DISCUSSION PAPER SERIES

DP16199

Do capital structure models square with the dynamics of payout?

Shiqi Chen and Bart Lambrecht

FINANCIAL ECONOMICS

ISSN 0265-8003

Do capital structure models square with the dynamics of payout?

Shiqi Chen and Bart Lambrecht

Discussion Paper DP16199
Published 28 May 2021
Submitted 26 May 2021

Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
www.cepr.org

Do capital structure models square with the dynamics of payout?

Abstract

We explore whether theoretically the target leverage and pecking order models can be reconciled with payout smoothing. Investment absorbs a significant part of income and asset volatility if the firm follows both a payout target and a net debt ratio (NDR) target. A positive (negative) NDR amplifies (dampens) shocks in assets. Slow adjustment towards the NDR target facilitates payout smoothing. Under strict pecking order financing, income shocks are absorbed primarily by changes in net debt. More payout smoothing implies a stronger negative relation between debt and net income. Shocks to assets in place need not affect current payout.

JEL Classification: G35, G32, G11

Keywords: payout smoothing, Capital Structure, pecking order model, leverage target

Shiqi Chen - sc884@cam.ac.uk
University of Cambridge

Bart Lambrecht - b.lambrecht@jbs.cam.ac.uk
University of Cambridge and CEPR

Acknowledgements
The authors gratefully acknowledge financial support from the Cambridge Endowment for Research in Finance (CERF). Comments can be sent to Shiqi Chen (sc884@jbs.cam.ac.uk) or Bart Lambrecht (b.lambrecht@jbs.cam.ac.uk).

Do capital structure models square with the dynamics of payout?*

Shiqi Chen

Cambridge Judge Business School

Bart M. Lambrecht

Cambridge Judge Business School and CEPR

May 26, 2021

Abstract

We explore whether theoretically the target leverage and pecking order models can be reconciled with payout smoothing. Investment absorbs a significant part of income and asset volatility if the firm follows both a payout target and a net debt ratio (NDR) target. A positive (negative) NDR amplifies (dampens) shocks in assets. Slow adjustment towards the NDR target facilitates payout smoothing. Under strict pecking order financing, income shocks are absorbed primarily by changes in net debt. More payout smoothing implies a stronger negative relation between debt and net income. Shocks to assets in place need not affect current payout.

Keywords: payout smoothing, capital structure, pecking order model, leverage target, investment (G35, G32, G11)

*The authors gratefully acknowledge financial support from the Cambridge Endowment for Research in Finance (CERF). Comments can be sent to Shiqi Chen (sc884@jbs.cam.ac.uk) or Bart Lambrecht (b.lambrecht@jbs.cam.ac.uk).

1 Introduction

Traditionally, the finance literature has studied the firm's three main financial policies in isolation. There are separate literatures on payout policy, capital structure and investment policy. Each literature puts forward different theories or paradigms to explain corporate policies based on key frictions such as asymmetric information (signalling models), taxes, and agency conflicts.[1] However, in reality these three key corporate decisions are not independent as they are linked by the firm's sources and uses of funds constraint.[2] This reduces the degrees of freedom in the decision-making process. Furthermore, if the firm adheres to a leverage target, the firm's financing (liabilities) and investment (assets) policies are even more intertwined. This raises, for instance, the question whether a leverage target policy or pecking order policy can be consistent with the longstanding empirical evidence of dividend smoothing (Lintner 1956), or payout smoothing more generally (Skinner 2008). Furthermore, what are the implications for investment policy if a firm follows both a leverage target and a payout target?

Traditional theoretical models do not address these questions because they derive optimal corporate policies for a very specific set of assumptions that often lead to very stylized policies. For example, the optimal payout policy at any moment in time may be either to pay out all earnings after interest or either to reinvest everything into the firm. Optimal policies may not be robust to minor changes in the assumptions. Moreover, it

[1] The trade-off theory of capital structure goes back to papers by Robichek & Myers (1966) and Kraus & Litzenberger (1973). Myers & Majluf (1984) develop a pecking order theory of capital structure based on asymmetric information, whereas Jensen & Meckling (1976) and Myers (1977) are early papers outlining the role of agency issues. Seminal dividend signalling models include Bhattacharya (1979), Miller & Rock (1985), and John & Williams (1985). Ambarish, John & Willams (1987) model efficient signalling with dividends and stock issues. Brennan (1970) considers the role of personal taxes for dividend policy. The classic behaviorial model for dividend smoothing is Lintner (1956). Seminal papers by Brennan & Schwartz (1985) and McDonald & Siegel (1986) started off a large literature on optimal investment decisions under uncertainty.

[2] Early models studying the interaction between corporate decisions include Dotan & Ravid (1985), John & Nachman (1985) and Williams (1988). Dotan & Ravid (1985) study the interaction between investment and financing decisions under complete information, whereas John & Nachman (1985) model the joint decision of risky debt financing and investment in a dynamic sequential game under asymmetric information. Williams (1988) models the efficient mix of dividends, investments and stock repurchases under asymmetric information.

is hard to disentangle the interaction between the firm's corporate policies and to bring the models to the data.

This paper revisits the features and implications of existing capital structure and payout models by following a very different approach. We do not derive the firm's optimal policies, but instead take the selected financing or payout policy as exogenously given and explore the implications for the firm's remaining policies. No other assumptions are required as the results follow directly from the firm's sources and uses of funds constraint and the balance sheet identity for assets and liabilities. Our approach enables us to explore the dynamics across the firm's policies and to check, for example, whether Lintner style payout smoothing can be reconciled with a net debt ratio (NDR) target. From the resulting dynamics and behavior, we are also able to eliminate certain types of policies (e.g. a very negative NDR target) because they imply empirically implausible behavior. Although our framework is simple, it generates rich empirical predictions, which can be brought to the data to identify what kind of financial policies can be reconciled with each other.[3]

We believe that the above exercise is worthwhile and overdue. Farre-Mensa, Michaely & Schmalz (2014) provide a comprehensive review of the empirical payout literature over the past three decades, and in their conclusion state: "Moving away from mechanisms and looking at the bigger picture, we observe that, until recently, most of the academic literature has analysed payout policy in isolation... one promising area of future research is to further analyse the interaction of payouts with other corporate financing decisions. Although others, including Allen & Michaely (2003) and DeAngelo, DeAngelo & Skinner (2008), have pointed out before the need to fill the gap between the financing and payout literatures, little work has been done to that end." Lambrecht & Myers (2016) conclude their paper on managerial agency dynamics stating: "No doubt there are ways to make our models more realistic... But we think these complications should wait until we or others achieve a more complete understanding of agency dynamics and of how rational, self-interested managers make the joint decision about CAPEX, debt, and payout in a world without frictions or imperfections."

[3]As pointed out by Strebulaev & Whited (2012): "there is a sharp trade-off between the feasibility of taking a model directly to the data and the stringency of the assumptions regarding financial contracts".

We now briefly sketch our research strategy and state a few key results. The starting point is that corporate policies cannot be chosen independently because the firm's budget constraint requires sources of funds to equal uses of funds. The budget constraint therefore eliminates one degree of freedom. If the firm commits to follow a NDR target, L, then this eliminates a second degree of freedom. If, for example, the firm invests then a target NDR policy requires that the change in debt equals L times the change in risky assets due to investment (i.e. $\Delta D_t = L\Delta A_t$). Payout then follows from the sources and uses of funds constraint. Analogously, if the firm sets a payout target then investment and changes in net debt follow from the budget constraint and the NDR target constraint. Firms following an NDR target therefore only have one degree of freedom left.

This paper does not explain why firms adopt a NDR target. We take this as given and refer to existing theory papers that generate an optimal NDR target policy (see e.g. Lambrecht & Myers 2017). Instead, we analyze the implications for the dynamics of debt, investment and payout if a firm adopts an NDR target.

A NDR target means that exogenous shocks to the value of the firm's risky assets are transmitted to the debt and equity in the proportions L and $1 - L$, respectively. If the NDR is positive (negative) then the outstanding amount of net debt goes up (down) in response to a positive shock to assets. Let us first assume that payout is given. We show that a positive (negative) NDR amplifies (dampens) the effect of economic shocks to risky assets in place and net income. Rebalancing towards a positive NDR target requires firms with a positive NDR to invest (disinvest) after a positive (negative) shock to risky assets. Similarly, shocks to net income feed into cashholdings, and therefore net debt. Positive gearing then amplifies the effect on assets and leads to investment (disinvestment) after a positive (negative) income shock. Conversely, firms with a negative NDR target disinvest (invest) after a positive (negative) shock to risky assets in place or net income. This dampens the effect of income and asset volatility on the firm's balance sheet. A positive NDR implies a pro-cyclical investment policy, whereas a negative NDR leads to a counter-cyclical investment policy. The latter is arguably empirically less plausible, generating the empirical hypothesis that firms are unlikely to adopt a very negative NDR target.

Let us next assume that investment policy is switched off (i.e. the firm cannot buy or sell risky assets). Although shocks to the value of assets in place do not generate actual cash-flows, they require the firm to rebalance the amount of net debt which, for a given investment policy, alters payout. A firm with a positive NDR target experiencing a positive (negative) shock to assets in place becomes underlevered (overlevered), and rebalances by issuing more (paying down) debt. The proceeds of a debt issue are paid out, whereas equity is raised to pay down debt. Positive (negative) shocks to assets in place are therefore absorbed by a payout (equity issue). Conversely, firms with a negative NDR may have to issue equity after a positive shock to assets in place, and pay out cash after a negative shock, generating a counter-cyclical payout policy. Furthermore, it implies that firms with ample cashholdings issue more equity, even though they could easily afford to finance the new investment with retained earnings. Equity issues of this nature appear empirically rather implausible. Although we observe firms with a very high NDR target (e.g. banks), we hypothesize that firms with a very negative NDR target are rare.

There is strong empirical (going back to Lintner (1956) and more recently Skinner (2008)) and anecdotal evidence that firms engage in payout smoothing and are extremely reluctant to cut dividends.[4] The sources and uses of funds constraint implies that payout volatility is driven by variation in net income, debt and investment. Fluctuations in income and investment to some extent wash out if both are positively correlated and the NDR is positive. Any remaining volatility has to be absorbed by net debt to keep payout smooth. But, as previously explained, it is harder to smooth out shocks to assets in place if the NDR target is extremely negative. Payout smoothing and no (or rare) reliance on equity issues are, however, possible for firms with a moderately negative NDR, especially

[4] In 2020 Royal Dutch Shell and British Petroleum cut their dividend for the first time since World War Two and the 2010 deadly Deepwater Horizon rig explosion, respectively. Unlike its rivals, Exxon raised its dividend in 2020 for the 37th straight year. Chevron's CEO Michael Wirth said on CNBC's Squawk Box on 03/24/2020: "The dividend is our number one priority and it is very secure... We're taking actions to preserve cash. It will have some impact on production in the near term, but we've stayed with our financial priorities, which include protecting the dividend." Exxon, Shell and BP were among those companies that tapped the bond market in March 2020 to preserve shareholder payouts, while slashing CAPEX and suspending share buyback programmes. Janus Henderson's Global Dividend Index for May 2020 notes that 79 per cent of US payouts should be safe in 2020, although companies may carry out fewer share buybacks as they move through the coronavirus crisis. In Europe, banks and leisure companies were among the worst hit by the 2020 dividend drought. Regulators imposed dividend restrictions on the former, whereas the latter were subject to government restrictions because of bailouts or indirect state aid (such as furloughs).

if the firm adopts a book (rather than market) leverage target because in that case changes in the market value of the firm's risky assets need not lead to changes in debt. Payout smoothing can further be enhanced if the firm adopts an investment policy that is strongly positively correlated with net income (i.e. a pro-cyclical investment policy).

Next, we explore whether a NDR target is compatible with the empirically observed Lintner-style payout smoothing. If the firm follows both a NDR target and a Lintner payout target then investment is pinned down as the residual policy. This means that investment becomes a shock absorber and temporary store of value that enables payout smoothing. We show that positive shocks in income have a large positive instantaneous effect on investment, but a negative lagged effect in subsequent periods through possible disinvestment. This predicted behavior is hard to square with empirical evidence. Dasgupta, Noe & Wang (2011) find that the shocks in net income gradually and partially feed into investment over time with net debt acting as a shock absorber and smoothing device. Gatchev, Pulvino & Tarham (2010) find that for every dollar of cash-flow, firms change debt by \$0.85, but increase capital expenditure by a statistically insignificant \$0.04. We conclude that Lintner-style payout smoothing is hard to square with strict adherence to an NDR target.

