Firm Payouts and Innovation Under Asymmetric Information

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Abstract

We study how stock repurchases affect corporate financing, innovation, and growth. We build a signaling model in which managers privately observe R&D project quality and use costly buybacks to credibly separate high-quality from low-quality firms. Embedding this mechanism in an endogenous growth framework with earnings-based constraints, we show that repurchases restore efficient R&D investment for high-quality firms at the expense of higher leverage. In equilibrium, buybacks serve as an informational device that reallocates resources toward high-quality innovators rather than crowding out innovation, though this comes at the cost of greater corporate indebtedness.

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1 Introduction

Share repurchases have become one of the dominant mechanisms through which firms return cash to shareholders. In recent years, the scale of corporate share repurchases has increased particularly among large, innovative U.S. firms, drawing significant attention. For example, large U.S. public firms routinely announce share repurchase programs on the order of tens of billions of dollars. In 2025 alone, Apple announced a $100 billion repurchase program, corresponding to roughly 2.8% of its market capitalization. While share repurchases are often perceived as a signal of managerial confidence, the growing reliance on buybacks has raised concerns about whether repurchase activity distorts firms' investment and innovation decisions. Critics argue that repurchases may encourage managers to prioritize short-term share price support over long-run value creation, potentially at the expense of innovation and sustained growth.

In this paper, we quantitatively study the impact of share repurchases on firms' innovation and long-run growth in an environment with asymmetric information. Firms' R&D projects are rarely disclosed to the public and are instead privately known by managers. In an environment in which managers possess superior information about the quality of their R&D portfolios, share repurchases can serve as an instrument through which managers mitigate asymmetric information (Vermaelen, 1981; Dittmar, 2000). By committing to costly buybacks, managers of high-quality firms may credibly reveal their type to outside investors, obtain better financing terms, and sustain higher levels of R&D investment and innovation than would be possible in a purely pooling environment. At the same time, the use of buybacks as a signal is not innocuous: it absorbs resources that could otherwise be used for innovation and pushes firms toward greater leverage.

The starting point of our analysis is a set of firm-level facts on the joint dynamics of repurchases, cash holdings, debt, and innovation outcomes. We document that firms initiating stock repurchases experience a marked decline in cash holdings and a sizable expansion of leverage over a multi-year horizon. Liquidity buffers are gradually depleted as repurchase commitments are fulfilled, while debt rises persistently, indicating a structural shift in capital structure rather than a transitory liquidity-management episode. At the same time, repurchasing firms increase R&D expenditures and exhibit stronger patenting performance than non-repurchasing firms. Innovation inputs and outputs rise, even as firms return substantial resources to shareholders and carry higher leverage, challenging the view that buybacks mechanically crowd out long-run investment.

These patterns are difficult to reconcile with benchmark models in which payouts are neutral and financing frictions are absent. If stock repurchases were simply a redundant way of distributing idle cash, we would not expect them to be systematically associated with higher leverage and stronger innovation outcomes. Conversely, if repurchases were purely a manifestation of short-termism, we would expect to see cuts in R&D and a deterioration of innovation performance, rather than the opposite. The evidence instead suggests that repurchasing firms reorganize their financing mix—substituting internal liquidity with external funding—in a way that allows them to sustain or even expand innovative investment while returning cash to shareholders. This motivates a framework in which asymmetric information about R&D quality and earnings-based borrowing constraints interact with payout policy in non-trivial ways.

To provide such a framework, we build a two-period model in which managers privately observe the quality of their R&D projects and may use costly stock repurchases to signal high quality to outside investors. Under full information, high-quality firms invest more in R&D and borrow more than low-quality firms, and find it optimal not to repurchase shares because buybacks are strictly costly when information is symmetric. Under asymmetric information, in contrast, a pooling equilibrium in which both types choose the same policies leads to distorted investment and borrowing: high-quality firms underinvest and borrow too little relative to the full-information benchmark, while low-quality firms overinvest and overborrow. In this environment, high-quality firms have an incentive to separate by choosing a positive level of repurchases that low-quality firms do not find profitable to mimic.

We show that a separating equilibrium arises in which high-quality firms optimally undertake a costly repurchase to credibly reveal their type, obtain more favorable financing terms, and restore the efficient level of R&D, while low-quality firms refrain from repurchasing and behave as under full information. The equilibrium repurchase size is pinned down as the least-cost separating signal: it is just large enough to deter low-quality firms from mimicking, so that the low-type incentive-compatibility constraint binds while the high-type constraint is slack. This mechanism implies that high-quality firms in equilibrium hold less cash, carry more debt, and invest more in R&D than they would under full information, while low-quality firms retain their full-information policies. The resulting joint dynamics of cash, leverage, and innovation align closely with the firm-level patterns described above.

We then embed this signaling mechanism into a quantitative endogenous growth model in the spirit of Romer (1990). Time is discrete and the economy grows through an expanding variety of intermediate goods produced by monopolistically competitive firms that invest in

R&D, finance their projects under earnings-based debt covenants, and may engage in share repurchases as a signaling device. An investment fund and a mass of debt investors observe firms' cash flows, debt positions, and repurchase decisions but not their latent R&D quality; they price equity and debt competitively based on posterior beliefs. Along a balanced growth path, the model admits a stationary representation in which firms' policies are expressed in terms of state variables normalized by the aggregate scale of the economy, and buybacks enter as costly signals that shape the allocation of R&D and the distribution of leverage across firms.

Within this environment, we characterize how repurchases affect both the micro allocation of innovation and the macro growth rate. High-quality firms that use buybacks to separate obtain better borrowing terms and choose higher R&D intensity, expanding their portfolio of patented varieties more rapidly than in a pooling equilibrium. Low-quality firms refrain from repurchasing and face tighter effective borrowing conditions, limiting their ability to overinvest and overborrow. At the aggregate level, this reallocation pushes resources toward high-quality innovators and sustains long-run growth, even though the signaling mechanism operates through costly payouts and higher leverage. The model thus delivers a disciplined account of how stock repurchases can simultaneously support innovation and raise corporate indebtedness, providing a structural interpretation of the empirical evidence.

The rest of the paper is organized as follows. Section 2 presents the empirical evidence on the dynamics of repurchases, cash holdings, leverage, R&D, and patenting. Section 3 introduces the signaling model with asymmetric information, derives the full-information, pooling, and separating equilibria, and links their implications to the firm-level facts. Section 4 embeds the signaling mechanism into the quantitative endogenous growth framework, describes the calibration, and analyzes the macroeconomic implications of repurchases for innovation and long-run growth. Section 6 concludes by discussing policy implications and directions for future research.

2 Empirics

In this section, we present the empirical results of the paper. We begin by describing the data and then analyze the impact of stock repurchases on firm outcomes.

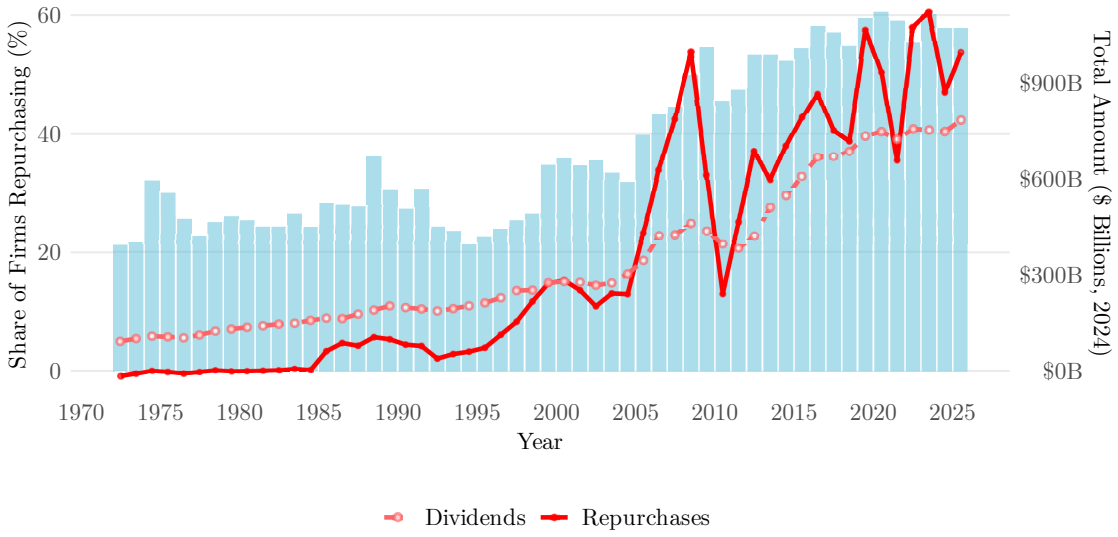
2.1 Data

Our primary data source is Compustat's North American Quarterly database for the period 1985–2024. We focus on U.S. incorporated firms and exclude financials, utilities, and public administration firms following standard practice. We apply conventional sample filters to ensure data quality: we retain only observations with positive assets and non-negative tangible capital, exclude acquisitions exceeding 5 percent of assets, and require at least 40 consecutive quarters of investment data per firm. Extreme outliers are winsorized following Ottonello and Winberry (2020). These filters yield 256,328 firm–quarter observations for 11,200 firms. For each observation, we have information on key firm-level variables, such as assets, capital expediture and R&D spending, debt stock and equity value. We complement the Compustat panel with U.S. public firm patent dataset of Kogan, Papanikolaou, Seru, and Stoffman (2017), which provides patent counts and citation-weighted patent stocks matched to firms via standard linking tables. We leverage patent information to gauge the effect of stock repurchase on innovation output. Additional details on variable construction and sample filters are provided in Appendix A.

2.2 Dynamics of Stock Repurchase

Figure 1 documents the evolution of stock repurchases among U.S. public firms from 1970 to 2024. Two striking patterns emerge. First, the share of firms engaging in open-market repurchases has risen sharply, particularly from the late 1990s onward. This reflects both increased adoption of buyback programs and regulatory changes–notably the elimination of SEC Rule 10b-18 safe harbor restrictions in 2003. Second, the aggregate dollar value of buybacks has increased dramatically since the late 1990s, far outpacing the growth of dividend payouts. Stock repurchases and dividend payouts are equivalent in their effect on total shareholders' wealth, as both tools entail the distribution of the company's cash to its shareholders. In 2024 dollars, annual repurchases have grown from near zero in 1980 to over $600 billion in recent years, outpacing the rise in dividend payouts. This compositional shift in corporate payouts toward stock repurchases has raised questions about their implications for investment, capital structure, and innovation.

Figure 1: Stock Repurchases Over Time



Notes: The Figure plots the share of firms engaging in stock repurchases in a given year (left axis, bars) and the aggregate dollar value of stock repurchases and dividend payouts (right axis, lines) over time. Stock repurchases are defined as open-market stock buybacks from SEC filings (post-2004) and Compustat cash-flow data (pre-2004). Dividend payout refer to cash dividend payments from Compustat. Dollar values are expressed in billions of 2024 dollars using implicit price deflators from FRED.

2.3 Effects of Stock Repurchases

Methodology. To estimate the impact of stock repurchase initiation on selected firm outcomes, we employ panel local projection methods. The central treatment variable is a binary indicator for stock repurchase initiation in a given quarter, measured from cash-flow statements. Prior to 2004, we use imputed repurchase data; from 2004 onward, we replace this with SEC disclosure-based measures when available. Outcome variables include balance-sheet items (debt, equity, cash) and innovation measures (R&D spending, patent stocks). All outcome variables are scaled by lagged total assets. The normalization allows us to interpret coefficients as the change in each outcome variable as a fraction of firm size.

