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Why Do Firms Repurchase their Shares when They are Overpriced?

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Why Do Firms Repurchase their Shares when They are Overpriced?*

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Abstract

Firms are commonly assumed to engage in repurchase programs in order to take advantage of mispricing and buy their shares when they are underpriced. However, recent empirical evidence indicates these programs are often executed when shares are overpriced. We characterize the situations in which repurchase of overpriced shares is likely to occur and show it can actually be value enhancing. In the model, informed insiders trade-off private benefits from free cash waste against common benefits from waste prevention. Since private benefits from waste are negatively related to governance quality, our findings highlight the importance of having good governance in place when boards approve repurchase programs.

JEL Classifications: G14, G30, G35

Keywords: payout policy; stock repurchases; informed trade; agency costs of free cash, corporate governance.

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1 Introduction

During the height of the COVID-19 pandemic, the Federal Reserve placed restrictions on large banks' dividends and share repurchases. These restrictions were intended to enhance banks' resiliency by bolstering their capital considering the uncertain economic environment and concerns that banks might face large losses should bad-case scenarios materialize. When it became clear that the outlook had improved and that the losses banks experienced were unlikely to threaten their stability, the Federal Reserve Removed this restriction.

While the Federal Reserve treated dividends and repurchases equally in this case, there is a big difference between them: once announced dividends must be paid. Furthermore, firms that pay dividends are expected to keep dividends at least at the same level in the future. If they don't financial markets penalize them. Therefore, firms rarely reduce their dividends. In contrast, firms do not have to execute repurchase programs they announce, nor are they expected to follow up a repurchase program with subsequent programs. In other words, repurchases equip firms with great financial flexibility that dividends do not share. This flexibility is important for all firms facing uncertainty about their cash flows but is particularly important for banks. This is, in turn, because banks have capital requirements they have to follow, while most other firms do not. In this paper we build on the financial flexibility of repurchase programs.

Repurchase activity is currently at record levels. S&P 500 companies plowed $940 billion into buying their own shares in 2025, up 19% from 2023, which was also a record year.[1] Firms are commonly assumed to engage in repurchase programs in order to take advantage of mispricing and buy their shares at bargain prices, if and when they become undervalued.[2] However, recent empirical evidence suggests that the execution of these programs is often performed when the stock is overvalued and does not enhance value.[3]

[1] See S&P Global, March 19, 2025.

[2] The vast majority (about 90%) of stock buybacks are performed through open-market programs. The rest are performed through tender offers and privately negotiated repurchases. See, for example, Peyer and Vermaelen 2005, and Banyi, Dyl and Kahle 2008.

[3] See Bonaime, Hankins and Jordan 2016, Edmans, Fang and Huang 2021, Moore 2022,

For example, between 2007 and 2016, GE bought back almost $44 billion of its own shares (17% of its market cap). Over the same period, its stock fell by 15%. Arguments raised in the financial press suggested that by inefficiently utilizing valuable capital to buy back stock at inflated prices, GE destroyed value for its long-term shareholders.[4] Furthermore, while program announcing firms can choose when to repurchase (execute the program), if at all, Bonaime and Kahle (2022) report that many firms now repurchase on a regular basis, implying mispricing has little if any effect on repurchase program executions. Interestingly, over the years, a higher fraction of repurchases have happened during periods of overvaluation than periods of undervaluation.[5] At the same time, many program announcing firms repurchase only a fraction of the program announced or do not repurchase at all (Stephens and Weisbach 1998).

In this paper we propose an explanation why firms repurchase their shares not only when they are undervalued, but also when they are overvalued, and characterize the situations in which this is likely to happen. We argue that repurchasing at inflated prices does not necessarily destroy value, and overall benefits the shareholders. In our approach, repurchases are a resolution of an agency problem, not another way in which it is manifested. We also offer an explanation why announced programs are not always executed.

We consider a firm that faces uncertainty about the value of its assets, and also realizes free cash. The value of free cash deteriorates if it is not disbursed to shareholders. We first assume that insider shareholders control the firm's decisions. Following a program announcement they can keep the cash, in which case part of it is wasted (e.g., on negative NPV projects) but they realize private benefits from waste, or, use the cash to repurchase stock which prevents the waste. Insiders privately observe the firm's value realization before they decide whether to execute the program. If the value realized is high, they face a tradeoff between repurchasing undervalued shares which enhances the value of their shares, and, keeping the cash where cash is wasted

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and Guest, Kothary and Venkat 2022.

[4] See Forbes May 24, 2016 "How Stock Buybacks Destroy Shareholder Value."

[5] E.g. Kahle and Stulz (2021) Figure 1. Repurchase of overvalued shares may reflect mistakes firms make, but documented tendency to repurchase regardless of mispricing, and underperformance of repurchase executions suggests it is not merely due to mistakes.

but they realize private benefits from this waste. The interesting result is that, if instead, the assets value realized is low so that the shares are overvalued, insiders may still find it optimal to repurchase if benefits from waste are low. To see this, consider an extreme example where without repurchase free cash is completely wasted but with zero private benefits from waste to insiders. In this scenario, insiders gain nothing from keeping the cash, but with repurchase, the number of shares is reduced, so that the repurchase still enhances the value of the remaining shares relative to the situation without repurchase. This is, in turn, because the exact same remaining firm value is divided into a smaller number of shares.[6]

The model generates three types of equilibria: one where firms never repurchase, another where they repurchase only when shares are undervalued, and another where firms repurchase regardless of mispricing. The resulting equilibrium depends on waste rate, benefits from waste, insider ownership, and variance of firm value.

In the model, free cash waste and insiders' benefits from this waste are two different aspects of the agency problem. The first happens simply because the cash is free. Indeed, empirical evidence suggests that the waste of free cash is industry related, often stems from natural organizational inefficiencies, conflicts of interests, and coordination problems among shareholders, tax disadvantage of holding cash and loss of investment opportunities outside the firm. This loss can be, but is not necessarily related to governance quality (Jensen 1986). The second aspect, private benefits from waste, however, is more tied to the quality of governance. Private benefits from empire building (e.g. investment in negative NPV projects) are likely lower than private benefits from perks. Moreover, Insiders/management are more likely to dare and go for the latter type of waste when governance is bad.

The model generates several novel results. First, naturally, the lower the private benefits from waste (the better the governance), the lower the motivation to waste free cash, and hence the more likely the firm to repurchase

[6] For example, suppose initial assets value is 10 and the firm also has free cash of 3, and suppose there are 10 shares outstanding. If the firm does not repurchase, the cash is lost resulting in 10 shares with the value of 1 each. But if the firm uses the cash to repurchase shares, then regardless of the repurchase price, assets value 10 ends up being owned by less than 10 shares, so each share will be worth more than 1.

shares regardless of mispricing. Similarly, higher insider ownership leads to more repurchases, and hence also to less waste of free cash. This is because the higher the insider ownership, the greater the insiders' gain from enhancing share value, while by assumption, the benefits from waste do not depend on the fraction of ownership.[7] Other things being equal, the higher the free cash waste rate, the more likely the firm is to repurchase regardless of mispricing. This happens because while more waste increases private benefits from waste, as we show, insiders' benefits from waste prevention increase with the waste rate more than their private benefits from waste.

Lastly, other things being equal, the higher the variance in firm value, the more likely is the firm to repurchase strategically (i.e., only when the shares are undervalued). This is because the higher the variance, the more overvalued are the shares when they are overvalued, and the more costly it becomes to repurchase overvalued shares. As mentioned above, there exists great variability in repurchase program completion rates. Our results imply that program completion rates will be positively related to governance quality, likelihood of free cash waste, and insider ownership, and negatively related to firm and industry risk.

For robustness, we explore different extensions. Unlike in our base case, in practice, many firms have no insider-blockholders at all, and are owned by large diversified institutional blockholders. (Amel-Zadeh, Kaspek and Schmalz, 2022). Therefore, we first consider the setting where outsiders (uninformed shareholders who do not benefit from waste) instead of insiders control the firm and make the decision whether or not to announce a repurchase program. The execution however is still left to the discretion of the insiders/managers. In a broader context, giving outsiders the control over the decision could be thought of as involvement of the board, shareholder activism, or tighter regulation of repurchases.[8] Under this alternative set up, we show that like the insiders, outsiders will always announce a program if a full repurchase equilibrium can hold (repurchase regardless of mispricing).

[7] As an insider, my private benefits from wasting company cash on an art collection for my office are independent of my ownership, but the cost to me as a shareholder from this waste increases with my ownership.

[8] In most countries, it is the board, which represents not only the insiders but also the outsider shareholders, that approves the repurchase program.

Intuitively, outsiders have no benefits from free cash waste, so if a full repurchase equilibrium dominates no announcement for insiders, then certainly it dominates no announcement for outsiders.

However, while insiders always prefer a partial repurchase equilibrium (repurchase of only undervalued shares) when it can hold, over no payout, outsiders may prefer not to announce a program even if a partial repurchase equilibrium can hold. This is because in a partial repurchase equilibrium insiders have information gains from repurchasing strategically. But their information gains are exactly outsiders' information losses, so when these losses are too high, outsiders will pass on announcing. This, in turn, implies that when outsiders are in control, given a program announcement, program executions are less strategic, and program completion rates are higher.

Next, we add dividends to the model. Following earlier literature, we assume dividends are taxed while repurchases are not, and consider the choice between them. Here too, the results depend on whether insiders or outsiders are in control. Specifically, whenever a full repurchase equilibrium can hold, that is, when given an announcement, firms repurchase regardless of mispricing, repurchases dominate dividends regardless of whether insiders or outsiders are in control. But, when given a program announcement, firms repurchase strategically (only when shares are undervalued), then a repurchase program always prevails only when insiders are in control, while outsiders favor dividends over repurchases for low dividend tax rates. This happens because under strategic repurchase while insiders have both gains from free cash waste when the firm does not repurchase and gains from repurchase of undervalued shares (adverse selection) when the firm does repurchase, outside shareholders have no benefits from waste and suffer losses from strategic repurchases. When neither repurchase equilibrium can hold, insiders will always favor no payout over dividends, while outsiders will favor dividends for low and moderate dividend tax rates and will prefer no payout only for high dividend tax rates. This happens similarly because with no payout insiders have benefits from waste while outsiders do not.

The dramatic growth in repurchase activity has not passed without notice. Recently it has fueled criticism that firms repurchase their shares to boost EPS and offset dilution from stock and options compensation. The objection to buybacks increased after firms received ample financial support to help overcome difficulties they faced due to the COVID-19 pandemic, and instead of using it to invest and hire workforce, they used it to repurchase shares. This objection resulted in a 1% excise tax imposed on repurchases in the US, starting January 2023 (as part of the Inflation Reduction Act). We do not address these negative motivations, but rather highlight one positive property of buybacks: they help disburse free cash even when shares are overvalued. Recent data suggests the new repurchase tax did not have a significant impact on repurchase activity.[9] However, a higher tax rate may cause firms to repurchase less. If, as we argue in this paper, a strong motive for share repurchases stems from the desire to prevent the waste of free cash, then taxing buybacks at a higher rate could result in more free cash waste not more investment.[10]

Furthermore, our findings imply that repurchasing overvalued shares does not necessarily destroy value, and is beneficial to shareholders as a whole. First, it prevents the waste of free cash. Second, shareholders that end up surrendering their shares at high prices clearly benefit from it, but they could have also been long-term investors. In expectation shareholders end up with the benefit of preventing free cash waste. The remainder of this paper is organized as follows. Section 2 reviews the related literature, and section 3 presents the model. Section 4 discusses implications. Section 5 considers extensions, and section 6 concludes.

2 Related literature

In a frictionless world payout policy does not matter (Miller and Modigliani 1961). The frictions we build on in this paper, and accordingly the relevant literature are about agency problems, information asymmetry, and taxes.

Agency costs of free cash literature originates in Jensen's (1986) argument that firms waste free cash, and that debt prevents this waste by taking free cash out of the firm. Subsequent studies apply this idea to pay-

[9] E.g., Yardeni Research https://yardeni.com/charts/sp-500-dividends-buybacks/

[10] Supportive empirical evidence for this argument is given in DeAngelo 2022B, Brockman, Lee and Salas 2023, and Brockman, Guo and Lee 2023.

out policy, which like debt removes free cash (Chowdhry and Nanda 1994, Oded 2020).[11] Lambrecht and Stewart (2017) build a dynamic agency model that incorporates all three major corporate-finance decisions: investment, borrowing, and payout plus managerial compensation. They demonstrate that payout depends on cumulative retained income (net worth) and is sensitive to risk aversion. Decamps, Gryglewicz, Morellec and Villeneuve (2016) construct a dynamic model of a firm facing financing frictions and subject to transitory and permanent cash flow shocks. They show that combining permanent and transitory shocks helps explain cash holdings and payout.

Governance Quality is another aspect of the agency problem. Buffa and Nicodano (2008) focus on the wealth transfers under mispricing that open-market repurchases engender. They show outsiders are better off if insiders are allowed to freely trade their own shares, implying regulation of insider trading should be relaxed when repurchases are allowed. Huang and Thakor (2013) show that while firms are more likely to repurchase when managers and investors disagree, repurchases improve manager-shareholder agreement by filtering out investors who disagree with (optimistic) managers and thus tender their shares. Guthrie (2020) shows that in firms with poor governance, buybacks that harm shareholders occur, while in firms with good governance some value-enhancing buybacks do not occur.

Empirically, evidence suggests that governance quality is indeed positively related to dividend payouts (La Porta et al., 2000) to stock repurchases (Alzahrani and Lasfer, 2012) and to total payout (Crane, Michenaud and Weston, 2016). Lu and Skinner (2023) find that the non-committing nature (flexibility) of repurchases relative to dividends is associated with lower overall management credibility.

The asymmetric information literature suggests good firms initiate repurchases in order to distinguish themselves from bad firms (signal) or take advantage of undervaluation (Vermaelen 1981, Ofer and Thakor 1987, Kumar, Langberg, Oded and Sivaramakrishnan 2017). Bond and Zhong (2016) build a model in which firms repurchase to signal and improve the terms of subsequent IPOs.

[11] Consistent with the free cash flow hypothesis, John, Knyazeva and Knyazeva (2015) show empirically that firms with greater agency costs of free cash flow make larger payouts.

Babenko Tserlukevich and Wan (2020) provide an alternative and novel explanation why firms may repurchase over-valued shares. In their model, the main reason a repurchase of overvalued shares makes sense is that it increases the price at which some of the existing shareholders sell. In particular, if managers maximize current (rather than long-term) shareholders' wealth, and current shareholders are net sellers, then in equilibrium managers may repurchase shares even if they are overpriced.

Empirical findings of positive abnormal returns on repurchase program announcements (Vermaelen 1981, Grullon and Michaely 2002) and positive long-run return following program announcements (Ikenberry et al. 1995, Peyer and Vermaelen 2005) support the signaling motivation. Studies of later periods, however, report substantial decrease in program announcement returns (Grullon and Michaely 2004, Guest et al. 2023), and in the long-run returns following program announcements (Obernberger 2014, Fu and Huang, 2016, Lee, Park and Pearson 2020). Other papers suggest that insider purchases prior to repurchase announcements add credibility to the undervaluation signal (Babenko, Tserlukevich and Vedrashko 2012, Cziraki, Lyandres and Michaely 2021) as do high prior repurchase plan completion rates (Ota, Kawase and Lau 2019).

Recent years have witnessed increase in the use of Accelerated Share Repurchase programs (ASRs) and Rule 10-b-5 programs which commit firms to repurchase in the future, and generate higher announcement returns relative to regular programs (Michel, Oded and Shaked 2010, Bonaime et al. 2020).[12] Higher return is consistent with stronger commitment generating a stronger signal. Moreover, firms using these programs commit to repurchase regardless of the future stock price, that is, regardless of mispricing.

Studies of program executions also find repurchase of overvalued shares is common. Bonaime et al. (2016) show that actual repurchases underperform a naive repurchase strategy by 2% per year, questioning management's ability or intention to time actual repurchases. Edmans et al. (2021) and Moore

[12] Specifically, relative to open market repurchases, Rule 10b5-1 plans provide an expanded repurchase window and increased legal cover, at the cost of reducing the option to time repurchases. In an ASR the firm borrows the shares from a broker and eliminates the shares. Then it repurchases shares over time and returns them to the broker.

(2022) report price underperformance following actual repurchases.

The tax-based literature suggests that payout policy matters because payouts trigger a tax liability. Repurchases are tax-advantageous compared to dividends, which should impact the choice of payout method (Black 1976). Several models build on this tax differential to explain the choice between buybacks and dividends (e.g. Ofer and Thakor 1987, Brennan and Thakor 1990, Green and Hollifield 2003). Empirical evidence indeed suggests that the tax differential between dividends and repurchases affects payout policy (Moser 2007, Jacob and Jacob 2013, and Kahle and Stulz 2021).

Retire an expensive financing resource: Building on the idea that equity financing is expensive relative to debt (Myers and Majluf 1984), Frank and Sanati (2021) suggest repurchases serve as a tool to change the financing of the firm over its life cycle. In the early stage, firms cannot raise debt, because they do not have collateral, so they issue equity. Once they have enough collateral, they repurchase shares and substitute expensive equity with cheap debt. This approach is consistent with repurchase regardless of overpricing. Supportive evidence that funding concerns determine payout policies is in DeAngelo, DeAngelo and Skinner (2009) and DeAngelo (2022A).[13]

Behavioral aspects also affect financial policy. For example, managerial overconfidence has been shown to affect investment policy (Andreou, Doukas, Koursaros and Louca, 2019) and repurchase policy (Andreou, Cooper, de Olalla Lopez and Louca, 2018). In particular Andreou at al. (2018) show that long-run abnormal returns following share repurchase announcements are substantially lower when CEOs are overconfident, consistent with stock mispricing being a motive for buybacks. Banerjee, Humphery-Jenner and Nanda (2018) also show that program announcement returns are lower when managers are overconfident. Andriosupoulos, Andriosopoulos and Hoque (2013) show that repurchase program completion rates are positively related to managerial overconfidence.

