theory has important implications for empirical research on capital structure. We have shown that target adjustment models for payout and capital structure cannot coexist. If the capital stock is taken as fixed, and payout adjusts smoothly to a permanent-income target, then debt cannot adjust smoothly to a target debt

ratio. If debt does so adjust, then payout cannot be smoothed, and in addition the volatility of payout must amplify the volatility of net income. This suggests empirical work on the volatility of payout and changes in debt, relative to the volatility of net income.

E. The New Dividend Puzzle

DeAngelo and DeAngelo (2004, p. 1) characterize the dividend puzzle as follows:

As posed by Black (1976), the dividend puzzle is actually two distinct enigmas which share the common element that observed payout decisions are tax-inefficient for stockholders. The first, which we label “the payout puzzle”, is that firms make large payouts despite the tax advantages of retention. The second, which we call “the repurchase puzzle”, is that stock repurchases have not displaced dividends as the preferred form of payout, despite their tax advantages.

Corporate-finance practice has largely answered the second enigma. As Skinner (2008, p. 584) notes, repurchases are now “the dominant form of payout”. Our paper sheds some light on the first enigma. We say that mature firms pay out cash to investors because a broad coalition of managers wants to take out a flow of rents. The capital market constraint forces payout to move in lockstep with rents. If managers want a smooth flow of rents, shareholders receive a smooth payout stream. This result holds with corporate taxes, although taxes squeeze payout relative to rents.

A new puzzle is emerging. Why has the speed of adjustment for dividends (for companies that pay regular cash dividends) declined to barely significant levels? It may be that repurchases now absorb most of the variance in permanent income, allowing financial managers to stabilize cash dividends in order to better appeal to the widows and orphans who want a dependable quarterly check in the mail. But our model cannot explain why dividends are smooth relative to repurchases. Other models are, as far as we can see, similarly deficient.

IV. Conclusion

This paper has presented a theory of payout policy. Our original goal was to explain dividend smoothing and to see whether Lintner's (1956) target-adjustment model could be derived from deeper principles. It was quickly clear, however, that net total payout, not cash dividends, is what matters in an agency model of payout. It was also clear that the dynamics of payout policy had to be modeled jointly with debt and investment policy. The three policies are tied together by the firm's budget constraint. A dynamic theory of payout and investment defines a dynamic theory of capital structure.

We show how investment policy affects debt policy and payout policy. Managers' risk aversion leads to underinvestment – the managers do not maximize market value. Once payout and investment policy are set, changes in debt must serve as the shock absorber. The residual cash flow is not payout –because managers smooth payout and rents– but changes in borrowing (or lending, for cash-rich firms). For example, a positive transitory earnings shock is used primarily to reduce net debt. Only a small fraction (less than 5% for realistic parameter values) of transitory earnings are paid out. A positive persistent shock in earnings leads to a much smaller decrease in net debt, however, and may even increase debt if the shock leads to expanded investment.

Several important issues are not addressed in this paper. We assume that corporate debt is risk-free. Therefore our model does not apply to distressed firms or firms in declining markets that sooner or later must disinvest. We also ignore the forces that drive conventional theories of capital structure, including interest tax shields, costs of financial distress and information. We do not consider the dynamics of investment. Expanding our model on these dimensions should generate further insights, but will probably pose serious technical challenges.

Given permanent income, Lintner's target-adjustment regression would fit in our model with an R-squared of 1.0. But we have simplified by bright-line assumptions that cannot be so bright in practice. For example, we assume that shareholders know rents exactly and that they and the managers know the tipping point for shareholder intervention exactly.

A more "realistic" version of the model would have the managers estimating an increasing probability of shareholder intervention as the managers' take of rents relative to dividends and repurchases increases.⁴² The shareholders' decision to intervene would depend on their estimate of rents and their trust in accounting and governance to stop runaway rents and tunneling. Also the shareholders would not rely exclusively on the threat of all-or-nothing intervention. For example, they would encourage compensation schemes to help align *top* managers' economic interests with their own. The schemes would reward top managers based on income *after* rents and on stock-price performance. (Recall that we distinguish total rents, which go to a broad cohort of managers and staff, from compensation to the CEO and his or her inner circle.) Thus one can think of more complex models in which rents and payouts do not move in exact lockstep, as in our model, but nevertheless move together on average and in the longer run. Rents and payouts would still be smoothed in such models, and Lintner's target-adjustment specification should still work when fitted to blue-chip firms that make regular cash payouts to investors.