We know that if firms fully and instantaneously adjust towards the NDR target then changes in debt are determined by contemporaneous changes in asset values. What happens if firms partially and gradually adjust towards a leverage target, as has been observed empirically (see e.g. Flannery & Rangan 2006)? Partial adjustment towards a debt target (or "debt smoothing") implies that past changes in asset values also have an effect on current changes in debt. Since changes in net debt are a key source of payout funding, payout is now affected by current and lagged changes in asset values. This induces payout smoothing provided that adjustment in debt levels is not too slow (in the extreme case where the debt level does not respond to shocks and remains fixed at its original level, payout becomes the residual variable and shock absorber). We show that the degree of payout smoothing is an inverted U-shaped function of the degree of debt smoothing. A fairly slow speed of adjustment in debt levels generates the maximum amount of payout smoothing. We show that maximum payout smoothing is achieved for debt related partial adjustment coefficients between zero and one half. A low predicted speed of adjustment is consistent with empirical evidence (see Fama & French 2002, Flannery & Rangan 2006).

Next, we explore the link between debt and payout policy under the strict pecking order model of capital structure. The strict pecking order model predicts that changes in net debt are equal to the firm's total net deficit (see e.g. Shyam-Sunder & Myers 1999). Increases in net debt make up for any deficit between the firm's outgoings -i.e. dividends plus CAPEX- and its net income. Surpluses are used to pay down net debt. The pecking order model does not impose a link between the firm's assets and liabilities, and shocks in the firm's asset value do not affect changes in net debt. The strict pecking order model allows payout and investment to be freely determined, except that payout should be positive (i.e. no equity issues). Firms following the strict pecking order model can easily accommodate payout smoothing, provided they have not reached their debt capacity. Under perfect smoothing (i.e. payout remains at a constant fixed level), shocks in net income are entirely absorbed by increases in net debt, creating a strong negative relation between net income and changes in net debt. As the degree of payout smoothing decreases (i.e. payout adjusts more quickly to income shocks), the negative relation between net income and debt weakens because debt plays less of a role in absorbing income shocks. Changes in debt increase with the level of investment, but are not influenced by the NPV of the investment (unlike a debt policy that adopts a market NDR target). Instead, the NPV of the investment affects changes in the firm's net worth.

2 Related Literature

Our paper is related to a strand of theory papers that model the dynamics of corporate financial decisions. In the interest of space, we only cite a few representative papers, and refer to Strebulaev & Whited (2012) and Sannikov (2013) for more comprehensive reviews. The vast majority of existing models focuses on the dynamic interaction between investment and borrowing. Payout is the residual policy and, at any moment in time, typically has "all or nothing" features (i.e. either all or no net income is paid out).

This literature includes papers that examine the interdependency of the two decisions from different perspectives such as taxes (e.g. Morellec & Schürhoff 2010), bankruptcy (e.g. Antill & Grenadier 2019), asymmetric information (e.g. Morellec & Schürhoff 2011, Strebulaev, Zhu & Zryomov 2016), agency conflicts (see Mello & Parsons 1992, Childs, Mauer & Ott 2005, Sundaresan & Wang 2007, Hackbarth & Mauer 2012), and debt choices (e.g. Morellec, Valta & Zhdanov 2015, Hackbarth, Hennessy & Leland 2007). In these papers, investment is modelled in a real-option setting, and firms have to determine the debt-equity mix before exercising the option. Frictions in the spirit of the trade-off theory of capital structure determine the financing and investment exercise strategy. However, these real option models are less suitable to study the joint dynamics of investment and capital structure if investment and financing are one-time decisions.[5]

Dynamic models that examine all three decisions are comparatively limited, and include Hennessy & Whited (2005, 2007), Gamba & Triantis (2008), DeAngelo, DeAngelo & Whited (2011), Gryglewicz (2011), Bolton, Chen & Wang (2011, 2013), Décamps et al. (2016), Bolton, Wang & Yang (2019), among others. In these models, investment is endogenously determined at par with the financing decisions. Firms can finance investment not only from debt and equity but also from cash holding and payout cuts. By focusing on different factors such as taxes, agency issues, financial constraints and cash holdings, they reach different conclusions about the capital structure dynamics and the interactions between financial policies. For example, Hennessy & Whited (2005) show that there is no target leverage ratio and leverage is path-dependent. DeAngelo et al. (2011) demonstrate that firms do have a leverage target, which is determined by trading off the tax benefits against the opportunity cost of borrowing now. Taking on more debt now reduces the debt capacity available for future investment.

In many of these models, firms initiate payout only when the corresponding state variable exceeds a certain threshold, above which the cost of carrying extra cash is too expensive. This means payouts can be very volatile as firms switch from one regime to another. For example, Décamps et al. (2016) show that it is optimal for firms to start

[5] Some papers try to study the joint dynamics of financing and investment decisions within a real-option framework. See Mauer & Triantis (1994), Chen, Miao & Wang (2010), Campello & Hackbarth (2012) and others.

distributing to shareholders when the scaled cashflows (cash reserves scaled by firms' profitability) reach a certain level in the presence of both permanent and transitory shocks. In Bolton et al. (2011), because of costly external financing, firms only initiate payout when the cash-capital ratio is high enough, and the access to a credit line reduces the payout boundary significantly. Bolton et al. (2019) show that the payout region is two-dimensional depending not only on the earning fundamental but also on the firm's liquidity. Although these papers help to explain why and whether firms pay out (i.e. cross-sectional payout differences), they are less realistic with respect to the time-series properties of payout.

A few papers focus on the dynamics of payout or dividend smoothing. Kumar (1988) derives a coarse signaling equilibrium in which a firm's dividends are more stable than its performance and prospects. Guttman, Kadan & Kandel (2010) derive an equilibrium in a Miller & Rock (1985) setup in which dividends are constant over a range of earnings. Acharya & Lambrecht (2015) develop a theory of income and payout smoothing when (risk-neutral) insiders know more than outsiders. Insiders set payout to meet outsiders' expectations. Outsiders learn from noisy signals about the firm's fundamentals, and gradually and partially adjust their payout expectations in response. In equilibrium, this induces insiders' to adopt a Lintner-style payout policy for which asymmetric information increases payout smoothing. DeMarzo & Sannikov (2017) study a principal-agent setting in which dividend smoothing occurs because earnings surprises are used to adjust financial slack in line with profitability. Lambrecht & Myers (2012) assume that inside equityholders are risk-averse and subject to habit formation. They show that payout is smoothed because rents are smoothed: the governance constraint forces payout to follow rents. The optimal payout policy matches the Lintner (1956) model. Changes in debt soak up transitory income shocks and accommodate the gradual adjustment of rents and payout to changes in permanent income. Lambrecht & Myers (2017) show that risk-averse managers with power utility (CRRA) follow a constant NDR target in order to maximize their life-time utility of payouts ("managerial rents").[6] On the other hand, managers with exponential utility (CARA) fix the firm's asset level, and any earnings generated

[6]Chen & Lambrecht (2020) show that the NDR target is time-varying if decisions are made by a group of insiders with heterogeneous risk preferences.

are used as payout or to reduce net debt (i.e. there is no net reinvestment). As a result, profitable firms pay down net debt and become unlevered (or end up having a surplus of cash compared to debt liabilities), whereas loss making firms become highly geared and may ultimately go bankrupt.

There are separate strands of empirical literature on payout and capital structure. A full review is not possible here. We refer to Allen & Michaely (2003), Kalay & Lemmon (2008), DeAngelo, DeAngelo & Skinner (2008), and Farre-Mensa, Michaely & Schmalz (2014) for comprehensive reviews of the empirical literature on payout policy. For a survey of empirical research in capital structure, we refer to Parsons & Titman (2009), Graham & Leary (2011), and Sundaresan (2013).

Empirical capital structure research has a long-standing tradition of comparing the two dominant theories: the trade-off theory and the pecking order theory. However, the results are mixed and still far from consensus. Graham & Harvey (2001), Hovakimian, Opler & Titman (2001), Leary & Roberts (2005), Flannery & Rangan (2006), Huang & Ritter (2009), Öztekin & Flannery (2012), Faulkender et al. (2012), among others confirm that firms actively manage their capital structure by partially and gradually adjusting towards a leverage target. However, the speed with which these targets are reached is surprisingly slow.[7]

Shyam-Sunder & Myers (1999) discover strong support for pecking order theory on a sample that consists of 157 firms trading during 1971 - 1989. Less supportive evidence is found by Frank & Goyal (2003) who test the pecking order theory on a broader sample over the period 1971 - 1998.

Fama & French (2002) test the predictions about dividends and debt implied by the two theories. They conclude that there is "one scar on the trade-off model (the negative relation between leverage and profitability)", and "one deep wound on pecking order (the large equity issues of small low-leverage growth firms)". Lemmon & Zender (2010), who

[7]The estimates of the speed of adjustment range from 7% per year (Fama & French 2002) to 34% per year (Flannery & Rangan 2006), depending on estimation specifications. However, Chang & Dasgupta (2004) show that leverage targeting behavior also manifests in a simulated sample that is independent of the firm's current debt ratio and target. They suggest that the existing tests of target behavior based on leverage ratio changes can be inconclusive.

are the first to control for the firms' debt capacity, find empirical evidence in support of the pecking order theory. In particular, they find that firms with low debt capacity initially finance small amounts of their deficit with debt and the rest is covered with equity, whilst firms with high debt capacity initially finance larger amounts of their deficit with debt and the rest is covered with equity. Therefore, the frequent use of equity issues by small, high-growth firms can be attributed to their high growth options value and restricted debt capacity.

Finally, our paper is also related to a recent strand of empirical literature that examines the three financial policies simultaneously (see Sarig 2004, Gatchev et al. 2010, Dasgupta et al. 2011, Chang et al. 2014, Lewellen & Lewellen 2016, Hoang & Hoxha 2016, among others). Gatchev et al. (2010) find that financing-cashflow sensitivities dominate investment-cashflow sensitivities, revealing that firms absorb cashflow fluctations primarily by altering net debt, not by changing real assets. This is consistent with the pecking order model, but inconsistent with the trade-off theory. Dasgupta et al. (2011) study the intertemporal pattern of the use of cash flow. Consistent with Gatchev et al. (2010) the majority of a dollar goes to increases in cash saving and reductions in debt holding, suggesting there is a pecking order in the use of funds.[8] More importantly, they find that a dollar cash inflow today can affect investment over the next three years, and the effect is larger for unconstrained firms. The additional investment in the subsequent two years comes from the cash saved today and additional external financing. Hoang & Hoxha (2016) find that firms mainly use debt and to a lesser extent investment to absorb net income shocks, with payout only absorbing the remaining 2.4% of the shocks to net income. These papers demonstrate the importance of examining the joint dynamics of financial policies. Failure to do so can result in a fragmented picture and misleading conclusions.

[8] Gatchev et al. (2010), using only one lagged variable, find that, for every dollar of cashflow, firms change debt by \$0.85, but increase CAPEX by a statistically insignificant \$0.04. By looking at a longer horizon, Dasgupta et al. (2011) show that firms raise external financing and spend it together with the cash saved on investment. As a result, a dollar today increases investment over a 3-year period by \$0.38, which is statistically significant.

3 Model Setup

We start off by describing a firm's key decision variables and their relations using a few accounting identities. The firm's balance sheet identity requires that assets (A_t) equal equity (N_t) plus net debt (D_t):

$$A_t = N_t + D_t \tag{1}$$

Solvency requires that the firm's equity (net worth) is positive, i.e. $N_t = A_t - D_t > 0$. Negative debt ($D_t < 0$) means that the firm has a surplus of cash over its debt liabilities. Our definition of negative debt means that assets A_t do *not* include cash. For example, for an all equity financed firm (i.e. no debt) that holds some cash D_t (< 0), we get $N_t = A_t + (-D_t)$, where A_t correspond to the firm's productive or risky assets, $-D_t$ corresponds to the firm's cashholding, and N_t captures the firm's equity or "net worth".

The firm's budget constraint is given by:

$$D_t = D_{t-1}(1 + \rho) - [\pi_t - \tau(\pi_t - \rho D_{t-1} - Dep_t)] + I_t + Dep_t + p_t$$

where ρ and τ denote the firm's before-tax rate of interest on net debt and the corporate tax rate, respectively. π_t, Dep_t and I_t denote, respectively, the gross operating profit, the depreciation charge and investment expenditure. We think of I_t primarily in terms of capital expenditure (CAPEX), but it could also include acquisitions net of asset sales. Finally, p_t denotes the firm's net payout, which equals dividends plus repurchases minus equity issues.