For each outcome variable $Y_{i,t}$, we estimate the following main specification:

$$Y_{i,t+12} - Y_{i,t-1} = \gamma \cdot \text{Repurchase}_{i,t} + \boldsymbol{\beta}_h' \mathbf{X}_{i,t} + \alpha_i + \mu_{s(i),t+12} + \epsilon_{i,t+12}, \tag{1}$$

where the dependent variable is the change in outcome from quarter $t-1$ to 12 quarter ahead scaled by total asset at quarter $t-1$; $\text{Repurchase}_{i,t}$ is our binary treatment indicator,

which equals one if firm i repurchases in quarter t, zero otherwise; $\mathbf{X}_{i,t}$ includes lagged assets, lagged sales growth; $\mu_{s(i),t+12}$ and α_i are sector-time (two-digit SIC $\times$ quarter) and firm fixed effects, respectively; and $\epsilon_{i,t+12}$ is the regression error.

Identification relies on several assumptions. Firm fixed effects α_i eliminate time-invariant firm heterogeneity such as persistent differences in management quality or corporate culture. Sector-time fixed effects $\mu_{s(i),t+12}$ absorb common shocks to industry peers in the same quarter, such as sector-wide demand changes or input price pressures. The coefficient of interest, γ, is identified from within-firm variation in repurchase timing, conditional on these fixed effects and lagged controls. Identification further requires that within-firm repurchase timing is uncorrelated with unobserved shocks to firm outcomes conditional on controls. While this is a strong assumption, the inclusion of sector-time fixed effects substantially reduces concerns about reverse causality and omitted variable bias by partialling out macro shocks.

Results. Table 1 presents regression results examining the impact of stock repurchases on firm outcomes over a three-year (12-quarter) horizon. We show that stock repurchases, despite supporting short-term stock prices and shareholder value[1], do not reduce R&D spending or innovation output. The reason is that the reduction in liquidity is offset by an expansion of leverage, which supports the expansion of R&D efforts and long-term innovation outputs.

The column (1) in Panel B shows that, rather than reducing productivity-enhancing spending, firms that initiate repurchases significantly expand R&D investment over the three-year horizon. R&D spending increases by 0.17 percent of assets; given that the average firm spends 2.63 percent of assets on R&D, this represents a 6.5 percent increase in innovation spending. This evidence fundamentally contradicts the narrative that stock repurchases crowd out innovation, forcing firms to retrench on productive activities.

The first two columns in Panel A show that the increase in R&D spending reflects a persistent shift toward greater financial leverage, as opposed to short-run cash management behavior. Cash declines by 2.57 percent of assets, suggesting that firms' liquidity reserves are gradually depleted as ongoing repurchase commitments are fulfilled. However, debt increases substantially by 5.40 percent of lagged assets over the three-year window, indicating that firms pursuing repurchases systematically expand leverage. Together, these results suggest that firms manage to sustain and expand productive investment while simultaneously returning value to shareholders through stock repurchases.

[1]Column (3) in Panel A of Table 1 reports the mechanical reduction in firms' equity, defined as the difference between total assets and liabilities. Figure 5 in Appendix A also shows that the rise in the price of outstanding stock is increasing in the size of the repurchasing initiative.

Table 1: Impact of Repurchase on Firms' Outcomes

Panel A: Capital Structure			
	Cash	Debt	Equity
	(1)	(2)	(3)
Repurchase	-0.0240***	0.0541***	-0.0364***
	(0.0050)	(0.0056)	(0.0092)
% Effect at Median	-27.9%	25.9%	-7.4%
Firm & Sector × Quarter FE	Yes	Yes	Yes
R^2	0.16495	0.39498	0.25357
Observations	284,392	267,944	284,287
Panel B: Investment and Innovation			
	R&D	SG&A	Patent Count
	(1)	(2)	(3)
Repurchase	0.0021***	0.0028***	0.0010***
	(0.0007)	(0.0010)	(0.0002)
% Effect at Median	14.2%	4.0%	26.5%
Firm & Sector × Quarter FE	Yes	Yes	Yes
R^2	0.25993	0.33255	0.32735
Observations	110,088	255,956	284,392

Notes: The Table presents coefficient estimates from fixed-effects regressions examining the relationship between share repurchases and multiple firm outcomes. The dependent variable in each specification is constructed as the year-over-year change in the outcome (measured from $t-1$ to $t+12$) and normalized by lagged total assets. Panel A reports effects on capital structure decisions: cash, debt and equity. Panel B presents effects on investment and innovation outcomes: R&D expenditures, selling general and administrative expenses, and patent numbers. Patenting variables are the inverse hyperbolic sine of the count, market value and forward citations. All models include fixed effects for firm (gvkey) and sector-by-quarter interactions to account for time-invariant firm heterogeneity and common time-sector shocks. Standard errors are two-way clustered by firm and date. Standard errors, clustered at the firm-quarter level, are in parentheses. $*$ = 10% level, $**$ = 5% level, and $***$ = 1% level. See Appendix A for further details.

The last column of Panel B shows that stock repurchases increase measurable innovation output such as patents, consistent with the rise in R&D investment. Patent counts increase significantly, as do value-weighted and citation-weighted patent stocks, all statistically significant at the 1 percent level. For the median firm with $194 million in assets, a 0.19 percent increase in citation-weighted patent stock represents a substantial expansion in innovation output. The consistent increases in both R&D spending and patenting metrics across the three-year window are striking precisely because they challenge the conventional crowding-out narrative. Firms do not sacrifice innovation when pursuing stock repurchase; instead, the evidence suggests that repurchasing firms adjust their capital structure toward greater leverage and improve their innovation output.

Table **??** in Appendix A shows that the results are qualitatively similar when we proxy R&D with alternative measures such as changes in capital expenditure or the dynamics of overhead costs (SG&A). Similarly, results do not change when we consider patent value or citations instead of patent counts. Moreover, Figure 4 in Appendix A shows the effects of stock repurchases at different horizons, from 1 to 20 quarters ahead. Results are unchanged qualitatively.

3 Stock Repurchase as Signal for R&D Quality

A simple model shows that stock repurchase can be used by firms to signal their R&D quality to market participants in an economy with asymmetric information.

Consider two types of firms in a two-period environment, t (today) and $t+1$ (tomorrow). At the beginning of period t, Nature draws each firm's project quality $\theta \in \{\theta_L, \theta_H\}$, with $\theta_H > \theta_L$. The draw occurs according to a commonly known distribution: with probability $0 < p_H < 1$, a randomly selected firm has high project quality θ_H, and with probability $1 - p_H$, it has low project quality θ_L. The firm's manager privately observes the realization of θ, while outside investors do not observe θ but know the prior distribution.

Upon privately observing project quality θ, each manager announces the dollar amount e_t to be spent on repurchasing a fraction s_t of outstanding shares. Repurchasing shares is costly, and for each dollar paid to shareholders the firm incurs an additional cost of $\phi > 0$ dollars. Outside investors observe e_t and form beliefs about the firm's project quality, $\mu_t(\theta \mid e_t)$.

Given investors' beliefs and resulting market prices, the manager then chooses R&D investment and debt issuance. Each firm chooses R&D expenditure today w_t to profits from

products with mass M_{t+1} tomorrow through

$$M_{t+1}(w_t, \theta) \;=\; \theta\, w_t^{\alpha}, \qquad 0 < \alpha < 1 \tag{2}$$

The probability that today's R&D investment successfully generates an innovation tomorrow follows a Poisson arrival process:

$$p_{t+1}(\theta, w_t) = 1 - \exp\big(-\lambda_t(\theta, w_t)\big) \tag{3}$$

The arrival rate $\lambda_t(\theta, w_t) = \chi(\theta)\, w_t^{\psi}$ depends on current R&D spending and privately observed project quality, with $0 < \psi < 1$.[2] Conditional on success, the product yields a per-unit profit of one; unsuccessful products generate zero revenue.

Today's revenues are zero and firm must therefore finance their expenditures using a one-period debt contract with face value b_{t+1}. Because the firm has no tangible collateral and its value derives entirely from future product revenues, lenders impose earnings-based financial covenants that restrict total debt as a function of realized operating earnings.

$$b_{t+1} \;\leq\; \kappa\, M_{t+1}(w_t, \theta), \tag{4}$$

where $\kappa > 0$ governs the tightness of the earnings-based covenant. The covenant is enforced ex-post. In particular, the firm can repay its debt if and only if its products successfully reach the market; when products fail, operating earnings are zero and the firm defaults.[3] Given lender's beliefs about firm types, competitive risk-neutral lenders break even on the aggregate portfolio of loans extended to firms, so that

$$\mathcal{Q}_t(\mu_t) = \frac{1}{R}\, \frac{\mathbb{E}[p_{t+1}(\theta) \cdot b_{t+1}(\theta) \mid \mu_t(\theta \mid e_t)]}{\mathbb{E}[b_{t+1}(\theta) \mid \mu_t(\theta \mid e_t)]}, \tag{5}$$

That is, the unit price of debt equals expected total repayment divided by expected total lending across firms sharing the same level of repurchasing.

The present value of dividends to the current shares outstanding is

$$V_t^0(\theta) = \max_{e_t \geq 0} \; \frac{1}{1 - s_t(e_t)}\, V_t(e_t, \theta), \tag{6}$$

[2]This specification is common in the innovation literature, Klette and Kortum (2004), Acemoglu, Akcigit, Alp, Bloom, and Kerr (2018).

[3]This earnings-based covenant follows Lian and Ma (2021), who discipline borrowing through enforcement based on realized operating earnings rather than pledgeable collateral.

where $\frac{1}{1-s_t}$ captures the accretion effect associated with repurchasing a fraction s_t of outstanding shares. The function $V_t(e_t, \theta)$ denotes the continuation value of the firm conditional on spending e_t dollars on repurchases, and is given by

$$V_t\left(e_t, \theta\right) = \max_{w_t, b_{t+1}, D_t \geq 0} D_t + \frac{1}{R}\left[M_{t+1}(w_t, \theta) - b_{t+1}\right] \cdot p_{t+1}\left(\theta, w_t\right) \tag{7}$$

where D_t are today's dividends:

$$D_t\left(w_t, b_{t+1}, e_t\right) = -w_t + \mathcal{Q}_t\left(\mu_t\right) b_{t+1} - e_t(1+\phi) \geq 0 \tag{8}$$

The fraction of shares the manager repurchase depends on the dollars spent on the repurchase and on the price per share in the equity market. Assuming perfectly competitive investors, the zero-profit condition in the equity market implies:

$$e_t = \frac{s_t(e_t)}{1 - s_t(e_t)} \mathbb{E}\left[V_t\left(e_t, \theta\right) \mid \mu_t(\theta \mid e_t)\right]. \tag{9}$$

The amount of cash received by incumbent shareholders (right-hand side) is equal to the market value of the shares sold back to the firm (left-hand side).