⁴²See Myers (2000, pp. 1017-1018) for a discussion of equilibrium when managers do not know shareholders' cost of intervention.

Appendix

Proof of Proposition 1: The payoff to shareholders from taking collective action at time t (instead of accepting the proposed payout) is by assumption given by:

$$S_t = \alpha \left[\pi_t - (1 + \rho)D_{t-1} + \sum_{j=1}^{\infty} \beta^j E_t [\pi_{t+j}] \right] \quad (\text{A1})$$

The payoff to shareholders from accepting the payout d_t and not taking collective action at t is given by:

$$\begin{aligned} S_t &= d_t + \beta E_t [S_{t+1}] \\ &= d_t + \alpha \beta \left[E_t [\pi_{t+1}] - (1 + \rho)D_t + \sum_{j=1}^{\infty} \beta^j E_t [\pi_{t+1+j}] \right] \end{aligned} \quad (\text{A2})$$

The payout set by managers is such that shareholders are indifferent between taking collective action and keeping managers in place for another period. Substituting the budget condition at time t into D_t and solving for d_t gives: $d_t = \left(\frac{\alpha}{1-\alpha} \right) r_t \equiv \gamma r_t$. Hence payout plus rents ($r_t + d_t$) at time t can be expressed as $(1 + \gamma)r_t$.

Proof of Proposition 2: The managers' decision problem is to solve for an optimal rent policy plan $P^o = \{r_t^o, r_{t+1}^o, r_{t+2}^o, \dots\}$. The first order condition for the decision variable r_t can be found by applying a variational argument as, for example, in Hall (1978). Define a variation P^1 on the optimal plan that varies rents at t .

$$P_t^1(e) = \{(r_t^o + e; r_{t-1}), (r_{t+1}^o - (1 + \rho)e; r_t^o + e), (r_{t+2}^o; r_{t+1}^o - (1 + \rho)e), (r_{t+3}^o; r_{t+2}^o), \dots\}$$

For clarity's sake we have added a second argument representing the habit stock. If the optimal plan P_t^o satisfies the budget constraint at t (as it must, by definition) then by construction the variation $P_t^1(e)$ will also. Let $M_t^{(1)}(e)$ denote the managers' expected utility as of time t associated with the plan $P_t^1(e)$. Since the variation equals the optimal plan when $e = 0$ and since the optimal plan maximizes expected utility, it follows that $\left. \frac{dM_t^{(1)}(e)}{de} \right|_{e=0} = 0$, or equivalently r_t^o must satisfy:

$$E_t [u'(r_t - hr_{t-1}) - \omega hu'(r_{t+1} - hr_t)] = \frac{\omega}{\beta} E_t [u'(r_{t+1} - hr_t) - \omega hu'(r_{t+2} - hr_{t+1})]$$

The condition says that along the optimal path the managers must receive the same present utility from an extra dollar of rents today as from $(1 + \rho)$ dollars tomorrow. In the absence of habit formation ($h = 0$) this condition simplifies to the traditional Euler equation $u'(r_t) = \frac{\omega}{\beta} E_t [u'(r_{t+1})]$.⁴³

⁴³See, for example, equation (16.26) on page 556 in Acemoglu (2009). A more detailed derivation of the Euler equation can be found in Acemoglu (2009) or in Stokey, Lucas and Prescott (1989).

Following Muellbauer (1988) we define the transformed variable: $\hat{r}_{t+j} \equiv r_{t+j} - hr_{t+j-1}$ (for $j = 0, 1, 2, \dots$). Substituting into the above condition and replacing $u(\cdot)$ by the exponential utility function $u(r) = 1 - \frac{1}{\theta}e^{-\theta r}$ gives:

$$\left(\frac{\beta}{\omega}\right) e^{-\theta \hat{r}_t} = E_t \left[e^{-\theta \hat{r}_{t+1}} (1 + \beta h) - \omega h e^{-\theta \hat{r}_{t+2}} \right] \quad (\text{A3})$$

The transformed condition encapsulates the Caballero (1990) model as a special case. The proof follows closely Caballero (1990). The first step in finding a feedback solution is to make a guess on the form of the stochastic process followed by \hat{r}_t . The functional form of this process is chosen by using the Euler equation. In this particular case with exponential utility we know from the existing literature that the best guess is to assume that the process \hat{r}_t is linear in levels:

$$\hat{r}_{t+j} = \phi_{t+j-1} \hat{r}_{t+j-1} + \Gamma_{t+j-1} + v_{t+j} \quad j = 0, 1, 2, \dots \quad (\text{A4})$$

where v_{t+j} , ϕ_{t+j-1} and Γ_{t+j-1} remain to be determined and where v_{t+j} is the shock to rents that results from the shock η_t in earnings.