The budget constraint can be rewritten as the firm's sources and uses of funds constraint:

$$\underbrace{\Delta D_t + (\pi_t - Dep_t)(1 - \tau)}_{\text{sources of funds}} = \underbrace{\rho(1 - \tau)D_{t-1} + p_t + I_t}_{\text{uses of funds}} \tag{2}$$

Define NI_t as the firm's net income after interest, depreciation and taxes, i.e. $NI_t \equiv (\pi_t - \rho D_{t-1} - Dep_t)(1 - \tau)$. Hence, the budget constraint becomes

$$\Delta D_t = p_t + I_t - NI_t \tag{3}$$

In what follows, we focus on firms with safe debt that can borrow at competitive terms.

3.1 Intertemporal budget constraint

The budget constraint (2) can be rewritten as:

$$p_t = D_t - D_{t-1}(1+\rho(1-\tau)) + (\pi_t - Dep_t)(1-\tau) - I_t \equiv D_t - D_{t-1}(1+\rho(1-\tau)) + FCF_t \tag{4}$$

where $FCF_t \equiv (\pi_t - Dep_t)(1-\tau) - I_t$ denotes the firm's free cashflows at time t. Let equityholders' discount rate and discount factor, respectively, be denoted by $\hat{\rho}$ and $\hat{\beta} \equiv 1/(1+\hat{\rho})$. Since the firm's budget constraint must hold at each point in the future, we obtain the following intertemporal budget constraint (IBC):

$$\sum_{j=0}^{T} \hat{\beta}^j p_{t+j} = \sum_{j=0}^{T} \hat{\beta}^j FCF_{t+j} + \sum_{j=0}^{T} \hat{\beta}^{j-1} D_{t+j-1} (1-\hat{\beta}(1+\rho(1-\tau))) + \hat{\beta}^T D_{t+T} - (1+\rho(1-\tau))D_{t-1} \tag{5}$$

Imposing the no-Ponzi condition $\lim_{T\to\infty} \beta^T D_{t+T} = 0$ prevents the debt from growing at a faster rate than $\hat{\rho}$ and leads to the following IBC:

$$\sum_{j=0}^{\infty} \hat{\beta}^j p_{t+j} = \sum_{j=0}^{\infty} \hat{\beta}^j FCF_{t+j} + \underbrace{\sum_{j=0}^{\infty} \hat{\beta}^{j-1} D_{t+j-1} (1-\hat{\beta}(1+\rho(1-\tau)))}_{\text{tax shield}} - \underbrace{(1+\rho(1-\tau))D_{t-1}}_{\text{outstanding net debt}} \tag{6}$$

The IBC illustrates how the firm's payout, investment and financing decisions are interdependent. The IBC states that the present value of payouts to equityholders equals the present value of free cash-flows plus the present value of interest tax shields minus any outstanding debt. The IBC captures the pool or reservoir of cashflows generated over the firm's lifecycle that can be paid out to shareholders. Outstanding debt is a prior claim on the future cashflows that does not constrain current payout but the present value of total amount of payouts that are paid out over the firm's entire lifespan. The firm's payout policy determines how these payouts will be spread out over time. Lambrecht & Myers (2017) show that if inside equityholders are risk-averse then payout is smoothed over time, and insiders underinvest compared to risk neutral investors.

If equityholders are risk neutral and discount at the risk free rate ρ, then the present value of the taxshield simplies to the well known expression:

$$\text{Tax shield} \;=\; \sum_{j=0}^{\infty} \beta^{j} \frac{\tau \rho D_{t+j}}{1+\rho} \tag{7}$$

More generally, if equityholders have a discount rate $\hat{\rho}$ then the taxshield is positive if and only if:

$$\sum_{j=0}^{\infty} \hat{\beta}^{j-1} D_{t+j-1} \left(1 - \hat{\beta}(1+\rho(1-\tau))\right) \;>(<)\, 0 \iff \hat{\rho} \;>(<)\, \rho(1-\tau) \tag{8}$$

Therefore, the tax shield increases in the cost of equity and its value is positive if equityholders' discount rate, $\hat{\rho}$, exceeds the after-tax cost of debt, $\rho(1-\tau)$. Firms for which the cost of equity is high may therefore rely relatively more on debt financing. This is consistent with empirical evidence. Brav (2009) finds that private firms rely almost exclusively on debt financing, and have higher leverage ratios than public firms. He argues that these differences are due to private equity being more costly than public equity because of the higher degree of information asymmetry for private firms.

3.2 Net leverage

To study the interaction between payout, investment and the firm's financing policy, we need a measure of leverage. In what follows we use the net debt ratio (NDR), which we define as *net* debt divided by risky assets:

$$L_t \;\equiv\; \frac{D_t}{A_t} \;=\; \frac{D_t}{N_t + D_t} \quad \text{with } L_t \in (-\infty, 1] \tag{9}$$

The NDR differs from the standard leverage ratio in that it is based on *net* debt (i.e. debt liabilities minus cash) rather than gross debt. Consequently, the NDR can go negative whereas the standard leverage ratio varies between 0 and 1. Under the standard leverage measure, firms with zero or negative debt are all classified as zero leverage firms. Yet, they could be quite different in terms of their financial risk, depending on the amount of cash they have. After all, abundant cash reserves can be used to pay down debt or to cover interest repayments. The NDR adjusts for this by offsetting cash against debt liabilities. Cash is considered to be negative debt, and is therefore not included in our definition of the assets A_t.[9]

The NDR, L, ranges from $-\infty$ to $+1$. Indeed, L goes to one as the debt-equity ratio goes to positive infinity (i.e. $\lim_{\frac{D}{N}\to+\infty} L = 1$), which corresponds to an all-debt financed firm. Since $A_t \geq 0$, the lowest possible value for D_t is $D_t = -N_t$, in which case $\lim_{\frac{D_t}{N_t}\to-1} L = -\infty$. The polar case $L = -\infty$ corresponds to an all-equity financed firm that has "invested" in cash only. Since the firm has no productive assets ($A_t = 0$), it resembles more a bank account than a firm.[10]

3.3 Risky assets and investment

Given that A_t excludes cash, changes in A_t result from investment (or disinvestment) I_t in the firm's risky assets or from exogenous shocks ξ_t to the value of existing assets.

If the firm invests an amount I_t at time t then the change in the firm's asset value depends on I_t and the NPV of the investment, which is given by

$$NPV_t = mI_t - I_t = (m - 1)I_t \tag{10}$$

The investment has a negative NPV if $m < 1$. In the extreme case where managers burn or squander cash (i.e. $m = 0$) the value of productive assets remains the same ($\Delta A_t = 0$) but net debt goes up by an amount I_t. The investment has a positive NPV ($m > 1$), for

[9] Acharya, Almeida & Campello (2007) show that cash is not equivalent to negative debt for financially constrained firms. As previously mentioned, we focus on firms that have easy access to debt financing at competitive terms.

[10] Some studies (e.g. Lambrecht & Myers 2017) define the NDR in a piece-wise fashion, i.e. $L_t = D_t/(N_t + \psi D_t)$ where $\psi = 1$ for $D_t \geq 0$ and $\psi = 0$ for $D_t < 0$. Under this definition the NDR varies from -1 to +1. Although there are theoretical arguments for adopting this definition (see Lambrecht & Pawlina 2013), we do not follow this definition here as the piece-wise definition complicates the notation and exposition later in the paper.

instance, if assets are acquired at a discount. For example, a bank may pay out 10 million as a loan, but report its asset value at 11 million if that is the fair value it could obtain by selling or securitizing the loan in an arm's length transaction.[11] If $I_t < 0$ then the firm disinvests, for example by selling assets. $m > (<) 1$ means that assets are disposed of at a discount (premium).[12] Apart from investment, changes in the value of the firm's risky assets can also result from a revaluation due to economic shocks ξ_t.[13]

In summary, under a market value approach, the change in the value of the firm's assets is:

$$\Delta A_t = \Delta D_t + \Delta N_t = p_t + I_t - NI_t + \Delta N_t = mI_t + \xi_t$$

Hence,

$$\Delta N_t = (m-1)I_t + NI_t - p_t + \xi_t \tag{11}$$

The change in the firm's net worth is given by the investment's NPV, $(m-1)I_t$, plus the retained income, $NI_t - p_t$, plus any exogenous shocks ξ_t to the value of its assets in place. Shocks to the firm's existing asset value are entirely absorbed by equityholders when the debt is safe.

In what follows we assume that $mL < 1$, unless otherwise mentioned.

4 Payout and Debt under a Leverage Target Model

We will now derive the firm's payout policy if it follows a constant NDR target, L. We do not assume that the NDR is held constant forever, but merely that firms have a constant

[11] More generally, positive values for m may result from a lack of competition within the industry, or imply that the firm has some advantage compared to other firms that cannot be competed away.

[12] Most industries adopt historical cost accounting standards in which case the historical cost I_t is recorded on the balance sheet (i.e. $\Delta A_t = I_t$) and not mI_t. Under historical cost, the NPV of the investment only accrues into the balance sheet as and when profits are earned over time. These profits are obtained from the profit and loss statement and added to the firm's net worth and its assets (e.g. cash balance). In what follows, we set $\Delta A_t = mI_t$, allowing historical cost accounts to be retrieved by setting $m = 1$ where appropriate.

[13] Market values may incorporate shocks instantaneously. Book values incorporate shocks if assets become impaired or written down. This happens, for instance, when creditors may default. Fair value accounting (as applied in the banking sector, for instance) report the market value of assets when such values are available or can reliably be computed.

debt ratio target at least in the short term. In particular, we assume that $\frac{D_{t-1}}{A_{t-1}} = \frac{D_t}{A_t} = L$. It follows that

$$
\begin{aligned}
L &= \frac{D_{t-1} + \Delta D_t}{A_{t-1} + \Delta A_t} = \frac{D_{t-1} + p_t + I_t - NI_t}{A_{t-1} + mI_t + \xi_t} = \frac{L + \frac{p_t + I_t - NI_t}{A_{t-1}}}{1 + \frac{mI_t + \xi_t}{A_{t-1}}} \\
&\iff L\frac{(mI_t + \xi_t)}{A_{t-1}} = \frac{p_t + I_t - NI_t}{A_{t-1}} \\
&\iff p_t = NI_t + L(mI_t + \xi_t) - I_t
\end{aligned}
$$

Substituting into Equations (3) and (11), we get the following proposition:

Proposition 1 *If the firm follows a NDR target, L, then its payout, investment, change in net debt, change in net worth and change in risky assets are, respectively, given by*

$$p_t = NI_t - I_t(1 - mL) + L\xi_t = NI_t - I_t + L\Delta A_t \tag{12}$$

$$I_t = \frac{NI_t - p_t + L\xi_t}{1 - mL} \tag{13}$$

$$\Delta D_t = L(mI_t + \xi_t) = L\Delta A_t \tag{14}$$

$$\Delta N_t = (1 - L)(mI_t + \xi_t) = (1 - L)\Delta A_t \tag{15}$$

$$\Delta A_t = \frac{\xi_t + m(NI_t - p_t)}{1 - mL} = mI_t + \xi_t \tag{16}$$

The proposition shows that a target NDR leaves only one degree of freedom. For example, once I_t is set ΔA_t, ΔD_t and p_t follow immediately. Corporate financial policies are quite different depending on the sign of the NDR L. Let us first take payout p_t as exogenously given. Since $\frac{\partial I_t}{\partial \xi_t} = \frac{L}{1-mL}$, a positive shock to the value of assets in place ξ_t increases (reduces) investment if $L > (<)0$ because a positive (negative) NDR allows (requires) the firm to borrow (delever) against the increase (decrease) in assets in place. Consequently, a positive (negative) NDR amplifies (dampens) the effect of ξ_t on changes in the firm's assets, i.e. for a given payout level p_t it is the case that $\frac{\partial \Delta A_t}{\partial \xi_t} = \frac{1}{1-mL} > (<)1 \iff L > (<)0$. We conclude that a shock to assets in place feeds into the firm's investment policy through its target NDR. The investment (or disinvestment) feeds back into the firm's asset base and amplifies (or dampens) the initial shock to assets in place.