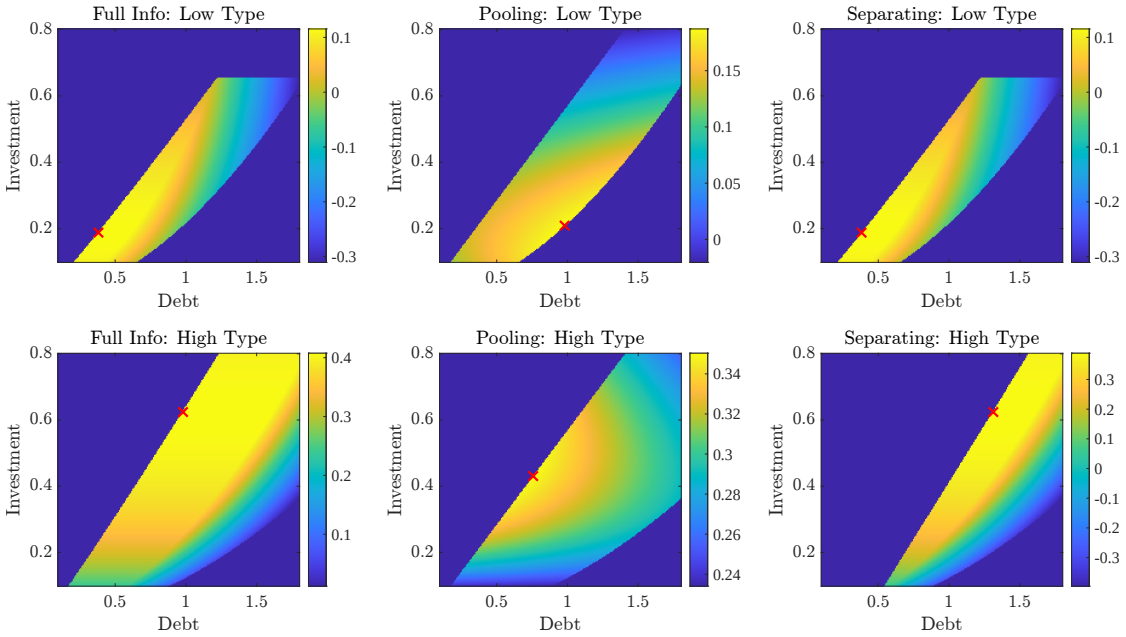
A Perfect Bayesian Equilibrium (PBE) consists of managerial policies $w_t(\theta)$, $b_{t+1}(\theta)$, and $e_t(\theta)$, a debt price schedule $\mathcal{Q}_t(\mu_t)$, equity-market shares $s_t(\theta)$, and beliefs $\mu_t(\theta)$ such that: (i) managers maximize incumbent shareholders' value in (6)—(7) subject to the earnings-based constraint (4); (ii) upon observing repurchasing e_t, investors form beliefs and set the price of debt and the share-repurchase schedule so that the zero-profit conditions (5) and (9) are satisfied; (iii) given firms' decisions, beliefs $\mu_t(\theta)$ are updated via Bayes' rule on the equilibrium path.

3.1 Characterization of the PBE

The presence of asymmetric information create a distorsion in the optimal decisions of R&D expenditure and debt policy. Figure 2 shows the value function and optimal policies for each firm-type under different information structure.

Full Information and Pooling Equilibria. The first column reports the manager's optimal decisions by type in the full-information benchmark, i.e. when investors observe θ. Firms with high-quality projects exhibit a higher marginal return to current R&D relative to

Figure 2: Optimal Choices of Debt and R&D



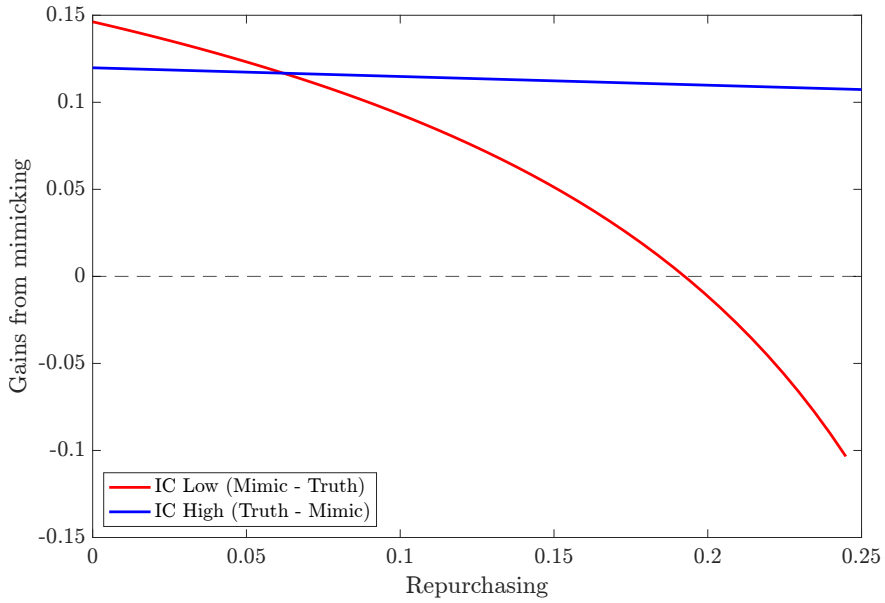
Notes: The figure plots the value function over the grid of investment and debt choices for the low- and high-type firms under both full information and pooling. Each subplot displays the corresponding value matrix, with darker colors indicating lower value. The red "x" marker identifies the optimal choice (b^*, w^*) for the respective type and information structure. Results are obtained using an illustrative parametrization.

low-quality firms. Consequently, type θ_H firms optimally choose higher R&D expenditures than type θ_L firms. Higher R&D investment increases the probability of innovation success, which in turn lowers the cost of external debt financing for high-quality firms. Since larger investment requires additional resources, and cash on hand is zero, debt issuance is also increasing in firm type. Importantly, when firm types are perfectly observed by outside investors, firms find it optimal not to engage in equity repurchases, as doing so would only incur unnecessary transaction costs without yielding any informational benefit.[4]

The second column shows the pooling equilibrium under asymmetric information. In this case, outside investors do not observe firms' project quality. As a result, the market cannot condition financing terms on firm type and instead prices securities based on prior beliefs over the distribution of types. Debt prices therefore reflect the average probability of success of R&D problem implied by these beliefs, as given in Equation 5. As a consequence,

[4]If equity repurchasing were costless, the Modigliani-Miller theorem would apply and firms would be indifferent between distributing earnings through dividends or through share repurchases.

Figure 3: Gains from Mimicking in the Separating Equilibrium



Notes: The figure plots the two incentive-compatibility conditions in terms of the "gains from mimicking." For each repurchase size e, the red curve computes the low type' s gain from imitating the high type ($V^l_{\text{mimic}} - V^l_{\text{truth}}$), while the blue curve shows the high type's loss from imitating the low type ($V^h_{\text{truth}} - V^h_{\text{mimic}}$). The horizontal dashed line at zero indicates the threshold at which a deviation becomes profitable.

high-quality firms optimally reduce R&D investment and debt issuance relative to the full-information case, while low-quality firms expand both.[5] Finally, neither firm type chooses to repurchase shares, as doing so would only incur repurchasing costs.

Signaling and Separating Equilibrium. Although pooling equilibria always exist under asymmetric information, they are generally dominated by separating equilibria. Pooling distorts firms' investment and financing decisions, reducing the value of high-quality firms while increasing the value of low-quality firms relative to the full-information benchmark. As a result, high-type firms have incentives to send the market a costly signal that credibly reveal their type. We consider the case in which costly stock repurchases are used to signal the quality of R&D projects.

In the separating equilibrium, high-quality firms choose a positive repurchase level $e_h > 0$ to credibly signal their project quality, while low-quality firms refrain from repurchasing $e_l =$

[5]In a pooling equilibrium, low-quality firms' debt is priced using a success probability above its true level, implying unbounded borrowing absent a constraint and binding borrowing limits in equilibrium.

0. Accordingly, upon observing a positive repurchase, outside investors assign probability one to the firm being of high quality; upon observing no repurchase, they assign probability one to the firm being of low quality. Given these beliefs, equity markets and lenders price shares and debt as high-type securities following a repurchase and as low-type securities otherwise.

Candidate separating equilibria are characterized by incentive-compatibility constraints (ICs) for both firm types. Given a repurchase level e_h, the value of a high-type firm that truthfully signals its type is

$$V^h_{\text{truth}}(e_h) = \frac{1}{1 - s_h(e_h)} \left[-w^*_h - e_h(1+\phi) + \mathcal{Q}_h(e_h) b^*_h + \beta\, p_h\big(\theta_h\, w^{*,\alpha}_h - b^*_h\big) \right], \tag{10}$$

where $\mathcal{Q}_h(e_h)$ denotes the debt price conditional on the firm being perceived as high quality, and $s_h(e_h)$ is the fraction of equity repurchased implied by equation 9. For e_h to sustain separation,

$$V^h_{truth}(e_h) \geq V^h_{mimic} = V^h_{truth}(e_h = 0), \tag{IC-high}$$

that is, the high-type firm's truthful value $V^h_{truth}(e_h)$ must be at least as large as the value obtained by mimicking the low type, V^h_{mimic} which is equal to the true value of the high type firm that chooses no repurchase ($e_h = 0$) and faces a debt price based on beliefs that the firm is low quality.

Similarly, if the low-type firm mimics the high type by choosing the repurchase e_h, its value after repurchasing s_h fraction of shares is

$$V^l_{mimic}(e_h) = \frac{1}{1 - s_h(e_h)} \left[-w^*_l - e_h(1+\phi) + \mathcal{Q}_l(e_h) b^*_l + \beta\, p_l\big(\theta_l\, w^{*,\alpha}_l - b^*_l\big) \right], \tag{11}$$

A repurchase level e_h can support a separating equilibrium only if the low-type firm does not find it profitable to imitate the high type. This requires that the low-type firm's value from behaving truthfully exceeds its value from mimicking:

$$V^l_{truth}(0); \geq; V^l_{mimic}(e_h), . \tag{IC-low}$$

When behaving truthfully, the low-type firm optimally chooses zero repurchases to avoid additional costs and its debt is priced as a low-quality firm.

A separating equilibrium requires that neither firm type has an incentive to deviate. The condition in Equation (IC-high) ensures that high-quality firms prefer to signal their type

through repurchases rather than mimic low-quality firms and borrow at unfavorable terms. Similarly, the condition in Equation (IC-low) ensures that low-quality firms do not find it profitable to imitate the signaling behavior of high-quality firms, as the cost of repurchasing outweighs the financing benefits from being perceived as high quality. Among all repurchase levels that satisfy both incentive-compatibility conditions, the optimal equilibrium repurchase level is the least-cost separating signal:

$$e_h^* = \min \left\{ e_h \geq 0 \ : \ V_{truth}^l \geq V_{mimic}^l(e_h) \text{ and } V_{truth}^h(e_h) \geq V_{mimic}^h \right\}. \tag{12}$$

At e_h^*, the low-type incentive constraint binds, while the high-type constraint is slack. This choice minimizes the signaling cost borne by high-quality firms and pins down a unique separating equilibrium.

Figure 3 illustrates the mimicking gains for high- and low-type firms when stock repurchases are used as a signal of project quality. The point at which the IC-Low constraint crosses the x-axis identifies the candidate least-cost separating equilibrium. For this equilibrium to be sustained, the value of the high-type firm must exceed the value it would obtain by not signaling its type to the market (i.e., the blue line is above zero when the red line crosses the x-axis).