Substituting the conjecture for \hat{r}_{t+1} and \hat{r}_{t+2} into (A3) gives:

$$\left(\frac{\beta}{\omega}\right) e^{-\theta \hat{r}_t} = e^{-\theta \phi_t \hat{r}_t} e^{-\theta \Gamma_t} (1 + \beta h) E_t \left[e^{-\theta v_{t+1}} \right] - \omega h E_t \left[e^{-\theta \Gamma_{t+1}} e^{-\theta v_{t+2}} e^{-\theta \phi_{t+1} (\phi_t \hat{r}_t + \Gamma_t + v_{t+1})} \right] \quad (\text{A5})$$

Rearranging gives:

$$\left(\frac{\beta}{\omega}\right) e^{-\theta \hat{r}_t (1 - \phi_t) + \theta \Gamma_t} = (1 + \beta h) E_t \left[e^{-\theta v_{t+1}} \right] - \omega h E_t \left[e^{-\theta [\Gamma_{t+1} + v_{t+2} + \phi_t \hat{r}_t (\phi_{t+1} - 1) + v_{t+1} \phi_{t+1} + \Gamma_t (\phi_{t+1} - 1)]} \right]$$

It must be the case that $\phi_t = \phi_{t+1} = 1$ as otherwise rents would be determined by the Euler equation regardless of the budget constraint. Therefore:

$$\begin{aligned} \left(\frac{\beta}{\omega}\right) e^{\theta \Gamma_t} &= (1 + \beta h) E_t \left[e^{-\theta v_{t+1}} \right] - \omega h E_t \left[e^{-\theta [\Gamma_{t+1} + v_{t+2} + v_{t+1}]} \right] \\ &= E_t \left[e^{-\theta v_{t+1}} \left\{ (1 + \beta h) - \omega h e^{-\theta (\Gamma_{t+1} + v_{t+2})} \right\} \right] \end{aligned} \quad (\text{A6})$$

Since the shocks η_{t+j} in earnings are i.i.d., we conjecture that the shocks in rents v_{t+j} are also i.i.d. and verify this conjecture below. Using a property of the moment generating function of the normal distribution, it follows that:

$$\begin{aligned} \left(\frac{\beta}{\omega}\right) e^{\theta \Gamma_t} &= \left[e^{-\theta E_t[v_{t+1}] + \frac{\theta^2}{2} \sigma_v^2} \left\{ (1 + \beta h) - \omega h e^{-\theta \Gamma_{t+1}} e^{-\theta E_t[v_{t+2}] + \frac{\theta^2}{2} \sigma_v^2} \right\} \right] \\ \left(\frac{\beta}{\omega}\right) e^{\theta [\Gamma_t + E_t[v_{t+1}] - \frac{\theta}{2} \sigma_v^2]} &= 1 + \beta h - \omega h e^{-\theta [\Gamma_{t+1} + E_t[v_{t+2}] - \frac{\theta}{2} \sigma_v^2]} \end{aligned} \quad (\text{A7})$$

For the equality to hold at all times, it must be the case that:

$$\Gamma_t - \frac{\theta}{2}\sigma_v^2 + E_t[v_{t+1}] = \Gamma_{t+1} - \frac{\theta}{2}\sigma_v^2 + E_t[v_{t+2}] \equiv g \quad (\text{A8})$$

The constant g can be found by solving for the positive root of the following quadratic equation:

$$\left(\frac{\beta}{\omega}\right) \left(e^{\theta g}\right)^2 - (1 + \beta h)e^{\theta g} + \omega h = 0 \quad (\text{A9})$$

Solving gives: $e^{\theta g} = \frac{\omega}{\beta}$ or $g = \frac{1}{\theta} \ln\left(\frac{\omega}{\beta}\right)$. Consequently:

$$\begin{aligned} \Gamma_t &= \frac{\theta}{2}\sigma_v^2 - E_t[v_{t+1}] + \frac{1}{\theta} \ln\left(\frac{\omega}{\beta}\right) \\ \Gamma_{t+1} &= \frac{\theta}{2}\sigma_v^2 - E_t[v_{t+2}] + \frac{1}{\theta} \ln\left(\frac{\omega}{\beta}\right) \end{aligned} \quad (\text{A10})$$

