Share Buybacks, Monetary Policy, and the Cost of Debt*

Assia Elgouacem[a] and Riccardo Zago[b]
[a]OECD
[b]Banque de France

Share buybacks have become common practice across U.S. corporations. This paper shows that firms finance these operations mostly through newly issued corporate bonds, and that the exogenous variation in the cost of debt—due to innovations in monetary policy—is key in explaining managers' incentives to repurchase their own shares. Under our identification strategy, we find that firms are more likely to repurchase in periods of accommodative monetary policy when the yield on their bonds adjusts in the same direction. This behavior has macroeconomic implications, as it diverts resources from investment and employment, thus reducing the transmission of accommodative monetary policy at firm level.

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1. Introduction

Since 1985, U.S. corporations are allowed to buy back their own shares on the stock market. Very quickly buybacks have become common practice used to return cash to particular categories of investors,

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to send signals of confidence to markets, to concentrate firms' ownership, or also to adjust stock prices. However, these operations tend to divert resources from productive investments (Almeida, Fos, and Kronlund 2016) such that many raised concerns about the legitimacy of repurchase programs, particularly about the way managers use their financial resources and on the impact of buybacks on the real economy. These arguments became of interest to legislators and economists in the aftermath of the Great Recession, a period in which firms—despite having at their disposal substantial internal and external liquidity—devoted considerable resources to buybacks rather than to new investments and job openings.[1]

Much is already known about the negative effect of repurchases on real variables (Wang, Yin, and Yu 2021), on the market timing of repurchases (Stein 1996; Ma 2019; Baker and Wurgler 2002) and the reason why firms do buy back (Grullon and Michaely 2004; Hribar, Jenkins, and Johnson 2006). Yet, little is known about how firms finance this operation and to what extent the cost of financing affects managers' decision to buy back their own shares.

This paper aims to fill this gap in the literature and shows that buyback programs are mostly financed through new corporate debt issuance, and they are most likely and bigger in periods of accommodative monetary policy. In fact, for an exogenous fall in the federal funds rate, firms that benefit from a downward adjustment of their corporate yield tend to repurchase more by issuing more debt in the same quarter. Using low-cost debt to finance repurchases takes away resources from capital expenditures and new employment, thus reducing the effectiveness of accommodative monetary policy at firm level. The contribution of the paper is to properly quantify by how much the use of resources to repurchase programs is due to accommodative monetary policy, and to causally assess by how much the

[1]After the introduction of the stimulus package following the financial crisis of 2008, the Obama administration publicly opposed this managerial behavior since many bailed-out banks started using public money to buy back shares or compensate managers. Similar concerns were raised also in the aftermath of the current pandemic crisis. See, for example, the speech President Biden gave in Dunmore on July 9, 2020, or the most recent statement of Senator Elizabeth Warren of March 2, 2021. Both advocate for a reduction of repurchases, since they are primarily beneficial for managers and shareholders, they discourage new investments, and they hinder inequality reduction.

transmission of monetary policy on real variables is attenuated by the share buyback channel.

In light of this evidence, this paper not only unveils a new fact that informs on the use of share repurchases and the allocation of firms' financial resources, but it also highlights how these corporate decisions prevent a full transmission of an expansionary monetary policy on real variables. Hence, this work is also linked to a growing literature investigating how firm-level heterogeneity influences corporate dynamics and the transmission of macroeconomic shocks to the real economy (see, for example, Bloom, Bond, and Van Reenen 2007; Armenter and Hnatkovska 2011; Acharya, Almeida, and Campello 2013; Falato, Kadyrzhanova, and Sim 2013; and Bacchetta, Benhima, and Poilly 2014).

The first part of the paper shows some basic facts that motivated our investigation. First, we use corporate balance sheet data and provide evidence that, in the cross-section, firms use 75 cents of each dollar of newly issued debt to finance repurchase programs, whereas corporate cash plays a minor role. Second, we combine firm-level and macro data to show that repurchase programs are 3 percent more likely and 10 percent larger in periods in which a 1 percent negative monetary policy shock realizes. However, these estimates are biased due to the fact that there are many different channels through which monetary policy can operate and influence managerial decisions on share repurchases.