[13] Other motivations for buybacks suggested in the literature, that we do not build on but are consistent with the repurchase of overvalued shares, include EPS enhancement (Cheng, Harford and Zhang 2015, Almeida, Fos and Kronlund, 2016), and enhancing the value and supporting the sale price of executive equity compensation (Kahle 2002, Babenko 2009, Edmans, Fang and Huang 2021).

3 The model

We consider an all-equity financed and financially constrained firm. There are three dates indexed by t_i, where $i \in \{0, 1, 2\}$. All agents are risk neutral, the interest rate is zero, and there are no taxes or transaction costs. At t_0 the firm's only asset is an investment it makes of $I = 1$. The return on this investment is uncertain at t_0. At t_1, the investment generates assets with value $X \in \{H, L\}$ with equal probability (henceforth, states H and L), where $H = \alpha + \sigma$ and $L = \alpha - \sigma$. We further assume $0 < \sigma < \alpha - 1$ so that $1 < L < H$, and hence also the expected value $E[X] = (H + L)/2 = \alpha > 1$. In addition, in both states the investment generates free cash flow c, where $0 < c < 1$. At t_2, funds that were invested at t_0 deliver returns according to the state realized at t_1 and the payout policy.

For simplicity, we normalize the initial number of shares outstanding to 1. A fraction β of the shares is held by insiders, where $0 < \beta < 1$, and the rest is held by outside shareholders. The insiders control the firm and hire a manager who makes decisions that maximize insiders' wealth.[14] (In section 5 we consider the case where outsider shareholders are in control.)

Information is symmetric at t_0, but at t_1 the realization of value of assets in place (H or L) is observed by the insiders only. At t_2 all information is public, the firm is dismantled, and shareholders are paid in proportion to their ownership.

Agency costs of free cash – Free cash realized at t_1 and not disbursed to shareholders at t_1 deteriorates (gets wasted) between t_1 and t_2. The retention rate is $0 \leq \delta \leq 1$, where when $\delta = 0$ all free cash is wasted, and when $\delta = 1$ no cash is wasted. The free cash waste rate is thus $1 - \delta$. The insiders realize private benefits of γ on every dollar they waste, where $0 \leq \gamma \leq 1$. The waste of free cash is costly to all shareholders, but benefits accrue only to insiders. We assume insiders cannot prevent waste of free cash,[15] and cannot waste

[14] See Maug (1998) for justification of why insiders can control the firm even when β is small, in particular, even if $\beta < 0.5$.

[15] This could be due to coordination problems, or "a prisoners dilemma" where each insider has an incentive to deviate from the insiders' social optimum and waste the free cash. Other reasons for no control over free cash waste include pressure from employee for raises and waste by lower level management.

cash that is not free (shave investment at t_1). Presumably when the value of assets in place is realized at t_1, cash that is not free is already tied to the investment. Supportive evidence that buybacks do not hurt investment is provided in Fried and Wang (2019) and Guest et al. (2023).

Elaboration on the parameters δ and γ is warranted. As we later show, to generate repurchase of overvalued shares, introducing free cash waste δ alone is not enough, and introducing a limit on benefits from waste ($\gamma < 1$), is also required. Both δ and γ are given exogenously and capture two different dimensions of the agency problem. The parameter δ reflects mostly loss caused by objective inefficiencies, related to nature of industry and projects (see Jensen 1986), tax disadvantage of holding cash, and loss of outside investment opportunity, as discussed in the introduction. In contrast, we interpret γ, as a quality-of-governance parameter. When governance is good, insiders are able to waste free cash only on things that look like they are good for the firm (i.e., "empire building"), and they receive little private benefits, but when governance is poor, insiders are able to spend directly on things they benefit from the most (e.g., perks). For example, when the loss $1 - \delta$ reflects investment in negative NPV (bad) projects because the firm had free cash and was tempted to overinvest, or hire redundant employees, then insiders' benefits from waste γ are likely low. But if they can spend excess cash on art collections or private jets, then their private benefits from waste are likely higher. It is easier to present empire building activities as necessary expenses than to do so with perks. Better governance thus (e.g. through more monitoring) makes it harder for insiders to choose wasting activities yielding considerable private benefits. In sum, waste activities with high γ are by nature less relevant to enhancement of firm value, and hence we associate better governance with lower γ. We acknowledge that governance quality may also affect the waste rate δ, but suggest it is mostly reflected through benefits from waste γ.[16] We also acknowledge that private benefits from waste can serve as a valuable tool to motivate managers and align

[16] On the association between governance quality and waste, see, for example, Shleifer and Vishny (1997). Benefits from waste of free cash need not result from insiders actively wasting the cash, but can rather stem from passive management due to the availability of free cash, as in "quiet life" models (Bertrand and Mullainathan 2003).

their interests with value creation (e.g., Rajan and Wulf, 2006; Marino and Zabojnik, 2008). We therefore view δC as the erosion of cash *net* of value enhancement from incentives to managers that their private benefits from waste engender.

Trade – At t_1 a subset of the *outside* shareholders face an uninsurable liquidity shock and must sell a portion q of their shares, where $q < 1 - \beta$. Insiders, cannot trade *their own* shares in the market at t_1, however.[17] As outsiders today tend to be well diversified (e.g. large institutional blockholders), imposing liquidity constraints on them should be justified. We suggest even large outside investors have significant liquidity needs. For example, many are passive funds that are forced to sell when net flows are negative. In fact, even active funds have holding constrains they commit to in their declared investment policy, that engender liquidity needs. As discussed in the introduction, such passive and active funds are often in control (Apple Gormley and Keim, 2016, and Albuquerque, Fos and Schroth, 2021).

There is a market for the stock in which a market maker sets the price p before investors place their quantity bids (anticipating the possibility of informed trade from the firm side) to earn zero expected profit.[18] We will generally omit the time index for t_1, as most of the action happens on this date. We acknowledge standard liquidity constraints are about demand for liquid wealth not quantity, we do this for tractability in order to focus on the nonlinear impact of the repurchase trade. The qualitative results are similar: the informed firm gains at the expense of liquidity sellers, while the market maker, by construction, breaks even. While often liquidity de-

[17]That is, like most repurchase models, we assume insiders do not trade for their own portfolio based on private information. While in practice such trade exists, restriction are in place. In the US, SEC Rule 10b-5 requires insiders, including the firm and its officers, to refrain from trading in the firm's shares while in possession of "material" non-public information regarding their value.
Repurchases thus result in increased insider ownership which gives them benefits from increased control that we abstract from in this model and counter benefits from waste γ. We can instead think of γ as benefits from waste net of these benefits from repurchase.
The restriction on liquidity trade $q < (1 - \beta)$ is made without loss of generality, and limits the discussion to the feasible range of the results.

[18]Prices are thus independent of the order flow as in Glosten and Milgrom (1985), Rock (1986), Noe (2002), and Oded (2005). We focus on t_1 because this is when the repurchase takes place, but it could be assumed that the market opens also at t_0 and t_2.

mand is for a cash amount, not a number of shares (e.g. for an investment as in Nachman and Noe ,1994, or Duffie and DeMarso, 1999), in practice, when firms/investors come to satisfy this demand, they bid quantity (limit or market)- not cash value. Hence, also in practice, they never know ex-ante how much wealth they will liquidate. Figure 1 describes the time line.

Repurchase Policy – At t_0 the insider shareholders can 1) approve (announce) an open-market stock repurchase program; or 2) do nothing. An open-market program announcement authorizes but does not commit the insiders to buy back shares at t_1, where we assume the firm can use only free cash c to repurchase shares. We also assume that $\frac{c}{\alpha-\sigma} < q$.[19] Execution of the program takes place at the manager's discretion, and is not contractible. Information as to whether the firm repurchased or not becomes public only at t_2.[20] Without loss of generality, we assume that insider shareholders (manager) will not announce a program whenever they are indifferent and that if they announce a repurchase program, they will repurchase rather than waste free cash whenever they are indifferent.

Definition 1 *Equilibrium is a set consisting of 1) a repurchase policy set by the inside shareholders that specifies an open-market program announcement, or not; 2) a price p set by the market maker, given the repurchase policy; and 3) a repurchase program execution strategy set by the insiders if the payout policy is an open-market program, given p and the state realized (L or H), such that the market maker makes zero expected profit and the insiders maximize their expected wealth, given the information they have.*

We first note that at t_0 when the insiders determine the repurchase policy (announce a repurchase program or not) they do so before knowing the realized value of assets in place. Therefore, the repurchase announcement in our model has no signaling effect. An open-market program announcement at

[19] The assumption $\frac{c}{\alpha-\sigma} < q$ assures repurchase is always less than the liquidity trade; It is consistent with trade limitations in Rule 10b-5 (regulation of repurchase programs).

[20] In the US, there is no reporting requirement on actual repurchases other than in the financial statements. The regulation of actual repurchases in other countries is more restrictive. Generally firms cannot start a repurchase program without announcing it before hand. (In the US, this requirement comes from the exchanges.)

t_0 enables the insiders to repurchase shares at t_1 depending on the assets in place value realized and the price set by the market maker at t_1. Insiders may choose to repurchase strategically, because they are privately informed about the assets' value prospects at t_1, which in turn generates wealth transfers to the insiders at the expense of uninformed (outside) shareholders. When coming to decide whether to announce a program and/or execute it, insiders thus face a tradeoff between waste prevention and information gains, and private benefits from waste of free cash.

3.1 Equilibrium Characterization

The analysis proceeds by solving the model backward using subgame perfection as a solution concept. Assuming a repurchase announcement at t_0, and starting from t_1, equilibrium requires that the market maker sets a price that reflects the repurchase strategy, and that this repurchase strategy will be optimal for the insiders, given the price set by the market maker. We first characterize the price that the market maker will set in equilibrium at t_1, given each of the possible repurchase strategies, and consider the conditions under which the insiders will not deviate from these repurchase strategies. Then, we go back to t_0 and compare insiders' expected wealth with and without repurchase program announcement to determine when will the firm announce a program.

3.1.1 Full repurchase equilibrium (repurchase in both states H and L)

Consider the range where an equilibrium in which the firm repurchases in both states H and L, henceforth "a full repurchase equilibrium" can hold. Given a repurchase announcement at t_0, suppose that insiders' strategy at t_1 is to repurchase in both states. To earn zero expected profit, the market maker sets p such that

$$0 = \frac{1}{2}\left[\left(q - \frac{c}{p}\right)\left(\frac{H}{1-\frac{c}{p}} - p\right) + \left(q - \frac{c}{p}\right)\left(\frac{L}{1-\frac{c}{p}} - p\right)\right] \qquad (1)$$

which we can rearrange to

$$p_f = \alpha + c. \tag{2}$$

where p_f denotes the price set by the market maker assuming repurchase in both states (i.e., in a full repurchase equilibrium).

For repurchase in both states to be the equilibrium outcome, the insiders must be better off with repurchase in *each* of the states, separately. Given the market maker price p, insiders will repurchase in state $X \in \{L, H\}$ at t_1 only if

$$\beta (X + \delta c) + (1 - \delta) c\gamma < \beta \frac{X}{1 - \frac{c}{p}}$$

which we can rearrange to

$$\beta\delta + (1 - \delta)\gamma < \frac{\beta X}{p - c} \tag{3}$$

By inspection, condition (3) suggests that if the firm (insiders) repurchases in state L, it will always repurchase in state H since $L < H$. Hence, the condition for repurchase in both states is dictated by state L only, and is

$$\beta\delta + (1 - \delta)\gamma < \beta \frac{L}{p_f - c}$$

which upon substitution of $L = \alpha - \sigma$ we can rearrange to

$$p_f < \frac{\beta(\alpha - \sigma)}{\beta\delta + (1 - \delta)\gamma} + c. \tag{4}$$

Upon substitution of $p_f = \alpha + c$ we can rearrange this condition to

$$\gamma < \beta\left(1 - \frac{\sigma}{\alpha(1 - \delta)}\right) = \frac{\beta}{1 - \delta}\left(\frac{\alpha - \sigma}{\alpha} - \delta\right). \tag{5}$$

Special Cases Consider first the case where insiders have complete benefit from waste ($\gamma = 1$). In this case, condition (5) never holds. This case demonstrates why for a full repurchase equilibrium to hold, the variable δ (waste of free cash) alone is not enough, and $\gamma < 1$ (limit on benefits from waste) must be introduced into the model. At the other end, where insiders have no benefit from waste ($\gamma = 0$), condition (5) boils down to $\frac{\sigma}{\alpha} < (1 - \delta)$, and the relation between variance and waste dictates the outcome. Intuitively, with no benefits from waste, the tension between variance (mispricing in state L) and free cash loss determines whether a full repurchase equilibrium can hold.

Next consider the case where no cash is wasted ($\delta = 1$). In this case, the condition for repurchase in state L (4) boils down to $\sigma < 0$, which never holds.[21] Intuitively, without waste insiders have no benefits from waste, but they will reduce the value of their shares if they repurchase in state L at the market price $p_f = \alpha + c > L = \alpha - \sigma$. Lastly, in the case where all cash is wasted ($\delta = 0$) the condition for repurchase in state L (5) boils down to $\gamma < \beta\left(1 - \frac{\sigma}{\alpha}\right)$. That is, for a full repurchase equilibrium to hold, benefit from waste γ must be low enough, and variance $\frac{\sigma}{\alpha}$ should also be small. Intuitively, the higher the variance, the lower the value in state L. When this value is low enough, insiders are better off wasting the cash than repurchasing at p_f. At the same time, for this condition to hold, insiders' ownership β should not be too small relative to their benefit from waste γ. This is because for insiders to repurchase, the share price enhancement through repurchase should have sufficient impact on their wealth relative to their benefits from waste.

Repurchase of overvalued shares in a full repurchase equilibrium

Definition 2 *Define the repurchase of overvalued shares as the situation where the firm repurchases its shares when the predicted post-repurchase price is lower than the repurchase price, that is,* $p > p_{2|R}$.

Proposition 1 *An equilibrium in which the firm repurchases in both states (a full repurchase equilibrium) involves repurchase of overvalued shares.*

All proofs are relegated to the Appendix.

3.1.2 Equilibrium with no repurchase

As in the case of repurchase in both states, starting from t_1, given a repurchase announcement at t_0, suppose that insiders' strategy at t_1 is to never

[21] We use Condition (4) here, because Condition (5) is undefined for $\delta = 1$.

repurchase (this is essentially also their only possible strategy without a program announcement at t_0). To earn zero expected profit, the market maker will set the t_1 price assuming the firm never repurchases as follows:

$$0 = \frac{1}{2}\left(q\left[H + \delta c - p\right] + q\left[L + \delta c - p\right]\right). \tag{6}$$

which upon substitution of $H = \alpha + \sigma$ and $L = \alpha - \sigma$ boils down to

$$p_n = \alpha + \delta c \tag{7}$$

where p_n denotes the price set by the market maker assuming no repurchase in either state (i.e., in a no-repurchase equilibrium).

Using reasoning similar to that used in the case of repurchase in both states, for the firm not to repurchase in state X we must have

$$\beta \frac{X}{1 - \frac{c}{p}} < \beta\left(X + \delta c\right) + \left(1 - \delta\right) c\gamma$$

and upon rearrangement

$$\beta \frac{X}{p - c} < \beta\delta + \left(1 - \delta\right)\gamma. \tag{8}$$

Since $L < H$, now the H state is binding. Accordingly, no-repurchase in both states requires

$$\beta \frac{H}{p - c} < \beta\delta + \left(1 - \delta\right)\gamma.$$

Upon substitution of $H = \alpha + \sigma$ we can rearrange this to

$$\frac{\beta\left(\alpha + \sigma\right)}{\beta\delta + \left(1 - \delta\right)\gamma} + c < p_n. \tag{9}$$

Upon substitution of $p_n = \alpha + \delta c$, we can rearrange the condition for no repurchase relative to γ as

$$\beta\left(1 + \frac{\sigma + c\left(1 - \delta\right)}{\left[\alpha - c\left(1 - \delta\right)\right]\left(1 - \delta\right)}\right) \equiv \gamma_n < \gamma. \tag{10}$$

We can recap the analysis of full repurchase and no repurchase so far as follows. In the range (5), if the firm announces and the market maker sets the price to $p = p_f = \alpha + c$, the firm (insiders) will repurchase in both states L and H, so that a full repurchase equilibrium may exist. In the range (10), if the firm announces and the market maker assumes no repurchase and sets the market price to $p = p_n = \alpha + \delta c$, the firm will never repurchase so that insiders will be indifferent to announcing or not and hence an equilibrium in which the firm does not announce (and hence does not repurchase) may exist.[22] In the range where neither (5) nor (10) hold

$$\beta\left(1-\frac{\sigma}{\alpha\left(1-\delta\right)}\right)<\gamma<\beta\left(1+\frac{\sigma+c\left(1-\delta\right)}{\left[\alpha-c\left(1-\delta\right)\right]\left(1-\delta\right)}\right), \tag{11}$$

given announcement, neither repurchase in both states nor no repurchase can hold. Clearly, this range on γ is non-empty, hence there is no range where given announcement, both full repurchase and no repurchase can hold.