We now substitute the solution for \hat{r}_t into the Intertemporal Budget Constraint (IBC). To derive this intertemporal constraint first note that the budget constraint at times $t, t+1, t+2, \dots$ can be written as:

$$\begin{aligned} (1 + \gamma)r_t &= D_t - (1 + \rho)D_{t-1} + K^\phi \pi_t \\ (1 + \gamma)\beta r_{t+1} &= D_{t+1}\beta - D_t + \beta K^\phi \pi_{t+1} \\ (1 + \gamma)\beta^2 r_{t+2} &= D_{t+2}\beta^2 - \beta D_{t+1} + \beta^2 K^\phi \pi_{t+2} \\ (1 + \gamma)\beta^3 r_{t+3} &= \dots \end{aligned} \quad (\text{A11})$$

Summing the above budget conditions it must be the case that for any time interval T :

$$(1 + \gamma) \sum_{j=0}^T \beta^j r_{t+j} = \beta^T D_{t+T} + \sum_{j=0}^T \beta^j K^\phi \pi_{t+j} - (1 + \rho)D_{t-1} \quad (\text{A12})$$

Taking the limit as $T \rightarrow \infty$ and enforcing the no-Ponzi condition (6) gives the Intertemporal Budget Constraint (IBC):

$$(1 + \gamma) \sum_{j=0}^{\infty} \beta^j r_{t+j} = \sum_{j=0}^{\infty} \beta^j K^\phi \pi_{t+j} - (1 + \rho)D_{t-1} \quad (\text{A13})$$

Therefore,

$$\begin{aligned} h \sum_{j=0}^{\infty} (1 + \gamma)\beta^j r_{t+j-1} &= h \sum_{j=0}^{\infty} \beta^j K^\phi \pi_{t+j-1} - h(1 + \rho)D_{t-2} \\ &= h\beta \sum_{j=0}^{\infty} \beta^j K^\phi \pi_{t+j} - h(1 + \rho)D_{t-2} + hK^\phi \pi_{t-1} \end{aligned} \quad (\text{A14})$$

Using the definition of \hat{r}_{t+j} and the budget constraint $-K^\phi \pi_{t-1} + (1 + \rho)D_{t-2} = D_{t-1} - (1 + \gamma)r_{t-1}$ gives, after simplifying, the transformed IBC:

$$\sum_{j=0}^{\infty} (1 + \gamma)\beta^j \hat{r}_{t+j} = (1 - h\beta) \left[\sum_{j=0}^{\infty} \beta^j K^\phi \pi_{t+j} - (1 + \rho)D_{t-1} \right] - h(1 + \gamma)r_{t-1} \quad (\text{A15})$$

Since $\hat{r}_{t+1} = \hat{r}_t + \Gamma_t + v_{t+1}$, repeated substitution means that our conjectured solution for \hat{r}_{t+j} is $\hat{r}_{t+j} = \hat{r}_t + \sum_{i=1}^j (\Gamma_{t+i-1} + v_{t+i})$. Substituting \hat{r}_{t+j} into the IBC gives:

$$\begin{aligned} & \frac{(1+\gamma)\hat{r}_t}{(1-\beta)} + (1+\gamma) \sum_{j=1}^{\infty} \beta^j \sum_{i=1}^j (\Gamma_{t+i-1} + v_{t+i}) + h(1+\gamma)r_{t-1} \\ &= (1-h\beta) \left[\sum_{j=0}^{\infty} \beta^j K^\phi \pi_{t+j} - (1+\rho)D_{t-1} \right] \end{aligned} \quad (\text{A16})$$

Furthermore,

$$\begin{aligned} & \sum_{j=1}^{\infty} \beta^j \sum_{i=1}^j (\Gamma_{t+i-1} + v_{t+i}) \\ &= \beta(\Gamma_t + v_{t+1}) + \beta^2(\Gamma_t + v_{t+1} + \Gamma_{t+1} + v_{t+2}) + \dots \\ &= (\Gamma_t + v_{t+1})\beta(1 + \beta + \beta^2 + \beta^3 + \dots) + (\Gamma_{t+1} + v_{t+2})\beta^2(1 + \beta + \beta^2 + \beta^3 \dots) + \dots \\ &= \frac{1}{1-\beta} \sum_{j=1}^{\infty} \beta^j (v_{t+j} + \Gamma_{t+j-1}) \end{aligned} \quad (\text{A17})$$