R&D and Debt in the Separating Equilibrium. The third column of Figure 2 illustrates the optimal allocation of R&D investment and debt in the least-cost separating equilibrium. Through a costly signal, firms with high project quality restore the efficient R&D allocation that prevails under full information. This improvement, however, comes at a cost. To finance share repurchases used for signaling, high-quality firms optimally increase their reliance on external debt, resulting in over-indebtedness relative to the full-information benchmark. Because low-quality firms optimally choose not to signal, their optimal policies coincide with those under full information. The separating equilibrium is therefore second best: while it raises firm value and R&D expenditure for firms with high-quality projects, it does so at the expense of higher leverage. These patterns are qualitatively in line with the effects of stock repurchases on R&D and debt dynamics shown in Section 2.

4 Quantitative Model

We develop a quantitative model to study the impact of share repurchases on innovation and long-run growth. Time is discrete, and there is no aggregate uncertainty. The economy grows through an expanding variety of products, following the standard endogenous growth model of Romer (1990).

4.1 Households

A representative household at time t owns final good firms, intermediate good firms and a representative investment fund in the economy. The household supplies inelastically one unit of labor and solve the consumption-savings problem

$$\max_{\{C_t,\, B_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\eta}}{1-\eta} \quad \text{s.t.} \tag{13}$$

$$C_t + B_{t+1} = W_t L_t + R_t B_t + D_t^{fin} + D_t^{int} + D_t^{fund}, \tag{14}$$

and the initial condition B_0 given. Here, $\beta \in (0,1)$ denotes the subjective discount factor, $\eta > 0$ the coefficient of relative risk aversion, W_t the real wage, R_t the gross risk-free interest rate, and D_t^{fin}, D_t^{int} and D_t^{fund} are payouts of the final and intermediate goods sectors and investment fund. Optimization implies the Euler equation:

$$\frac{1}{C_t^{\eta}} = \beta R_{t+1} \frac{1}{C_{t+1}^{\eta}}. \tag{15}$$

Since the representative household owns a diversified portfolio of all firms, idiosyncratic firm-level risk is fully insured.

4.2 Final Goods

A perfectly competitive final-good sector hires labor L_t and aggregates a continuum of differentiated intermediate inputs x_{jt} produced by monopolistically competitive firms indexed by $j \in [0, Q_t]$, where Q_t denotes the measure of available varieties at time t. The final output Y_t is homogeneous and produced using a constant-return technology:

$$Y_t = L_t^{1-\alpha} \int_0^{Q_t} z_{jt}^{1-\alpha} x_{jt}^{\alpha}\, dj, \tag{16}$$

where z_{jt} is an idiosyncratic productivity or demand shift for variety j, and $0 < \alpha < 1$ determines the elasticity of substitution across intermediate goods.

The final-good producer takes input prices p_{jt} and the wage W_t as given and chooses x_{jt} and L_t to maximize static profits:

$$\max_{\{x_{jt},\, L_t\}} \; L_t^{1-\alpha} \int_0^{Q_t} z_{jt}^{1-\alpha} x_{jt}^{\alpha}\, dj - W_t L_t - \int_0^{Q_t} p_{jt}\, x_{jt}\, dj \tag{17}$$

Given the representative household supplies one unit of labor inelastically ($L_t = 1$), the first-order condition for x_{jt} yields the demand for intermediate variety j:

$$x_{jt}\left(p_{jt}, z_{jt}\right) = z_{jt} \left(\frac{\alpha}{p_{jt}}\right)^{\frac{1}{1-\alpha}}. \tag{18}$$

The final-good producer earns zero profits in equilibrium and determines the aggregate demand faced by each intermediate producer.

4.3 Intermediate Goods

There is a unit mass of firms indexed by $k \in [0, 1]$. Each firm is managed by a risk-neutral manager who chooses how much to innovate, how to finance innovation, and how many shares to repurchase on the equity market, in order to maximize the value of shares held by incumbent shareholders.

Price setting. Firms enter in a period t with a portfolio of one period patented intermediate goods of measure M_{kt}. All patented goods j in their portfolio are subject to an idiosyncratic persistent demand shock z following

$$\log z_{kt+1} = \rho_z \log z_{kt} + \nu_{kt+1}, \qquad \nu_{kt+1} \sim \mathcal{N}(0, \sigma_z^2). \tag{19}$$

where $0 < \rho_z < 0$ and $\sigma_z > 0$. Each intermediate good j in the portfolio is produced using a technology with constant marginal cost ψ and sold to the final-good sector at price p_{jt}. The profit for a single j variety in a firm portfolio k sold at the optimal price is:

$$\pi_{jt}^{k}(z_{jt}) = \max_{p_{jt}} \; \left(p_{jt} - \psi\right) x_{jt}\left(p_{jt}, z_{jt}\right) = \left(1 - \alpha\right) \alpha^{\frac{\alpha}{1-\alpha}}\, \psi^{-\frac{\alpha}{1-\alpha}}\, z_{jt}. \tag{20}$$

The first-order condition yields a constant markup rule $p_{jt}^M = \frac{\psi}{\alpha}$ implying that each variety earns the same per-variety profit, proportional to the firm' s demand shock.

Since all variaties within firm k portfolio are subject to the same demand shock, total revenues for firm k from selling their portfolio of intermediate goods are

$$\Pi_{kt} = \pi_{jt}^k(z_{kt})\, M_{kt}. \tag{21}$$

Version no R&D stock

Innovation. A firm's R&D investment W_{kt} yields innovation of new varieties next period with mass M_{kt+1} with probability p_{kt}. The probability of successful R&D innovation depends endogenously on W_{kt}, scaled by the aggregate stock of patented varieties Q_t, following

$$p_{kt} = 1 - \exp(-\lambda_{kt})\,, \qquad \lambda_{kt} = \left(\frac{W_{kt}}{Q_t}\right)^{\chi}, \qquad 0 < \chi < 1, \tag{22}$$

where λ_{kt} is the arrival rate of innovated variaties. The firm k's portfolio of patented varieties produced tomorrow in the case of successful innovation is

$$M_{kt+1} = \bar{\xi}\, \theta_{kt}\, W_{kt}^{\gamma}\, Q_t^{1-\gamma}, \qquad 0 < \gamma < 1 \tag{23}$$

$\theta_{kt} \sim_{iid} \log N(-\frac{1}{2}\sigma_\epsilon^2, \sigma_\epsilon^2)$ is an idiosyncratic R&D project quality shock privately observed by the manager of firm k before making current-period decisions. Unsuccessful innovation yields zero patented variaties.

The aggregate stock of patented varieties Q_t generates positive knowledge-spillover effects, making it easier for firms to expand their variety portfolios.[6] At the aggregate level, the stock of available varieties evolves according to

$$Q_{t+1} = Q_t + M_t, \tag{24}$$

where $M_t = \int_0^1 M_{kt}\, dk$ is the total measure of patented varieties in the economy.

Managers. A risk-neutral manager at each firm chooses R&D investment W_{kt}, debt B_{kt+1} at price $\mathcal{Q}_{kt}$ and dollar spent on stock repurchases E_{kt} to maximize the value of the equity for incumbent shareholders. Before choosing R&D and debt, the manager announces a

[6] This captures the notion that a larger pool of existing inventions facilitates innovation through learning, recombination, and shared technological components.

repurchase expenditure of E_{kt} dollars for a fraction s_{kt} of outstanding shares, with the share price adjusting endogenously to the announcement. Repurchases are costly to execute, requiring the firm to pay the repurchase amount E_{kt} plus transaction costs $(\phi_0 + \phi_1 E_{kt})$, where $\phi_0 \geq 0$ is a fixed cost and $\phi_1 > 0$ is a linear cost.

The manager decision of W_{kt} and B_{kt} conditional on E_{kt} solves

$$\max_{W_{kt}, B_{kt+1}} \; -W_{kt} + \mathcal{Q}_{kt} B_{kt+1} + \frac{1}{R_{t+1}} p_{kt} \left[\mathbb{E}_z \left(\pi^k_{t+1}(z_{kt+1}) M_{kt+1} \right) - B_{kt+1} \right] \tag{25}$$

subject to:

$$D_{kt} = \pi_{kt}(z_{kt})\, M_{kt} - B_{k,t} + \mathcal{Q}_{kt}\, B_{kt+1} - W_{kt} - (\phi_0 + \phi_1 E_{kt}) \mathbb{1}_{E_{kt}>0} \geq 0 \tag{26}$$

$$B_{kt+1} \;\leq\; \kappa\, \pi^k_{t+1}(\underline{z}_{kt+1}) \bar{\xi}\, \underline{\theta}_{kt}\, W^{\gamma}_{kt}\, Q_t^{1-\gamma} \tag{27}$$

The first is a non-negative constraint on cash-flow at time t; the second is a borrowing constraint to ensure that, in the event of successful innovation, the firm can repay its debt next period. Since project quality θ_{kt} is unobservable and low-quality firms have the strongest incentive to over-borrow, lenders optimally restrict borrowing capacity by basing it on the lowest project quality.

Shareholder value. The value of incumbent shareholders depends on the accretion effect of share repurchases and the discounted continuation value of future cash flows. Along the balanced growth path, firm value growth a constant rate g. Exploiting the homogeneity of the value function, the value of incumbent shareholders V^0_t admits the stationary representation $V^0_t(z_{kt}, \theta_{kt}, M_{kt}, B_{kt}, Q_t) = Q_t\, v^0_t(z_{kt}, \theta_{kt}, m_{kt}, b_{kt})$, where $m_{kt} = \frac{M_{kt}}{Q_t}$ and $b_{kt} = \frac{B_{kt}}{Q_t}$. Given manager policies for R&D and debt, the value of equity of the incumbent shareholders is

$$v^0_t(z_{kt}, \theta_{kt}, m_{kt}, b_{kt}) = \max_{e_{kt} \geq 0} \; \frac{1}{1 - s_{kt}(e_{kt})}\; v_t\left(e_{kt}; z_{kt}, \theta_{kt}, m_{kt}, b_{kt}\right), \tag{28}$$

The first term is the accretion effect of repurchasing a fraction s_{kt} of outstanding shares; the second term is the continuation value of cash-flows per share which is:

$$v_t\left(e_{kt}; z_{kt}, \theta_{kt}, m_{kt}, b_{kt}\right) = d_{kt} + \frac{1}{R_{t+1}} \mathbb{E}_t \left[\sum_{s \in \{0,1\}} p_{kt}(s)\, v^0_{t+1}\left(z_{k,t+1}, m^s_{k,t+1}, b^s_{k,t+1}\right) \right] \tag{29}$$

where s indexes the realization of the innovation outcome, with $s = 1$ denoting success and $s = 0$ denoting failure. In the event of success, the firm enters next period with the chosen financial positions, $(m^1_{k,t+1}, b^1_{k,t+1}) = (m^*, b^*)$ from solving (36), whereas in the event of failure, $(m^0_{k,t+1}, b^0_{k,t+1}) = (0, 0)$. The expectation is taken over future idiosyncratic demand, conditional on the firm's information today.