Consider next the effect of shocks to net income. $\frac{\partial I_t}{\partial NI_t} = \frac{1}{1-mL} \geq (\leq)1 \iff L \geq (\leq)0$ (assuming $mL < 1$). Hence, a positive (negative) NDR amplifies (dampens) the effect of net income on investment. $\frac{\partial \Delta A_t}{\partial NI_t} \geq (\leq)0 \iff m \geq (\leq)\frac{1}{1+L}$. An extra dollar of net income increases the firm's risky asset base if $m \geq \frac{1}{1+L}$. For a positive NDR the risky asset base expands provided the NPV is not too negative, whereas for a negative NDR the asset base expands if the NPV is sufficiently positive.

Examining the effect of payout on investment, we find that an extra dollar of payout reduces investment by more (less) than a dollar if $L > (<)0$. Changes in investment, in turn, feed back into the firm's asset base since $\frac{\partial \Delta A_t}{\partial p_t} = \frac{\partial \Delta A_t}{\partial I_t}\frac{\partial I_t}{\partial p_t} = \frac{-m}{1-mL}$.

Consider next the firm's investment policy I_t as exogenously given. In that case shocks in ξ_t are 100% transmitted into asset changes ($\frac{\partial \Delta A_t}{\partial \xi_t} = 1$ for given I_t) as there is no feedback effect into investment policy. Since $\frac{\partial p_t}{\partial \xi_t} = L$, payout increases (decreases) in response to shocks to assets in place if $L > (<)0$ even though these shocks do not directly generate actual cash-flows, but merely revalue assets in place on paper.

Next, changes in the firm's asset base ΔA_t get transmitted into its liabilities because the target NDR policy requires that changes in net debt and changes in equity are both proportional to changes in the firm's assets (see Equations (14) and (15)). A positive NDR means that increases in the firm's assets are funded partially by debt and partially by retained income. Outside equity issues (i.e. $p_t < 0$) may not or only occasionally be needed. A negative NDR implies that an increase in risky assets coincides with a *decrease* in net debt. To maintain a negative NDR, L, the firm has to use retained income and possibly issue new equity to pay down net debt (i.e. to increase net cashholdings). Therefore, it may be hard to square a very negative target NDR with firms or industries for which equity issues are rare.

The proposition shows that if the firm follows a target NDR, L, then payout is positively related to net income and negatively related to investment ($\frac{\partial p_t}{\partial I_t} = -(1-mL)$). Increasing the NDR reduces the sensitivity of payout to investment because it allows external borrowing (rather than reduced payout) to absorb spikes in CAPEX, i.e. $\Delta D_t - I_t =$

$L\Delta A_t - I_t = -(1 - mL)I_t$.[14]

The direction of the effect of shocks to assets on payout depends on the sign of the NDR, L. A positive shock ξ_t increases (decreases) payout if the firm has a positive (negative) NDR because rebalancing requires the firm to increase (decrease) net debt, which increases (decreases) the amount available for payout. The fact that a positive economic shock can decrease payout may come across as counter-intuitive and its implications for financial policies have not been fully recognized in the literature. It implies, for example, that firms tracking a negative market NDR target ($L < 0$) have to issue equity (i.e. $p_t < 0$) whenever net income is less than investment minus a fraction L of the increase in risky assets, i.e. $p_t < 0 \iff NI_t < I_t - L\Delta A_t$. Hence, even mature cash cow firms that no longer invest ($I_t = 0$) have to issue new equity following a significant revaluation of assets in place if the NDR is sufficiently negative (recall that $L \in (-\infty, 1]$). Equity issues of this nature seem unlikely in practice. It appears more plausible that firms may wish to raise their highly negative NDR target or, alternatively, they may prefer to disinvest ($I_t < 0$) by scaling down the firm's activities in response to a positive revaluation of assets in place.

Unlike shocks to the value of risky assets in place, shocks to net income do not necessarily lead to a change in the firm's risky asset base, and neither should they affect changes in debt, unless the income is used to invest in more risky projects. NI_t therefore indirectly affects the firm's net debt, whereas shocks to the risky assets in place directly affect changes in net debt for firms that follow a target NDR. Income shocks feed directly into payout, though, as every dollar of income that is not invested or used to pay down debt increases payout.

Consider next payout smoothing. Payout is smoothed if it is less volatile than net income. From Equation (12) it follows that payout not only absorbs the variation in net income but also volatility in investment and the firm's asset value. This can induce excess

[14] In the rather extreme case for which $mL > 1$, the relation between payout and investment becomes positive. Take the example of a highly geared bank that issues a loan at a significant premium ($m \gg 1$). In that case, the investment coincides with an instantaneous large increase in firm value against which the bank can issue further debt to pay for higher payout. A further rise in leverage increases the sensitivity of payout to investment when $mL > 1$. As previously stated, we assume $mL < 1$, unless otherwise mentioned.

volatility in payout. A higher *absolute* level of the NDR ($|L|$) amplifies the effect on payout of shocks to assets in place, where a higher NDR L dampens the effect on payout of shocks to investment. It follows that a very negative NDR may be incompatible with payout smoothing unless the fluctuations in investment and the firm's assets in place partially offset fluctuations in net income by moving in opposite directions. From Equation (12) one can infer that the larger the investment I_t is relative to net income NI_t, the higher the NDR has to be to smooth out fluctuations in investment as a higher NDR allows a higher degree of debt financing to absorb shocks in CAPEX.

Although, the above analysis indicates that it is hard to reconcile a leverage target policy with payout smoothing, the two are not necessarily incompatible if one or both of the following conditions are satisfied. First, if the NDR is slightly negative ($L < 0$) and assuming that ΔA_t and NI_t are positively correlated, then shocks in net income may be partially offset by changes in the firm's asset value, reducing payout volatility (see Equation (12)). We illustrate these types of dynamics in Section 6, where the dichotomy between firms with a positive versus a negative NDR is made explicit. Second, payout smoothing may be achieved if firms adopt a book leverage target, rather than a market leverage target, because book values are much less affected by fluctuations in the value of the firm's assets. It is likely that in practice managers rely on book values because market values for the firm's assets are usually not observable. Even if market values are observable, market volatility may make it impossible for managers to track the firm's debt target. If managers base financial policies on book values (i.e. ignoring ξ_t) and historical accounting ($m = 1$) then payout volatility is reduced because changes in assets are given by $\Delta A_t = I_t$ (instead of $\Delta A_t = mI_t + \xi_t$). In that case, the firm's payout and variance of next period's payout are:

$$p_t = NI_t - (1 - L)\, I_t \tag{17}$$

$$var_t(p_{t+1}) = var_t(NI_{t+1}) + (1 - L)^2\, var_t(I_{t+1}) - 2(1 - L)\, cov_t(NI_{t+1}, I_{t+1}) \tag{18}$$

Even with book values and historical accounting, payout is typically more volatile than net income because, to maintain the leverage target, payout has to absorb shocks in net income and CAPEX. The exception is the case where there is a high positive correlation between NI_t and I_t, causing shocks in NI_t to be partially absorbed by investment. Indeed,

$$var_t(p_{t+1}) \; < \; var_t(NI_t) \quad \Longleftrightarrow \quad corr(NI_{t+1}, I_{t+1}) \; > \; \frac{(1-L)\sqrt{var_t(I_{t+1})}}{2\sqrt{var_t(NI_{t+1})}} \tag{19}$$

It follows that a pro-cyclical investment policy (i.e. $corr(NI_{t+1}, I_{t+1}) > 0$) is a necessary condition for payout smoothing if the firm follows a book leverage target. If we measure the degree of payout smoothing by (the inverse of) the ratio $\frac{var_t(p_{t+1})}{var_t(NI_{t+1})}$ then it is easy to show that the lowest achievable ratio for $\frac{var_t(p_{t+1})}{var_t(NI_{t+1})}$ and the corresponding NDR L are, respectively, given by:

$$\frac{var_t(p_{t+1})}{var_t(NI_{t+1})} \; = \; 1 \; - \; corr_t(NI_{t+1}, I_{t+1}) \tag{20}$$

$$L \; = \; 1 - \frac{cov_t(NI_{t+1}, I_{t+1})}{var_t(I_{t+1})} \; = \; 1 \; - \; \frac{corr_t(NI_{t+1}, I_{t+1})\sqrt{var_t(NI_{t+1})}}{\sqrt{var_t(I_{t+1})}} \tag{21}$$

Therefore, a stronger positive relation between net income and investment policy allows for a higher degree of payout smoothing. If NI_t and I_t are perfectly positively correlated then any shocks in net income are perfectly hedged by the firm's (dis)investment policy causing payout to be perfectly smooth. Furthermore, to obtain maximum payout smoothing, the NDR target should decrease in the correlation between investment and net income. Whether investment policy can (or should) be used as a device to smooth payout is another matter. Frequent switches in investment policy may be possible for firms with highly liquid and marketable assets (such as banks), but not for most regular, bricks and mortar companies.

In the remaining part of this section we first explore the implications of payout smoothing for a firm that follows a debt target ratio. Next, we consider the scenario where adjustment towards the debt target ratio is not instantaneous but gradual. We study the implications of partial and gradual capital structure adjustment for the firm's payout policy.

4.1 Leverage target with payout target

The above proposition shows that once we fix the firm's financing policy (i.e. constant NDR), we only have one degree of freedom left. If we also fix payout, p_t, then the investment policy I_t follows immediately from Proposition 1. The empirical literature (going back to Lintner 1956) shows that firms smooth payout, and that payout gradually and partially adjusts towards a payout target. What then are the implications for investment policy if a firm adopts both a constant NDR target and a Lintner payout policy? This is the question we explore next.

Skinner (2008) shows that total payout follows a Lintner (1956) partial adjustment model, i.e. payout partially and gradually adjusts toward a target p_t^o that depends on NI_t:

$$p_t - p_{t-1} = a(p_t^o - p_{t-1}) \quad \text{with } 0 \leq a \leq 1 \tag{22}$$

$$p_t^o = c + b\,NI_t + \epsilon_t \tag{23}$$

Repeated substitution of (23) into (22) gives

$$\begin{aligned} p_t &= a\,c + (1 - a)\,p_{t-1} + a\,b\,NI_t + a\,\epsilon_t & (24) \\ &= c + a\,b\sum_{i=0}^{\infty}(1-a)^i\,NI_{t-i} + a\sum_{i=0}^{\infty}(1-a)^i\,\epsilon_{t-i} & (25) \end{aligned}$$

Equation (24) (which is known as the Lintner model) can be expressed as a distributed lag model in which current payouts are a weighted average of current income and all past incomes, with more recent income realizations receiving higher weightings than those in the more distant past. Skinner (2008) shows that the Lintner model not only applies to dividends but also to total payouts, even though repurchases can be less smooth than dividends. The model is quite general in that it captures a wide variety of payout patterns. If $a = 0$, then $p_t = p_{t-1}$ for all t and we obtain a constant payout. If $a = 1$, then $p_t = p_t^o = c + b\,NI_t + \epsilon_t$ for all t and payout adjusts fully and instantaneously towards the target.

What are the implications for the investment policy if the firm follows a NDR target *and* a Lintner payout target? Since payout must satisfy both Equations (12) and (25), it follows that investment policy must follow a distributed lag function of current and past income as given in the next corollary.

Corollary 1 *If the firm follows a net debt ratio target L, as well as a Lintner payout policy then the firm's investment policy is given by the following distributed lag model:*

$$I_t = \left[(1-ab)NI_t \;-\; ab\sum_{i=1}^{\infty}(1-a)^i NI_{t-i} + L\xi_t - a\sum_{i=0}^{\infty}(1-a)^i\epsilon_{t-i} \;-c\right]/(1-mL) \tag{26}$$

$$= (1-a)I_{t-1} + \frac{[(1-ab)NI_t - (1-a)NI_{t-1} + L\xi_t - (1-a)L\xi_{t-1} - ac - a\epsilon_t]}{(1-mL)} \tag{27}$$

Equation (27) corresponds to an autoregressive distributed lag (ARDL) model. In particular, it is an ARDL(1,1) model as it includes a first order (AR $=$ 1) autoregressive process in the dependent variable I_t, and a first order distributed lag (DL $=$ 1) in the independent variables NI_t and ξ_t.

Payout smoothing and leverage increase the immediate effect of income shocks on investment. A marginal increase in NI_t of one dollar raises investment I_t instantaneously by $(1-ab)/(1-mL)$ but lagged effects reduce investment in aggregate by $-ab\sum_{i=1}^{\infty}(1-a)^i/(1-mL) = -b(1-a)/(1-mL)$. The net long run effect of a marginal increase in net income on investment is therefore $(1-b)/(1-mL)$, which is the retention rate $(1-b)$ scaled up by an adjustment for leverage (L) and the value of the investment (m).