Substituting (A17) into (A16) gives:

$$\frac{(1+\gamma)\hat{r}_t}{1-\beta} + \frac{(1+\gamma)}{1-\beta} \sum_{j=1}^{\infty} \beta^j (\Gamma_{t+j-1} + v_{t+j}) + h(1+\gamma)r_{t-1} = (1-h\beta) \left[\sum_{j=0}^{\infty} \beta^j K^\phi \pi_{t+j} - (1+\rho)D_{t-1} \right]$$

Taking expectations (on both sides of the equation) conditional on the information available at t , using our conjecture that the shocks v_{t+j} in rents are i.i.d. with zero mean, and solving for \hat{r}_t gives:

$$(1+\gamma)\hat{r}_t = \rho\beta(1-h\beta) \left[\sum_{j=0}^{\infty} \beta^j K^\phi E_t[\pi_{t+j}] - (1+\rho)D_{t-1} \right] - (1+\gamma)\rho\beta hr_{t-1} - (1+\gamma) \sum_{j=1}^{\infty} \beta^j \Gamma_{t+j-1}$$

where we used the fact that $1-\beta = \rho\beta$. Since $\hat{r}_t \equiv r_t - hr_{t-1}$, simplifying gives:

$$(1+\gamma)r_t = (1-h\beta)Y_t + h\beta r_{t-1}(1+\gamma) - (1+\gamma) \sum_{j=1}^{\infty} \beta^j \Gamma_{t+j-1}$$

where Y_t is permanent income as defined by equation (11). The stochastic sequence for v_{t+j} can be derived by substituting the solution for \hat{r}_t back into the (ex-post) IBC (A16). Using the assumption that $\pi_t = \mu\pi_{t-1} + \eta_t$, the IBC simplifies to the following condition:

$$\frac{1+\gamma}{1-\beta} \sum_{j=1}^{\infty} \beta^j v_{t+j} = \frac{(1-h\beta)}{(1-\beta\mu)} \sum_{j=1}^{\infty} \beta^j K^\phi \eta_{t+j} \quad (\text{A18})$$

Consequently, this pins down the stochastic sequence $\{v_{t+j}\}$ as a function of the earning shocks sequence $\{\eta_{t+j}\}$

$$v_{t+j} = \frac{K^\phi(1-\alpha)(1-\beta)(1-h\beta)\eta_{t+j}}{(1-\beta\mu)} \equiv \delta K^\phi \eta_{t+j} \quad (\text{A19})$$

One can verify our conjecture that the shocks v_{t+j} are indeed i.i.d. with zero mean because η_{t+j} are i.i.d. with zero mean. It follows that $\sigma_v = \delta K^\phi \sigma_\eta$. Since v_{t+j} are i.i.d. shocks with zero mean, it follows from (A10) that $\Gamma_t = \Gamma_{t+1} = \dots \equiv \Gamma$ and therefore:

$$\sum_{j=1}^{\infty} \beta^j \Gamma_{t+j-1} = \frac{\beta}{(1-\beta)} \left[\frac{\theta}{2} \sigma_v^2 + \frac{1}{\theta} \ln \left(\frac{\omega}{\beta} \right) \right] = \frac{\beta(1-\beta)(1-\alpha)^2(1-h\beta)^2 \theta}{(1-\beta\mu)^2} \frac{\theta}{2} K^{2\phi} \sigma_\eta^2 + \frac{\beta}{1-\beta} \frac{1}{\theta} \ln \left(\frac{\omega}{\beta} \right)$$

Substituting into the solution for r_t gives:

$$r_t = (1-h\beta) \frac{Y_t}{1+\gamma} + h\beta r_{t-1} - \frac{(1-\alpha)^2 \beta (1-\beta) (1-h\beta)^2 \theta}{(1-\beta\mu)^2} \frac{\theta}{2} K^{2\phi} \sigma_\eta^2 + \left(\frac{\beta}{(1-\beta)\theta} \right) \ln \left(\frac{\beta}{\omega} \right)$$