Debt investors. A mass of competitive, risk-neutral debt investors lend funds to finance firms' R&D projects and price debt under a zero-profit condition. In period t, investors form posterior beliefs μ_t about the firm's project quality θ_{kt} based on its public states and the announced share repurchase. Because debt investors do not observe θ_{kt}, they extend credit to all firms at a common price. Since innovation may fail to generate sufficient revenues to repay debt, the equilibrium debt price $\mathcal{Q}_t(\mu_t)$ satisfies the break-even condition for the portfolio of debt issued

$$\mathcal{Q}_t(\mu_t(\theta_{kt}; z_{kt}, m_{kt}, b_{kt}, e_{kt}))\, \mathbb{E}[B_{kt+1}(\theta_{kt}) \mid \mu_t] = \frac{1}{R_{t+1}}\, \mathbb{E}[p_{kt} B_{kt+1}(\theta_{kt}) \mid \mu_t] \tag{30}$$

The amount investors pay today for the debt (left-hand side) equals the expected discounted cash flow they will receive from the debt (right-hand side).

4.4 Investment Fund

A risk-neutral investment fund holds and manages the equity of intermediate-good firms on behalf of the representative household. At the beginning of each period, the fund observes the firm's public states but not its project quality θ_{kt}. After observing the share repurchase e_{kt}, it forms posterior beliefs $\mu_t(\theta_{kt} \mid z_{kt}, m_{kt}, b_{kt}, e_{kt})$. Under competitive risk-neutral pricing, the fund must be indifferent between selling and holding shares.

$$e_{kt} = \frac{s_{kt}}{1 - s_{kt}}\, \mathbb{E}[v_t(e_{kt}; z_{kt}, \theta_{kt}, m_{kt}, b_{kt}) \mid \mu_t(\theta_{kt} \mid z_{kt}, m_{kt}, b_{kt}, e_{kt})]\,. \tag{31}$$

The left-hand side is the total repurchase payment, while the right-hand side is the market's expected valuation of the repurchased shares given posterior beliefs. In equilibrium, the total repurchase payment to the fund must equal the expected value of the surrendered equity from the fund's perspective.

Version with R&D stock

Innovation. A firm's R&D investment W_{kt} today increases its R&D stock A_{kt} in the next period with probability p_{kt}. The probability of successful R&D innovation depends endogenously on W_{kt}, scaled by the aggregate stock of patented varieties Q_t, following

$$p_{kt} = 1 - \exp(-\lambda_{kt}), \qquad \lambda_{kt} = \left(\frac{W_{kt}}{Q_t}\right)^{\chi}, \qquad 0 < \chi < 1, \tag{32}$$

λ_{kt} is the arrival rate of an innovation. The firm's R&D stock evolves according to

$$A_{kt} = (1-\delta)A_{kt-1} + \mathbb{1}_{kt}(s)\, W_{kt}, \qquad 0 < \delta < 1, \tag{33}$$

$\mathbb{1}_{kt}(s)$ is a dummy that takes value 1 if an innovation is successful, and 0 otherwise. The firm's portfolio of patented varieties produced tomorrow depends on the firm's accumulated R&D stock and is given by

$$M_{kt+1} = \bar{\xi}\, \theta_{kt}\, A_{kt}^{\gamma}\, Q_t^{1-\gamma}, \qquad 0 < \gamma < 1 \tag{34}$$

$\theta_{kt} \sim_{iid} \log N(-\frac{1}{2}\sigma_\epsilon^2, \sigma_\epsilon^2)$ is an idiosyncratic R&D project quality shock privately observed by the manager of firm k before making current-period decisions.

The aggregate stock of patented varieties Q_t generates positive knowledge-spillover effects, making it easier for firms to expand their variety portfolios.[7] At the aggregate level, the stock of available varieties evolves according to

$$Q_{t+1} = Q_t + M_t, \tag{35}$$

where $M_t = \int_0^1 M_{kt}\, dk$ is the total measure of patented varieties in the economy.

Managers. A risk-neutral manager at each firm chooses R&D investment W_{kt}, debt B_{kt+1} at price $\mathcal{Q}_{kt}$ and dollar spent on stock repurchases E_{kt} to maximize the value of the equity for incumbent shareholders. Before choosing R&D and debt, the manager announces a repurchase expenditure of E_{kt} dollars for a fraction s_{kt} of outstanding shares, with the share price adjusting endogenously to the announcement. Repurchases are costly to execute, requiring the firm to pay the repurchase amount E_{kt} plus transaction costs $(\phi_0 + \phi_1 E_{kt})$,

[7] This captures the notion that a larger pool of existing inventions facilitates innovation through learning, recombination, and shared technological components.

where $\phi_0 \geq 0$ is a fixed cost and $\phi_1 > 0$ is a linear cost.

The manager decision of W_{kt} and B_{kt} conditional on E_{kt} solves

$$\max_{W_{kt}, B_{kt+1}} -W_{kt} + \mathcal{Q}_{kt} B_{kt+1} + \frac{1}{R_{t+1}} \mathbb{E}_t \left[\sum_{s \in \{0,1\}} p_{kt}(s)\, \pi^k_{t+1}(z_{kt+1}) M_{kt+1}(s) - B_{kt+1} \right] \tag{36}$$

subject to:

$$D_{kt} = \pi_{kt}(z_{kt})\, M_{kt} - B_{k,t} + \mathcal{Q}_{kt}\, B_{kt+1} - W_{kt} - (\phi_0 + \phi_1 E_{kt}) \mathbb{1}_{E_{kt}>0} \geq 0 \tag{37}$$

$$B_{kt+1} \;\leq\; \kappa\, \pi^k_{t+1}(\underline{z}_{kt+1}) \bar{\xi}\, \underline{\theta}_{kt}\, \left[(1-\delta) A_{kt-1} + W_{kt}\right]^{\gamma}\, Q_t^{1-\gamma} \tag{38}$$

In equation (36), s indexes the realization of the innovation outcome, with $s = 1$ denoting success and $s = 0$ denoting failure.[8] Equation (37) is a non-negative constraint on cash-flow at time t; Equation (38) is a borrowing constraint that ensure that, in the event of successful innovation, the firm can repay its debt next period. Since project quality θ_{kt} is unobservable and low-quality firms have the strongest incentive to over-borrow, lenders optimally restrict borrowing capacity by basing it on the lowest project quality.

Shareholder value. The value of incumbent shareholders depends on the accretion effect of share repurchases and the discounted continuation value of future cash flows. Along the balanced growth path, firm value growth a constant rate g. Exploiting the homogeneity of the value function, the value of incumbent shareholders V_t^0 admits the stationary representation $V_t^0(z_{kt}, \theta_{kt}, A_{kt-1}, B_{kt}, Q_t) = Q_t\, v_t^0(z_{kt}, \theta_{kt}, a_{kt-1}, b_{kt})$, where $a_{kt-1} = \frac{A_{kt-1}}{Q_t}$ and $b_{kt} = \frac{B_{kt}}{Q_t}$. Given manager policies for R&D and debt, the value of equity of the incumbent shareholders is

$$v_t^0(z_{kt}, \theta_{kt}, a_{kt-1}, b_{kt}) = \max_{e_{kt} \geq 0} \frac{1}{1 - s_{kt}(e_{kt})}\, v_t\left(e_{kt}; z_{kt}, \theta_{kt}, a_{kt-1}, b_{kt}\right), \tag{39}$$

The first term is the accretion effect of repurchasing a fraction s_{kt} of outstanding shares; the second term is the continuation value of cash-flows per share which is:

$$v_t\left(e_{kt}; z_{kt}, \theta_{kt}, a_{kt-1}, b_{kt}\right) = d_{kt} + \frac{1}{R_{t+1}} \mathbb{E}_t \left[\sum_{s \in \{0,1\}} p_{kt}(s)\, v^0_{t+1}\left(z_{k,t+1}, a^s_{k,t}, b^s_{k,t+1}\right) \right] \tag{40}$$

[8] If an innovation is unsuccessful, the firm repays debt up to the revenues generated.

In the event of success ($s = 1$), the firm enters next period with the chosen financial positions, $(a^1_{kt}, b^1_{kt+1}) = (a^*, b^*)$ from solving (36), whereas in the event of failure ($s = 0$), firm states are $(a^0_{kt}, b^0_{kt+1}) = ((1-\delta)a_{kt-1}, 0)$. The expectation is taken over future idiosyncratic demand, conditional on the firm's information today.

Debt investors. A mass of competitive, risk-neutral debt investors lend funds to finance firms' R&D projects and price debt under a zero-profit condition. In period t, investors observe firm's idiosyncratic states, but not project quality. Because investors do not observe θ_{kt}, they extend credit to all firms at a common price, based on their beliefs μ_t. Debt investors incur losses if innovation fails to generate sufficient revenues. In the event of unsuccessful innovation, they recover at most the firm's operating profits:

$$R_{kt+1} = \min\left(\pi^k_{t+1}(z_{kt+1})\bar{\xi}\,\theta_{kt}\ [(1-\delta)A_{kt-1}]^{\gamma}\ Q_t^{1-\gamma}, B_{kt+1}\right), \tag{41}$$

The equilibrium debt price $Q_t(\mu_t)$ satisfies the break-even condition for the portfolio of debt issued

$$\mathcal{Q}_t(\mu_t(\theta_{kt}; z_{kt}, a_{kt-1}, b_{kt}, e_{kt})) = \frac{1}{R_{t+1}} \frac{\mathbb{E}\ [p_{kt}B_{kt+1}(\theta_{kt}) + (1-p_{kt})R_{kt+1}|\mu_t(\theta_{kt})]}{\mathbb{E}\ [B_{kt+1}(\theta_{kt})|\mu_t(\theta_{kt})]} \tag{42}$$

The price of debt equals the expected discounted repayment divided by the total amount of debt lent.

4.5 Investment Fund

A risk-neutral investment fund holds and manages the equity of intermediate-good firms on behalf of the representative household. At the beginning of each period, the fund observes the firm's public states but not its project quality θ_{kt}. After observing the share repurchase e_{kt}, it forms posterior beliefs $\mu_t(\theta_{kt} \mid z_{kt}, a_{kt-1}, b_{kt}, e_{kt})$. Under competitive risk-neutral pricing, the fund must be indifferent between selling and holding shares.

$$e_{kt} = \frac{s_{kt}}{1-s_{kt}}\,\mathbb{E}[v_t(e_{kt}; z_{kt}, \theta_{kt}, a_{kt-1}, b_{kt}) \mid \mu_t(\theta_{kt} \mid z_{kt}, a_{kt-1}, b_{kt}, e_{kt})]\,. \tag{43}$$

The left-hand side is the total repurchase payment, while the right-hand side is the market's expected valuation of the repurchased shares given posterior beliefs. In equilibrium, the total repurchase payment to the fund must equal the expected value of the surrendered equity

from the fund's perspective.

4.6 Equilibrium and Solution

4.7 Manager Policies

5 Quantitative Results

5.1 Estimating the Model

5.2 The Impact of Stock Repurchasing

6 Conclusion

This paper studies how stock repurchases shape firms' financing decisions, innovation activity, and long-run growth in an environment with asymmetric information about R&D quality and earnings-based borrowing constraints. We document that repurchase initiation is followed by a persistent decline in cash holdings, a sizable increase in leverage, and sustained increases in both R&D expenditures and patenting over a multi-year horizon. These patterns are robust across alternative measures of innovation and horizons, and they challenge the conventional view that buybacks systematically crowd out productivity-enhancing investment.