3.1.3 Partial repurchase equilibrium (repurchase in state H only)

We now consider the range where, given announcement, an equilibrium in which the firm repurchases only in one state may hold. As we have shown above, if the firm repurchases in state L, it will always repurchase in state H. We are thus looking for an equilibrium in which the firm repurchases only in state H, henceforth "a partial repurchase equilibrium." Because the price the market maker sets assuming partial repurchase is different than the price the market maker sets in the other equilibria, a partial repurchase equilibrium may or may not exist in the range (11), or outside this range.

Given announcement at t_0, and given that at t_1 the firm repurchases only in state H, to earn zero expected profit, the market maker sets p such that

$$0=\frac{1}{2}\left[\left(q-\frac{c}{p}\right)\left(\frac{H}{1-\frac{c}{p}}-p\right)+q\left(L+\delta c-p\right)\right]. \tag{12}$$

[22] For the existence of no-repurchase equilibrium in this range we need to show (as we later do) that there does not exist an equilibrium with repurchase in one state in which the insiders gain more than without repurchase.

Upon substitution of $H = \alpha + \sigma$ and $L = \alpha - \sigma$ and rearrangement

$$0 = p^2 - \left[\alpha + c + \frac{c}{2}\left(\delta + \frac{1}{q}\right)\right] p + \left[\alpha + \sigma + (1 + q\delta) c + q(\alpha - \sigma)\right] \frac{c}{2q}$$

and solving this quadratic in p gives the price that the market maker will set assuming partial repurchase p_p:[23]

$$p_p = \frac{\Psi + \sqrt{\Psi^2 - 4\zeta}}{2} \tag{13}$$

where

$$\Psi \equiv \alpha + c + \frac{c}{2}\left(\delta + \frac{1}{q}\right)$$

and

$$\zeta \equiv \left[\alpha + \sigma + c(1 + \delta q) + q(\alpha - \sigma)\right] \frac{c}{2q}$$

As this price is much more complex than the price in the other equilibria, we are not able to characterize it in a closed form, but we can outline qualitative limitations and properties that help determine the range where a partial repurchase equilibrium will hold.

Limitations on p in a partial repurchase equilibrium For insiders not to repurchase in state L, their ending wealth with repurchase must be lower than without it, which using condition (8) we can write as

$$\beta \frac{L}{p - c} < \beta\delta + (1 - \delta)\gamma$$

which upon substitution of $L = \alpha - \sigma$ and rearrangement we can write as

$$\frac{\beta(\alpha - \sigma)}{\beta\delta + (1 - \delta)\gamma} + c < p. \tag{14}$$

[23] Under the relevant parameter range the descriminant is positive, and because we must have $p > \alpha - \sigma + \delta c$, then only the '+' solution is feasible.

For insiders to repurchase in state H we similarly need

$$\beta\delta + (1-\delta)\gamma < \beta\frac{H}{p-c}$$

which upon substitution of $H = \alpha + \sigma$ and rearrangement we can write as

$$p < \frac{\beta(\alpha+\sigma)}{\beta\delta + (1-\delta)\gamma} + c. \tag{15}$$

We can combine the conditions (14) and (15) to

$$\frac{\beta(\alpha-\sigma)}{\beta\delta + (1-\delta)\gamma} + c < p_p < \frac{\beta(\alpha+\sigma)}{\beta\delta + (1-\delta)\gamma} + c \tag{16}$$

where p_p is from (13), and further rearrange this relative to γ as

$$\frac{\beta}{1-\delta}\left(\frac{\alpha-\sigma}{p_p-c} - \delta\right) < \gamma < \frac{\beta}{1-\delta}\left(\frac{\alpha+\sigma}{p_p-c} - \delta\right). \tag{17}$$

Properties of the price p in a partial repurchase equilibrium By inspection of (13), the market price in a partial repurchase equilibrium, p_p, does not depend on γ or β.

Proposition 2 *The price that the market maker sets in a partial repurchase equilibrium, p_p, increases with δ and decreases with σ.*

Intuitively, in a partial repurchase equilibrium, p_p decreases in σ because variability in value increases the market maker's loss resulting from adverse selection. This price increases in δ because higher retention rate increases value in state L in which cash is wasted.

Lemma 1 *[**Relation between** p_p **and** p_f] Everything else being equal, the price that the market maker sets in a partial repurchase equilibrium is always lower than the price he sets in a full repurchase equilibrium, that is, $p_p < p_f$.*

Intuitively, $p_p < p_f$ because in a partial repurchase equilibrium the market maker expects both adverse selection and lower expected terminal value due to free cash waste, and hence is willing to pay less for the stock.

Lemma 2 *[**Relation between** p_p **and** p_n] Define*

$$\Omega \equiv \frac{1-\delta}{1-q}\left[(\alpha-\delta c)\,q-c\right]. \tag{18}$$

Then whenever variability $\sigma = \Omega$, the price the market maker sets in a partial repurchase equilibrium will be equal to the price he sets in a no-repurchase equilibrium, that is, $p_p = p_n = \alpha + \delta c$. If $\sigma > \Omega$ then $p_p < p_n$, and if $\sigma < \Omega$ then $p_p > p_n$.

The intuition for Lemma 2 is as follows. The higher the variance, the more the market maker is affected by the adverse selection induced as the firm repurchases strategically (only in state H). The benefit from enhancing the value through repurchase in state H, however, is fixed. When $\sigma = \Omega$ these two effects offset each other, resulting in $p_p = p_n$. For lower values, $\sigma < \Omega$, the value enhancement effect dominates and $p_p > p_n$, and for higher values $\sigma > \Omega$, the adverse selection effect dominates and $p_p < p_n$. The relation between p_p and p_n (Lemma 2) is more complex than the relation between p_p and p_f (Lemma 1). This is because adverse selection acts to lower p_p relative to p_n, but value enhancement from repurchase in state L only vs. no value enhancement from repurchase at all, acts to increase p_p relative to p_n.

Proposition 3 *In a partial repurchase equilibrium the firm never repurchases overvalued shares.*

Intuitively, in a partial repurchase equilibrium, the firm repurchases only when the value realization is high, while the repurchase price p_p is lower than the average value. Hence certainly the terminal share value is higher than p_p, which by Definition 2 is repurchase of undervalued, not overvalued, shares.

3.2 Equilibrium Existence

To determine which of the three possible equilibria will prevail and when, we need to compare insiders' expected wealth under these equilibria when they can hold. Specifically, when a full repurchase equilibrium or a partial repurchase equilibrium can hold, insiders will announce only if their expected wealth is higher with announcement than without announcement.

3.2.1 Insiders' wealth under each equilibrium

With repurchase in both states, insiders' expected wealth is

$$\frac{1}{2}\left(\beta\frac{L}{1-\frac{c}{p_f}}+\beta\frac{H}{1-\frac{c}{p_f}}\right)=\beta\frac{\alpha}{1-\frac{c}{p_f}}=\beta\alpha\frac{p_f}{p_f-c},$$

which upon substitution of $p_f=\alpha+c$ boils down to

$$\beta\left(\alpha+c\right). \tag{19}$$

Without repurchase at all, (with or without announcement) insiders' expected wealth is

$$\frac{1}{2}\left[\beta\left(L+\delta c\right)+\left(1-\delta\right)c\gamma+\beta\left(H+\delta c\right)+\left(1-\delta\right)c\gamma\right],$$

which upon substitution of $H=\alpha+\sigma$ and $L=\alpha-\sigma$ can be rearranged to

$$\beta\left(\alpha+\delta c\right)+\left(1-\delta\right)c\gamma. \tag{20}$$

With repurchase in state H only, insiders expected wealth is

$$\frac{1}{2}\left(\beta\left(L+\delta c\right)+\left(1-\delta\right)c\gamma+\beta\frac{H}{1-\frac{c}{p_p}}\right), \tag{21}$$

where p_p is from (13). Upon substitution of $H=\alpha+\sigma$ and $L=\alpha-\sigma$ this can be rearranged to

$$\beta\alpha+\frac{c}{2}\left(\beta\delta+\left(1-\delta\right)\gamma+\beta\frac{\alpha+\sigma}{p_p-c}\right) \tag{22}$$

3.2.2 Wealth Comparison

We next compare insiders' expected wealth under the three possible insider strategies: full repurchase, partial repurchase, and no repurchase in order to determine when each of the equilibria will prevail.

Wealth under full repurchase vs. no repurchase

Lemma 3 *Whenever given announcement, a full repurchase equilibrium can hold (i.e., when condition (5) holds), insiders prefer full repurchase over no announcement (no repurchase).*

We note that for γ higher than in the range given in condition (5), when

$$\beta\left(1-\frac{\sigma}{\alpha(1-\delta)}\right)<\gamma<\beta$$

a full repurchase equilibrium is better for the insiders than no repurchase, but they cannot commit to it. Hence in this range a full repurchase equilibrium cannot hold. For any higher γ, that is, in the range $\beta<\gamma$, insiders are better off with no repurchase relative to full repurchase, but given a repurchase announcement, no-repurchase equilibrium can hold only under the more restrictive condition $\gamma_n<\gamma$, where γ_n is from (10).

Wealth under full repurchase vs. partial repurchase

Lemma 4 *Whenever given announcement, a full repurchase equilibrium can hold (i.e., when condition (5) holds), a partial repurchase equilibrium cannot hold.*

Intuitively, because $p_p<p_f$ (see Lemma 1) then if the firm repurchases in both states when the price the market maker sets is p_f, it will always repurchase in both states when the market maker sets the price to p_p.

Proposition 4 ***[Existence of Full Repurchase Equilibrium]*** *In the range where condition (5) holds, and only in this range, the firm will announce a repurchase program and a full repurchase equilibrium will prevail. This is also the range where repurchase of overvalued shares can occur.*

Now, outside the range (5) we may have either a partial repurchase equilibrium or a no-repurchase equilibrium. To determine which equilibrium will prevail outside the range (5), we next compare insiders' wealth under partial repurchase equilibrium to their wealth under no repurchase.

Wealth under partial repurchase vs. no repurchase

Lemma 5 *Whenever given announcement, a partial repurchase equilibrium can hold, it is better for the insiders than no repurchase.*

While given announcement there is a range where both partial and no repurchase equilibria can hold, the firm will announce a program only if insiders' wealth is higher with a partial repurchase program. The following proposition extends over Proposition 4, to establish the existence of the three types of equilibria as a function of the benefit from waste to the manager γ.

Proposition 5 ***[Existence of Equilibria]*** *Define*

$$\gamma_1 \equiv \frac{\beta}{1-\delta}\left(\frac{\alpha-\sigma}{\alpha}-\delta\right) \tag{23}$$

$$\gamma_2 \equiv \frac{\beta}{1-\delta}\left(\frac{\alpha-\sigma}{p_p-c}-\delta\right) \tag{24}$$

$$\gamma_3 \equiv \frac{\beta}{1-\delta}\left(\frac{\alpha+\sigma}{p_p-c}-\delta\right) \tag{25}$$

Then $\gamma_1 < \gamma_2 < \gamma_3$. In the range $\gamma < \gamma_1$ the firm will announce a repurchase program and a full repurchase equilibrium will prevail. In the range $\gamma_2 < \gamma < \gamma_3$ the firm will announce a repurchase program and a partial repurchase equilibrium will prevail. In the range $\gamma > \gamma_3$ the firm will not announce.

The intuition for this proposition is as follows. γ_1 is the limit in condition (5). When $\gamma < \gamma_1$ benefits from waste are too low, so that insiders are better off with full repurchase. Next, γ_2 and γ_3 are, respectively, the lower and upper limits on γ in (17). In the range $\gamma_2 < \gamma < \gamma_3$, given announcement, a full repurchase equilibrium cannot hold, but a partial repurchase equilibrium can hold, and it gives insiders higher expected wealth than without announcement. Hence the firm will announce a program in this range and a partial repurchase equilibrium will prevail. Once $\gamma > \gamma_3$, neither a full nor a partial repurchase equilibrium can hold, and also insiders' expected wealth is higher without announcement, because their benefits from waste are high.

Hence, when $\gamma > \gamma_3$ the firm will not announce a program.[24]

Lastly, in the range $\gamma_1 < \gamma < \gamma_2$ given the price that the market maker sets assuming full repurchase p_f, the insiders are better of wasting the cash in the low state L, but under the lower price, $p_p < p_f$, insiders are better off repurchasing in state L so that neither a full nor a partial repurchase equilibrium in pure strategies can hold. Only a no-repurchase (no announcement) equilibrium in pure strategies can hold in this range. In Proposition 6 (section 5.1) we show that when we allow for mixed strategies, a partial repurchase equilibrium with mixed strategies exists in this range.

Corollary 1 *Whenever a full repurchase equilibrium or a partial repurchase equilibrium can hold, the firm will announce a repurchase program. Otherwise, the firm will not announce a program.*

In the appendix, we utilize a numerical example, to demonstrates how the existence of a repurchase equilibrium depends on the degree of cash waste $(1 - \delta)$, insiders' rate of benefit from waste γ, insider ownership β, and variability in the rate of return on investment σ.

It is possible to show that in a revised model, where insiders also face a liquidity shock, the full repurchase and partial repurchase equilibria still hold but the levels of γ_1, γ_2 and γ_3 are lower. Intuitively, this happens because when insiders also face a liquidity shock at t_1, they have less share at t_2 to benefit from value enhancement or adverse selection. Therefore, the benefits from waste where they stop repurchasing in states L and H are lower. Similarly, it is possible to show that adding a cost to announcing will result in γ_1, γ_2 and γ_3 shifting downwards. The higher the cost of announcing, the less likely are the equilibria with repurchase announcements. Intuitively, this is because this cost reduces the benefit of announcing.

Lastly, we used a market model where prices are set up-front expecting the firm's strategy. If instead, prices are based on the order flow (e.g. as in Kyle, 1985), it can be shown the results are qualitatively similar. With low enough private benefits from waste, the full repurchase equilibrium prevails.

[24] It is possible to show that, in equilibrium, when insiders repurchase, they are always better off repurchasing with all free cash c than with part of it.

The manager always repurchases with all free cash, and prices are the same as in the current model, because in the full repurchase equilibrium there is no adverse selection. With higher levels of private benefits from waste the partial repurchase equilibrium holds. Here prices will depend on the order flow: the higher the net demand, the higher the price. However, because prices here increase with the order flow, the firm will have to optimize the quantity it repurchases. Hence when it does repurchase it will not use all free cash so some cash is always wasted. When benefits from waste are high, there will be no repurchase, and prices will reflect the no-repurchase value as in the current market mechanism.

4 Implications and Empirical Predictions

As the above analysis shows, the model gives rise to three types of equilibria. One with no repurchase, where waste of free cash is high. Another with partial (strategic) execution and partial waste of free cash, and is the type of equilibrium generally considered in earlier literature. In this equilibrium the firm repurchases only when the shares are underpriced, resulting in wealth transfers from the uninformed public to informed insiders. The last equilibrium is one in which the firm always repurchases, regardless of mispricing, and program completion rates are high. This full repurchase equilibrium is the only equilibrium in which the firm repurchases overvalued shares.

As the analysis in Section 3 demonstrates, (see also the numerical example in the appendix), whenever a full or partial repurchase equilibrium can hold, the firm will announce a program. The lower the benefit from waste rate γ, the more likely is a full repurchase equilibrium to prevail. For higher rates of γ a partial repurchase equilibrium will prevail, but for high rates of γ the firm will not announce a program. This happens because the higher the benefit from waste γ, the more likely are insiders to be better off with waste relative to with waste prevention. Similarly, the higher the insider ownership β, the more likely is the full repurchase equilibrium to prevail. Lower levels of β will result in a partial repurchase equilibrium, but the very low levels of β will result in no announcement. This is because while the benefit from waste prevention increases with ownership β as it accrues evenly to all shares remaining, the benefit to insiders from waste is independent of β.

Everything else being equal, higher waste $1-\delta$ increases the likelihood of a full repurchase equilibrium, whereas lower levels of waste increase the likelihood of a partial repurchase equilibrium. This happens because while the benefit from waste does increase with the waste $1-\delta$, at the insider ownership level where full repurchase is possible at all, $\beta > \gamma$, and so the benefit from waste prevention increases with $1-\delta$ more. Less waste of free cash reduces the benefit from waste prevention, but increases the wealth transfers associated with strategic (partial) repurchase. Lastly, the lower the variance σ, the more likely is the full repurchase equilibrium to prevail because the lower the variance σ, the less overvalued are the shares when they are overvalued, whereas high σ increases the benefit (trading gains) from repurchasing strategically.

Accordingly, the model generates several novel empirical predictions. First, in firms with good corporate governance (low private benefits from waste rate γ), we expect more repurchase program announcements, and a higher program completion rate, while the opposite will hold for firms with poor corporate governance. Second, the higher the insider ownership β, the more likely the firm is to announce a program, and the higher the program completion rate. Third, in industries/firms with high waste of free cash rate $(1-\delta)$, given announcement we expect a higher program completion rate. Lastly, the more risky the firm/industry is (higher σ), given announcement, firms are more likely to repurchase strategically, that is, actual repurchase rates are expected to be low; conversely in low risk firms/industries we expect higher program completion rates.

The model may also explain the empirical discrepancy between post program announcement returns and post actual repurchase returns (see introduction). The documented underperformance of actual repurchases relative to a naive program execution strategy (e.g. Bonaime et al. 2016) is not necessarily bad news. This is because when firms repurchase regardless of mispricing the execution will be followed by lower returns relative to repurchase of only undervalued shares. Hence we would expect higher completion rates to be associated with relatively lower post execution long-run returns, but not with lower post announcement long-run returns.