In the second part of the paper we deal with this problem. This is not a trivial task since the relationship between buybacks, monetary policy, and real variables is exposed to several sources of endogeneity: a firm can self-select into a repurchase program at any time and for reasons other than an exogenous change in the cost of debt. Similarly, there are factors—monetary policy included—that can simultaneously affect employment and investment such that the decision to repurchase, and the size of the buyback program, might be an endogenous outcome. To solve the endogeneity issue, quantify the correct effect of monetary policy on repurchase, and impute by how much the crowding out of buybacks on real variables is due to an accommodative monetary shock, we need a rigorous identification strategy. More specifically, we need an exogenous factor, orthogonal to firm characteristics and monetary policy itself, able to explain ex ante firms' repurchase behavior. This, in a first stage, would allow us to correctly evaluate how monetary policy influences buyback behavior by comparing the effect of monetary innovations between firms that are ex ante supposed to repurchase and those that are not. Thereafter, in a second stage, we can use this strategy to assess the causal crowding-out effect of repurchase on real variables, by how much an accommodative monetary policy exacerbates such effect and by how much share buybacks attenuate the overall transmission of an accommodative monetary policy shock.

To do so, we exploit a discontinuity in the likelihood of repurchasing that is driven by management earnings considerations. As shown in Hribar, Jenkins, and Johnson (2006), firms whose earning-per-share (EPS) ratio is below the analysts' forecast are more prone to launch an accretive buyback program in order to meet markets' expectations, build credibility, and avoid markets' future punishment.[2] This maneuver allows us to split the sample of firms into a "treatment" group, i.e., those who need to adjust the EPS to meet the target, and a "control" group, i.e., those who do not need to adjust the EPS. Both groups are very similar in terms of leverage, size, cost of debt, growth opportunities, and financial constraints, and exhibit also similar dynamics in investments and employment before the EPS forecast is announced. Moreover, monetary policy shocks and the implied changes of corporate debt cost are not correlated anyhow with the EPS forecast. Hence, all the identifying assumptions for a regression discontinuity design hold and the distance from the EPS forecast is a valid predictor of repurchase behavior.

Under this strategy, first we study how an exogenous fall in the cost of corporate debt—as explained by a monetary policy shock—affects both groups of firms around the discontinuity at the moment of the EPS forecast announcement and show that it has a significant positive impact only for the "treatment" group. In other words, if a manager needs to repurchase to satisfy EPS market expectations, (s)he is more likely and capable to do so if, at the same time, (s)he benefits from a fall in the cost of debt, i.e., if (s)he can raise money at a low cost to finance this operation. In particular, from this analysis,

[2] An accretive buyback program is one that raises the EPS by more than the opportunity cost of not saving resources.

we find that a 1 percent exogenous fall in the 10-year corporate bond yield leads to an increase of 0.5 percent of repurchase among firms in the "treatment" group. Thereafter, by using the distance from the EPS forecasts and monetary policy shocks as instruments, we study the causal effect of repurchases, the cost of debt, and their interaction on real variables.

From this analysis, the result is that repurchases causally lead to a considerable crowding-out effect on future investments and employment, and any accommodative monetary policy shock lowering the corporate cost of debt exacerbates such effect. In particular, we find that—through the repurchase channel—a 1 percent fall in the corporate cost of debt leads to an extra decrease of investments by 11,200 dollars and 0.10 employees for every million dollars of a firm's assets. Such diversion of resources from real variables calls into question the effectiveness of monetary policy and its transmission at firm level. By doing a simple back-of-the-envelope calculation, we find that indeed buybacks attenuate the transmission of expansionary monetary policy and, if the repurchase channel was muted, the transmission of a 1 percent accommodative shock on investments and employment would be, respectively, 11 percent and 15 percent stronger.

Related Literature. This paper is related to three strands of literature. The first is the vast literature on share buybacks. This tells us that repurchases are typically conducted when firms have the private information that their stock price is undervalued (Ikenberry, Lakonishok, and Vermaelen 1995; Stein 1996; Brockman and Chung 2001; Peyer and Vermaelen 2008), when they lack future growth opportunities (Grullon and Michaely 2004), to signal confidence to markets on strong future performance (Hribar, Jenkins, and Johnson 2006), to increase employees' effort (Babenko 2009), to mitigate the dilutive effect of stock option exercises (Kahle 2002; Bens et al. 2003), or to distribute excess capital (Dittmar 2000). Moreover, we know that repurchase programs follow market timing. For example, firms repurchase when the value of equity is relatively low with respect to other sources of financing (Ma 2019; Baker and Wurgler 2002). Finally, Almeida, Fos, and Kronlund (2016) tell us that share buybacks crowd out future capital investment, employment, and R&D (research and development) investment. Also Lazonick (2014) goes in this direction and cites repurchases as a possible explanation for why, in the post-recession era, firms have high corporate profitability but low growth in employment.