Proof of Property 1:

$$Y_{t+1} = \rho \left[\beta \sum_{j=0}^{\infty} E_{t+1} [\pi_{t+1+j}] K^\phi \beta^j - D_t \right] \quad (\text{A20})$$

$$= \rho \left[\sum_{j=1}^{\infty} K^\phi E_{t+1} [\pi_{t+j}] \beta^j - D_{t-1} (1+\rho) - (1+\gamma)r_t + K^\phi \pi_t \right] \quad (\text{A21})$$

$$E_t [Y_{t+1}] = \rho \left[\sum_{j=0}^{\infty} K^\phi E_t [\pi_{t+j}] \beta^j - \frac{D_{t-1}}{\beta} \right] - \rho(1+\gamma)r_t \quad (\text{A22})$$

$$= \frac{\rho}{\beta} \left[\beta \sum_{j=0}^{\infty} K^\phi E_t [\pi_{t+j}] \beta^j - D_{t-1} \right] - \rho(1+\gamma)r_t \quad (\text{A23})$$

$$= Y_t(1+\rho) - \rho(1+\gamma)r_t \quad (\text{A24})$$

Proof of Proposition 4: The proof will require the evaluation of the following integral:

$$I \equiv \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{+\infty} x e^{tx} e^{-\frac{1}{2} \frac{(x-\mu)^2}{\sigma^2}} dx \quad (\text{A25})$$

$$= e^{\left(\mu t + \frac{\sigma^2 t^2}{2}\right)} \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{+\infty} x e^{-\frac{1}{2} \frac{(x-\mu-t\sigma^2)^2}{\sigma^2}} dx \quad (\text{A26})$$

$$= e^{\left(\mu t + \frac{\sigma^2 t^2}{2}\right)} (\mu + t\sigma^2) \quad (\text{A27})$$

The first equality is obtained by completing the square. The final step follows from the fact that the second integral calculates the expected value of a normally distributed value with mean $\mu + t\sigma^2$.

The proof requires us to solve the following first order condition (see Eq. (32)):

$$\sum_{j=0}^{\infty} \omega^j E_t \left[u'(\hat{r}_{t+j}) \frac{\partial \hat{r}_{t+j}}{\partial K} \right] = 0 \quad (\text{A28})$$

We know from the proof to proposition 2 that:

$$\hat{r}_{t+j} = \hat{r}_t + j \left[\frac{\theta}{2} \sigma_v^2 + \frac{1}{\theta} \ln\left(\frac{\omega}{\beta}\right) \right] + \sum_{i=1}^j v_{t+i} \quad (\text{A29})$$

$$= \hat{r}_t + j \frac{\theta}{2} \delta^2 K^{2\phi} \sigma_\eta^2 - \frac{j}{\theta} \ln\left(\frac{\beta}{\omega}\right) + \delta K^\phi \sum_{i=1}^j \eta_{t+i} \quad (\text{A30})$$

where $\delta \equiv \frac{(1-\alpha)(1-\beta)(1-h\beta)}{(1-\beta\mu)}$. It follows that:

$$\frac{\partial \hat{r}_{t+j}}{\partial K} = \frac{\partial \hat{r}_t}{\partial K} + j \theta \delta^2 K^{2\phi-1} \phi \sigma_\eta^2 + \phi \delta K^{\phi-1} \sum_{i=1}^j \eta_{t+i} \quad (\text{A31})$$

Before we substitute this into the first order condition note the following results:

$$E_t \left[e^{-\theta \delta K^\phi \sum_{i=1}^j \eta_{t+i}} \right] = e^{\frac{j}{2} \theta^2 \delta^2 K^{2\phi} \sigma_\eta^2} \quad (\text{A32})$$

$$E_t \left[\eta_{t+j} e^{-\theta \delta K^\phi \sum_{i=1}^j \eta_{t+i}} \right] = -\theta \delta K^\phi \sigma_\eta^2 e^{\frac{j}{2} \theta^2 \delta^2 K^{2\phi} \sigma_\eta^2} \quad (\text{A33})$$

where the second result is a special case of the above integral I (for $\mu = 0$, $\sigma = \sigma_\eta$ and $t = -\theta \delta K^\phi$).

We can now calculate:

$$\begin{aligned} & E_t \left[\sum_{i=1}^j \eta_{t+i} e^{-\theta \delta K^\phi \sum_{i=1}^j \eta_{t+i}} \right] \\ &= E_t \left[\eta_{t+1} e^{-\theta \delta K^\phi \eta_{t+1}} \right] e^{\frac{1}{2} \theta^2 \delta^2 K^{2\phi} \sigma_\eta^2 (j-1)} + E_t \left[\eta_{t+2} e^{-\theta \delta K^\phi \eta_{t+2}} \right] e^{\frac{1}{2} \theta^2 \delta^2 K^{2\phi} \sigma_\eta^2 (j-1)} \\ &\quad + \dots + E_t \left[\eta_{t+j} e^{-\theta \delta K^\phi \eta_{t+j}} \right] e^{\frac{1}{2} \theta^2 \delta^2 K^{2\phi} \sigma_\eta^2 (j-1)} \\ &= -\theta \delta K^\phi \sigma_\eta^2 e^{\frac{1}{2} \theta^2 \delta^2 K^{2\phi} \sigma_\eta^2} j e^{\frac{1}{2} \theta^2 \delta^2 K^{2\phi} \sigma_\eta^2 (j-1)} \\ &= -j \theta \delta K^\phi \sigma_\eta^2 e^{\frac{1}{2} j \theta^2 \delta^2 K^{2\phi} \sigma_\eta^2} \end{aligned} \quad (\text{A34})$$

where we make use of the fact that η_{t+i} are i.i.d. shocks. Define now the following auxiliary variables:

$$a_t \equiv \hat{r}_t + \frac{j}{2} \theta \delta^2 K^{2\phi} \sigma_\eta^2 - \frac{j}{\theta} \ln\left(\frac{\beta}{\omega}\right) \quad (\text{A35})$$

$$b_t \equiv \frac{\partial \hat{r}_t}{\partial K} + j \phi \theta \delta^2 K^{2\phi-1} \sigma_\eta^2 \quad (\text{A36})$$

Using these results allows us to calculate:

$$\begin{aligned} E_t \left[u'(\hat{r}_{t+j}) \frac{\partial \hat{r}_{t+j}}{\partial K} \right] &= E_t \left[e^{-\theta(a_t + \delta K^\phi \sum_{i=1}^j \eta_{t+i})} \left(b_t + \phi \delta K^{\phi-1} \sum_{i=1}^j \eta_{t+i} \right) \right] \\ &= e^{-\theta a_t} e^{\frac{1}{2} j \theta^2 \delta^2 K^{2\phi} \sigma_\eta^2} \left[b_t - j \phi \theta \delta^2 K^{2\phi-1} \sigma_\eta^2 \right] \\ &= e^{-\theta a_t} e^{\frac{1}{2} j \theta^2 \delta^2 K^{2\phi} \sigma_\eta^2} \frac{\partial \hat{r}_t}{\partial K} \\ &= e^{-\theta \hat{r}_t} \left(\frac{\beta}{\omega} \right)^j \frac{\partial \hat{r}_t}{\partial K} \end{aligned} \quad (\text{A37})$$

Substituting this into the first order condition gives:

$$\begin{aligned} \sum_{j=0}^{\infty} \omega^j E_t \left[u'(\hat{r}_{t+j}) \frac{\partial \hat{r}_{t+j}}{\partial K} \right] &= e^{-\theta \hat{r}_t} \frac{\partial \hat{r}_t}{\partial K} \left(1 + \omega \left(\frac{\beta}{\omega} \right) + \omega^2 \left(\frac{\beta}{\omega} \right)^2 + \dots \right) \\ &= \frac{e^{-\theta \hat{r}_t} \frac{\partial \hat{r}_t}{\partial K}}{1 - \beta} = 0 \iff \frac{\partial \hat{r}_t}{\partial K} = 0 \end{aligned} \quad (\text{A38})$$

We know from the proof of proposition 2 that:

$$\hat{r}_t = (1 - \alpha)(1 - h\beta)Y_t[K] - h\rho\beta r_{t-1} - \frac{\theta\sigma_\eta^2\delta^2 K^{2\phi}}{2\rho} + \frac{1}{\rho\theta} \ln\left(\frac{\beta}{\omega}\right) \quad (\text{A39})$$

Using equation (30) and differentiating \hat{r}_t with respect to K gives:

$$\frac{\partial \hat{r}_t}{\partial K} = \rho\beta(1 - \beta h) \left[\frac{\phi K^{\phi-1} \beta \mu \pi_t}{1 - \beta \mu} - 1 \right] - \frac{\phi}{\rho} \theta \sigma_\eta^2 \delta^2 K^{2\phi-1} = 0 \quad (\text{A40})$$

which gives the condition in proposition 4.