The prediction that firms may repurchase shares regardless of mispricing supports the argument (e.g., DeAngelo, 2022B) that repurchases are more of a tool to disburse cash rather than abuse uninformed investors. The prediction that higher risk will be associated with a partial repurchase equilibrium is consistent with the positive relation Ben-Rephael, Oded and Wohl (2014) find between firm size and program completion rate, as smaller firms are more risky. Similarly, the evidence that firms are increasingly repurchasing regardless of mispricing may be related to the increasing awareness to quality of corporate governance, associated with the rise in institutional investor holdings and shareholder activism.

Our findings also suggest new testable predictions. For example, that corporate governance proxies such as E-index and Tobins' Q would be negatively related to program completion rates, and that a positive shock to a firm's governance quality will result in higher program completion rates. Similarly, the cross country differences in program completion rates (see introduction) would be related to cross country corporate governance differences. For regulators these findings suggest that the tightness of buyback regulation should be related to corporate governance quality.

5 Extensions

5.1 Partial repurchase in mixed strategies when $\gamma_1<\gamma<\gamma_2$

Recall that in the range $\gamma_1 < \gamma < \gamma_2$ there does not exist a pure strategy equilibrium. In this subsection we show that in this range a mixed strategy equilibrium with partial repurchase exists. Suppose insiders play a mixed strategy as follows. In state H they repurchase and in state L they mix: they repurchase with probability ω and do not repurchase with probability $1-\omega$. The market maker zero expected profit condition is accordingly

$$0=\left(q-\frac{c}{p_m}\right)\left(\frac{H}{1-\frac{c}{p_m}}-p_m\right)+\omega\left(q-\frac{c}{p_m}\right)\left(\frac{L}{1-\frac{c}{p_m}}-p_m\right)+(1-\omega)\,q\,(L+\delta c-p_m) \tag{26}$$

where p_m denotes the price the market maker sets in this mixed strategy equilibrium.

Proposition 6 *In the range $\gamma_1 < \gamma < \gamma_2$ there exists a mixed strategy equilibrium with partial repurchase. In this equilibrium, the market maker sets*

$$p_m = \frac{\alpha - \sigma}{(1-\delta)\frac{\gamma}{\beta} + \delta} + c, \tag{27}$$

where $p_p < p_m < p_f$. The insiders always repurchase in state H. In state L they mix between repurchasing with probability $0 < \omega < 1$ and not repurchasing (wasting the cash) with probability $1 - \omega$, where

$$\omega = \frac{\left(q - \frac{c}{p_m}\right)\left(p_m - \frac{H}{1-\frac{c}{p_m}}\right) + q\left(p_m - (L + \delta c)\right)}{\left(q - \frac{c}{p_m}\right)\left(\frac{L}{1-\frac{c}{p_m}} - p_m\right) + q\left(p_m - (L + \delta c)\right)}. \tag{28}$$

A partial repurchase in mixed strategies equilibrium requires that the manager will be indifferent at t_1 between repurchasing or not in state L given the price, p_m. As the proof of Proposition 6 shows, if the market maker sets p_m such that the manager is indifferent between repurchasing and not repurchasing in state L, then an equilibrium in which he mixes with probability ω between repurchasing and not repurchasing in state L and always repurchases in state H will hold

Allowing for mixed strategies enables us to characterize the prevailing equilibria as a function of the rate of benefits from waste γ as follows:

Range of γ	**Equilibrium Type**
$\gamma < \gamma_1$	Full Repurchase Equilibrium
$\gamma_1 < \gamma < \gamma_2$	Partial Repurchase Equilibrium in Mixed Strategies
$\gamma_2 < \gamma < \gamma_3$	Partial Repurchase Equilibrium in Pure Strategies
$\gamma_3 < \gamma$	No-Announcement (no-repurchase) Equilibrium

The results when mixing is allowed extend the results of the basic model to suggest that the lower the γ, the more the firm repurchases, and that repurchase of overvalued shares exists only in the two equilibria with low γ (when $\gamma < \gamma_2$). Furthermore, recall that the feasible range for γ is $0 < \gamma < 1$. By inspection of (5), it is always the case that $\gamma_1 < 1$ and hence a full repurchase equilibrium does not prevails for all γ. However, by inspection of (17), we may have $\gamma_3 > 1$, in which case a repurchase equilibrium (full, mixed, or partial) prevails for all γ.[25]

5.2 Outsiders in Control

As discussed in the introduction, firms are often owned by large diversified institutional blockholders and have no insider blockholders at all. (Amel-Zadeh, Kaspek and Schmalz, 2022). In this subsection we investigate if and how the repurchase policy changes when (uninformed) outsiders rather than (informed) insiders are in control. One way to think of passing control to outsiders, is board involvement in the payout policy, shareholders activism, and regulatory restrictions on payout policy. In most countries, the board, which represents all shareholders, must approve the repurchase program, but once the policy is set, the execution is performed at the insiders' discretion. The outside shareholders cannot force managers to execute the program, and the actual repurchase level is reported only in the financial statements. In fact, one of the reasons often mentioned to justify repurchase program announcements is giving management the flexibility to determine if and when to repurchase.

Outsiders choose a repurchase policy (announce or not) to maximize their expected wealth. However, given their choice, the wealth terms of all agents (insiders, outsiders and the market maker) are unchanged, as it is the insiders who control the outcome (execution). Hence, given the policy, the conditions for the existence of a repurchase equilibrium, given announcement, are unchanged. To find the resulting equilibrium, it is thus enough to compare the wealth terms of the outside shareholders under each policy.

Proposition 7 *When outsiders are in control, they will announce a program whenever a full repurchase equilibrium can hold. When a partial repurchase*

[25] It is possible to show that when $\sigma < \Omega$, then $\gamma_3 < \gamma_n$, and there exists an equilibrium with mixing in the range $\gamma_3 < \gamma < \gamma_n$, where the firm never repurchases in state L and mixes in state H. We do not elaborate on this equilibrium as it does not involve repurchase of overvalued shares. The proof is available from the author upon request.

equilibrium can hold, outsiders will announce a repurchase program if $\gamma_3 < 1$, *where* γ_3 *is from (25), and have no payout otherwise.*

The intuition for Proposition 7 is as follows. Unlike insiders, outsiders have no benefits from waste of free cash. Since a full repurchase equilibrium dominates no announcement for insiders, then certainly it dominates no announcement for outsiders. Thus, like insiders, outsiders will announce a program whenever a full repurchase equilibrium can hold. With a partial repurchase equilibrium the tradeoff is more complex. This is because in a partial repurchase equilibrium in addition to benefits from free cash waste prevention, insiders have information gains, while the market maker passes his information losses to the outsiders in the form of the lower price he pays when they are forced to liquidate q shares at t_1. Because of this difference, outsiders may prefer not to announce when, given announcement, a partial repurchase equilibrium can hold. As it turns out, this happens when $\gamma_3 > 1$. Outsiders have no control on what the insiders/managers do after they announce, as they execute (or not) at their discretion. However, since insiders prefer a partial repurchase over no repurchase equilibrium (see Lemma 5), then outsiders know that if they announce when a partial equilibrium can hold, the insiders will execute in state H and not execute in state L, so that a partial repurchase equilibrium will indeed hold.

We note that the tensions here are different than when there is no free cash waste, and information about firm value is asymmetric already at t_0, as in Babenko, Tserlukevich and Wan (2020), for example. In their paper, the announcement can signal undervaluation, and current shareholders selling some shares at t_1 trade off benefits from pushing the price up at t_1 and getting less at t_2. In contrast, in our model, information asymmetry develops only at t_1, and the motivation to announce at t_0 is to prevent free cash waste. The outsiders know that if they announce, the impact on p_1 will depend on which is stronger, the adverse selection or the cash waste prevention, but at t_2 they will benefit from both. They calculate at t_0, whether their aggregate wealth is higher with partial repurchase, or with no repurchase, and decide accordingly whether or not to announce.

The intuition for why outsiders will announce given that a partial equilibrium holds only when $\gamma_3 < 1$ is as follows. Rearranging $\gamma_3 < 1$ as

$$\frac{\alpha + \sigma}{p_p - c} < \frac{1}{\beta} \left[1 - (1 + \beta)\, \delta\right]$$

suggests the condition is less likely to hold the higher σ, the higher the β, and the higher the δ. Higher σ is more adverse selection from which the outsiders suffer. Higher β is less outsider ownership, implying that outsiders benefit less when the firm repurchases and lose more when the firm is not repurchasing. Higher δ (less waste) means outsiders will suffer less from waste while still suffering from adverse selection, hence the higher the δ the more they are likely to prefer no repurchase.[26]

In the range $\gamma_1 < \gamma < \gamma_2$, the condition $\gamma_3 < 1$ is sufficient (but not necessary) for partial repurchase with mixed strategies to prevail when outsiders are in control. This is because by Proposition 6, given announcement, insiders will execute as they are better off with this equilibrium than without announcement. Mixing gives outsiders expected wealth in between their expected wealth with full repurchase and partial repurchase depending on ω. When γ is close to γ_1 the condition $\gamma_3 < 1$ is not binding, and when γ is close to γ_2 the condition $\gamma_3 < 1$ is binding.[27]

Note that because the feasible range for γ is $0 < \gamma < 1$, then when $\gamma_3 > 1$, insiders will surely announce a repurchase program for all γ while outsiders will only announce when $\gamma < \gamma_1$. Hence, when outsiders are in control, we should expect similar non-strategic repurchase but less strategic repurchase, that is, we expect less announcement but higher program completion rates.

[26] The price p_p does not depend on γ or β, and decreases with σ. Hence changing the above variables either has no impact through p_p, or magnifies the impact. While p_p increases with δ, it can be shown that the overall impact is that γ_3 increases with δ.

[27] It is possible to show that when outsiders are in control, for high values of the mixing probability ω (i.e. for low values of γ within the range $\gamma_1 < \gamma < \gamma_2$) the requirement $1 < \gamma_3$ is sufficient but not necessary for a partial repurchase equilibrium in mixed strategies to hold, but as ω is reduced (γ is increased within the range $\gamma_1 < \gamma < \gamma_2$), the requirement $1 < \gamma_3$ becomes binding for a partial repurchase equilibrium in mixed strategies to hold.

5.3 Dividends

5.3.1 Insiders' choice of repurchases and dividends

Although we focus on stock buybacks in this paper, dividend is another payout tool available to firms. In this section we incorporate dividends into the model and consider the impact on our results. While existing empirical literature suggests that dividends and repurchases are both substitutes and complements (Grullon and Michaely 2002), for tractability, like most earlier theoretical work on payout policy, we assume substitution. That is, we consider the decision to make the payout in the form of either dividends or a stock buyback. We also follow the earlier literature, and without loss of generality assume that dividends are taxed while repurchases are not (see literature review).[28]

Let T_D denote the dividend tax rate. We will generally assume that $T_D > 0$, to reflect a positive tax advantage for repurchases over dividends. Yet, for generality, we will also consider the situation where $T_D < 0$. Empirical evidence suggests that in some countries there are periods when the dividend tax rate is lower than the capital gains tax.[29] We allow the dividend tax to be negative to capture these situations. Furthermore, outside our model, a negative tax rate on dividends may capture other advantages that dividends have over repurchases, such as a negative sentiment toward repurchases relative to dividends. We also assume that dividends must be announced up front at t_0, and if announced, must be paid at t_1. In practice, dividends are indeed less flexible than repurchases, and once announced, must be paid. Because in our model the level of free cash is expected up-front, dividends, like repurchases, do not result in investment shaving.

If insiders choose to announce a dividend at t_0 and then pay a dividend of c at t_1, then following the realization of $X \in \{H, L\}$, they end up with

[28] The Inflation Reduction Act provision levies a 1% excise tax on the market value of net corporate shares repurchased starting in 2023. This new 1% is a small addition to the capital gains tax on buybacks and its impact on the tax differential between dividends and buybacks is likely minor.

[29] See, for example, Ernst & Young, October 2012. "Coprorate Dividend and Capial Gains Taxation: A comparison of Sweden to other member nations of the OECD and EU and BRIC countries."

$\beta\,[X + (1 - T_D)\,c]$. Their expected terminal wealth is thus

$$\beta\,[\alpha + (1 - T_D)\,c] \tag{29}$$

Lemma 6 *Define*

$$T_{D1}(\gamma) \equiv \frac{1}{2}\left[(1-\delta)\left(1-\frac{\gamma}{\beta}\right) - \left(\frac{\alpha+\sigma}{p_p - c} - 1\right)\right], \tag{30}$$

where p_p is from (13), and

$$T_{D2}(\gamma) \equiv (1-\delta)\left(1-\frac{\gamma}{\beta}\right). \tag{31}$$

Then insiders will prefer a partial repurchase over dividends for all $T_D > T_{D1}(\gamma)$; they will prefer no repurchase over dividends for all $T_D > T_{D2}(\gamma)$. Furthermore, $T_{D1}(\gamma) < T_{D2}(\gamma)$ for all $\gamma < \gamma_3$.

$T_{D1}(\gamma)$ is the tax rate for which insiders are indifferent between partial repurchase and dividends as a function of γ in the range where a partial repurchase equilibrium can hold $\gamma_2 < \gamma < \gamma_3$. $T_{D2}(\gamma)$ is the tax rate for which insiders are indifferent between no payout and dividends as a function of γ.

Proposition 8 ***[Insiders' choice of a repurchase announcement or a dividend]***
When insiders are in control then if $T_D > 0$ they will never announce a dividend. Specifically, for all $T_D > 0$, if a full or a partial repurchase equilibrium can hold insiders will announce a program, and if neither repurchase equilibrium holds, they will have no payout.

The intuition for Proposition 8 is as follows. For low benefits from waste ($\gamma < \gamma_1$) a full repurchase equilibrium holds, and insiders' wealth is higher with full repurchase relative to dividends for all positive dividend tax rates $T_D > 0$. This is, in turn, because a positive dividend tax rate destroys value for the shareholders, while a full repurchase equilibrium gives them the same expected wealth excluding the value destruction caused by the tax. A partial repurchase equilibrium holds for all $\gamma_2 < \gamma < \gamma_3$. But, as the proof of Proposition 8 shows, $T_{D1}(\gamma) < 0$ for all γ in this range. Hence, by Lemma 6, $T_{D1}(\gamma) < T_D$ for all $T_D > 0$. That is, a partial repurchase equilibrium always dominates dividends when it holds for all positive dividend tax rates. Furthermore, $T_{D1}(\gamma) < T_{D2}(\gamma)$ for all $\gamma < \gamma_3$ assures that whenever a partial equilibrium can hold it will be preferred by the insiders over no payout.

Similarly, for all $\gamma > \gamma_3$ neither repurchase equilibrium holds, but as the proof of Proposition 8 shows, $T_{D2}(\gamma) < 0$ for all $\gamma > \gamma_3$, hence by Lemma 6, $T_{D2}(\gamma) < T_D$ for all $T_D > 0$. That is, no repurchase equilibrium always dominates dividends in this range for all positive dividend tax rates. Lastly, in the range $\gamma_1 < \gamma < \gamma_2$, a partial repurchase equilibrium in mixed strategies (see subsection 5.1) always dominated dividends. This is because, as γ is increased in this range, insiders wealth changes monotonically and continuously between their wealth in a full repurchase equilibrium and their wealth in a partial repurchase equilibrium. However, at both edges of this range a program announcement dominates dividends for all $T_D > 0$, hence it dominates dividends throughout the whole range.

Figure 2 combines the results of the basic model and this extension to draw general predictions for payout policy (repurchase, dividends, and no payout) as a function of benefits from waste rate γ, and the dividend tax rate T_D when insiders are in control. In the figure, the red line depicts the limit on T_D below which dividends are the dominating payout policy. For all $\gamma < \gamma_1$, a full repurchase equilibrium prevails for all positive T_D. When $\gamma_1 < \gamma < \gamma_2$ a partial repurchase equilibrium in mixed strategies prevails not only for positive T_D, but also for small negative T_D, that is, even if dividends have a small tax advantage. The higher the γ, the higher the tax advantage of dividends must be for insiders to announce a dividend over repurchases. When $\gamma_2 < \gamma < \gamma_3$ insiders prefer repurchase announcement over dividends for all $T_D > 0$, and for even more negative tax rates. In the range $\gamma > \gamma_3$ neither repurchase equilibrium holds, but now the rate of benefit from waste γ is so high that insiders prefer no payout over dividends for all $T_D > 0$, and also for even more negative tax rates.

Overall, Figure 2 suggests that when firms can pay dividends instead of repurchasing shares, then if insiders are in control, stock buybacks or no payout will generally dominate dividends. In the next subsection we show that the result is different when outsiders are in control.