The second strand of literature this paper relates to is on earnings and EPS management. Our identification strategy is based on the fact that managers care about meeting market expectations on earnings, and it is well known that repurchases can help boost the EPS index (see, among the many, Burgstahler and Dichev 1997, Skinner and Sloan 2002, and Graham and Harvey 2005).

Third, this paper relates to the growing literature studying the role of firm heterogeneity for the transmission of macroeconomic shocks and for the comprehension of macroeconomic dynamics. For example, and consistently with the results of this paper, Bacchetta, Benhima, and Poilly (2014) show that firms exploit liquidity shocks to hoard cash for precautionary purposes at the detriment of employment. In the same vein, Armenter and Hnatkovska (2011), Falato, Kadyrzhanova, and Sim (2013), Acharya, Almeida, and Campello (2013), and Bloom, Bond, and Van Reenen (2007) show the effects of firms' precautionary behavior when productivity and uncertainty shocks materialize. Others, like Jeenas (2018) and Melcangi (2018), show that demand shocks and monetary shocks heterogeneously affect firms' employment choice depending on the capital structure of the firm, the degree of financial constraint, and the level of liquidity.

This paper develops as follows: Section 2 documents the financing and the timing of repurchase programs; Section 3 explains the identification strategy to study the causal crowding-out effect of repurchases on real variables and to impute correctly the attenuation of accommodative monetary policy due to buybacks; in Section 4 we do robustness checks; Section 5 reconciles the empirical evidence with a simple model showing the conditions under which a fall in the cost of debt allows for accretive repurchases; Section 6 concludes.

2. Repurchases, Debt, and Monetary Policy

In this introductory section, we describe the data and provide some basic evidence on how share buybacks, debt issuance, and monetary policy are all related. In particular, we show three facts. First, firms finance repurchase programs by issuing new debt and cutting their capital expenditure. Second, the timing and magnitude of buyback programs are correlated with unanticipated changes in monetary policy: they are more probable and larger in periods of accommodative monetary policy. Third, monetary shocks have a firm-specific effect on debt issuance through changes in the yield on corporate bonds.

2.1 Data and Sample Selection

We use two types of data: firm-level data and macroeconomic data on monetary policy shocks. Firm microdata come from different sources. We use Standard and Poor's Compustat to extract firms' fundamentals data at quarterly frequency between 1985 and 2016, with the exception of employment data, which are available at yearly frequency only. Following Almeida, Fos, and Kronlund (2016), we exclude regulated utility firms (Standard Industrial Classification (SIC) codes 4800–4829 and 4910–4949) and financial firms (SIC codes 6000–6999) as well as firms with missing or negative assets. Thereafter, we merge the Compustat sample with analysts' forecast data from the Institutional Brokers' Estimate System (IBES). Finally, we use data from the Trade Reporting and Compliance Engine (TRACE) to extract firm-level yields on newly and previously issued corporate bonds.[3] Regarding monetary policy shocks, we follow the literature on structural vector autoregression (SVAR) and recent developments as in Rossi and Zubairy (2011) and Ramey (2016) to extract innovations on the fund rate.[4] Table 1 shows summary statistics of the variables we use and describes their construction. In particular, as in Ma (2019), we define repurchases as the firm's net position on the equity market, i.e., difference between the value of the shares repurchased and the value of the newly issued shares normalized by total assets in the previous period. In this way, a negative value would stand for a net equity issuance, while a positive value would stand for a net equity repurchase. As the first panel of Table 1 reports, 24 percent of firms are net repurchasers across quarters. Among them, on average 3.1 percent of assets are repurchased every period with an average cash flow of 38 million dollars.

[3]Firm-level yields are calculated using equal weighted average on the different bonds issues of the same maturity.

[4]See Appendix A for details on the SVAR model we use to extract monetary policy shocks and its identifying assumptions.