Payout smoothing $(0 \leq a < 1)$ combined with a target debt ratio means that investment acts as a partial shock absorber and a temporary store of cashflow because the instantaneous propensity to invest $(1-ab)/(1-mL)$ exceeds the long run propensity $(1-b)/(1-mL)$ if $a < 1$. A fraction $b(1-a)/(1-mL)$ of marginal income is initially ploughed back and invested in the firm but (ceteris paribus) subsequently disinvested and paid out over time. Investment and disinvestment are therefore the devices that enable payout smoothing, particularly for highly levered firms. This is, however, inconsistent with empirical evidence (e.g. Dasgupta et al. 2011), which suggests that firms use borrowing and cashholdings to smooth payout, not (dis)investment in real assets.

In the absence of payout smoothing ($a = 1$ and $p_t = p_t^o$), investment is given by:

$$I_t = \frac{NI_t - p_t^o + L\xi_t}{1 - mL} = \frac{(1-b)NI_t - c - \epsilon_t + L\xi_t}{1 - mL} \tag{28}$$

For the other polar case of a constant payout level c (i.e. $a = 0$ and $p_t = p_0$), we get an investment policy that adjusts fully and instantaneously to changes in net income:

$$I_t = \frac{NI_t - p_o + L\xi_t}{1 - mL} \tag{29}$$

In the absence of payout smoothing, investment only absorbs a fraction $(1-b)/(1-mL)$ of the instantaneous volatility in net income, whereas with a constant payout (i.e. $a = 0$), investment becomes the residual policy that soaks up a fraction $1/(1-mL)$ of the variation in net income. A positive (negative) NDR increases (reduces) investment volatility.

The negative coefficients in Equation (26) on the lagged net income variables NI_{t-i} are inconsistent with empirical evidence. For example, Dasgupta et al. (2011) regress investment on current and one-period and two-period lagged ($t-1$, $t-2$) operating cashflow (and other control variables) and find positive and significant coefficients for all three variables.[15]

Their results indicate that the effect of cashflow shocks on investment is spread over time. A similar result is obtained when regressing dividends on current and lagged operating cash flows. On the other hand, when regressing cashholdings and external financing on current and lagged ($t-1$ and $t-2$) operating cash flows, they find that the

[15] We should point out that Dasgupta et al. (2011) (as well as many other empirical studies) scale all balance sheet and cash-flow variables by the one-period lagged book value of assets. Scaling is most often justified as a method of controlling for differences in firm size. Algebraic equalities remain intact if the right-hand side and the left-hand side are divided by the same value. However, in a regression the estimated coefficient can be seriously affected if the scaling variable is correlated with the variables in the equation. The parameter estimates we quote from the literature to illustrate our argument therefore have to be interpreted with this caveat in mind.

instantaneous effect of operating cashflow is to increase (reduce) cashholdings (outside debt) but the lagged effects have the opposite sign. In other words, net debt is first reduced through saving and paying down debt, but subsequently followed by dissavings and extra borrowing to finance CAPEX. In particular, Dasgupta et al. (2011) find that contemporaneous cashholdings (external debt) increase (decrease) with 36 cents (50 cents) per dollar increase in cashflow. In the next year cashholdings (debt) decrease (increase) by 7 cents (11 cents), and the following year cashholdings (debt) decrease (increase) by a further 4 cents (6 cents). This is consistent with debt and cash acting as shock absorbers and investment being spread over time. A dollar income generates an instant investment of 12.6 cents and a further investment of 16.4 cents and 9.3 cents in the subsequent two years. These results relate to the total sample of firms. Dasgupta et al. (2011) show that investment smoothing is less pronounced for unconstrained firms with a dollar of extra cash flows leading to an incremental investment equal to 23.5, 27.4 and 13.1 cents at time t, $t+1$ and $t+2$, respectively. This means that for unconstrained firms the bulk of a marginal dollar of cashflow is transmitted to investment within three years.

Gatchev et al. (2010) provide strong evidence that ignoring the interdependent and intertemporal nature of financial decisions results in misleading and often incorrect conclusions. Using the static single-equation empirical specification commonly used in prior studies, they confirm that capital expenditures decrease (increase) by a statistically and economically significant \$0.47 for every one dollar decrease (increase) in cash flow. However, estimates obtained using their system-of-equations model are significantly smaller. This difference in coefficient estimates is driven largely by the inclusion of lagged capital expenditures in the system-of-equations model, which suggests that failing to account for persistence can lead to biased results. Furthermore, financing-cash flow sensitivities dominate investment-cash flow sensitivities, revealing that firms absorb cash flow fluctuations primarily by altering net debt, not by changing real assets. Using their system-of-equations model, they find that for every dollar of cash flow, firms change debt by \$0.85, but increase capital expenditures by a statistically insignificant \$0.04.

Survey evidence by Brav et al. (2005) indicates that payout and investment are at par in terms of managers' priorities regarding the firm's financial policies, and external funds would be raised before dividends are cut. However, beyond maintaining the level of dividends per share, payout policy is a second-order concern; that is, increases in dividends are considered only after investment and liquidity needs are met. Managers clearly indicate that operational and investment decisions are more important than share repurchases.

Daniel, Denis & Naveen (2017) examine how firms resolve cashflow shortfalls. They find that the typical firm obtains financial flexibility almost exclusively in the form of new debt, while equity issues, reductions in cash balances, dividend cuts, and the sale of non-operating assets are economically trivial.

In summary, we conclude that the combination of a debt ratio target and payout smoothing leads to investment dynamics that are inconsistent with empirical evidence, especially for highly levered firms. We should stress that the investment dynamics described in Corollary 1 follow mechanically from our assumptions regarding the firm's financing and payout policies. There is no reason to believe that the resulting investment policy is optimal in any way.[16] Optimal policies have to be derived as the solution to managers' (or equityholders') maximization problem. We provide an example of this in Section 6. The above analysis does, however, allow us to explore how financial policies interact and what the empirical implications are for, say, investment if firms follow a financing or payout policy of a particular form. These testable predictions can then be brought to the data to identify what type of financial policies can be reconciled with each other.

4.2 Partial adjustment toward a debt target

Previously, we assumed that firms maintain a NDR target, and therefore fully and instantaneously adjust towards the debt target each period. Various types of frictions may, however, impede firms from doing so. Empirical studies indicate that firms partially and

[16]Take, for example, the extreme case in which investment is a complete waste of money (i.e. $m = 0$). Clearly, investment is suboptimal (at least from shareholders' viewpoint) if $m = 0$. Yet, according to Corollary 1, the firm will invest any amounts of money that are left after its Lintner payout policy and its debt target ratio have been implemented.

gradually adjust toward the debt target, i.e.

$$\Delta D_t = g\,(D_t^o - D_{t-1}) = g(L\,A_t - D_{t-1}) \quad \text{where} \quad 0 \leq g \leq 1 \tag{30}$$

Given that the financing policy interacts with payout, what are the implications of "debt smoothing" for payout policy? Equation (30) implies that the current debt level is a distributed lag function of current and past asset values. Indeed, iterative substitution of (30) gives:

$$D_t = gLA_t + gL\sum_{i=1}^{\infty}(1-g)^i\,A_{t-i} \tag{31}$$

Using the fact that $A_t = A_{t-1} + mI_t + \xi_t = \sum_{i=0}^{\infty}(mI_{t-i} + \xi_{t-i})$ gives:

$$D_t = gL\sum_{i=1}^{\infty}\frac{1-(1-g)^i}{g}(mI_{t-i+1} + \xi_{t-i+1}) \tag{32}$$

$$\Delta D_t = gL(mI_t + \xi_t) + gL\sum_{i=1}^{\infty}(1-g)^i(mI_{t-i} + \xi_{t-i}) = gL\sum_{i=0}^{\infty}(1-g)^i\,\Delta A_{t-i} \tag{33}$$

Substituting expression (33) for ΔD_t into budget constraint (3) gives the following corollary.

Corollary 2 *If a firm partially and gradually adjusts towards its optimal NDR (i.e. $\Delta D_t = g(LA_t - D_{t-1})$) then the firm's payout and investment policy are given by:*

$$\begin{aligned} p_t &= NI_t + gL(mI_t + \xi_t) - I_t + gL\sum_{i=1}^{\infty}(1-g)^i\,(mI_{t-i} + \xi_{t-i}) \\ &= NI_t - I_t + gL\sum_{i=0}^{\infty}(1-g)^i\Delta A_{t-i} \end{aligned} \tag{34}$$

$$I_t = \frac{1}{m(1-g)}\left[g\sum_{i=1}^{\infty}(1-g)^i\,(mI_{t-i} + \xi_{t-i}) - (1-g)\xi_t\right] \tag{35}$$

In the presence of debt smoothing, the firm's payout is determined by current net income and a weighted average of current and past changes in the firm's assets due to new investment and shocks to existing assets. A moderate amount of debt smoothing induces payout smoothing because changes to the firm's asset value (generated by past investments, mI_{t-i}, and past shocks ξ_{t-i}) feed gradually into payout. The degree of intertemporal payout smoothing is non-monotonic in the degree of debt smoothing, and reaches a maximum for some $\hat{g} \in (0, 1)$. The intuition is as follows. For $g = 1$, debt instantaneously and fully adjusts to the current debt target D_t which is determined by the most recent asset value (i.e. $D_t = LA_t$). Consequently, payout depends on contemporaneous investment (I_t) and shocks (ξ_t) only if $g = 1$, i.e. $p_t = NI_t - I_t + L(mI_t + \xi_t)$. Reducing g means that changes to asset values in the more distant past get increasingly more weight in determining the new debt target. Therefore, payout depends on contemporaneous and lagged shocks to investment and assets in place for $0 < g < 1$. In the extreme case of $g = 0$, debt no longer adjusts and remains fixed at its initial level D_0 at $t = 0$. This means that debt no longer absorbs shocks in net income leaving payout equal to net income after investment expenditure, i.e. $p_t = NI_t - I_t$. It follows that for both polar cases ($g = 0$ and $g = 1$), payout is determined by current investment only, whereas for intermediate values of g payout is determined by current and past investment. Given that past investment gets discounted by a factor $g(1-g)^i$, maximum payout smoothing is achieved for some $\hat{g} \in (0, \frac{1}{2})$.

Proxies for g are available in the empirical literature. For example, Fama & French (2002) show that the speed of adjustment g ranges from 7% to 10% for dividend payers and from 15% to 18% for non-dividend payers, indicating that the SOA towards the debt target is slower for dividend payers. DeAngelo & Roll (2015) show that simulation with a speed of adjustment equal to 15% per year does a good job in replicating empirical data. They show that the cross-section of firms' leverage is sticky in the short term, not in the long term. The cross-sectional instability in leverage is most closely replicated in a simulation of a model with a time-varying leverage ratio. Flannery & Rangan (2006) show that, with fixed effects, the speed of adjustment estimate increases, and is around 34.4% per year. They show that the tradeoff theory with time-varying leverage target has the most explanatory power.[17]

[17] Note that these empirical papers focus on the speed of adjustment of the leverage ratio rather than the net debt ratio. For example, Fama & French (2002) examine both market and book leverage ratio, and scale all variables by asset value. DeAngelo & Roll (2015) use the leverage ratio when estimating the partial adjustment model (but also examine the time-series of the NDR). They show that there is

Our main conclusion is that partial adjustment towards a debt target can be reconciled with payout smoothing whereas a financing policy that implies instantaneous and full adjustment towards a debt target, or a policy with zero adjustment (i.e. the debt level -in dollar terms- is held constant) are inconsistent with payout smoothing. Note that the relation between debt smoothing and payout smoothing is not monotonic. In particular, if the firm does not adjust its debt level ($g = 0$) but keeps it constant (in dollar terms), then payout becomes a residual policy that absorbs all shocks in net income and investment. Conversely, with full adjustment ($g = 1$), payout only depends on current net income and current investment (see Equation (34)), eliminating all persistence originating from lagged investment. Therefore maximum payout smoothing occurs for an intermediate value of g.

Debt smoothing also coincides with investment smoothing. If the amount of debt is fixed ($g = 0$) then investment absorbs shocks to assets in place (i.e. $I_t = \xi_t/m$), with negative shocks leading to disinvestment. If debt fully adjusts to its target ($g = 1$) then, as previously explained, investment acts as a partial shock absorber and store of value, and investment is not spread or smoothed over time. With partial adjustment towards the debt target ($0 < g < 1$), current investment is positively correlated with past levels of investment, and investment is smoothed. Investment smoothing is maximized for relatively low speeds of adjustment towards the debt target (i.e. $0 < g < 0.5$).