5.3.2 Outsiders' choice of repurchases or dividends

We next consider the outcome (payout policy) when outsiders are in control and can choose between a program announcement, forcing a dividend, and no payout. Outsiders' expected wealth when free cash is paid out using dividends is

$$(1-\beta)\left[\alpha+(1-T_D)\,c\right] \tag{32}$$

Proposition 9 ***[Outsiders' choice of a repurchase announcement or a dividend]*** *Define*

$$T_{D3} \equiv 1-\frac{1}{2}\left(\delta+\frac{1}{1-\beta}\left[1-\beta\frac{\alpha+\sigma}{p_p-c}\right]\right) \tag{33}$$

where p_p is given in (13), and

$$T_{D4} \equiv 1-\delta. \tag{34}$$

Suppose outsiders are in control, and can choose between a repurchase program announcement, a dividend, and no payout. Then, whenever a full repurchase equilibrium can hold (i.e., when condition (5) holds), the firm will announce a repurchase program for all $T_D > 0$. Otherwise, if given announcement a partial repurchase equilibrium can hold, (i.e. when condition (17) holds) and $\gamma_3 < 1$, the firm will pay a dividend of c for all $T_D < T_{D3}$ and announce a repurchase program for all $T_D > T_{D3}$. Otherwise, the firm will pay a dividend of c for all $T_D < T_{D4}$ and have no payout for all $T_D > T_{D4}$. Furthermore, $0 < T_{D3}$, and $T_{D3} < T_{D4}$ for all $\gamma_3 < 1$.

T_{D3} is the tax rate for which outside shareholders are indifferent between partial repurchase and dividends in the range where a partial repurchase equilibrium can hold ($\gamma_2 < \gamma < \gamma_3$). T_{D4} is the tax rate for which outsiders are indifferent between no payout and dividends. Because outsiders have no benefit from waste, these indifference tax rates are not directly affected by γ. Proposition 9 suggests that when firms can pay dividends, then like the insiders, whenever, given announcement, a full repurchase equilibrium can hold, outsiders will favor it over dividends for all $T_D > 0$. However when a full repurchase equilibrium cannot hold, but given announcement, a partial repurchase equilibrium does hold, outsiders are less likely to announce a program relative to insiders. Specifically, only if $\gamma_3 < 1$, will outsiders prefer a repurchase program over no payout. Also, because $T_{D3} < T_{D4}$ for all $\gamma_3 < 1$, then if a partial repurchase equilibrium can hold it will be preferred by the outsiders over no payout. This is because $T_{D3} < T_{D4}$ reflects the dominance of a partial repurchase equilibrium over no payout, for the outsiders. Lastly, because $0 < T_{D3} < T_{D4}$, then unlike the case in which insiders are in control, there are always dividend tax rates $0 < T_D$ for which a dividend will be preferred over partial repurchase or no payout.

Figure 3 considers payout policy when outsiders are in control as a function of insiders' benefits from waste γ and the dividend tax rate T_D. In the figure, the red line depicts the limit on T_D below which dividends are the dominating payout policy. For all $\gamma < \gamma_1$, as in the case where insiders are in control, a full repurchase equilibrium prevails for all $T_D > 0$. When $\gamma_1 < \gamma < \gamma_2$ then, for all $0 < T_D < T_{D3}$ as γ is increased between γ_1 and γ_2 the dividend tax rate below which dividends prevail increases from 0 to T_{D3}. Above this indifference line, if $\gamma_3 < 1$, the firm will announce a program and a partial repurchase equilibrium in mixed strategies equilibrium will prevail. If $\gamma_3 > 1$, either partial repurchase in mixed strategies or no payout will prevail (see also footnote 27 above). When $\gamma_2 < \gamma < \gamma_3$ then: for all $T_D < T_{D3}$ dividends will prevail. In the range $T_{D3} < T_D$, if $\gamma_3 < 1$ a partial repurchase equilibrium will prevail, and no payout will prevail if $\gamma_3 > 1$. When $\gamma > \gamma_3$ repurchase equilibria cannot hold. The firm will pay dividends for all $T_D < T_{D4}$ and have no payout otherwise.

To summarize, when outsiders rather than insiders are in control, and firms can pay dividends, payout policy is altered as follows. 1) As with insiders, when a full repurchase equilibrium can hold, it will prevail for all dividend tax rates $T_D > 0$. 2) If a partial repurchase equilibrium can hold, outsiders pay dividends when the dividend tax rate is low, but as the tax rate is increased, they switch to announcing a program or have no payout. 3) When no repurchase equilibrium can hold, outsiders pay dividends as long as the dividend tax rate is not high, and have no payout otherwise.

Unlike insiders, outsiders have no benefits from waste when there is no payout, and suffer from adverse selection when they sell in a partial repurchase equilibrium. Hence, when outsiders rather than insiders are in control, we are likely to see more dividends and less repurchase program announced, but given a program announcement, completion rates will be higher.

Overall, incorporating dividends into the model suggests the following:

a) When announcing a program results in the firm always executing the program (a full repurchase equilibrium can hold), a repurchase program will always be the dominating payout policy regardless of whether insiders or outsiders control the firm. This prediction, in turn, suggests that firms with a high program completion rate (firms that tend to repurchase regardless of mispricing) will tend to pay less dividends.

b) If a full repurchase equilibrium does not hold, but a partial repurchase equilibrium holds, the firm will always announce a program when insiders are in control. When outsiders are in control unlike the case where insiders are in control, dividends may become first priority: The firm will pay a dividend if the dividend tax rate T_D is low, and repurchase or have no payout when the dividend tax rate is high.

c) When neither a full nor a partial repurchase equilibrium can hold, the firm will have no payout if insiders are in control. When outsiders are in control, the firm will pay a dividend if the dividend tax rate T_D is low or moderate, and have no payout, otherwise (for high dividend tax rates).

We note that under both the full repurchase equilibrium and with dividend no cash is wasted, hence value is maximized. It is possible to show that depending on the tax rates on dividends and repurchases, the firm may shift from partial repurchase or no payout to dividends, therefore helping prevent free cash waste and enhancing value. This is more likely to happen when outsiders are in control.

With respect to governance quality, the findings in this subsection suggest that when governance is good (benefits from waste γ are low), it does not really matter who controls the firm, insiders or outsiders. The good repurchase equilibrium will prevail. As the quality of governance deteriorates, giving the control to insiders will result in more strategic repurchases that abuse the outside shareholders, while dividends are in the interest of the outside shareholders. When governance is bad insiders will stop having payout, while when outsiders are in control, they will solve the waste problem demanding dividends as long as the dividend tax rate is not high. One interpretation we can thus make is when should outsiders (activists, institutional investors) intervene though the board in order to dictate payout policy and when they can leave the decision to management. We are not aware of a systematic empirical inquiry into these predictions/implications for governance quality.

5.3.3 Debt and Payout

Dividends are not the only alternative to repurchases for taking free cash out of the firm. If fact, Jensen (1986) seminal agency paper considers debt for removing free cash and Stulz (1990) elaborates this path. Debt as a payout mechanism has advantages and disadvantages relative to dividends and repurchases. For example, once taken, debt must be repaid, which is an advantage in preventing free cash waste relative to dividends and repurchases. This is because dividend payments can be stopped, while repurchase programs announced do not even have to be executed. On the other hand, debt does not leave any flexibility for the firm in case it does eventually need the cash. It also introduces further limitations on the firm through debt covenants, and can lead to bankruptcy and bankruptcy costs.

6 Conclusion

Existing information models of stock buybacks generally suggest firms will repurchase their shares either to signal undervaluation, or to take advantage of it. However, increasing empirical evidence suggests firms repurchase their shares also when they are overvalued. This paper aims to explain why.

Building on agency costs of free cash we suggest repurchase policy is determined by insiders as an optimization over private benefits from free cash waste, common benefits from the prevention of this waste, and private gains/loss associated with repurchase under mispricing. In particular, we show that if free cash waste is high and private benefits from waste are low, firms may ignore their information advantage and repurchase regardless of mispricing. This, in turn, results in repurchase of overvalued shares and high program completion rates. We characterize such an equilibrium and its likelihood to prevail, relative to the traditional equilibrium in which firms either repurchase only undervalued shares or do not repurchase at all. The equilibrium with repurchase regardless of mispricing is a "good equilibrium" in the sense that it is socially optimal. This implies repurchases are a good payout mechanism in corporations with good corporate governance.

Our model also suggests that when power is given to outside shareholders (e.g. institutions investors, activists), payout policy will be characterized with more repurchase of overvalued shares, higher program completion rates, and with more dividend payouts relative to repurchases.

7 Appendix A - Numerical Example

The following example demonstrates how the existence of a repurchase equilibrium depends on the degree of cash waste $(1-\delta)$, insiders' rate of benefit from waste γ, insider ownership β, and variability in the rate of return on investment σ. Let $\delta = 0.7$, $\gamma = 0.2$, and $\beta = 0.3$. Assume further that $\alpha = 3.5$, $\sigma = 0.5$, $c = 0.1$, and $q = 0.2$.

Consider first the market maker's strategy (price) given the firm's repurchase strategy. If he assumes the firm repurchases in both states he sets the price using (2) to $p_f = \alpha + c = 3.6$. Similarly, if he assumes no repurchase he sets the price using (7) to $p_n = \alpha + \delta c = 3.57$, and if he assumes repurchase only in state H he sets the price using (13) to $p_p = 3.5533$.

For the insiders to repurchase in both states, condition (4) requires under the example parameter values that $p_f = 3.433$, and does not hold since the market maker sets $p_f = 3.6 > 3.433$ (see above). At this price, the firm will never repurchase in state L, and hence a full repurchase equilibrium cannot hold. The equivalent condition on γ given in (5) also does not hold since using the example parameter values $\gamma_1 = 0.1571 < \gamma = 0.2$.

For the insiders to repurchase in state H only, the condition on p_p given in (16) requires that $3.433 < p_p < 4.54$. This condition holds since $p_p = 3.5533$, so that a partial repurchase equilibrium can hold. The equivalent condition on γ given in (17) also holds. Indeed,

$$\gamma_2 = 0.1687 < \gamma = 0.2 < 0.4583 = \gamma_3.$$

Furthermore, insiders' wealth in a partial repurchase equilibrium (22) is higher than their wealth without announcement (20). Indeed,

$$\beta\alpha + \frac{c}{2}\left(\beta\delta + (1-\delta)\gamma + \beta\frac{\alpha+\sigma}{p_p - c}\right) = 1.081 > 1.077 = \beta(\alpha + \delta c) + (1-\delta)c\gamma$$

and, hence, insiders announce and a partial repurchase equilibrium prevails.

Next, we demonstrate how existence of the different equilibria is affected by each of the variables γ, δ, β, and σ. Specifically, we change each of the variables, γ, δ, β, and σ, separately, holding all other variables fixed and consider how this affects the equilibrium outcome. Figure 4 demonstrates how the existence of the different equilibria in this example depends on the rate of benefit from waste γ. Specifically, we change γ in the range $[0, 1]$ while holding all other parameters fixed. In the figure (and also in Figures 5-7), the green line represents the rate of benefit from waste in this example, $\gamma = 0.2$. The purple line represents γ_1, the upper limit on γ given in condition (5), below which a full repurchase equilibrium can hold. The brown and blue lines represent, respectively, γ_2, and γ_3, the lower and upper limits on γ given in condition (17) for a partial repurchase equilibrium to hold. The lines representing γ_1, γ_2, and γ_3 are parallel to the X axis in Figure 4, as these limits do not depend on γ. For a partial repurchase equilibrium, the green line must be between the brown and the blue lines. For all $\gamma < \gamma_1 = 0.157$ the green line is below the purple line and a full repurchase equilibrium prevails. This happens because when insiders have no benefits from waste, and given that the market maker sets $p_f = 3.6$, the insiders will repurchase regardless of whether the shares are overvalued (state L) or undervalued (state H). Moving up, once $\gamma > \gamma_1 = 0.157$, the green line becomes above the purple line, reflecting that benefits from waste become high enough so that at $p_f = 3.6$, in state L, insiders are better off wasting the cash rather than repurchasing, and a full repurchase equilibrium no longer holds. In the range $0.157 = \gamma_1 < \gamma < \gamma_2 = 0.169$, there is discontinuity and neither a full nor a partial repurchase equilibrium hold. This happens because $p_p = 3.5533 < p_f = 3.6$, so that while the firm would no longer repurchase in state L at p_f, it would still repurchase at p_p (in addition to state H).[30] In section 5 (Extensions) we show that a partial repurchase equilibrium in mixed strategies exists in this range. Once $\gamma > \gamma_2 = 0.169$ (when the green line becomes above the brown line), the benefit from waste becomes high enough for the insiders to stop repurchasing in state L at $p_p = 3.5533$, and a partial repurchase equilibrium starts holding. It holds up to $\gamma_3 = 0.458$. Once $\gamma > \gamma_3$ (the green line becomes above the blue line), the benefit from waste becomes too high so that at $p_p = 3.5533$, the firm will not repurchase in state H either. This is also the point where insiders' wealth under a partial repurchase equilibrium stops being higher than under no-repurchase equilibrium (Lemma 5). Hence, for any $\gamma > \gamma_3 = 0.458$ no-repurchase equilibrium prevails.

Figure 5 demonstrates how the existence of equilibria depends on insider ownership β. Specifically, we change insider ownership β in the range $[0, 0.5]$[31] holding all other parameters fixed. Starting from $\beta = 0$ and moving up, until $\beta = 0.13$ the green line (i.e., $\gamma = 0.2$) is above all the other lines, reflecting that a no-repurchase equilibrium prevails. Intuitively, as long as insiders' ownership is small, they are better off wasting the cash regardless of the value realized. This is because they privately enjoy the benefits from waste, while the costs of the waste are borne by all shareholders. As β increases, the insiders' share in the cash loss increases, and once $\beta > 0.13$, the blue line crosses the green line to become above it while the brown line is still below the green line ($\gamma_2 < \gamma = 0.2 < \gamma_3$), and a partial repurchase equilibrium starts holding. A partial repurchase equilibrium prevails in the range $0.13 < \beta < 0.35$. For $\beta > 0.35$ the brown line also crosses the green line, reflecting $\gamma_2 > \gamma = 0.2$, and a partial repurchase equilibrium stops holding. In the range $0.35 < \beta < 0.38$, the green line becomes below both the blue and brown lines, but still above the purple line ($\gamma_1 < \gamma = 0.2 < \gamma_2$) hence neither a partial nor a full repurchase equilibrium holds. Once $\beta > 0.38$ the purple line also crosses the green line, ($\gamma_1 > \gamma = 0.2$), reflecting that at

[30] Market maker prices do not depend on γ, as he is not affected by benefits from waste.
[31] Figure 5 considers only $\beta \leqslant 0.5$ without loss of generality for convenience of exposition.

$p_f = 3.6$ the insiders will repurchase in both states. Intuitively, now insider ownership has become substantial so that their benefit from waste prevention becomes higher than their benefit from waste in both state, so that insiders are now better off repurchasing even when the shares are overvalued. Since γ_1 is increasing in β then for all $\beta > 0.38$ result in $\gamma_1 > \gamma = 0.2$, and a full repurchase equilibrium prevails.

Figure 6 demonstrates how the existence of the different equilibria depends on the cash retention rate δ. Specifically, we change δ in the range $[0, 1]$ holding all other parameters fixed. Starting from $\delta = 0$ (complete cash waste), and moving up, until $\delta = 0.57$ the purple line is above the green line (i.e., $\gamma_1 > \gamma = 0.2$), and a full repurchase equilibrium prevails. Intuitively, as long as the waste rate $1-\delta$ is high (δ is low), insiders are better off repurchasing given $p_f = 3.6$. As the retention rate δ further increases, insider benefits from waste $(1 - \delta)\, c\gamma$ decrease, but their retention $\beta\delta c$ increases more, because in any full repurchase equilibrium $\beta > \gamma$. On the other hand, given $p_f = \alpha + c$, insiders' wealth with full repurchase is independent of δ. Hence, once $\delta > 0.57$, the purple line becomes below the green line (i.e. $\gamma_1 < \gamma$), insiders stop repurchasing in state L. In the range $0.57 < \delta < 0.6$, the green line is above the purple line, but still below the brown line ($\gamma_1 < \gamma < \gamma_2$), and neither a full nor a partial repurchase equilibrium holds. Once $\delta > 0.6$, the brown line becomes below the green line, while the blue line is still above the green line ($\gamma_2 < \gamma = 0.2 < \gamma_3$). Because γ_3 is increasing in δ, then for any $\delta > 0.6$ the blue line remains above the green line ($\gamma_3 > \gamma = 0.2$), and a partial repurchase equilibrium prevails.

Figure 7 demonstrates how equilibria existence depends on variability of value of assets in place σ. For all $0 < \sigma < 0.35$, the green line is below the purple line, reflecting $\gamma_1 > \gamma = 0.2$, and a full repurchase equilibrium prevails. A full repurchase equilibrium holds when variability is low because the resulting overvaluation in state L is low, hence the cost of overpaying and foregoing private benefits from waste is lower than benefit from waste prevention. Once $\sigma > 0.35$, overvaluation in state L becomes too high, so that at $p_f = 3.6$, insiders are better off not repurchasing in state L, and a full repurchase equilibrium stops holding. In the range $0.35 < \sigma < 0.38$ the purple line is below the green line, but the brown line is still above the green line ($\gamma_1 < \gamma = 0.2 < \gamma_2$), so that neither a full nor a partial repurchase equilibrium holds. Once $\sigma > 0.38$, the brown line becomes below the green line ($\gamma_2 < \gamma = 0.2$) and a partial repurchase equilibrium holds. It holds for all $\sigma > 0.38$ because overvaluation and undervaluation in states L and H, respectively, increases with σ. This is reflected in γ_2 (brown line) decreasing in σ while γ_3 (blue line) increasing in σ.