To interpret these facts, we develop a signaling model in which managers privately observe the quality of their R&D projects and may use costly stock repurchases to credibly reveal high project quality to investors. Under full information, high-quality firms borrow and invest more in R&D than low-quality firms, and find repurchases redundant and strictly costly. Under asymmetric information, by contrast, a pooling equilibrium distorts R&D and debt choices, inducing underinvestment and underborrowing by high-quality firms and excessive borrowing by low-quality firms. We show that a separating equilibrium can be sustained in which high-quality firms optimally choose positive repurchases to signal their type, obtain more favorable financing terms, and restore efficient R&D, while low-quality firms refrain from repurchasing. This equilibrium is second best: it improves capital allocation and innovation for high-quality firms but does so at the cost of higher leverage and costly payouts.

We then embed this signaling mechanism into a quantitative endogenous growth model with an expanding variety of intermediate goods, earnings-based debt covenants, and competitive debt and equity markets. In this environment, repurchases act as costly signals that shape firms' borrowing conditions, R&D choices, and portfolio dynamics of patented varieties along a balanced growth path. High-quality repurchasing firms tilt their financing mix toward external debt, expand R&D intensity, and grow faster in terms of their innovation portfolios, while low-quality firms optimally forgo repurchases and face tighter effective borrowing conditions. The resulting joint dynamics of cash, leverage, and innovation are qualitatively consistent with the empirical impulse responses, and the model provides a structural interpretation of how buybacks can support innovation while raising corporate indebtedness.

Taken together, our results highlight a nuanced view of stock repurchases. When asymmetric information about R&D quality is severe, buybacks need not be purely symptomatic

of short-termism; they can serve an allocative role by allowing high-quality innovators to separate from low-quality firms and gain better access to external finance. At the same time, this signaling role relies on costly balance-sheet adjustments and pushes high-quality firms toward higher leverage than under full information, potentially increasing the vulnerability of the corporate sector to earnings or credit shocks. From a policy perspective, blanket restrictions on repurchases risk weakening innovation incentives precisely for those firms whose projects are most valuable, while reforms that enhance the observability of R&D quality or make earnings-based covenants more sensitive to realized success could reduce the need for costly signaling through buybacks.

Several avenues for future research remain. On the empirical side, an important next step is to explore heterogeneity in the signaling role of repurchases across industries, firm life-cycle stages, and macroeconomic conditions, as well as to investigate interactions with other corporate policies such as executive compensation and dividend payouts. On the theoretical side, extending the quantitative framework to incorporate aggregate uncertainty, intermediary balance sheets, and richer default dynamics would allow for a fuller assessment of how buyback-driven leverage interacts with systemic risk and macroprudential policy. More broadly, integrating payout decisions into models of endogenous growth with realistic financial frictions appears crucial for understanding when corporate payouts are compatible with, or even supportive of, long-run innovation and productivity growth.

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Appendix

A Empirics

This section provides more detail on the data used and additional empirical results.

A.1 Data sources

We use data from three main sources.

1. **Compustat/CRSP**. Our primary panel comes from Compustat's North American Quarterly database covering 1985–2024. We select U.S. incorporated firms (FIC = "USA") with consolidated, standard-format reporting. We exclude financials (SIC 6000–6999), utilities (SIC 4900–4999), and public administration (SIC 9900–9999). Following Ottonello and Winberry (2020), we retain only observations with positive total assets and non-negative capital. We drop quarters with acquisitions exceeding 5 percent of assets and require at least 40 consecutive quarters of investment data per firm for sufficient time-series variation. We restrict net current assets to $[-10, +10]\times$ total assets, debt-to-assets ratios to $[0, 10]$, and real quarterly sales growth to $[-1, +1]$. We exclude observations in the bottom and top 0.5% of the investment rate distribution, as these typically reflect data errors or major restructurings. We remove observations whose prior quarter was filtered, ensuring continuous firm histories. Final sample: 248,513 firm–quarter observations for 11,200 firms. We merge with CRSP using the standard CRSP–Compustat link table (restricting to primary and confirmed links over active link periods) to obtain PERMNO for stock prices and event studies.

   Balance-sheet outcomes include total debt (sum of long-term debt and current portion of long-term debt, DLCQ + DLTTQ), equity (total assets minus total liabilities, ATQ - LTQ), and cash and cash equivalents (CHE). Capital is via a perpetual-inventory method cumulating changes in investments (changes in PPENT) (Ottonello and Winberry, 2020). Operating outcomes include capital expenditures, R&D spending, selling general and administrative (SG&A) expenses, and cost of goods sold (COGS), all measured quarterly. All outcomes and key predictors are winsorized at the 0.5% and 99.5% levels to limit influence of measurement errors or extreme observations.

   Control variables include lagged firm size (natural log of real total assets at $t-1$) and

lagged sales growth (log-difference in real quarterly sales between $t-1$ and $t-2$). Both controls are standardized to mean zero and unit standard deviation to improve numerical stability and coefficient interpretability.

2. **SDC Platinum**. We use SDC Platinum data on U.S. share repurchases, selecting transactions explicitly classified as repurchases. We exclude non-completed deals, reorganizations, and transactions exceeding 95 percent of market capitalization (reflecting special economic circumstances that differ from standard buybacks). Deal values are deflated to 2024 dollars using annual implicit price deflators from FRED. We link SDC deals to CRSP via permno–date identifiers for event studies, ensuring temporal alignment between announcement dates and price data.

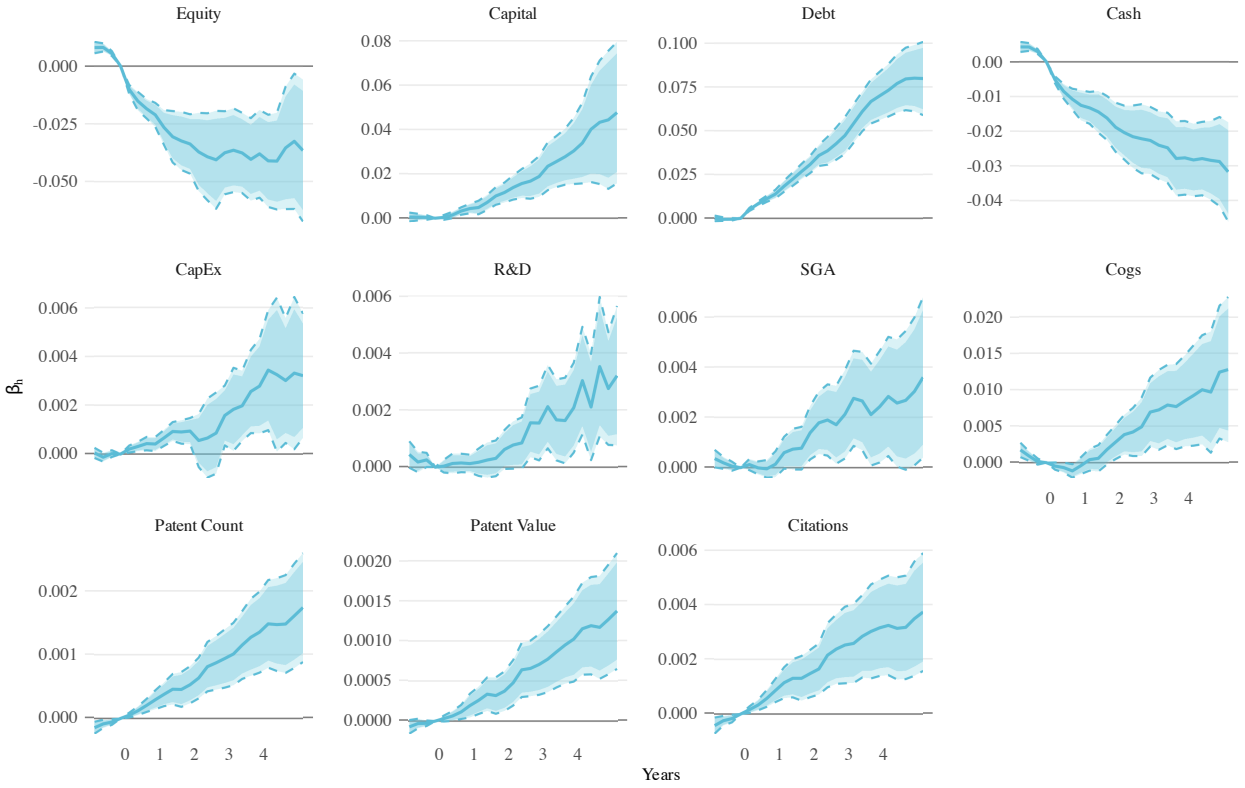
3. **Patenting Data** . We use the U.S. public firm patent dataset constructed by Kogan et al. (2017) (KPSS), which provides: (i) raw patent counts (number of patents granted to each firm-quarter), (ii) market value-weighted patents (estimated economic value of patented inventions), and (iii) citations (forward citations received, capturing innovation quality and impact). Patent flows are matched to our quarterly Compustat panel via the CRSP–Compustat link table using PERMNO identifiers. We construct patent stocks by accumulating patents (following KPSS conventions). We apply inverse hyperbolic sine (IHS) transformations to all three patent measures to handle zeros: $\text{IHS}(x) = \ln(x + \sqrt{x^2+1})$, which preserves sign and magnitude for small values while compressing large values and enabling consistent coefficient interpretation across the distribution.

A.2 Variables construction

The central variable in the analysis is the firm's decision to repurchase shares. In Compustat, we measure repurchases from the consolidated cash-flow statement item "Purchase of Common and Preferred Stock" (PRSTKCY) and net out changes in preferred stock to isolate common equity buybacks. From 2004 onward, when firms began reporting quarterly repurchases in SEC filings, we replace the imputed Compustat series with the direct measure based on shares repurchased times the average repurchase price whenever available. We then define a binary repurchase indicator that equals one if a firm repurchases in a given quarter and zero otherwise.

A.3 Additional results

Figure 4: Dynamic Impact of Stock Repurchase



Notes: R&D is research and development. SG&A is selling, general, and administrative expenses. Capital expenditure is spending on plants, property, and equipment. Standard error are two-way clustering by firm and calendar quarter. *,**,*** denote 10, 5, 1% significance.

A.4 Market response on repurchases announcements

We perform an event study using SDC repurchase announcements linked to CRSP. We compute cumulative abnormal returns (CAR) over the window $[t-1, t+1]$ relative to announcement, where t is the announcement date. Abnormal returns are calculated as actual returns minus market returns.