Table 1. Descriptive Statistics

	Mean	SD	p1	p5	p25	p50	p75	p95	p99	N
Repurchase Statistics										
$\mathbb{I}(Repurchases > 0)$	.24	.43	0	0	0	0	0	1	1	831,649
For $\mathbb{I}(Repurchases > 0) = 1$										
Repurchases/Assets	.03	.06	.00	.00	.00	.01	.03	.12	.30	204,794
Repurchases ($M)	38.27	88.90	.00	.02	.36	3.141	25.56	229.51	474.184	204,794
EPS Distance Statistics										
Distance (%)	–.07	1.91	–7.33	–3.34	–.48	.04	.61	2.30	5.91	196,378
$\mathbb{I}(Distance \geq 0)$	.54	.49	0	0	0	1	1	1	1	196,378
$\mathbb{I}(Distance < 0)$	.46	.49	0	0	0	0	1	1	1	196,378
Firm Characteristics										
Market Cap. ($M)	2,630	14,901	.33	2.02	22.70	141.86	876.99	9,428	46,011	248,137
Market-to-Book	3.46	4.98	.15	.41	1.11	1.98	3.65	11.46	28.16	211,214
Assets ($M)	1,946	13,13	.02	.91	14.43	84.68	507.06	6,533	34,235	831,649
Money/Assets	.17	.19	.00	.00	.03	.09	.23	.63	.88	223,742
Profits/Assets	–.01	.19	–.79	–.42	–.03	.02	.06	.17	.33	586,650
Debt/Assets	.23	.20	.00	.00	.05	.18	.34	.65	.87	562,305
Investments/Assets	.04	.07	.00	.00	.00	.02	.05	.17	.40	723,171
Employment/Assets	16.98	22.01	.08	.41	2.44	5.72	12.12	36.44	110.49	653,749
10-Year Yield (%)	5.20	2.52	1.38	2.07	3.41	4.88	6.34	9.59	14.67	48,560
Q	2.43	2.61	.35	.65	1.09	1.55	2.58	7.51	14.97	234,911
*PE*10	21.74	352.78	.03	.15	1.10	3.50	10.65	52.94	212.20	95,314
$\mathbb{I}(Dividend > 0)$	.16	.37	0	0	0	0	0	1	1	831,649
Fin. Constraint	–2.58	0.72	–3.27	–3.25	–3.11	–2.79	–2.28	–1.27	–.15	351,375
Monetary Innovations										
Shock (%)	0.00	0.11								128

Note: All variables are built on quarterly data, with the exception of employment. *Repurchases* is the difference between stock purchases and stock issuances (in $M). *Distance* is the difference between the reported EPS and the median EPS forecast at the end of the quarter, normalized by the end-of-quarter stock price. *Market-to-Book* is the market value of common equity divided by the book value of common equity. *Money* is the total value of cash holdings (in $M). *Profits* is defined as net income plus depreciation (in $M). *Debt* is the value of total debt (in $M). *Investments* equates capital expenditure (in $M). *Employment* is the stock of employees (in Ks). This variable is available only at yearly frequency, but we use it at quarterly frequency when normalized by the (quarterly) value of assets. *Yield* is the firm's yield on a 10-year-maturity corporate bond. *Q* is the book value of liabilities plus the market value of common equity divided by the book value of assets. The measure of *Fin. Constraint* follows Hadlock and Pierce (2010). *PE*10 is the 10-quarter moving average of the price-earning ratio. *Shock* is the monetary shock obtained from an SVAR (see Appendix A).

The second panel reports statistics on firms' ex post EPS distance from the analysts' target and frequency for a (weakly) positive and negative distance from the target. Such distance is measured as the difference between the EPS forecast and the end-of-the-quarter EPS as reported by the firm. The (price-normalized) average distance is negative and 0.07 percent off the median analysts' consensus. Across quarters, 54 percent of the time firms are on target or above (i.e., they are reporting an end-of-the-quarter EPS at least as big as the forecast) while 46 percent of the time they are below the target. The third panel reports on other firm characteristics like market capitalization, the market-to-book value of the firm, assets, internal and external financial resources (cash holdings, profits, debt issuance), investments, employment, the cost of debt (measured as the yield on a 10-year corporate bond), the Q-value, the 10-quarter moving average of the price-earning ratio (PE10), an indicator on whether the firm has paid dividends in the previous four quarters, and a measure for financial constraint (built after Hadlock and Pierce 2010). The fourth panel reports the mean and standard deviation of monetary policy innovations as extracted from the SVAR. These shocks have mean zero and standard deviation equal to 11 basis points, very similarly to the (quarterly aggregated) high-frequency monetary shocks identified in Gertler and Karadi (2015) and Ottonello and Winberry (2018).