8 Appendix B - Proofs of Lemmas and Propositions

Proof of Proposition 1: Consider the post-repurchase price $p_{2|R}$ in a full repurchase equilibrium, i.e., when $p_1 = p_f = \alpha + c$. When value realization is H,

$$p_{2|RH} = \frac{H}{1-\frac{c}{p}} = \frac{\alpha+\sigma}{1-\frac{c}{\alpha+c}} = \left(1+\frac{\sigma}{\alpha}\right)(\alpha+c),$$

and when value realization is L,

$$p_{2|RL} = \frac{L}{1-\frac{c}{p}} = \frac{\alpha-\sigma}{1-\frac{c}{\alpha+c}} = \left(1-\frac{\sigma}{\alpha}\right)(\alpha+c) < \alpha+c = p_f.$$

That is, in state L the firm is repurchasing overvalued shares.■

Proof of Proposition 2: Denote the discriminant in the numerator of p_p in (13) with Δ. Then

$$\frac{\partial p_p}{\partial \sigma} = \frac{-4(1-q)\frac{c}{2q}}{4\sqrt{\Delta}} < 0.$$

$$\frac{\partial p_p}{\partial \delta} = \frac{c}{4} + \frac{\alpha - c + \frac{c}{2}\left(\delta + \frac{1}{q}\right)}{4\sqrt{\Delta}} c > 0.$$

Hence p_p is always decreasing in σ and increasing in δ.■

Proof of Lemma 1: Under repurchase in both states, the market maker sets the price to $p = p_f = \alpha + c$ (see (2)) and his gains in states H and L are, respectively,

$$\frac{H}{1-\frac{c}{p_f}} - p_f = (\alpha+c)\frac{\sigma}{\alpha} > 0$$

and

$$\frac{L}{1-\frac{c}{p_f}}-p_f=-\left(\alpha+c\right)\frac{\sigma}{\alpha}<0.$$

Suppose that under repurchase in state H only, the market maker sets $p_p=p_f$. By inspection of conditions (1) and (12), he still gains the same in state H. In state L, his loss is $q\left(L+\delta c-p_f\right)$, whereas with repurchase in both states, his gain (negative) is $\left(q-\frac{c}{p_f}\right)\left(\frac{L}{1-\frac{c}{p_f}}-p_f\right)$. Hence if

$$q\left(L+\delta c-p_f\right)<\left(q-\frac{c}{p_f}\right)\left(\frac{L}{1-\frac{c}{p_f}}-p_f\right)$$

the market maker must set $p_p<p_f$. Upon substitution of $p_f=\alpha+c$ and $L=\alpha-\sigma$ and rearrangement we can write this condition as

$$0<\alpha q\left(1-\delta\right)+\sigma\left(1-q\right),$$

which is always true, as the right hand side is always positive.■

Proof of Lemma 2: Under no repurchase, the market maker sets the price to $p=p_n=\alpha+\delta c$ (see (7)), and his gains in states H and L are, respectively,

$$q\left(H+\delta c-p_n\right)=q\left(\alpha+\sigma+\delta c-\alpha-\delta c\right)=q\sigma$$

and

$$q\left(L+\delta c-p_n\right)=q\left(\alpha-\sigma+\delta c-\alpha-\delta c\right)=-q\sigma.$$

Suppose that under repurchase in state H only the market maker sets $p_p=p_n$. Consider the market maker zero expected profit condition in a partial repurchase equilibrium (12), which for convenience we rewrite here:

$$0=\frac{1}{2}\left[\left(q-\frac{c}{p}\right)\left(\frac{H}{1-\frac{c}{p}}-p\right)+q\left(L+\delta c-p\right)\right].$$

In state L, the market maker's gain is exactly the same as under no-repurchase

$$q\left(L+\delta c-p\right)=q\left(\alpha-\sigma+\delta c-\alpha-\delta c\right)=-q\sigma.$$

In state H, the market maker's gain is

$$\left(q - \frac{c}{p_n}\right)\left(\frac{H}{1-\frac{c}{p_n}} - p_n\right) = (qp_n - c)\,\frac{H - (p_n - c)}{p_n - c}.$$

For $p_p = p_n$ it must be the case that

$$(qp_n - c)\,\frac{H - (p_n - c)}{p_n - c} = q\sigma \tag{35}$$

which upon substitution of $p_n = \alpha + \delta c$ and $H = \alpha + \sigma$ and rearrangement we can write as

$$\sigma = \frac{1-\delta}{1-q}\left[(\alpha - \delta c)\,q - c\right] \equiv \Omega.$$

Hence when $\sigma = \Omega$ then $p_p = p_n$.

By inspection, the derivative of the left hand side (henceforth, L.H.S.) of (35) in σ at $p = p_n$ is

$$\frac{qp_n - c}{p_n - c}$$

and the derivative of the right hand side (R.H.S.) in σ at $p = p_n$ is q. Also,

$$\frac{qp_n - c}{p_n - c} < q,$$

because $q < 1$. That is, in (35), the derivative in σ of the L.H.S. of is always lower than the derivative in σ of the R.H.S. Hence, for any

$$\sigma > \Omega \equiv \frac{1-\delta}{1-q}\left[(\alpha - \delta c)\,q - c\right]$$

p must change so that the whole expression (market maker expected gain) increases (back to 0). So consider how (12) changes with p. That is, consider

$$\frac{1}{2}\left[\left(q - \frac{c}{p}\right)\left(\frac{H}{1-\frac{c}{p}} - p\right) + q\,(L + \delta c - p)\right].$$

By inspection, as p increases, this expression decreases because in state L the loss is on the whole q. In state H the gain shrinks on an increasing quantity, but that quantity is still smaller than q. Hence p must decrease as σ increases for market maker to still make zero expected profit, implying $p_p < p_n$. In a similar manner we can show that $\Omega > \sigma$ implies $p_p > p_n$.$\blacksquare$

Proof of Proposition 3: In a partial repurchase equilibrium the firm repurchases only in state H, so we only need to consider state H. No repurchase of overvalued shares in state H requires

$$p_p \leq \frac{H}{1-\frac{c}{p_p}},$$

which we can rearrange to $p_p \leq p_f + \sigma$ which always holds because by Lemma 2, $p_p < p_f$.$\blacksquare$

Proof of Lemma 3: Comparing insiders' expected wealth in a full repurchase equilibrium (19) to their wealth without repurchase (20) suggests that insiders are better off with a full repurchase equilibrium whenever

$$\beta\alpha + [\beta\delta + \gamma(1-\delta)]\, c < \beta(\alpha + c)$$

which boils down to $\gamma < \beta$. However, a full repurchase equilibrium can hold only in the more restricted range of γ given in (5), that is, when

$$\gamma < \beta\left(1 - \frac{\sigma}{\alpha(1-\delta)}\right).$$

Hence, whenever a full repurchase equilibrium can hold, for the insiders, it is always better than a no-repurchase equilibrium.$\blacksquare$

Proof of Lemma 4: When a full equilibrium holds (i.e., when condition (5) holds), if the market maker sets the price to p_p, the firm will repurchase in both states because by Lemma 1 above, $p_p < p_f$. Hence, a partial repurchase equilibrium is not sustainable in the range where a full equilibrium holds.$\blacksquare$

Proof of Proposition 4: By Lemma 3, in the range where a full repurchase equilibrium can hold (5), insiders' wealth is higher than without announcement (i.e., under no repurchase). By Lemma 4, in this range a partial repurchase equilibrium cannot hold. Hence in this range a full repurchase equilibrium will prevail.$\blacksquare$

Proof of Lemma 5: For the insiders, a partial repurchase equilibrium is better than no repurchase equilibrium whenever insiders' wealth under partial repurchase given in (22) is higher than their wealth under no repurchase given in (20), or explicitly, whenever

$$\beta\alpha + (\beta\delta + \gamma(1-\delta))\, c < \beta\alpha + \frac{c}{2}\left(\beta\delta + (1-\delta)\,\gamma + \beta\frac{\alpha+\sigma}{p_p - c}\right),$$

which we can rearrange to

$$\gamma < \frac{\beta}{(1-\delta)}\left[\frac{\alpha+\sigma}{p_p - c} - \delta\right],$$

and note that this limit on γ is the right limit of the range where a partial repurchase equilibrium can hold (17). Hence, whenever partial repurchase holds it is better than no repurchase.■

Proof of Proposition 5: The condition for full repurchase (5) is $\gamma < \gamma_1$. Similarly, the condition for partial repurchase (17) is $\gamma_2 < \gamma < \gamma_3$. We can further rearrange this condition to

$$\gamma_2 = \beta\left(1 + \frac{\alpha - \sigma - (p_p - c)}{(p_p - c)\,(1-\delta)}\right) < \gamma < \beta\left(1 + \frac{\alpha + \sigma - (p_p - c)}{(p_p - c)\,(1-\delta)}\right) = \gamma_3.$$

We first show that, given announcement, there is no range where both a full repurchase equilibrium and a partial repurchase equilibrium can hold. For this it is enough to show that $\gamma_1 < \gamma_2$, namely that

$$\beta\left(1 - \frac{\sigma}{\alpha\,(1-\delta)}\right) < \beta\left(1 + \frac{\alpha - \sigma - (p_p - c)}{(p_p - c)\,(1-\delta)}\right),$$

which boils down to $p_p < \alpha + c$, which is always true because by Lemma 1, $p_p < p_f = \alpha + c$. Now because γ_1 is the upper limit on γ where a full equilibrium can hold, and γ_2 is the lower limit where a partial equilibrium can hold, then in the range $\gamma_1 < \gamma < \gamma_2$ an equilibrium with repurchase in pure strategies does not exist.

Next consider that the upper limit of the range where a partial equilibrium can hold, γ_3, is exactly the lower limit where a no-repurchase equilibrium is better for the insiders than a partial repurchase equilibrium. Now because if the firm does not announce, the firm cannot repurchase, then the limit above which the firm will not repurchase given announcement (9) is not relevant for the firm's decision to announce. Hence in the range $\gamma_2 < \gamma < \gamma_3$ the firm will announce a program and a partial repurchase equilibrium will prevail, and in the range $\gamma > \gamma_3$ the firm will not announce and a no-repurchase equilibrium will prevail.$\blacksquare$

Proof of Proposition 6: Existence of equilibrium requires that: 1) there exists a price p_m such that insiders are indifferent between repurchasing and not repurchasing in state L; 2) given p_m, there exists $0 < \omega < 1$ such that condition (26) holds; 3) the insiders are better off with this equilibrium than without announcing.

For 1), insiders are indifferent between repurchasing and wasting in state L, only if

$$\beta\left(L + \delta c\right) + \left(1 - \delta\right) c\gamma = \beta \frac{L}{1 - \frac{c}{p_m}}. \tag{36}$$

Upon substitution of $L = \alpha - \sigma$ we can rearrange this to (27). By inspection of (27), the price p_m is decreasing in γ. Upon substitution of $\gamma = \gamma_1$ from (23) into (27) and rearrangement, $p_m(\gamma_1) = p_f$. Also, upon substitution of $\gamma = \gamma_2$ using (24) into (27) and rearrangement, $p_m(\gamma_2) = p_p$. That is, as γ is increased over the range $\gamma_1 < \gamma < \gamma_2$, p_m decreases from p_f to p_p.

For 2), we show that there exists $0 < \omega < 1$ such that given p_m, condition (26) holds. We can rearrange condition (26) to (28). By inspection of (28), for there to exist $0 < \omega < 1$ it is enough to show that

$$p_m - \frac{H}{1 - \frac{c}{p_m}} < \frac{L}{1 - \frac{c}{p_m}} - p_m, \tag{37}$$

which boils down to $p_m < \alpha + c$, which is always true because for all $\gamma_1 < \gamma < \gamma_2$, $p_m < p_f = \alpha + c$. Note that when $p_m = p_f$, condition (26) dictates that $\omega = 1$, since

$$p_f - \frac{H}{1 - \frac{c}{p_f}} = \frac{L}{1 - \frac{c}{p_f}} - p_f$$

and when $p_m = p_p$, then $\omega = 0$, because in this case the numerator of (26) is zero. This is, in turn, because upon substitution of $p_m = p_p$, this numerator becomes exactly the zero expected profit condition for the market maker in the partial repurchase equilibrium.

For 3), we show that insiders are always better off in this mixed strategy equilibrium over no announcement. First, in the mixed strategy equilibrium insiders are indifferent between repurchasing and not repurchasing in state L, so that their wealth in this state is exactly the same as without repurchase. We can therefore write their wealth as

$$\frac{1}{2}\left(\beta\left(L+\delta c\right)+\left(1-\delta\right)c\gamma+\beta\frac{H}{1-\frac{c}{p_m}}\right). \tag{38}$$

Comparing insiders' wealth in a no-repurchase equilibrium (20) to their wealth in the mixed strategies repurchase equilibrium (38), we need to show

$$\beta\left(\alpha+\delta c\right)+\left(1-\delta\right)c\gamma<\frac{1}{2}\left(\beta\left(L+\delta c\right)+\left(1-\delta\right)c\gamma+\beta\frac{H}{1-\frac{c}{p_m}}\right),$$

which we can rearrange to

$$\beta\left(\alpha+\delta c\right)+\left(1-\delta\right)c\gamma<\beta\frac{H}{1-\frac{c}{p_m}}. \tag{39}$$

The minimum of the R.H.S. of (39) is attained when $p_m = p_f$. At that point, $\gamma = \gamma_1$. Upon substitution of $p_m = p_f = \alpha + c$ into the R.H.S. and $\gamma_1 = \frac{\beta}{1-\delta}\left(\frac{\alpha-\sigma}{\alpha}-\delta\right)$ into the L.H.S. and rearrangement (39) becomes

$$\beta\left(\alpha+\delta c\right)+\left(1-\delta\right)c\frac{\beta}{1-\delta}\left(\frac{\alpha-\sigma}{\alpha}-\delta\right)<\beta\left(\frac{\alpha+\sigma}{1-\frac{c}{\alpha+c}}\right),$$

which boils down to $0 < \alpha\sigma$, which is always true. Now the L.H.S. of (39) is increasing in γ and the R.H.S. in decreasing in γ (because p_m is decreasing in γ), so it is enough to show that for $\gamma = \gamma_2$ condition (39) still holds. But, for $\gamma = \gamma_2$ we have shown above that $p_m = p_p$, so that the insiders' wealth in the mixed strategy equilibrium given in (38) is exactly their wealth in a partial repurchase equilibrium. By Lemma 5, insiders' wealth in a partial repurchase equilibrium is always higher than their wealth without repurchase. Hence insiders' wealth in the partial repurchase in mixed strategies equilibrium is always higher than without announcement, so they prefer it over not announcing.■

Proof of Proposition 7: Comparing outsiders' expected wealth in a full repurchase equilibrium to their wealth without announcement we get that

$$(1-\beta)(\alpha+\delta c)<(1-\beta)(\alpha+c).$$

Hence, like the insiders, they will always prefer to announce when a full repurchase equilibrium can hold.

Next, consider outsiders' expected wealth in a partial repurchase equilibrium. It is convenient to consider this wealth as the difference between the expected firm value and the expected ownership of the insiders (the market maker has zero expected profit). Outsiders' expected wealth in a partial repurchase equilibrium is the difference

$$\frac{1}{2}(L+\delta c+H+c)-\frac{1}{2}\beta\left((L+\delta c)+\frac{H}{1-\frac{c}{p_p}}\right)$$

(The latter term here is not insiders' total wealth because they also have benefits from waste.) Upon substitution of $L=\alpha-\sigma$ and $H=\alpha+\sigma$ and rearrangement this becomes

$$(1-\beta)\left(\alpha+\frac{\delta c}{2}\right)+\frac{c}{2}\left[1-\beta\frac{\alpha+\sigma}{p_p-c}\right]. \tag{40}$$

Outsiders' expected wealth under partial repurchase is higher than without repurchase whenever

$$(1-\beta)(\alpha+\delta c)<(1-\beta)\left(\alpha+\frac{\delta c}{2}\right)+\frac{c}{2}\left[1-\beta\frac{\alpha+\sigma}{p_p-c}\right],$$

which boils down to

$$\frac{\beta}{1-\delta}\left(\frac{\alpha+\sigma}{p_p-c}-\delta\right)<1. \tag{41}$$

But, the L.H.S. of (41) is exactly the upper limit for a partial repurchase equilibrium to hold given in (17), γ_3. Thus, we can rewrite (41) as $\gamma_3 < 1$.

Now since $0 < \gamma < 1$ then if $\gamma_3 > 1$ we will always have $\gamma < \gamma_3$, so that if $\gamma_2 < \gamma < \gamma_3$ although a partial repurchase equilibrium can hold given announcement, outsiders will prefer not to announce. If, instead, $\gamma_3 < 1$, outsiders will announce a program whenever insiders would. Thus, a partial repurchase equilibrium will prevail for all $\gamma_2 < \gamma < \gamma_3$ and a full repurchase equilibrium will prevail for all $\gamma < \gamma_1$.■

Proof of Lemma 6: For insiders, no repurchase announcement is better than a dividend whenever their wealth without announcement given in (20) is higher than their wealth with a dividend, that is, whenever

$$\beta\left[\alpha + (1 - T_D)\, c\right] < \beta\left(\alpha + \delta c\right) + (1 - \delta)\, c\gamma,$$

which upon rearrangement we can write as

$$T_D > (1 - \delta)\left(1 - \frac{\gamma}{\beta}\right) = T_{D2}(\gamma).$$

Similarly, for the insiders, a partial repurchase equilibrium is better than dividends whenever

$$\beta\left[\alpha + (1 - T_D)\, c\right] < \beta\alpha + \frac{c}{2}\left(\beta\delta + (1 - \delta)\,\gamma + \beta\frac{\alpha + \sigma}{p_p - c}\right),$$

which upon rearrangement we can write as

$$T_D > \frac{1}{2}\left[(1 - \delta)\left(1 - \frac{\gamma}{\beta}\right) - \left(\frac{\alpha + \sigma}{p_p - c} - 1\right)\right] = T_{D1}(\gamma).$$

Also, $0 < \frac{\alpha+\sigma}{p_p-c} - 1$ because $p_p < p_f = \alpha + c$, and hence, by inspection, $T_{D1}(\gamma) < T_{D2}(\gamma)$ for all γ.■

Proof of Proposition 8: Insiders prefer a full repurchase equilibrium whenever their wealth in a full repurchase equilibrium given in (19) is higher than their wealth under dividends given in (29), that is, whenever

$$\beta\left[\alpha + (1 - T_D)\, c\right] < \beta\left(\alpha + c\right),$$

which boils down to $0 < T_D$, which always holds. Hence, when a full repurchase equilibrium holds (i.e., when $\gamma < \gamma_1$), for the insiders, a repurchase announcement is always better than a dividend payment.