Our simple theoretical framework suggests that payout smoothing and investment smoothing are maximized for some $\hat{g} \in (0, \frac{1}{2})$. Empirical estimates for the SOA to the debt target range from 7% to 34%. It would be interesting to test the hypothesis whether gradual adjustment towards a debt target coincides with a significant degree of payout and investment smoothing.

a large within-firm variation in leverage. Stable leverage is rarely observed and mainly concentrated at low leverage regimes. The primary measure adopted in Flannery & Rangan (2006) is the market debt ratio. Some empirical papers focus on the time-series behavior of firms' cash holdings and suggest that firms are actively managing their cash balance toward a target. For example, the early paper by Opler et al. (1999) discovers evidence in support of a target adjustment model of cash holdings. Gao et al. (2013) find that U.S. private firms hold less cash than public firms, and that public firms have a slower speed of adjustment towards the target, especially when they have excess cash.

5 Payout and Debt under the Strict Pecking Order Model

According to the pecking order theory (Myers & Majluf 1984) there is no optimal debt ratio. The debt ratio changes when there is an imbalance of internal cashflows net of dividends and real investment opportunities. As such increases in the NDR are driven by the firm's need for external funds.

Under the strict pecking order model external funds are raised through safe (investment-grade) debt financing because it is not affected by managers' inside information. The firm does not issue equity due to asymmetric information regarding assets in place. Likewise firms are reluctant to repurchase stock because uninformed shareholders prefer dividends over repurchases in order to avoid being expropriated by informed investors (see Brennan & Thakor 1990).[18]

Stock issues happen in an extended pecking order model when the firm has reached its debt capacity (e.g. when the firm can only issue junk debt and costs of financial distress are high).[19] However, as mentioned before, in this paper we focus on unconstrained firms that have easy access to debt financing. These are likely to be more mature firms.[20]

In what follows, we split up total payout into dividends and net stock repurchases, i.e. $p_t = d_t + s_t$ where s_t denotes repurchases minus equity issues. The firm now has two decision variables with respect to payout (d_t and s_t), and therefore an extra degree

[18]Issuance costs and personal taxes may also induce pecking order like behavior. By financing investments internally, firms avoid the transaction costs associated with issuing debt or equity. By retaining funds within the firm, equityholders and bondholders reduce personal taxes on dividends and interest repayments and defer taxes on capital gains from repurchases.

[19]Identifying a firm's debt capacity remains a challenge as there is no widely accepted operational definition available in the literature (see Lemmon & Zender 2010, Leary & Roberts 2010 for example).

[20]It is well known that growth firms rely on equity issues as a source of external financing. However, it is mostly managers' information about assets in place (not growth options) that blocks equity issues according to Myers & Majluf (1984). Arguably, we may need different models for the financing and payout behavior of young firms that consist primarily of growth opportunities, or existing models need to be integrated with life-cycle models of the firm.

of freedom has been created. From the balance sheet and budget constraint it follows

$$\Delta A_t = \Delta D_t + \Delta N_t = d_t + s_t + I_t - NI_t + \Delta N_t = m\, I_t + \xi_t \tag{36}$$

The strict pecking order states that firms finance CAPEX and dividends from internal funds, with any shortfall ("deficit") financed with debt, i.e.

$$\Delta D_t = d_t + I_t - NI_t \equiv Def_t \tag{37}$$

where Def_t represents the firm's net deficit (with $Def_t < 0$ corresponding to a net surplus).

Equation (37) is not the firm's budget constraint (3) as it excludes equity issues and stock repurchases, i.e. the strict pecking order model constrains $d_t \geq 0$ and $s_t = 0$. This eliminates the extra degree of freedom that was created by splitting up payout (p_t) into dividends and repurchases.

Unlike a target debt ratio financing policy, the pecking order model (37) does not impose a link between the firm's assets and its liabilities. Debt changes are conditional on d_t and I_t. As such we need to determine both the dividend (d_t) and investment (I_t) policies before debt policy is completely identified.

The strict pecking order model predicts that debt changes are equal to the firm's total net deficit. Shyam-Sunder & Myers (1999) therefore test the following model

$$\Delta D_t = \beta_0 + \beta_1 Def_t + \eta_t \tag{38}$$

with the null hypothesis H_0: $\beta_0 = 0$ and $\beta_1 = 1$. To the extent that the firm engages in net stock repurchases (stock issues), the coefficient β_1 will be biased above (below) 1.

5.1 Pecking order financing with a Lintner dividend policy

The pecking order theory states that firms pay the target dividend out of internal funds first, and use debt financing if there is a shortfall. The model is, however, silent as to what the target dividend is. In what follows, we assume that dividends follow a Lintner (1956) model, with partial adjustment coefficient $0 \leq a \leq 1$, i.e.

$$d_t = ac + (1 - a)d_{t-1} + abNI_t + a\epsilon_t \tag{39}$$

where the dividend target is $d_t^o = c + b\,NI_t + \epsilon_t$. Combining (39) with (37), (38) and the equality $\Delta N_t = mI_t + \xi_t - \Delta D_t$ gives the following proposition.

Proposition 2 *If the firm follows a simple pecking order financing model as well as a Lintner style dividend policy then the firm's changes in debt and net worth are given by:*

$$\Delta D_t = \beta_0 + \beta_1 ac + \beta_1(1 - a)d_{t-1} + \beta_1(ab - 1)NI_t + \beta_1 I_t + \beta_1 a\epsilon_t + \eta_t \tag{40}$$

$$\Delta N_t = -\beta_0 - \beta_1 ac - \beta_1(1 - a)d_{t-1} + \beta_1(1 - ab)NI_t + (m - \beta_1)I_t + \xi_t - \beta_1 a\epsilon_t - \eta_t \tag{41}$$

First, note that shocks to the value of the firm's existing assets do not affect ΔD_t, the amount of debt that is issued or retired because these shocks do not generate an immediate cashflow towards the firm's deficit or surplus. The shocks ξ_t are entirely absorbed by the firm's net worth position, and simply enter as additive shocks in Equation (41). All of this is, of course, under the premise that the firm's debt is safe.

Unlike a market leverage target policy that is significantly influenced by economic shocks to the value of the firm's existing assets, the amount of debt issued under the strict pecking order model is not affected by shocks to the firm's assets. This makes it much easier for managers to implement a pecking order strategy compared to a target debt ratio.

Next, recall that under the pecking order hypothesis $H_0 : \beta_1 = 1$. In light of empirical evidence regarding the partial adjustment coefficient a and the coefficient b (e.g. Fama & French 2002, Skinner 2008, Michaely & Roberts 2012 and Leary & Michaely 2011), it is reasonable to assume that $ab < 1$.[21] As a result the coefficient of NI_t in the regression (40) for ΔD_t is predicted to be negative. Furthermore, more dividend smoothing (i.e lower speed of adjustment, a, or lower sensitivity of dividends to net income, b) generates a stronger negative relation between NI_t and ΔD_t. For the extreme cases of constant or zero dividends ($a = 0$), or zero dividend-income sensitivity ($b = 0$), the coefficient on NI_t in (40) equals -1 under the strict pecking order model since $\beta_1 = 1$. However, to the extent that the firm adopts an extended pecking order model and issues equity (repurchases stock), the coefficient of NI_t can be less (more) negative.

For mature firms, we expect significantly more dividend smoothing, and therefore a strong negative relation between net income and changes in debt (since $a \ll 1$ and $b < 1$ implies $ab \ll 1$). The more dividend smoothing, the stronger this negative relation. The negative relation is strongest for firms having a constant or zero dividend. This negative relation has been confirmed in the literature and is the hallmark of pecking order behavior.

Brav (2009) estimates a partial adjustment model as in Shyam-Sunder & Myers (1999). He includes the deficit of a firm as an explanatory variable to examine how much of the deficit or surplus is offset by changes in debt, after controlling for the deviation between actual and target leverage. The regression coefficient on the deficit variable equals 0.75 and 0.28 for private and public firms, respectively. The respective partial adjustment coefficients are 0.10 and 0.23, which indicates that public firms' leverage adjusts to a target more quickly, presumably because they have easier access to capital markets. The difference between the coefficients on the deficit variable reveals that private firms rely on debt much more than public firms in financing their deficit. Brav (2009) argues this is consistent with the pecking order theory as private firms are more opaque than public

[21] Fama & French (2002) find that $a \in (0.27, 0.33)$ and $b \in (0.32, 0.33)$ (note that they scale all variables by lagged asset value). Skinner (2008) shows that for total payout, $a \in (0.4, 0.55)$ and $b \in (0.65, 0.75)$, while for dividends only, $a \in (0.18, 0.29)$ and $b \in (0.55, 0.61)$. Michaely & Roberts (2012) show that dividends are less smooth for private firms. Specifically, for private firms with concentrated ownership $a = 0.88$ and $b = 0.09$, for private firms with dispersed ownership $a = 0.65$ and $b = 0.08$, and for public firms $a = 0.33$ and $b = 0.14$. Leary & Michaely (2011) shows that dividend smoothing has increased from 1933 to 2011, with $a = 0.65$ in 1939 and $a = 0.1$ in 2001.

firms. When disaggregating the deficit in its components, dividends, investment, working capital and profits, Brav (2009) finds for private firms the regression coefficients 0.71, 0.72, 0.79, and -0.70, respectively. The corresponding figures for public firms are 0.19, 0.34, 0.27, and -0.18. These results lend support for the pecking order theory in the case of private firms, but much less so for public firms.

Empirical evidence by Michaely & Roberts (2012) indicates that private firms engage less in payout smoothing than public firms. In the extreme case of instantaneous adjustment $a = 1$, we get that the changes in debt no longer depend on lagged dividends, and the coefficient of NI_t moves towards zero (or could turn positive if $b > 1$). This could still be consistent with pecking order behavior if ΔD_t fully absorbs shocks to investment and the coefficient on I_t equals one (i.e $\beta_1 = 1$). Recall that the pecking order theory does not require dividends to be smooth, only that the firm tries to maintain its target dividend.

Under the strict pecking order model and a Lintner-style dividend policy, the changes in the net worth are given by (41). Hence, under the pecking order hypothesis ($\beta_1 = 1$), changes in net worth are positively related to the investments' NPV ($(m - \beta_1)I_t$), current income, NI_t, and shocks to existing assets, ξ_t, but negatively related to lagged dividends, d_{t-1}. Past income shocks gradually feed into current and future dividends, which in turn act as a drain on current and future net worth, generating a negative relation between lagged dividends and changes in net worth.

The following corollary summarizes the main results from the above discussion.

Corollary 3 *If a firm follows both a strict pecking order of financing and a Lintner-style dividend policy, then more dividend smoothing leads to a more negative (positive) relation between changes in debt (net worth) and contemporaneous net income. Changes in debt (net worth) increase with the amount (NPV) of CAPEX.*

From Equation (39) it follows that $var_t(d_{t+1}) = a^2b^2var_t(NI_{t+1}) < var_t(NI_{t+1})$. Hence, dividends are smooth relative to net income (under the reasonable assumption that $a^2b^2 < 1$). A low sensitivity of target dividends to current income ($b \ll 1$) and partial adjustment of dividends towards the target ($a < 1$) reduce the volatility of dividends relative to net income. Under a Lintner dividend policy, the volatility in dividends does not (directly) depend on the variation in CAPEX.

Dividend smoothing increases the volatility of debt changes because under the pecking order model changes in debt not only absorb shocks in investment but also shocks in net income. Under the target debt ratio policy, debt changes do not depend directly on variation in net income, but on variation in CAPEX and the value of assets in place.

6 A Continuous-time Model with Endogenous Financial Policies

So far we took the firm's financing and payout policies as exogenously given, and studied the implications for the joint dynamics of investment, debt and payout. In this section we endogenize the firm's three key financial policies and revisit their joint dynamics.