2.2 The Financing of Share Buybacks

How are share buybacks financed? We answer this question by considering the following "accounting equation" for firms conducting a (positive net) share repurchase:[5]

$$\begin{aligned} Repurchases_{i,t} &= \beta_1 \Delta Debt_{i,(t,t-1)} + \beta_2 \Delta Cash_{i,(t,t-1)} \\ &\quad + \beta_3 Investments_{i,t} + \beta_4 Dividends_{i,t} + \epsilon_{i,t}. \end{aligned}$$

Under this specification, we want to understand how much of each dollar (of assets) that the firm spends on repurchases is financed through the change in debt (β_1), the change in cash holdings

[5]We consider only firms for which the difference of the value of the shares repurchased and the value of the newly issued shares is positive.

Table 2. Financing Buybacks

	***Repurchases* (1)**	***Repurchases* (2)**	***Repurchases* (3)**	***Repurchases* (4)**	***Repurchases* (5)**
$\Delta Debt$	0.75***	0.79***	0.40***	0.40***	0.40***
	(0.11)	(0.07)	(0.05)	(0.05)	(0.05)
$\Delta Cash$		–0.23	–0.00	–0.00	–0.00
		(0.31)	(0.03)	(0.03)	(0.03)
Investments			–0.62***	–0.62***	–0.62***
			(0.04)	(0.04)	(0.04)
Dividends				0.06	0.06
				(0.05)	(0.05)
Observations	180,436	163,278	144,858	144,858	144,858
Time FE	No	No	No	No	Yes
Industry FE	No	No	No	No	Yes
Controls	No	No	No	No	No

Note: Standard errors are in parentheses, clustered at the firm level. The unit of observation *Repurchases* is the difference between the value of stock purchases and stock issuances from the statement of cash flows, and we consider only firms for which such difference is strictly positive. $\Delta Debt$ is the change in the value of current total debt of the firm. $\Delta Cash$ is the change in firm money holding plus current net profit. *Investments* is equal to capital expenditure. *Dividends* is equal to the value of the dividends paid. All variables are normalized by the value of total assets in $t - 4$. *, **, and *** indicate significance at the 90 percent, 95 percent, and 99 percent level, respectively.

including net profits from the current quarter (β_2), a reduction in capital expenditure (β_3), or in dividend distribution (β_4). All variables are normalized by the level of assets in $t - 4$, and errors are clustered at the firm level. As reported in the first column of Table 2, unconditionally on other sources of financing, a \$1 repurchase is explained by \$0.75 of new debt issuance. Controlling for the change in cash holding and quarterly profits (column 2) does not affect the role of debt by much. Moreover, the estimate for $\Delta Cash$ is insignificant, suggesting that firms do not use their liquidity from cash holdings or newly generated net profits to finance this operation. This is consistent with the trend across U.S. corporations of hoarding cash for precautionary savings (see Acharya, Almeida, and Campello 2013 and Falato, Kadyrzhanova, and Sim 2013). When controlling for all other variables in the accounting equation, as well as time and industry fixed effects—as in columns 3 to 5—the contribution of debt drops but remains quite substantial at 40 cents. On the other hand, now repurchase expenditure looks mostly financed by subtracting resources from new capital investments (around 62 cents).[6]

2.3 Share Buybacks and Monetary Policy

The fact that debt is an important source to finance buybacks suggests that these corporate operations might be sensitive to changes in the cost of money, i.e., changes in monetary policy. To check this fact in the data, we consider the following regressions:

$$\mathbb{I}(Repurchases_{i,t} > 0) = \alpha + \beta Shock_t + X'_{i,t-1}\gamma + \theta_t + \epsilon_{i,t} \quad (1)$$

$$Repurchases_{i,t} = \alpha + \beta Shock_t + X'_{i,t-1}\gamma + \theta_t + \epsilon_{i,t}, \quad (2)$$

where $\mathbb{I}(Repurchases_{i,t+1} > 0)$ takes value one when the firm is a net repurchaser in quarter t, $Shock_t$ is the exogenous innovation on the fund rate as predicted by our SVAR, and $X_{i,t-1}$ controls for firm-level characteristics such as Q-value of investment, return (profit) on assets, a dummy indicating whether the firm has redistributed dividends in the previous four quarters, and a dummy indicating the quintile of asset to which the firms belong.[7] This set of variables will help to take into account other factors influencing the decision and capability to repurchase, such as market valuation, profitability, payoff policies, and size. θ is a year-quarter fixed effect.[8]

Table 3 reports results for models (1) and (2). Since our measure of monetary policy shock is estimated from an SVAR, errors are double-clustered at firm level and date.[9] As from the specification in column 1, we find that a 1 percent exogenous fall of the federal funds rate leads to an increase in the probability of repurchase by 3 percent. For the model in column 2, we find that a 1 percent exogenous fall in the federal funds rate leads to a 16 percent increase in the size of the repurchase program. Therefore, we conclude that monetary

[6]In Appendix B we repeat the same analysis with variables in levels, and we further disaggregate the potential sources of financing. Yet, we find that debt issuance finances at least 35 cents of each dollar spent on buybacks.