Next, we show that $T_{D1}(\gamma) < 0$ whenever a partial repurchase equilibrium holds, namely in the range ($\gamma_2 < \gamma < \gamma_3$). To see this, first note that, by inspection, $T_{D1}(\gamma)$ is decreasing in γ (as p_p does not depend on γ). Now, upon substitution of γ_2 using (24) into $T_{D1}(\gamma)$, that is, into (30),

$$T_{D1}(\gamma_2) = \frac{1}{2}\left[(1-\delta)\left(1 - \frac{\frac{\beta}{1-\delta}\left(\frac{\alpha-\sigma}{p_p-c} - \delta\right)}{\beta}\right) - \left(\frac{\alpha+\sigma}{p_p-c} - 1\right)\right],$$

which boils down to

$$1 - \frac{\alpha}{p_p - c},$$

and where

$$1 - \frac{\alpha}{p_p - c} < 1 - \frac{\alpha}{p_f - c} = 1 - \frac{\alpha}{\alpha} = 0.$$

Upon substitution of γ_3 using (25) into $T_{D1}(\gamma)$, that is, into (30),

$$T_{D1}(\gamma_3) = \frac{1}{2}\left[(1-\delta)\left(1 - \frac{\frac{\beta}{1-\delta}\left(\frac{\alpha+\sigma}{p_p-c} - \delta\right)}{\beta}\right) - \left(\frac{\alpha+\sigma}{p_p-c} - 1\right)\right],$$

which boils down to

$$1 - \frac{\alpha+\sigma}{p_p - c},$$

and where

$$1 - \frac{\alpha+\sigma}{p_p - c} < 1 - \frac{\alpha+\sigma}{p_f - c} = 1 - \frac{\alpha+\sigma}{\alpha} < 0.$$

That is, $T_{D1}(\gamma) < 0$ for all $\gamma_2 < \gamma < \gamma_3$. Hence by Lemma 6 a partial repurchase equilibrium, when it holds, always dominates dividends for all positive dividend tax rates. Furthermore, $T_{D1}(\gamma) < T_{D2}(\gamma)$ for all $\gamma < \gamma_3$ assures that whenever a partial equilibrium can hold it will be preferred by the insiders over no payout.

Next, we show that $T_{D2}(\gamma) < 0$ whenever neither repurchase equilibrium holds (i.e., in the range $\gamma > \gamma_3$). First, by inspection, $T_{D2}(\gamma)$ is decreasing in γ. Upon substitution of γ_3 using (25) into $T_{D2}(\gamma)$, that is, into (31),

$$T_{D2}(\gamma_3) = (1-\delta)\left(1-\frac{\gamma_3}{\beta}\right) = (1-\delta)\left(1-\frac{\beta}{(1-\delta)\,\beta}\left(\frac{\alpha+\sigma}{p_p-c}-\delta\right)\right),$$

which boils down to

$$1-\frac{\alpha+\sigma}{p_p-c},$$

and where

$$1-\frac{\alpha+\sigma}{p_p-c} < 1-\frac{\alpha+\sigma}{p_f-c} = 1-\frac{\alpha+\sigma}{\alpha} < 0,$$

and since $T_{D2}(\gamma)$ is decreasing in γ, then $T_{D2}(\gamma) < 0$ for all $\gamma > \gamma_3$. Hence by Lemma 6, $T_{D2}(\gamma) < T_D$ for all $T_D > 0$, so that no repurchase always dominates dividends in this range for all positive dividend tax rates.

We note that the indifference between dividends and partial repurchase and the indifference between dividends and no repurchase is continuous in γ at γ_3. That is, $T_{D1}(\gamma_3) = T_{D2}(\gamma_3)$. Indeed, $T_{D1}(\gamma_3) = T_{D2}(\gamma_3)$ means

$$\frac{1}{2}\left[(1-\delta)\left(1-\frac{\gamma}{\beta}\right)-\left(\frac{\alpha+\sigma}{p_p-c}-1\right)\right] = (1-\delta)\left(1-\frac{\gamma}{\beta}\right),$$

which can be rearranged to

$$\gamma = \frac{\beta}{(1-\delta)}\left(\frac{\alpha+\sigma}{p_p-c}-\delta\right) = \gamma_3.$$

Lastly, in the range $\gamma_1 < \gamma < \gamma_2$, a partial repurchase equilibrium in mixed strategies (see subsection 5.1) always dominates dividends. This is because, as γ increases in this range, insiders' wealth changes monotonically and continuously between their wealth under full repurchase to their wealth under partial repurchase. However, at both edges of this range a program announcement dominates dividends for all $T_D > 0$, hence dominates dividends throughout the whole range.■

Proof of Proposition 9: Outsiders prefer full repurchase over dividends if their expected wealth under full repurchase is higher than their expected wealth under dividends, namely, if

$$(1-\beta)\left[\alpha+\left(1-T_D\right)c\right]<(1-\beta)(\alpha+c)\,,$$

which we can rearrange to $0 < T_D$, which always holds, and since

$$(1-\beta)(\alpha+\delta c)<(1-\beta)(\alpha+c)$$

they prefer full repurchase over no payout.

Outsiders prefer a dividend over no repurchase (no payout) whenever their expected wealth under a dividend given in (32) is higher than their expected wealth without announcement, namely when

$$(1-\beta)(\alpha+\delta c)<(1-\beta)\left[\alpha+\left(1-T_D\right)c\right].$$

which we can rearrange to

$$T_D<1-\delta=T_{D4}.$$

Next, outsiders prefer a dividend over a partial repurchase whenever their expected wealth under a dividend given in (32) is higher than their expected wealth under partial repurchase given in (40), that is when

$$(1-\beta)\left(\alpha+\frac{\delta c}{2}\right)+\frac{c}{2}\left[1-\beta\frac{\alpha+\sigma}{p_p-c}\right]<(1-\beta)\left[\alpha+\left(1-T_D\right)c\right]$$

which we can rearrange to

$$T_D<1-\frac{1}{2}\left(\delta+\frac{1}{(1-\beta)}\left[1-\beta\frac{\alpha+\sigma}{p_p-c}\right]\right)=T_{D3}.$$

Next, we show that if $\gamma_3 < 1$ then $T_{D3} < T_{D4}$, that is, the dividend tax rate at which outsiders switch from dividends to a partial repurchase when a partial repurchase equilibrium can hold is lower than the dividend tax rate at which outsiders switch from dividends to no payout when a partial repurchase equilibrium cannot hold. We can rearrange $T_{D3} < T_{D4}$, namely

$$1 - \frac{1}{2}\left(\delta + \frac{1}{(1-\beta)}\left[1 - \beta\frac{\alpha+\sigma}{p_p - c}\right]\right) < 1 - \delta$$

to

$$\frac{\beta}{1-\delta}\left(\frac{\alpha+\sigma}{p_p - c} - \delta\right) < 1,$$

which is $\gamma_3 < 1$. That is, the condition for $T_{D3} < T_{D4}$ is $\gamma_3 < 1$. But, we know that for T_{D3} to be relevant (partial repurchase better for outsiders than no announcement) we must have $\gamma_3 < 1$. Hence, whenever a partial equilibrium holds, $T_{D3} < T_{D4}$.

Lastly, it is always the case that $T_{D3} > 0$. To see this, write $T_{D3} > 0$ as

$$0 < 1 - \frac{1}{2}\left(\delta + \frac{1}{(1-\beta)}\left[1 - \beta\frac{\alpha+\sigma}{p_p - c}\right]\right)$$

and rearrange to

$$-\frac{(1-\delta)(1-\beta)}{\beta} < \left(\frac{\alpha+\sigma}{p_p - c} - 1\right),$$

which always holds, because the L.H.S. is negative while the R.H.S. is positive. The R.H.S. is positive because $p_p < p_f$, and hence

$$\frac{\alpha+\sigma}{p_p - c} > \frac{\alpha+\sigma}{p_f - c} = \frac{\alpha+\sigma}{\alpha} = 1 + \frac{\sigma}{\alpha} > 1. \blacksquare$$

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Figure 1: Time line

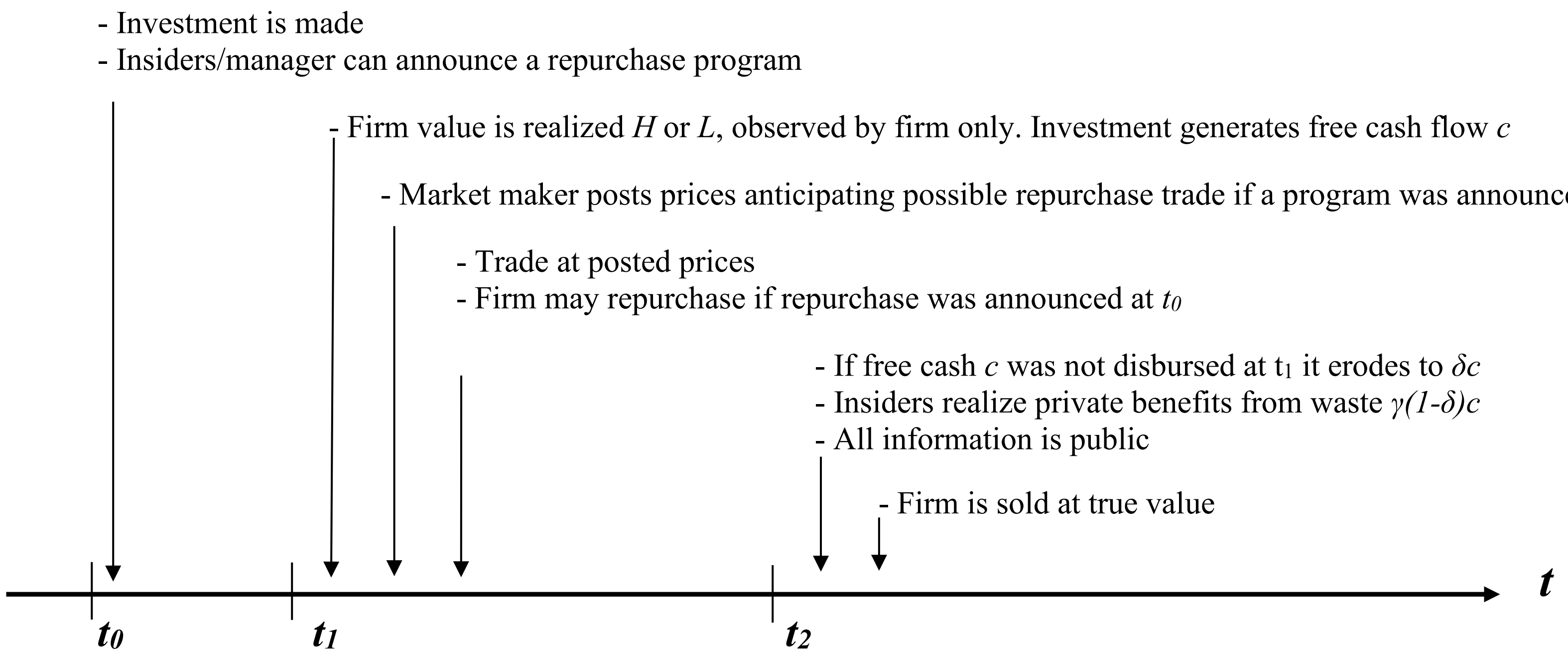

Figure 2: Payout policy when *insiders* are in control

Figure 2 describes equilibrium payout policy as a function of benefits from waste γ and dividend tax rate T_D , when insider shareholders are in control. In the figure, the red line depicts the limit on the dividend tax rate T_D below which dividends is the dominating payout policy for insider shareholders.

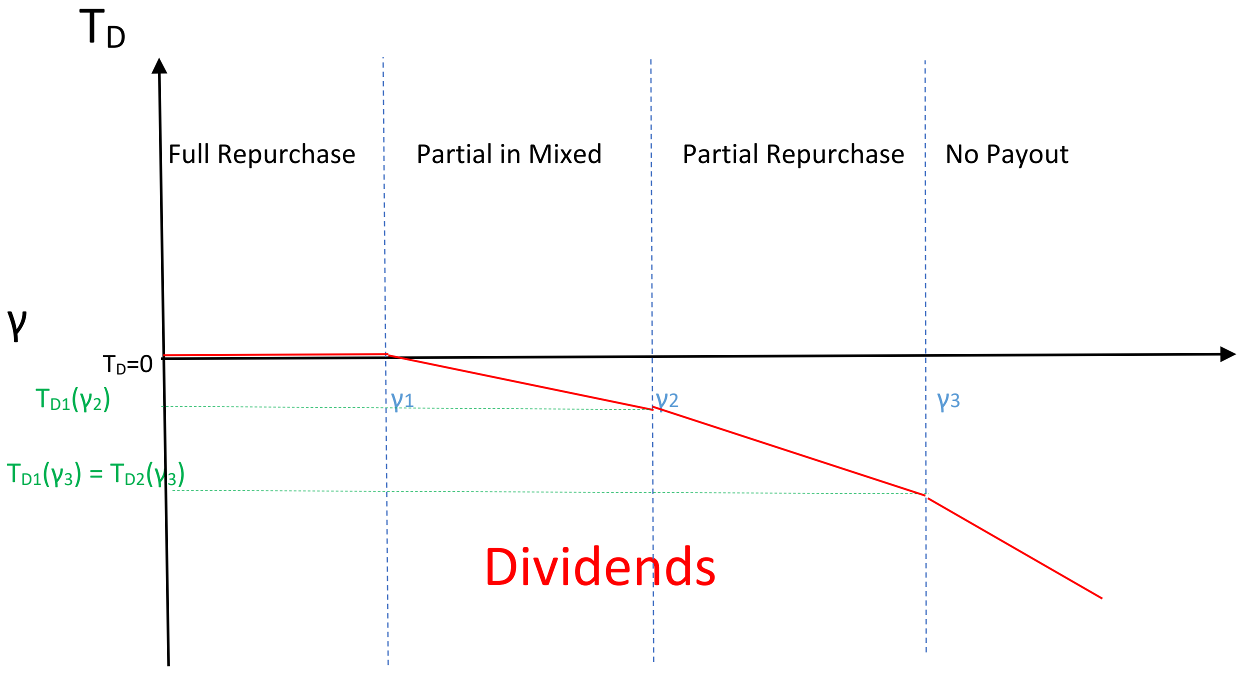

Figure 3: Payout policy when *outsiders* are in control

Figure 3 describes equilibrium payout policy as a function of benefits from waste γ and dividend tax rate T_D, when outsider shareholders are in control. In the figure, the red line depicts the limit on the dividend tax rate T_D below which dividends is the dominating payout policy for outside shareholders.

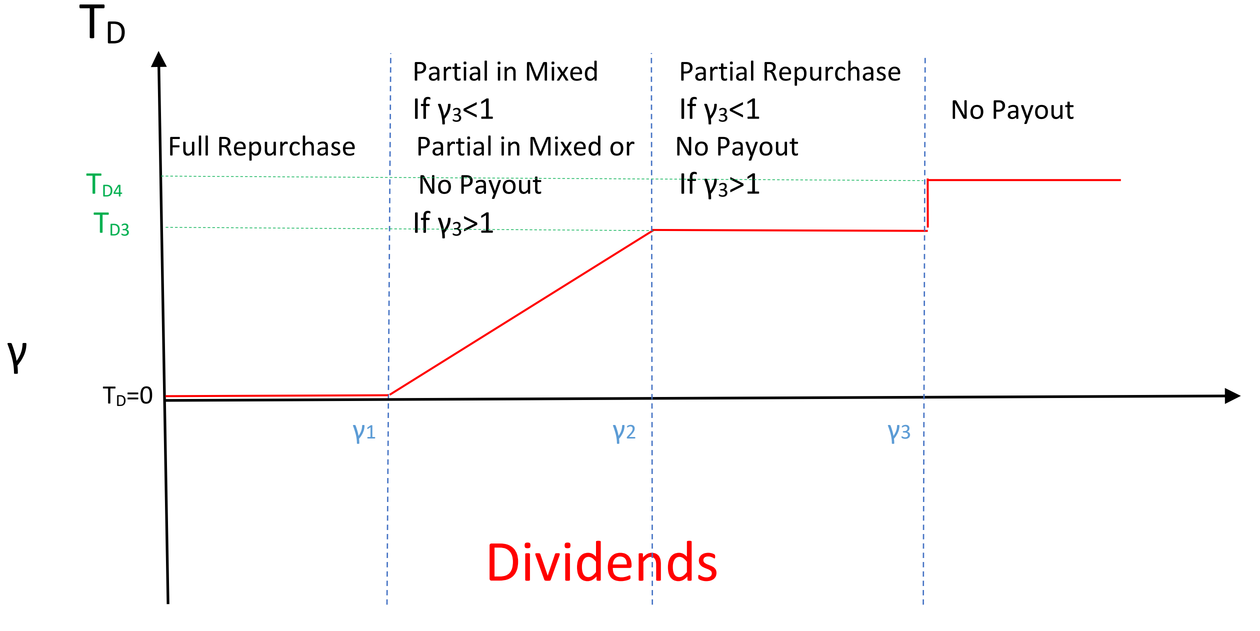

Figure 4: Existence of equilibrium as a function of benefits from cash waste rate γ

Figure 4 demonstrates how the existence of the different equilibria in this example depends on the rate of benefit from waste γ. Specifically, we change γ in the range $[0,1]$ while holding all other parameters fixed. In the figure (and also in Figures 5-7), the green line represents the rate of benefit from waste in this example, $\gamma=0.2$. The purple line represents γ_1, the upper limit on γ given in condition (5), below which a full repurchase equilibrium can hold. The brown and blue lines represent, respectively, γ_2, and γ_3, the lower and upper limits on γ given in condition (17) for a partial repurchase equilibrium to hold. The lines representing γ_1, γ_2, and γ_3 are parallel to the X axis in Figure 4, as these limits do not depend on γ. For a partial repurchase equilibrium, the green line must be between the brown and the blue lines.