We bin repurchases into groups based on deal size, measured as deal value over lagged market capitalization. Figure 5 plots average abnormal returns against repurchase size, revealing a striking pattern: announcement returns are positive and increasing across the distribution of repurchase sizes. Smaller repurchases (0–3% of market cap) generate positive

Panel A: Capital Structure

	Equity	Capital	Debt	Cash
	(1)	(2)	(3)	(4)
Repurchase	-0.0364***	0.0234***	0.0541***	-0.0240***
	(0.0092)	(0.0055)	(0.0056)	(0.0050)
% Effect at Median	-7.4%	5.7%	25.9%	-27.9%
Firm & Sector × Quarter FE	Yes	Yes	Yes	Yes
R^2	0.25357	0.33799	0.39498	0.16495
Observations	284,287	284,392	267,944	284,392

Panel B: Operating Outcomes

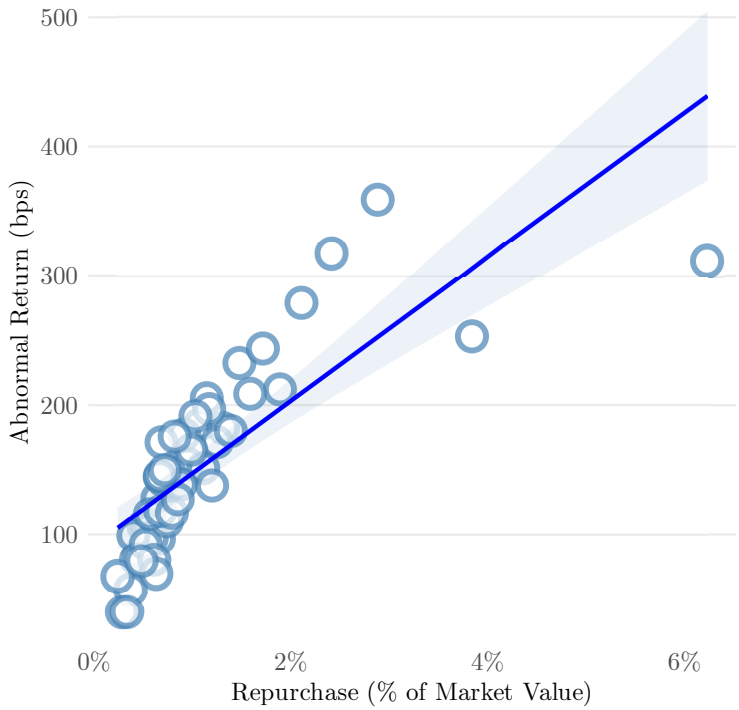
	CapEx	R&D	SG&A	COGS
	(1)	(2)	(3)	(4)
Repurchase	0.0018**	0.0021***	0.0028***	0.0072**
	(0.0009)	(0.0007)	(0.0010)	(0.0028)
% Effect at Median	21.6%	14.2%	4.0%	4.3%
Firm & Sector × Quarter FE	Yes	Yes	Yes	Yes
R^2	0.11941	0.25993	0.33255	0.30640
Observations	277,329	110,088	255,956	281,741

Panel C: Innovation Output

	Patent Count	Patent Value	Patent Citations
	(1)	(2)	(3)
Repurchase	0.0010***	0.0008***	0.0026***
	(0.0002)	(0.0002)	(0.0007)
% Effect at Median	26.5%	48.7%	57.1%
Firm & Sector × Quarter FE	Yes	Yes	Yes
R^2	0.32735	0.31913	0.24327
Observations	284,392	284,392	284,392

Notes: The Table presents coefficient estimates from fixed-effects regressions examining the relationship between share repurchases and multiple firm outcomes. The dependent variable in each specification is constructed as the year-over-year change in the outcome (measured from $t-1$ to $t+12$) and normalized by lagged total assets. Panel A reports effects on capital structure decisions: cash, debt and equity. Panel C presents effects on investment outcomes: Capex, R&D expenditures, selling general and administrative expenses, and cost of good sold. Panel C presents effects on patenting innovation. Patenting variables are the inverse hyperbolic sine of the count, market value and forward citations. All models include fixed effects for firm (gvkey) and sector-by-quarter interactions to account for time-invariant firm heterogeneity and common time-sector shocks. Standard errors are two-way clustered by firm and date. Standard errors, clustered at the firm-quarter level, are in parentheses. $* = 10\%$ level, $** = 5\%$ level, and $*** = 1\%$ level. See Appendix A for further details.

Figure 5: Cumulative Abnormal Returns on Announcement by Repurchase Size



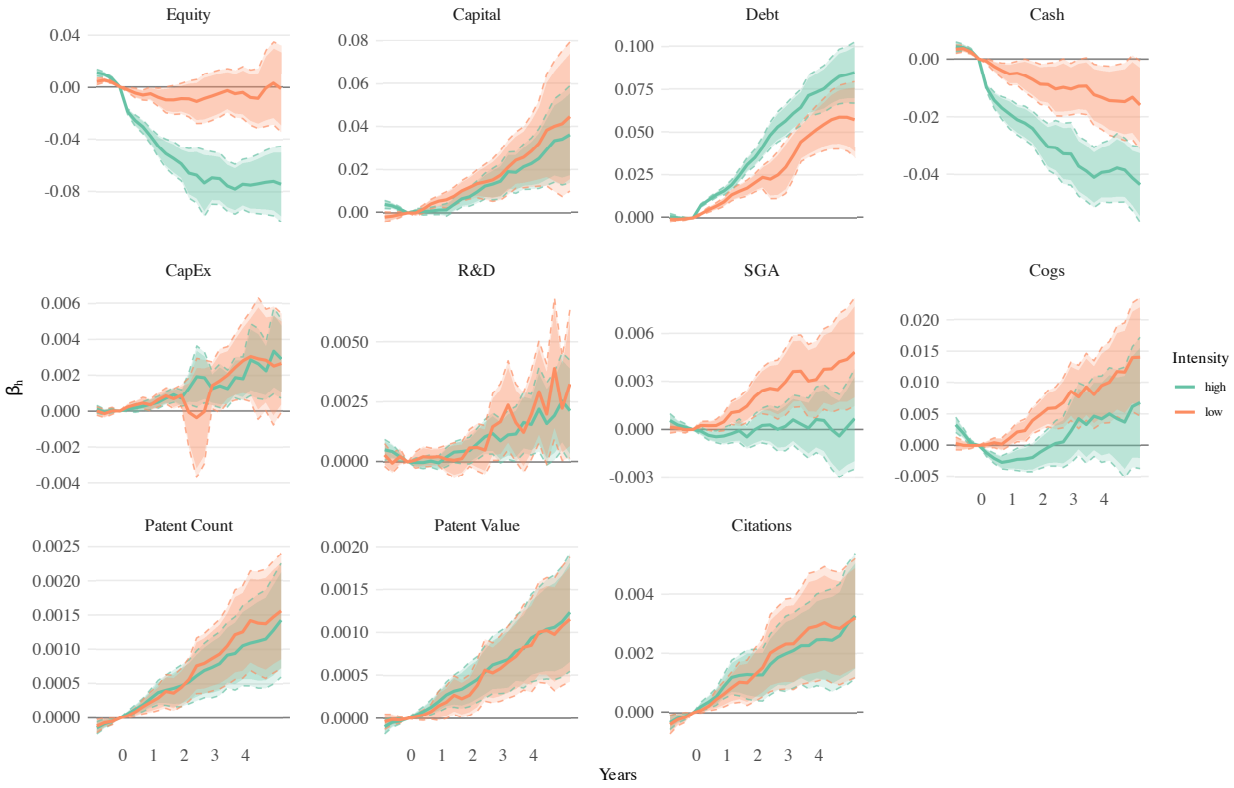
Notes: This figure presents average cumulative abnormal returns (CAR) for a 3-day window $[t-1, t+1]$ centered on repurchase announcement, binned by repurchase size as a fraction of lagged market capitalization. Abnormal returns are computed as actual returns minus CRSP value-weighted market returns. Sample includes U.S. share repurchases from SDC Platinum linked to CRSP, 1985–2024.

abnormal returns of roughly 2 percent, while larger repurchases produce increasingly positive returns. This pattern is consistent with market recognition that repurchasing firms maintain strong operational and investment performance, complementing the firm-level evidence from Table 1. The uniformly positive market reaction across all repurchase sizes suggests that investors view buyback announcements favorably regardless of transaction size.

In conclusion, our results present a striking picture of the repurchase phenomenon. Over the three-year horizon, we find that share repurchases are associated with increased rather than decreased investment in both tangible and intangible capital. Firms that initiate repurchases simultaneously expand capital expenditure, R&D spending, and patenting activity while adjusting their capital structure toward greater leverage. These patterns suggest that repurchases and productive investment are not competing uses of cash, but rather that firms conducting buybacks maintain strong investment postures. The market's uniformly positive reaction to repurchase announcements further reinforces this finding: investors appear to

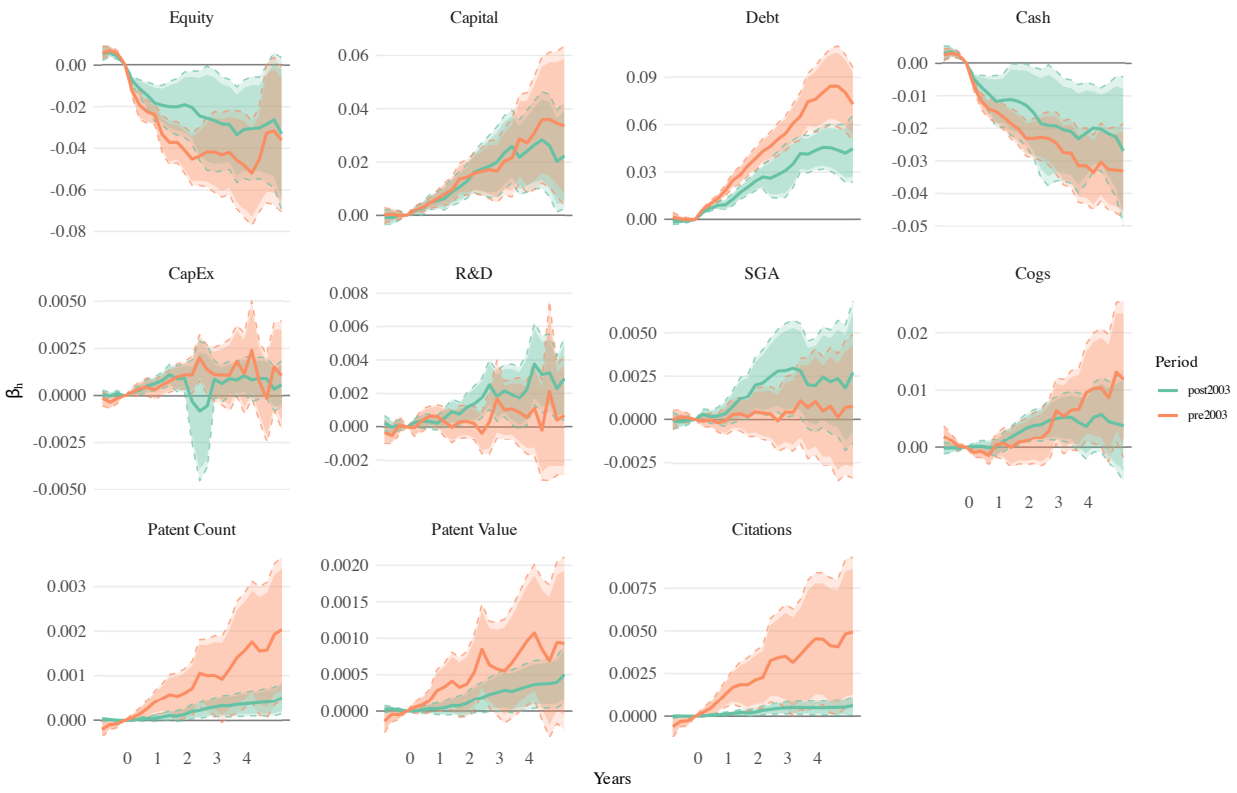
view buyback programs as consistent with firm strength and operational vitality.