[7]The set of control variables X will remain the same throughout the paper, if not otherwise specified.

[8]The year-quarter fixed effect implies controlling for a year dummy and a quarter dummy separately.

[9]From now until the end of Section 3, errors are always clustered at this level.

Table 3. Net Repurchases and Monetary Policy Shocks

	$\mathbb{I}(\boldsymbol{Repurchases} > \mathbf{0})$ **(1)**	***Repurchases*** **(2)**
Shock	–0.031*** (0.006)	–0.156** (0.065)
Observations	213,761	213,761
Time FE	Yes	Yes
Industry FE	Yes	Yes
Controls (X)	Yes	Yes

Note: Standard errors are in parentheses, double-clustered at firm level and date. In column 1, the unit of observation is $\mathbb{I}(Repurchases > 0)$, an indicator variable taking value one if the firm is a net repurchaser, i.e., the difference between equity repurchased and new equity issuance is positive. In column 2, the unit of observation *Repurchases* is the difference between the value of stock purchases and stock issuances from the statement of cash flows, normalized by total asset in t – 4. *Shock* is an exogenous monetary innovation as from an SVAR (see Appendix A for details). The set of controls X includes Q-value of investment, a dummy indicating whether the firm has redistributed dividends in the previous four quarters, a dummy indicating the quintile of asset the firms belong to. *, **, and *** indicate significance at the 90 percent, 95 percent, and 99 percent level, respectively.

policy shocks have an effect on both the propensity and the level of repurchase.

2.4 Corporate Yield and Monetary Policy

Although debt is important for the financing of share buybacks, it is not plausible to assume that common monetary shocks affect firms' capital structure and new debt issuance in the same way. This will ultimately depend on the responsiveness of the firm's bond yield to the shock. The following regressions investigate the effect of the unanticipated monetary shock on firm-level bond yields and debt issuance:

$$\Delta Yield_{i,t} = \alpha_1 + \beta_1 Shock_t + X'_{i,t-1}\gamma_1 + \theta_t + \epsilon_{i,t} \tag{3}$$

$$\Delta Debt_{i,t} = \alpha_2 + \beta_2 \Delta Yield_{i,t} + X'_{i,t-1}\gamma_2 + \theta_t + \nu_{i,t}, \tag{4}$$

where the variable $Yield_i$ is firm i's yield on a 10-year-maturity corporate bond.

Table 4. Corporate Bond Yield, Debt Issuance, and Monetary Shocks

	Δ *Yield* (1)	**Δ *Debt* (2)**	**Δ *Debt* (3)**
Shock	0.606***		
	(0.127)		
Δ *Yield*		–0.001**	
		(0.000)	
$\Delta \widehat{Yield}$			–0.004**
			(0.002)
Observations	41,624	41,624	41,624
Time FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Controls (X)	Yes	Yes	Yes
Estimator	OLS	OLS	2SLS

Note: Standard errors are in parentheses, double-clustered at firm level and date. In column 1, the unit of observation Δ *Yield* is the change in the firm's yield on a 10-year-maturity corporate bond. In columns 2 and 3, the unit of observation Δ *Debt* is the change in the value of current total debt of the firm, normalized by total asset in $t-4$. *Shock* is an exogenous monetary innovation as from an SVAR (see Appendix A for details). $\Delta \widehat{Yield}$ is the exogenous change in the 10-year corporate yield as predicted by monetary policy shocks, i.e., when *Shock* is used as instrument for the change in the cost of debt. Column 3 reports 2SLS estimates for Equation (4). Control X includes return on assets, Q-value of investment, a dummy indicating whether the firm has redistributed dividends in the previous four quarters, a dummy indicating the quintile of asset the firms belong to. *, **, and *** indicate significance at the 90 percent, 95 percent, and 99 percent level, respectively.