The model is based on a special case of Lambrecht & Myers (2017), which applies the Merton (1969) model for optimal investment and consumption to a firm's investment and payout decisions. Consider a firm that invests an amount A_t in risky projects that generate an after-tax rate of return given by the following diffusion process:

$$\frac{dA_t}{A_t} = [\mu' dt + \sigma' dB_t](1 - \tau) \equiv \mu dt + \sigma dB_t \tag{42}$$

where B_t is a Brownian motion and τ is the corporate tax rate (with $0 \leq \tau < 1$). The other parameters satisfy the conditions $\mu, \sigma > 0$. The firm finances its investments with equity (N_t) and debt (D_t), i.e. $A_t = N_t + D_t$. It can borrow and save at the before-tax rate ρ', and continuously roll over the net debt, i.e.

$$dD_t = \rho'(1 - \tau) D_t dt \equiv \rho D_t dt \tag{43}$$

At each instant in time inside equityholders decide how much to invest in risky projects (A_t) and how much to pay out to equityholders (p_t), given the amount of equity capital (net worth, N_t) in place. Using the balance sheet identity $D_t = A_t - N_t$, and the fact that safe debt earns the risk-free rate, the process for the firm's net worth is:

$$dN_t = dA_t - dD_t - p_t dt = [(\mu - \rho) A_t + \rho N_t - p_t] dt + \sigma A_t dB_t \tag{44}$$

We assume that equityholders have a power utility function with coefficient of risk aversion η and a subjective discount rate δ. Equityholders optimization problem is therefore given by:

$$V(N) = \max_{p_t, A_t} E\left(\int_0^\infty \frac{e^{-\delta t} p_t^{1-\eta}}{1-\eta} dt \Big| N_0 = N\right) \tag{45}$$

subject to the transversality condition $\lim_{t\to\infty} E\left[e^{-\delta t} V(N_t)\right] = 0$ and the intertemporal budget constraint (44). The solution is as follows (see Case 1 of Proposition 3 in Lambrecht & Myers 2017).

Proposition 3 *The optimal investment (A_t), payout (p_t) and debt (D_t) policies are:*

$$A_t = lN_t = \frac{N_t}{1-L} \tag{46}$$

$$p_t = qN_t \tag{47}$$

$$D_t = (l-1)N_t = \frac{LN_t}{1-L} \tag{48}$$

where L is the NDR and the constants l and q are defined by:

$$l = \tfrac{\mu-\rho}{\eta\sigma^2} \text{ and } L = 1 - \tfrac{\eta\sigma^2}{\mu-\rho} \tag{49}$$

$$\tfrac{q\eta}{1-\eta} + \rho(1-\tau) - \tfrac{\delta}{1-\eta} + (\mu-\rho)l - \tfrac{1}{2}\eta\sigma^2 l^2 = 0 \tag{50}$$

The proposition shows that under the optimal financial policies the firm's assets, net debt and payout are directly proportional to its net worth N_t. Through continuous rebalancing, the firm maintains a constant asset to net worth ratio l, and therefore a constant net debt ratio L (=$(l-1)/l$). Adherence to a constant NDR means that shocks to the firm's risky assets are amplified (mitigated) if $l >$ (<)1, or equivalently if $L >$ (<)0. For example, consider an exogenous shock that alters the firm's risky asset base by a fraction ξ_{t+1} and causes the firm to deviate from its debt NDR. In response, the firm will rebalance, and at the end of period $t+1$ the firm's risky assets, net worth, debt and payout are given, respectively, by $A_{t+1} = (1+\xi_{t+1}l)A_t$, $N_{t+1} = (1+\xi_{t+1}l)N_t$, $D_{t+1} = (1+\xi_{t+1}l)D_t$, and $p_{t+1} = (1+\xi_{t+1}l)p_t$. For example, assume $A_t = 100$, $N_t = 25$, $D_t = 75$, $l = 4$ (i.e. $L = 0.75$), and $\xi_{t+1} = +0.1$. Assets experience a positive 10% exogenous shock and rise to 110, with net worth increasing to 35, causing the firm to be underlevered ($110/35 = 3.14 < 4 = l$). In response, the firm invests an extra 30 financed with debt such that after rebalancing we have $A_{t+1} = 140$, $N_{t+1} = 35$, and $D_{t+1} = 105$. Hence, an initial shock of +10% to the firm's assets got amplified through rebalancing to a 40% increase in all balance sheet variables, and the firm's payout. Conversely, consider a firm with a negative NDR for which $A_t = 50$, $N_t = 100$, $D_t = -50$, $l = 0.5$ (i.e. $L = -1$) and $\xi_{t+1} = 0.1$. A positive 10% shock initially increases risky assets to 55, and net worth to 105, causing the firm to be overlevered ($l = 55/105 = 0.52$). In response, the firm sells off 2.5 in risky assets, hereby increasing its cashholding to 52.5. Rebalancing therefore dampens a +10% shock to risky assets to a 5% net increase in the firm's assets, cashholdings and net worth. The results are summarized in the following corollary.

Corollary 4 *If the firm follows a net debt ratio target, L, as described in Proposition 3, then a negative (positive) NDR leads to smoothing of (excess volatility in) payout. Furthermore, if the firm's risky assets experience an exogenous shock of 100 ξ_t% then, after rebalancing, the firm's balance sheet variables and its payout experience a change of 100 $l\,\xi_t$% (or 100 $\xi_t/(1-L)$%. Therefore, a negative (positive) NDR mitigates (amplifies) shocks.*

The idea that leverage amplifies risk and volatility is well established. The corollary that a negative NDR dampens shocks and is conducive to payout smoothing has received less attention, possibly because the capital structure literature traditionally focussed on positive leverage only (treating cash holdings separately).

Given that a high NDR target amplifies economic shocks, it is unlikely that a traditional brick and mortar private firm follows a high target debt ratio given it implies such dramatic swings in the firm's asset base, investment, debt and payouts. Clearly, at a minimum, periods of inaction and gradual adjustments towards the target would be required to avoid that the firm engages in a hit-and-miss policy and in the process piles up adjustment costs. Gradual and partial adjustment will then inevitably create a weak link between the firm's leverage target and its actual leverage level. Alternatively, the firm allows its debt ratio freely to float as in the pecking order model, for as long as it does not deplete its debt capacity and retains sufficient financial slack.

7 Conclusions

Our analysis allows us to classify firms into four different types. Firms adopting (1) a significantly positive NDR target, or (2) a signficantly negative NDR target, (3) firms with an NDR target around zero, and (4) firms following a (strict) pecking order of financing. These financing policies have different implications for the firm's payout and investment policies.

Firms with a significantly positive NDR target

We show that a positive NDR target L amplifies the effect of shocks in net income and assets in place because the firm rebalances its assets and liabilities in response to these shocks. A fraction L of the total changes in risky assets must be absorbed by changes in net debt. For the firm to be able to track closely its NDR target we expect it to have one or more of the following characteristics. First, one would expect low volatility of net income and assets in place to avoid frequent significant rebalancing. This may also imply a low degree of asymmetric information with respect to the value of assets in place. Income should not only be stable, but also sufficiently high for the firm to benefit from the debt taxshield. Second, the firm should have easy access to capital markets (e.g.

public firms) in order to keep the costs of rebalancing its capital structure low. Third, the firm's risky assets are sufficiently liquid to allow for asset sales (when needed) or highly tangible to serve as collateral for the debt.

Few types of firms may be able to handle and track a high NDR target. A mature industry with stable income such as the tobacco production industry may be a good candidate. DeAngelo & Roll (2015) show less than 0.5% of firms in their 1958 - 2008 sample maintain a leverage ratio above 50%. Their sample only includes industrial firms and excludes utilities and financial firms. Banks are one example of firms that can maintain a very high NDR. Banks can relatively easily rebalance their assets and liabilities in response to economic shocks. Barring periods of financial crises, banks normally have easy access to borrowing through money markets, and can securitize and sell off their assets (loans).

High leverage can, however, lead to volatile net income making payout smoothing very challenging. Payout smoothing can to some degree be achieved through a pro-cyclical investment policy that acts as a partial shock absorber. As costs of rebalancing of the firm's assets and liabilities increase, and as income and asset volatility increase, it may become prohibitively expensive for a firm to follow a high NDR target at all times. Instead, partial and gradual adjustment towards a positive NDR target or "debt smoothing" may be optimal. We showed that a modest degree of debt smoothing also enhances payout smoothing. Partial or gradual adjustment of debt allows for limited deviations from the NDR target and appears to be the most plausible strategy of implementing a positive NDR target combined with payout smoothing.

Firms with an NDR target around zero

Firms with an NDR target around zero, finance investment and payout through retained income (or the rare equity issue). Payout smoothing can be achieved through a pro-cyclical investment policy, or more effectively by allowing the NDR to fluctuate around the target. We would expect a large category of relatively mature, stable firms with few or modest investment opportunities to have an NDR target around zero. According to Bates, Kahle & Stulz (2009) the median and mean NDR of Compustate firms is 1.5% and -1%, respectively, in 2006.[22]

Firms with a significantly negative NDR target

We show that a very negative NDR is less likely to be optimal as it implies financing and investment behaviors that are hard to reconcile with empirical observations. A negative NDR target requires increases in the firm's risky assets to coincide with a reduction in the firm's net debt (i.e. an increase in the firm's net cashholding). Unless the firm internally generates high levels of net income this would require frequent asset sales or equity issues. Strebulaev & Yang (2013), examining the likelihood of a firm having zero leverage, find that firms having higher asset sales and CAPEX are more likely to be zero leverage firms. The combination of asset sales and zero leverage is quite striking considering these firms are sitting on high levels of cash and could finance investment internally if they were willing to raise or relinquish the negative NDR target. Empirical studies suggest that firms with a very negative NDR are rare though. Furthermore, Minton & Wruck (2001) find that these financially conservative firms follow a pecking order style financing policy.[23]

Firms following a (strict) pecking order of financing

The strict pecking order model does not impose a link or constraint between assets and liabilities provided that the firm has not reached its debt capacity. Instead the change in net debt acts as a shock absorber that allows firms to smooth payout and to implement a preferred investment policy. This means that the NDR is allowed to float freely in

[22] In the sample period from 1980 to 2006, the median and mean NDR of the sample is 17.8% and 16.4%, respectively, in 1980. The NDR continues to falll and turns negative in 2004.

[23] The median and mean NDR of all Compustat firms in Bates et al. (2009) suggest that the number of firms adopting a very negative NDR should be small, even though the NDR has been declining over time. Strebulaev & Yang (2013) find that the mean NDR of zero-leverage firms is -33%, while the ratio for control firms is -0.5%. Minton & Wruck (2001) find that firms for which leverage is in the bottom 20% of the sample have a mean NDR of -17.72% whereas control firms have a mean NDR of 24.18%. They find that these financially conservative firms follow a pecking order style financing policy. These firms drop the conservative NDR policy and raise leverage when faced with large discretionary outlays. Furthermore, low leverage firms are net repurchasers of equity while the control firms are net issuers.

response to economic shocks. The NDR of firms accumulating surpluses (deficits) will decrease over time. We predict that pecking order financing is optimal for firms that have not yet reached a stationary state, such as young, private firms that are still heavily investing, hereby increasing debt and the NDR over time. Conversely, firms that only recently reached maturity are also candidates for pecking order financing. Having built up a lot of debt over time these firms may now gradually pay down debt and reduce the NDR by a long string of surpluses till the firm has reached a steady state and an NDR target that is manageable and optimally trades off the long run benefits and costs of debt. It is therefore conceivable that firms switch between capital structure models during their life-cycle.

We show that pecking order financing can easily be squared with dividend smoothing as shocks to assets in place do not (directly) affect payout. A high degree of dividend smoothing or zero dividends generate a strongly negative relation between net income and changes in net debt.

References

Acharya, V. V., H. Almeida, and M. Campello (2007): "Is cash negative debt? A hedging perspective on corporate financial policies," *Journal of Financial Intermediation*, 16(4), 515–554.

Acharya, V. V., and B. M. Lambrecht (2015): "A theory of income smoothing when insiders know more than outsiders," *Review of Financial Studies*, 28(9), 2534–2574.

Allen, F., and R. Michaely (2003): "Payout policy," in *Handbook of the Economics of Finance*, vol. 1, pp. 337–430. Elsevier Science B.V.

Ambarish, R., K. John, and J. Williams (1987): "Efficient signalling with dividends and investments," *Journal of Finance*, 42(2), 321–343.

Antill, S., and S. R. Grenadier (2019): "Optimal capital structure and bankruptcy choice: Dynamic bargaining versus liquidation," *Journal of Financial Economics*, 133(1), 198–224.

Bates, T. W., K. M. Kahle, and R. M. Stulz (2009): "Why do U.S. firms hold so much more cash than they used to?," *Journal of Finance*, 64(5), 1985–2021.

Bhattacharya, S. (1979): "Imperfect information, dividend policy, and "the bird in the hand" fallacy," *The Bell Journal of Economics*, 10(1), 259–270.

Bolton, P., H. Chen, and N. Wang (2011): "A unified theory of Tobin's q, corporate investment, financing, and risk management," *Journal of Finance*, 66(5), 1545–1578.

——— (2013): "Market timing, investment, and risk management," *Journal of Financial Economics*, 109(1), 40–62.