As Figure 4 shows, For all $\gamma<\gamma_1=0.157$ the green line is below the purple line and a full repurchase equilibrium prevails. Moving up, once $\gamma>\gamma_1=0.157$, the green line becomes above the purple line, reflecting that benefits from waste become high enough so that at $p_f=3.6$, in state L, insiders are better off wasting the cash rather than repurchasing, and a full repurchase equilibrium no longer holds. In the range $0.157=\gamma_1<\gamma<\gamma_2=0.169$, there is discontinuity and neither a full nor a partial repurchase equilibrium hold. In section 5 (Extensions) we show that a partial equilibrium in mixed strategies exists in this range. Once $\gamma>\gamma_2=0.169$ (when the green line becomes above the brown line), the benefit from waste become high enough for the insiders to stop repurchasing in state L at $p_p=3.5533$, and a partial repurchase equilibrium starts holding. It holds as long as $\gamma\leq\gamma_3=0.458$. Once $\gamma>\gamma_3$ (the green line becomes above the blue line), the benefit from waste becomes too high so that at $p_p=3.5533$, the firm will not repurchase in state H either. This is also the point where wealth under a partial repurchase equilibrium stops being higher than the wealth under no-repurchase equilibrium (Lemma 5). Hence, for any $\gamma>\gamma_3=0.458$ the no-repurchase equilibrium prevails.

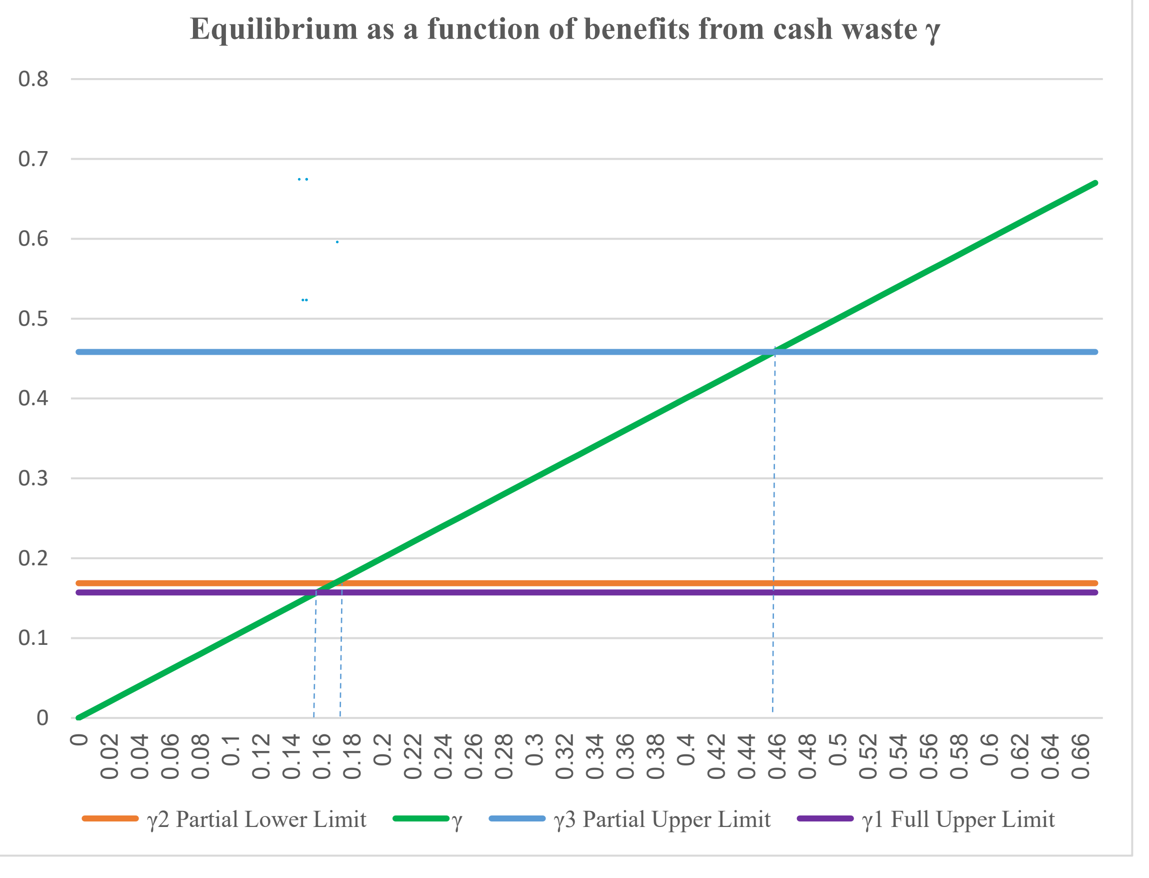

Figure 5: Existence of equilibria as a function of insider ownership β

Figure 5 demonstrates how the existence of equilibria in this example depends on insider ownership β. Specifically, we change insider ownership β in the range $[0,0.5]$, holding all other parameters fixed. In the chart, the green line represents the rate of benefit from waste in this example $\gamma=0.2$. The purple line represents γ_1, the limit on γ in (5) below which a full repurchase equilibrium can hold, as a function of β. The brown and blue lines represent, respectively, γ_2, and γ_3, the lower and upper limits on γ given in (17), for partial repurchase equilibrium to hold, as a function of β.
As Figure 5 shows, starting from $\beta=0$ and moving up, until $\beta=0.13$ the green line (i.e., $\gamma=0.2$) is above all the other lines, reflecting that a no-repurchase equilibrium prevails. Once $\beta>0.13$, the blue line crosses the green line to become above it while the brown line is still below the green line (i.e. $\gamma_2<\gamma=0.2<\gamma_3$), and partial repurchase equilibrium starts holding. A partial repurchase equilibrium prevails in the range $0.13<\beta<0.35$. For $\beta>0.35$ the brown line also crosses the green line, reflecting $\gamma_2>\gamma=0.2$, and a partial repurchase equilibrium stops holding. In the range $0.35<\beta<0.38$, the green line becomes below both the blue and brown line, but still above the purple line ($\gamma_1<\gamma=0.2<\gamma_2$) hence neither a partial nor a full repurchase equilibrium holds. Once $\beta>0.38$ the purple line also crosses the green line, ($\gamma_1>\gamma=0.2$), reflecting that at $p_f=3.6$ the insiders will repurchase in both states. Since γ_1 is increasing in β then for all $\beta>0.38$ result in $\gamma_1>\gamma=0.2$, and a full repurchase equilibrium prevails.

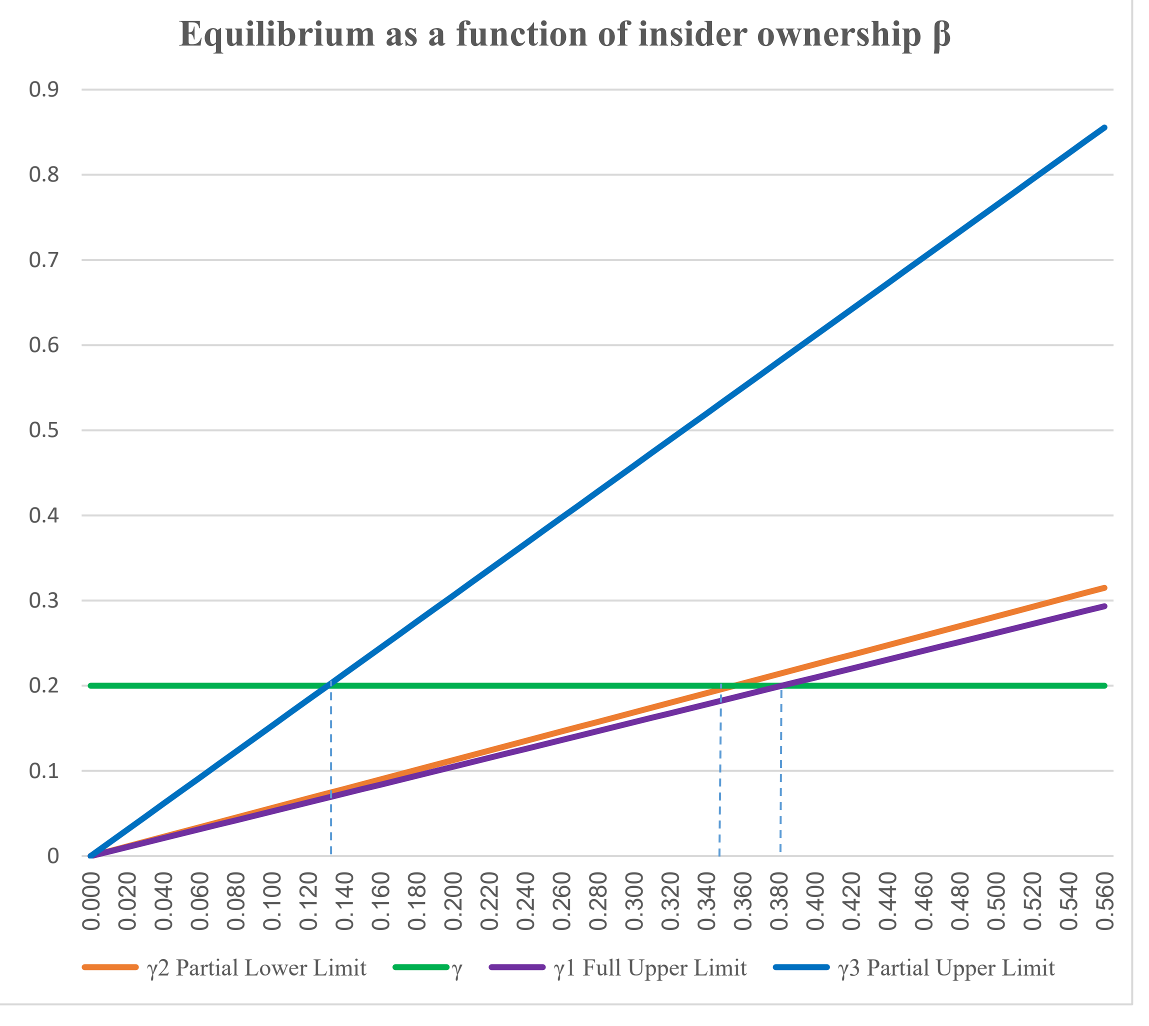

Figure 6 : Existence of equilibria as a function of cash retention rate δ

Figure 6 demonstrates how the existence of the different equilibria depends on the cash retention rate δ. Specifically, we change δ in the range $[0,1]$ holding all other parameters fixed. In the figure, the green line represents the rate of benefit from waste in this example $\gamma=0.2$. The purple line represents γ_1, the limit on γ given in condition (5) below which a full repurchase equilibrium can hold, as a function of δ. The brown and blue lines represent, respectively, γ_2, and γ_3, the lower and upper limits on γ given in condition (17), for a partial repurchase equilibrium to hold, as a function of δ.
As Figure 6 shows, starting from $\delta=0$ (complete cash waste), and moving up, until $\delta=0.57$ the purple line is above the green line (i.e., $\gamma_1>\gamma=0.2$), and a full repurchase equilibrium prevails. Once $\delta>0.57$, the purple line becomes below the green line (i.e. $\gamma_1<\gamma$), and insiders stop repurchasing in state L. In the range $0.57<\delta<0.6$, the green line is above the purple line, but still below the brown line (i.e., $\gamma_1<\gamma<\gamma_2$), and neither a full nor a partial repurchase equilibrium holds. Once $\delta>0.6$, the brown line becomes below the green line, while the blue line is still above the green line ($\gamma_2<\gamma=0.2<\gamma_3$). Because γ_3 is increasing in δ, then for any $\delta>0.6$ the blue line remains above the green line ($\gamma_3>\gamma=0.2$), and a partial repurchase equilibrium prevails.

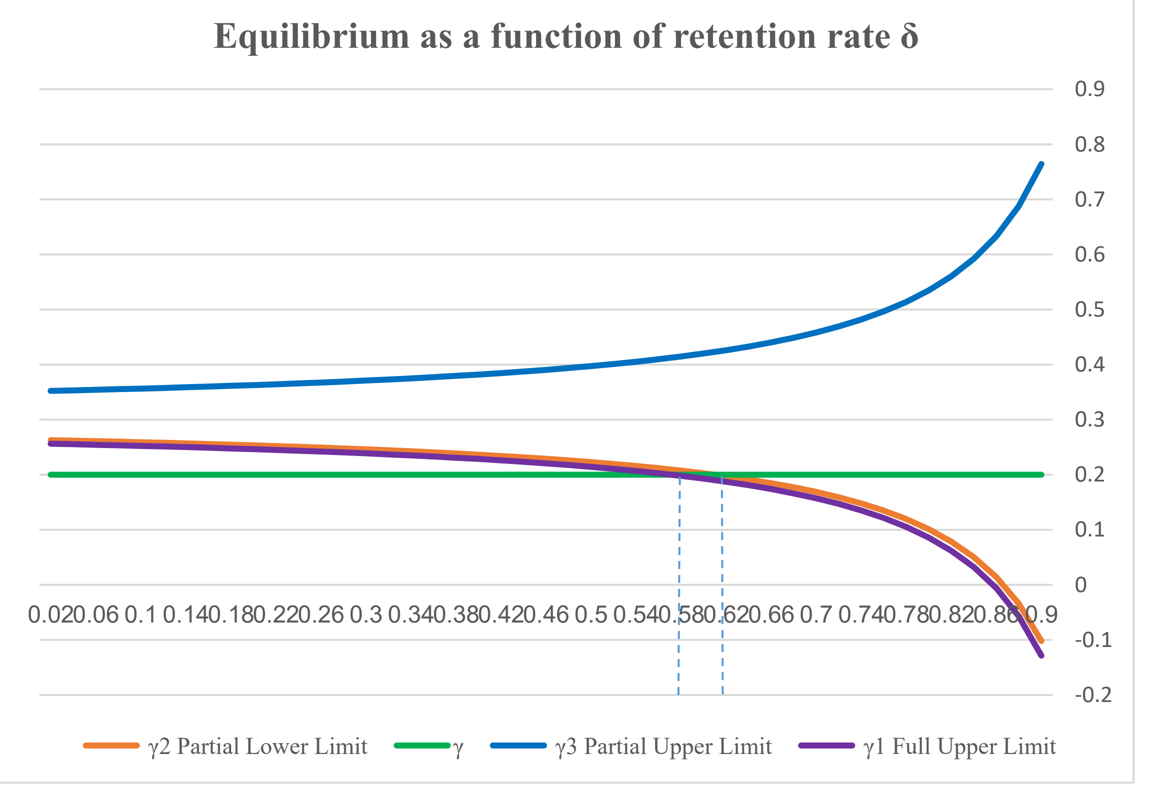

Figure 7: Existence of equilibria as a function of variability in asset value σ

Figure 7 demonstrates how the existence of equilibria in this example depends on the variability in the value of assets in place σ. Specifically, we change σ in the range [0,1.2], holding all other parameters fixed. In the chart, the green line represents the rate of benefit from waste in this example $\gamma=0.2$. The purple line represents γ_1, the limit on γ in (5) below which a full repurchase equilibrium can hold, as a function of σ. The brown and blue lines represent, respectively, γ_2, and γ_3, the lower and upper limits on γ given in (17) for a partial equilibrium to hold, as a function of σ.

As Figure 7 shows, for all $0<\sigma<0.35$, the green line is below the purple line, reflecting $\gamma_1>\gamma=0.2$, and a full repurchase equilibrium prevails. A full repurchase equilibrium holds when variability is low because the resulting overvaluation in state L is low, hence the cost of overpaying and foregoing private benefits from waste is lower than benefit from waste prevention. Once $\sigma>0.35$, overvaluation in state L becomes too high, so that at p_f, insiders are better off not repurchasing in state L, and a full repurchase equilibrium stops holding. In the range $0.35<\sigma<0.38$ the purple line is below the green line, but the brown line is still above the green line ($\gamma_1<\gamma=0.2<\gamma_2$), so that neither a full nor a partial repurchase equilibrium holds. Once $\sigma>0.38$, the brown line becomes below the green line ($\gamma_2<\gamma=0.2$) and a partial repurchase equilibrium holds. It holds for all $\sigma>0.38$ because overvaluation and undervaluation in states L and H, respectively, increases with σ. This is reflected in γ_2 (brown line) decreasing in σ while γ_3 (blue line) increasing in σ.