Column 1 of Table 4 shows results for regression (3), for which we find that an exogenous innovation of 10 basis points over the fund rate leads to an increase by 6.1 basis points of the 10-year yield. The results of regression (4) are reported in column 2, where we show that a 1 percent fall in the yield is associated with an increase of debt issuance by 0.1 percent. Since the relationship between debt issuance and changes in the yield is endogenous, we instrument $\Delta Yield$ of Equation (4) with the exogenous monetary innovations, i.e., we use Equation (3) as first stage to predict the exogenous change in the yield $\Delta\widehat{Yield}$. Then, we use the latter to explain the causal effect of an exogenous change of the yield on debt issuance. As reported in column 3, the (two-stage least-squares, 2SLS) estimator is four times larger: if the yield falls by 1 percent, the firm will issue 0.4 percent more debt.

3. Identifying the Effect of Monetary Policy on Real Variables through the Repurchase Channel

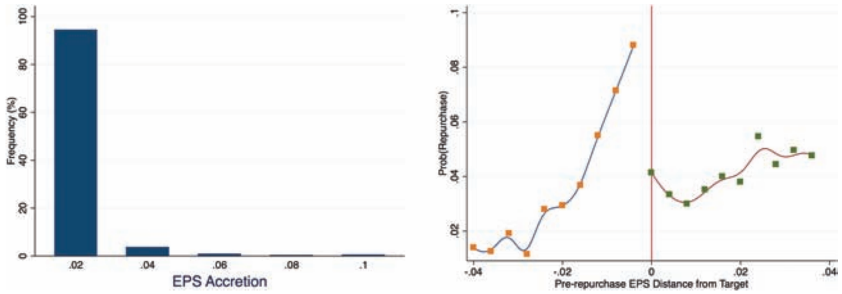
Despite the results of the previous section, it is important to stress that—when measuring the effect of monetary policy on the level of repurchase—our estimates are biased since monetary policy interacts with many firm's characteristics and time-varying variables (e.g., real variables) that can influence the size of the buyback program at the same time.

In fact, the option of buying back shares is always at managers' disposal and buybacks can happen for a long list of (endogenous) factors—such as poor growth prospects, lack of investment opportunities, or a need to adjust the balance sheet structure—that might correlate with monetary policy as well. Moreover, monetary policy might directly influence managers' choices over investment and employment such that repurchases might be a subsequent endogenous result. In other words, our identification is exposed to endogeneity problems mainly due to endogenous self-selection into a buyback program and reversed causality between repurchases and real variables (investment and employment). Therefore, monetary policy cannot explain alone repurchase behavior. In order to assess how much monetary policy encourages buybacks, first we must solve this issue. In particular, we need an exogenous factor, orthogonal to firm-level characteristics and monetary policy, capable to predict ex ante the repurchase behavior of the firm and to split the sample in two groups: repurchasers and non-repurchasers. This allows us to break the loop between monetary policy, repurchases, and real variables, and—more importantly—to assess correctly how exogenous changes in monetary policy affect both groups in their capability to repurchase. Finally, this strategy allows us to study the causal crowding-out effect of repurchase on real variables and evaluate by how much such crowding out is causally explained by accommodative monetary policy. By doing so, we can quantify the extent to which accommodative monetary policy transmits on real variables and by how much share buybacks reduce such transmission.

3.1 Identification Strategy

In order to overcome the endogeneity problem, we exploit a discontinuity in the level and probability of conducting an accretive repurchase. This discontinuity, first introduced by Hribar, Jenkins, and Johnson (2006) and more recently used in Almeida, Fos, and Kronlund (2016), exploits the misalignment between the firm EPS and the analysts' forecast. At the beginning of each quarter, analysts release their forecast for what the EPS of the firm will be at the end of that same quarter. Once the forecast is observed, managers decide whether to launch a buyback program to align their EPS at least with the level predicted by analysts. At the end of the quarter, firms announce their (adjusted) EPS along with information on the quantity and buying price of the repurchased shares. Hence, it is possible to reconstruct what the EPS would have been without repurchasing, i.e., the non-adjusted EPS (or the counterfactual) that would have prevailed without repurchasing. This information allows us to understand which firms were able to run an accretive buyback, by how much they were able to increase their EPS, and—for a given EPS forecast—which firms would have missed the EPS target without repurchasing. For example, say that analysts' EPS forecast for a certain firm is \$4 by the end of the quarter. For the same firm, we observe that the realized EPS is \$4.1 as announced at the end of the quarter. Thus, we check the number of shares held at the beginning of the period (say it was $N =$ 1,000 million), the number of shares repurchased (say $n = 50$ million) and at what price (say $P =$ \$50). Hence, we can build the forgone earnings due to buybacks as the opportunity cost of putting the amount $Pn =$ 2,500 million into a deposit with a quarterly rate of $r^s = 5\%$ at the net of taxes (e.g., $\tau = 30\%$). In our example, the forgone net earnings are equal to $Pnr(1-\tau) = 87.5$ million. Under this correction, the realized earnings (as reported at the end of the quarter) are equal to $4.1 * (1,000M - 50M) = 3,895$ million such that—if managers were not buying back their own shares—the EPS before adjustment would have been equal to $(3,895M + 87.5M)/1,000M = 3.98$ dollars per share. In this case, managers were able to beat the analysts'