Bolton, P., N. Wang, and J. Yang (2019): "Investment under uncertainty with financial constraints," *Journal of Economic Theory*, 184, 104912.

Brav, A., J. R. Graham, C. R. Harvey, and R. Michaely (2005): "Payout policy in the 21st century," *Journal of Financial Economics*, 77(3), 483–528.

Brav, O. (2009): "Access to capital, capital structure, and the funding of the firm," *Journal of Finance*, 64(1), 263–308.

Brennan, M. J. (1970): "Taxes, market valuation and corporate financial policy," *National Tax Journal*, 23(4), 417–427.

Brennan, M. J., and E. S. Schwartz (1985): "Evaluating natural resource investments," *Journal of Business*, 58(2), 135–157.

Brennan, M. J., and A. V. Thakor (1990): "Shareholder preferences and dividend policy," *Journal of Finance*, 45(4), 993–1018.

Campello, M., and D. Hackbarth (2012): "The firm-level credit multiplier," *Journal of Financial Intermediation*, 21(3), 446–472.

Chang, X., S. Dasgupta, G. Wong, and J. Yao (2014): "Cash-flow sensitivities and the allocation of internal cash flow," *Review of Financial Studies*, 27(12), 3628–3657.

Chen, H., J. Miao, and N. Wang (2010): "Entrepreneurial finance and nondiversifiable risk," *Review of Financial Studies*, 23(12), 4348–4388.

Chen, S., and B. M. Lambrecht (2021): "The dynamics of financial policies and group decisions in private firms," Working paper, University of Cambridge.

Childs, P. D., D. C. Mauer, and S. H. Ott (2005): "Interactions of corporate financing and investment decisions: The effects of agency conflicts," *Journal of Financial Economics*, 76(3), 667–690.

Daniel, N. D., D. J. Denis, and L. Naveen (2017): "How do firms use their financial flexibility," Working paper, Temple University.

Dasgupta, S., T. H. Noe, and Z. Wang (2011): "Where did all the dollars go? The effect of cash flows on capital and asset structure," *Journal of Financial and Quantitative Analysis*, 46(5), 1259–1294.

DeAngelo, H., L. DeAngelo, and D. J. Skinner (2008): "Corporate payout policy," *Foundations and Trends in Finance*, 3, 95–287.

DeAngelo, H., L. DeAngelo, and T. Whited (2011): "Capital structure dynamics and transitory debt," *Journal of Financial Economics*, 99(2), 235–261.

DeAngelo, H., and R. Roll (2015): "How stable are corporate capital structures?," *Journal of Finance*, 70(1), 373–418.

Demarzo, P. M., and Y. Sannikov (2017): "Learning, termination, and payout policy in dynamic incentive contracts," *Review of Economic Studies*, 84(1), 182–236.

Dotan, A., and S. A. Ravid (1985): "On the interaction of real and financial decisions of the firm under uncertainty," *Journal of Finance*, 40(2), 501–517.

Décamps, J.-P., S. Gryglewicz, E. Morellec, and S. Villeneuve (2016): "Corporate policies with permanent and transitory shocks," *Review of Financial Studies*, 30(1), 162–210.

Fama, E. F., and K. R. French (2002): "Testing trade-off and pecking order predictions about dividends and debt," *Review of Financial Studies*, 15(1), 1–33.

Farre-Mensa, J., R. Michaely, and M. Schmalz (2014): "Payout policy," *Annual Review of Financial Economics*, 6(1), 75–134.

Faulkender, M., M. J. Flannery, K. W. Hankins, and J. M. Smith (2012): "Cash flows and leverage adjustments," *Journal of Financial Economics*, 103(3), 632–646.

Flannery, M. J., and K. P. Rangan (2006): "Partial adjustment toward target capital structures," *Journal of Financial Economics*, 79(3), 469–506.

Frank, M. Z., and V. K. Goyal (2003): "Testing the pecking order theory of capital structure," *Journal of Financial Economics*, 67(2), 217–248.

Gamba, A., and A. Triantis (2008): "The value of financial flexibility," *Journal of Finance*, 63(5), 2263–2296.

Gao, H., J. Harford, and K. Li (2013): "Determinants of corporate cash policy: Insights from private firms," *Journal of Financial Economics*, 109(3), 623–639.

Gatchev, V. A., T. Pulvino, and V. Tarhan (2010): "The interdependent and intertemporal nature of financial decisions: An application to cash flow sensitivities," *Journal of Finance*, 65(2), 725–763.

Graham, J. R., and C. R. Harvey (2001): "The theory and practice of corporate finance: Evidence from the field," *Journal of Financial Economics*, 60(2), 187–243.

Graham, J. R., and M. T. Leary (2011): "A review of empirical capital structure research and directions for the future," *Annual Review of Financial Economics*, 3(1), 309–345.

Gryglewicz, S. (2011): “A theory of corporate financial decisions with liquidity and solvency concerns,” *Journal of Financial Economics*, 99(2), 365–384.

Guttman, I., O. Kadan, and E. Kandel (2010): “Dividend stickiness and strategic pooling,” *Review of Financial Studies*, 23(12), 4455–4495.

Hackbarth, D., C. A. Hennessy, and H. E. Leland (2007): “Can the trade-off theory explain debt structure?,” *Review of Financial Studies*, 20(5), 1389–1428.

Hackbarth, D., and D. C. Mauer (2012): “Optimal priority structure, capital structure, and investment,” *Review of Financial Studies*, 25(3), 747–796.

Hennessy, C. A., and T. M. Whited (2005): “Debt dynamics,” *Journal of Finance*, 60(3), 1129–1164.

——— (2007): “How costly is external financing? Evidence from a structural estimation,” *Journal of Finance*, 62(4), 1705–1745.

Hoang, E. C., and I. Hoxha (2016): “Corporate payout smoothing: A variance decomposition approach,” *Journal of Empirical Finance*, 35, 1–13.

Hovakimian, A., T. Opler, and S. Titman (2001): “The debt-equity choice,” *Journal of Financial and Quantitative Analysis*, 36(1), 1–24.

Huang, R., and J. R. Ritter (2009): “Testing theories of capital structure and estimating the speed of adjustment,” *Journal of Financial and Quantitative Analysis*, 44(2), 237–271.

Jensen, M. C., and W. Meckling (1976): “Theory of the firm: Managerial behavior, agency costs and ownership structure,” *Journal of Financial Economics*, 3(4), 305–360.

John, K., and D. C. Nachman (1985): “Risky debt, investment incentives, and reputation in a sequential equilibrium,” *Journal of Finance*, 40(3), 863–878.

John, K., and J. Williams (1985): “Dividends, dilution, and taxes: A signaling equilibrium,” *Journal of Finance*, 40(4), 1053–1070.

Kalay, A., and M. Lemmon (2007): "Payout policy," in *Handbook of Corporate Finance: Empirical Corporate Finance*, vol. 1. Elsevier B.V.

Kraus, A., and R. H. Litzenberger (1973): "A state-preference model of optimal financial leverage," *Journal of Finance*, 28(4), 911–922.

Kumar, P. (1988): "Shareholder-manager conflict and the information content of dividends," *Review of Financial Studies*, 1(2), 111–136.

Lambrecht, B. M., and S. C. Myers (2012): "A Lintner model of payout and managerial rents," *Journal of Finance*, 67(5), 1761–1810.

——— (2016): "Agency dynamics in corporate finance," *Annual Review of Financial Economics*, 8(1), 53–80.

——— (2017): "The dynamics of investment, payout and debt," *Review of Financial Studies*, 30(11), 3759–3800.

Lambrecht, B. M., and G. Pawlina (2013): "A theory of net debt and transferable human capital," *Review of Finance*, 17(1), 321–368.

Leary, M., and M. Roberts (2005): "Do firms rebalance their capital structures?," *Journal of Finance*, 60(6), 2575–2619.

Leary, M. T., and R. Michaely (2011): "Determinants of dividend smoothing: Empirical evidence," *Review of Financial Studies*, 24(10), 3197–3249.

Leary, M. T., and M. R. Roberts (2010): "The pecking order, debt capacity, and information asymmetry," *Journal of Financial Economics*, 95(3), 332–355.

Lemmon, M. L., and J. F. Zender (2010): "Debt capacity and tests of capital structure theories," *Journal of Financial and Quantitative Analysis*, 45(5), 1161–1187.

Lewellen, J., and K. Lewellen (2016): "Investment and cash flow: New evidence," *Journal of Financial and Quantitative Analysis*, 51(4), 1135–1164.

Lintner, J. (1956): "Distribution of incomes of corporations among dividends, retained earnings, and taxes," *American Economic Review*, 46(2), 97–113.

Mauer, D. C., and A. Triantis (1994): "Interactions of corporate financing and investment decisions: A dynamic Framework," *Journal of Finance*, 49(4), 1253–1277.

McDonald, R. L., and D. Siegel (1986): "The value of waiting to invest," *Quarterly Journal of Economics*, 101(4), 707–727.

Mello, A. S., and J. E. Parsons (1992): "Measuring the agency cost of debt," *Journal of Finance*, 47(5), 1887–1904.

Merton, R. C. (1969): "Lifetime portfolio selection under uncertainty: The continuous-time case," *The Review of Economics and Statistics*, 51(3), 247–257.

Michaely, R., and M. R. Roberts (2012): "Corporate dividend policies: Lessons from private firms," *Review of Financial Studies*, 25(3), 711–746.

Miller, M. H., and K. Rock (1985): "Dividend policy under asymmetric information," *Journal of Finance*, 40(4), 1031–1051.

Minton, B. A., and K. Wruck (2011): "Financial conservatism: Evidence on capital structure from low leverage firms," Working paper, Ohio State University.

Morellec, E., and N. Schürhoff (2010): "Dynamic investment and financing under personal taxation," *Review of Financial Studies*, 23(1), 101–146.

——— (2011): "Corporate investment and financing under asymmetric information," *Journal of Financial Economics*, 99(2), 262–288.

Morellec, E., P. Valta, and A. Zhdanov (2015): "Financing investment: The choice between bonds and bank loans," *Management Science*, 61(11), 2580–2602.

Myers, S. C. (1977): "Determinants of corporate borrowing," *Journal of Financial Economics*, 5(2), 147–176.

Myers, S. C., and N. S. Majluf (1984): "Corporate financing and investment decisions when firms have information that investors do not have," *Journal of Financial Economics*, 13(2), 187–221.

Opler, T., L. Pinkowitz, R. Stulz, and R. Williamson (1999): "The determinants and implications of corporate cash holdings," *Journal of Financial Economics*, 52(1), 3–46.

Öztekin, Ö., and M. J. Flannery (2012): "Institutional determinants of capital structure adjustment speeds," *Journal of Financial Economics*, 103(1), 88–112.

Parsons, C., and S. Titman (2009): "Empirical capital structure: A review," *Foundations and Trends in Finance*, 3, 1–87.

Robichek, A. A., and S. C. Myers (1966): "Problems in the theory of optimal capital structure," *Journal of Financial and Quantitative Analysis*, 1(2), 1–35.

Sannikov, Y. (2013): "Contracts: The theory of dynamic principal-agent relationships and the continuous-time approach," in *Advances in Economics and Econometrics*, pp. 89–124. Cambridge University Press.

Sarig, O. (2004): "A time-series analysis of corporate payout policies," *Review of Finance*, 8(4), 515–536.

Shyam-Sunder, L., and S. C. Myers (1999): "Testing static tradeoff against pecking order models of capital structure," *Journal of Financial Economics*, 51(2), 219–244.

Skinner, D. (2008): "The evolving relation between earnings, dividends, and stock repurchases," *Journal of Financial Economics*, 87(3), 582–609.

Strebulaev, I. A., and T. M. Whited (2012): "Dynamic models and structural estimation in corporate finance," *Foundations and Trends in Finance*, 6, 1–163.

Strebulaev, I. A., and B. Yang (2013): "The mystery of zero-leverage firms," *Journal of Financial Economics*, 109(1), 1–23.

Strebulaev, I. A., H. Zhu, and P. Zryumov (2016): "Optimal issuance under information asymmetry and accumulation of cash flows," Working paper, SSRN.

Sundaresan, S. (2013): "A review of Merton's model of the firm's capital structure with its wide applications," *Annual Review of Financial Economics*, 5(1), 21–41.

Sundaresan, S., and N. Wang (2007): "Investment under uncertainty with strategic debt service," *American Economic Review*, 97(2), 256–261.

Williams, J. (1988): "Efficient signalling with dividends, investment, and stock repurchases," *Journal of Finance*, 43(3), 737–747.