Proof of Proposition 5: Using the definition of permanent income it follows:

$$Y_t - Y_{t-1} = \rho\beta \sum_{j=0}^{\infty} \beta^j K^\phi [E_t(\pi_{t+j}) - E_{t-1}(\pi_{t+j-1})] - \rho(D_{t-1} - D_{t-2})$$

The budget constraint requires that $D_{t-1} - D_{t-2} = \rho D_{t-2} + (1 + \gamma)r_{t-1} - K^\phi \pi_{t-1}$. Substituting into the above expression gives:

$$\begin{aligned} Y_t - Y_{t-1} &= \rho\beta \sum_{j=0}^{\infty} \beta^j K^\phi [E_t(\pi_{t+j}) - E_{t-1}(\pi_{t+j})] + \rho\beta \sum_{j=0}^{\infty} \beta^j K^\phi E_{t-1}(\pi_{t+j}) \\ &\quad - \rho\beta \sum_{j=0}^{\infty} \beta^j K^\phi E_{t-1}(\pi_{t+j-1}) - \rho \left[\rho D_{t-2} + (1 + \gamma)r_{t-1} - K^\phi \pi_{t-1} \right] \\ &= \nu_t + \rho\beta \sum_{j=0}^{\infty} \beta^j K^\phi E_{t-1}(\pi_{t+j}) - \rho\beta \sum_{j=0}^{\infty} \beta^j K^\phi E_{t-1}(\pi_{t+j-1}) \\ &\quad - \rho \left[\rho D_{t-2} + (1 + \gamma)r_{t-1} - K^\phi \pi_{t-1} \right] \\ &= \nu_t - \rho \left[\rho\beta \sum_{j=0}^{\infty} \beta^j K^\phi E_{t-1}(\pi_{t+j-1}) - Y_{t-1} + (1 + \gamma)r_{t-1} - K^\phi \pi_{t-1} \right] \\ &\quad + \rho\beta \sum_{j=0}^{\infty} \beta^j K^\phi E_{t-1}(\pi_{t+j}) - \rho\beta \sum_{j=0}^{\infty} \beta^j K^\phi E_{t-1}(\pi_{t+j-1}) \\ &= \nu_t - (1 + \rho)\rho\beta \sum_{j=0}^{\infty} \beta^j K^\phi E_{t-1}(\pi_{t+j-1}) + \rho\beta \sum_{j=0}^{\infty} \beta^j K^\phi E_{t-1}(\pi_{t+j}) \\ &\quad + \rho \left[Y_{t-1} - (1 + \gamma)r_{t-1} + K^\phi \pi_{t-1} \right] \end{aligned} \quad (\text{A41})$$

where $\nu_t \equiv \rho\beta \sum_{j=0}^{\infty} \beta^j K^\phi [E_t(\pi_{t+j}) - E_{t-1}(\pi_{t+j})]$. Using the fact that $\beta \sum_{j=0}^{\infty} \beta^j K^\phi E_{t-1}(\pi_{t+j}) - \beta(1+\rho) \sum_{j=0}^{\infty} \beta^j K^\phi E_{t-1}(\pi_{t+j-1}) = -K^\phi \pi_{t-1}$, it follows that:

$$Y_t - Y_{t-1} = \nu_t - K^\phi \rho \pi_{t-1} + \rho Y_{t-1} - \rho(1+\gamma)r_{t-1} + K^\phi \rho \pi_{t-1} \quad (\text{A42})$$

$$= \nu_t + \rho Y_{t-1} - \rho(1+\gamma)r_{t-1} \quad (\text{A43})$$

Finally, from $\pi_t = \mu\pi_{t-1} + \eta_t$, it follows that $E_t(\pi_{t+j}) - E_{t-1}(\pi_{t+j}) = \mu^j \eta_t$. Consequently, $\nu_t = \frac{\rho\beta K^\phi \eta_t}{1-\beta\mu}$.

Using Eq. (9) one can write Y_{t-1} as a function of r_{t-1} and substitute for Y_{t-1} into equation (A43), which gives ΔY_t as a function of r_{t-1} and r_{t-2} . Substitute the resulting expression for ΔY_t into

$$\Delta r_t = \beta h \Delta r_{t-1} + (1 - \beta h) \Delta Y_t \quad (\text{A44})$$

This gives Δr_t as a function of the exogenous variables r_{t-1} and r_{t-2} only, which is the expression for Δr_t in the proposition. We obtain Δd_t as a function of the exogenous variables d_{t-1} and d_{t-2} in a similar fashion. The expressions for $\text{var}(\Delta d_t)$ and $\text{var}(\Delta r_t)$ can be derived using the previous result that $\nu_t = \frac{\rho\beta K^\phi \eta_t}{1-\beta\mu}$.

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