Figure 6: Dynamic Impact of Stock Repurchase (High vs Low Repurchases)



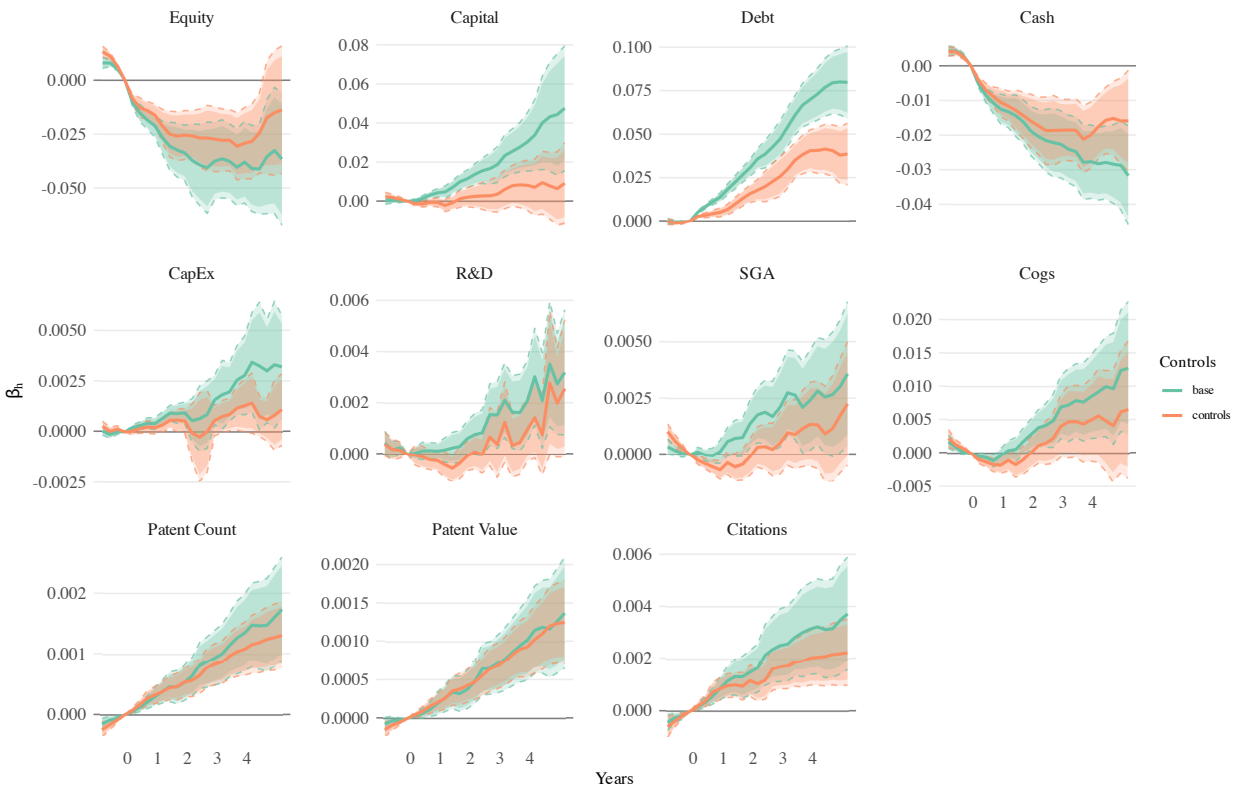
Notes: R&D is research and development. SG&A is selling, general, and administrative expenses. Capital expenditure is spending on plants, property, and equipment. Standard error are two-way clustering by firm and calendar quarter. *,**,*** denote 10, 5, 1% significance.

Figure 7: Dynamic Impact of Stock Repurchase (Pre-2003)



Notes: R&D is research and development. SG&A is selling, general, and administrative expenses. Capital expenditure is spending on plants, property, and equipment. Standard error are two-way clustering by firm and calendar quarter. *,**,*** denote 10, 5, 1% significance.

Figure 8: Dynamic Impact of Stock Repurchase



Notes: R&D is research and development. SG&A is selling, general, and administrative expenses. Capital expenditure is spending on plants, property, and equipment. Standard error are two-way clustering by firm and calendar quarter. *,**,*** denote 10, 5, 1% significance.

B Model

This section provides more detail on the quantitative model.

B.1 Existence of the Balanced Growth Path

We show that a balanced growth path (BGP) exists in which all aggregate variables grow at a constant rate g. Let the gross growth rate of any aggregate variable Z_t be denoted by $g^Z \equiv Z_{t+1}/Z_t - 1$.

Output. From the final-good technology,

$$Y_t = L_t^{1-\alpha} \int_0^{Q_t} z_{jt}^{1-\alpha} x_{jt}^{\alpha} \, dj, \qquad L_t = 1,$$

and the optimal input demand $x_{jt} = z_{jt}\left(\frac{\alpha^2}{\psi}\right)^{\frac{1}{1-\alpha}}$, we obtain

$$Y_t = \left(\frac{\alpha^2}{\psi}\right)^{\frac{\alpha}{1-\alpha}} \int_0^{Q_t} z_{jt} \, dj = \left(\frac{\alpha^2}{\psi}\right)^{\frac{\alpha}{1-\alpha}} \bar{z} \, Q_t,$$

where $\bar{z} = \mathbb{E}[z_{jt}]$ is constant under a stationary distribution. Hence, $Y_t \propto Q_t$ and aggregate output grows at the same rate as Q_t along the BGP.

Varieties. From the law of motion for the stock of varieties,

$$\frac{Q_{t+1} - Q_t}{Q_t} = \frac{M_t}{Q_t},$$

the growth rate of aggregate varieties equals the ratio of new to existing varieties. Along the BGP this ratio is constant, implying $g^Q = g^M = g$.

Intermediate Expenditure. With constant marginal cost ψ, total final output used for intermediates is

$$X_t = \int_0^{Q_t} \psi \, x_{jt} \, dj = \left(\alpha^2\right)^{\frac{1}{1-\alpha}} \psi^{-\frac{\alpha}{1-\alpha}} \bar{z} \, Q_t.$$

Thus $X_t \propto Q_t$ and $g^X = g^Q = g$ along the BGP.

R&D Expenditure. With a unit mass of firms $k \in [0,1]$,

$$W_t = \int_0^1 W_{kt}\, dk = \left(\int_0^1 \frac{W_{kt}}{Q_t}\, dk\right) Q_t = \bar{w}\, Q_t,$$

where $\bar{w}$ is a constant and $g^W = g^Q = g$ along the BGP.

Consumption. The goods-market clearing condition

$$Y_t = C_t + X_t + W_t$$

Since Y_t, X_t, and W_t are affine transformations of Q_t, aggregate consumption must also grow at the same rate g^Q along the BGP.

B.2 Balanced Growth Path

We characterize the firm's problem in stationary (scaled) units, which fully describe the economy along the balanced growth path (BGP). Along the BGP, all aggregate variables grow at the common rate g, determined by the growth of the stock of varieties Q_t. Dividing each variable by Q_t yields a stationary system in which firm-level variables and relative prices remain constant over time. We define per-variety (scaled) variables generically as

$$z_{kt} \equiv \frac{Z_{kt}}{Q_t},$$

where Z_{kt} denotes any firm-level variable in the model. All variables expressed in this scaled form are stationary along the BGP.

Firms' revenues (scaled) for firm k from selling their portfolio of intermediate goods are

$$r_{kt} \equiv \frac{R_{kt}}{Q_t} = \pi^k_{jt}(z_{kt})\, m_{kt} = (1-\alpha)\, \alpha^{\frac{\alpha}{1-\alpha}}\, \psi^{-\frac{\alpha}{1-\alpha}}\, z_{jt}\, m_{kt} \tag{44}$$

where $m_{kt} \equiv \frac{M_{kt}}{Q_t}$. Each firm invests $w_{kt} \equiv W_{kt}/Q_t$ units of the final good per existing variety in R&D to expand its portfolio of patented products.

$$m_{k,t+1} \equiv \frac{M_{k,t+1}}{Q_{t+1}} = \frac{\bar{\xi}}{1+g}\, \theta_{kt} w_{kt}^{\gamma}, \qquad 0 < \gamma < 1. \tag{45}$$

where g is the equilibrium growth rate of varieties Q_t

$$g = \int_0^1 m_{kt}\, dk. \tag{46}$$

Firms' residual profits per variety $\pi(z_{kt})$ can be written as:

$$\pi_{kt} \equiv \frac{\Pi_{kt}}{Q_t} = \pi(z_{kt})\, m_{kt} - b_{kt} + (1+g)\mathcal{Q}^{\mathcal{B}}_{kt+1}\, b_{kt+1} - w_{kt}, \tag{47}$$

The first term represents operating cash flow per variety, while the remaining terms capture debt repayment, new borrowing (adjusted by growth), and R&D spending.

Because firm residual profits scale linearly with the aggregate stock of varieties the firm's value function is homogeneous of degree one in Q_t. This allows the dynamic problem to be expressed in stationary form, eliminating Q_t from the state space. Therefore, along the balanced growth path, we have $V_t = Q_t v_t$. After the repurchase, firm value satisfies:

$$v_t^0(z_{kt}, m_{kt}, b_{kt}, \varepsilon_{kt}) = \max_{e_{kt}} \left\{ \frac{1}{1-s_{kt}}\, v_t(e_{kt}; z_{kt}, m_{kt}, b_{kt}, \varepsilon_{kt}) \right\}, \tag{48}$$

and the value of the firm, conditional on the size of the share repurchase, is:

$$v_t(e_{kt}; z_{kt}, m_{kt}, b_{kt}, \varepsilon_{kt}) = \max_{w_{kt},\, b_{k,t+1}} \left\{ \pi_{kt} - e_{kt} + \frac{(1+g)}{R_{t+1}}\, \mathbb{E}_t\left[v^0_{t+1}(z_{k,t+1}, m_{k,t+1}, b_{k,t+1}, \varepsilon_{k,t+1}) \right] \right\}. \tag{49}$$

Finally, from the equity market:

$$e_{kt} = \frac{s_{kt}}{1-s_{kt}}\, \mathbb{E}\Big[v(e_{kt}; z_{kt}, m_{kt}, b_{kt}, \varepsilon_{kt}) \mid \mathcal{B}(\varepsilon_{kt}; z_{kt}, m_{kt}, b_{kt}, e_{kt}) \Big] \tag{50}$$

and the price of debt from financial intermediaries:

$$\mathcal{Q}(z_{kt}, m_{kt+1}, b_{kt+1}) = \frac{1}{R_{t+1}} \mathbb{E}\Big[1 - \mathbb{1}^D(z_{kt+1}, m_{kt+1}, b_{kt+1}) \cdot (1 - \mathcal{R}(z_{kt}, m_{kt+1}, b_{kt+1})) \mid \mathcal{B}(\varepsilon) \Big] \tag{51}$$

Along the balanced growth path, the risk-free rate is constant. From the Euler equation,

$$\frac{1}{R_{t+1}} = \beta(1+g)^{-\eta}, \tag{52}$$

where g is the constant growth rate of consumption.

B.3 Solution Algorithm