Figure 1. EPS Accretion, Probability to Repurchase, and Distance from Target



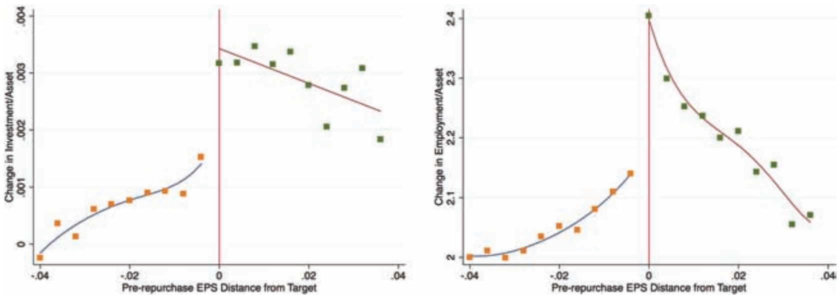
Note: The graph on the left-hand side plots the frequency of repurchases by EPS accretion bins. The accretion is the difference (normalized by the end-of-the-period stock price) between the adjusted EPS, i.e., the EPS as reported at the end of the quarter, and the EPS that would have prevailed if no buyback was conducted during the same quarter. The graph on the right-hand side plots the probability for a firm to buy back its own shares as a function of the distance of the pre-repurchase (non-adjusted) EPS and the analysts' EPS forecast (normalized by the end-of-the-period stock price).

forecast by 10 cents by increasing the EPS from \$3.98 to \$4.1. In this sense, the repurchase program was accretive because managers were able to boost the EPS above the level of inaction by 12 cents.

On the left-hand side of Figure 1, we plot the frequency of firms conducting a repurchase over bins of EPS accretion, i.e., the difference between announced EPS and pre-repurchase EPS (normalized by the stock price). More than 95 percent of firms conduct repurchases that allow to increase the EPS by 0 to 2 cents while only a few boost the EPS by more. As the numerical example suggests, this is because increasing the EPS by more than 2 cents through buybacks might be extremely expensive and too detrimental for earnings such that the operation would be overall ineffective.

Then, we exploit the distance from the EPS forecast and the pre-repurchase EPS to understand which firms are more likely to repurchase and by how much. The right-hand side of Figure 1 plots the share of repurchasing firms over the pre-repurchase distance from the forecast (normalized by the stock price). If firms that were already on target to exhibit an average probability of repurchasing around 4 percent, things are different for those on the left of the cut-off. In fact, those are the firms strategically more willing to buy back

Figure 2. Distance from Target and Changes in Investment and Employment



Note: The graph on the left-hand side plots the change in capital expenditure on the distance between the pre-repurchase (non-adjusted) EPS and the analysts' EPS forecast (normalized by the end-of-the-period stock price). The graph on the right-hand side plots the change in employment on the distance between the pre-repurchase (non-adjusted) EPS and the analysts' EPS forecast (normalized by the end-of-the-period stock price). The change in investment (employment) is defined as the difference between the average level of capital investment (employment) in the previous four quarters and the average level of capital investment (employment) in the following four quarters. Such difference is normalized by the level of assets in $t - 4$.

in order to correct the EPS and not disappoint capital markets.[10] This explains why, on the left-hand side of the cut-off, the probability to repurchase increases the closer a firm is to meeting the analysts' forecast. In fact, for firms ex ante closer to target, incentives to repurchase are high, since it is easier and does not take many resources to tilt the EPS to meet market expectations. Conversely, for firms far away from the cut-off, the probability is smaller, since any repurchase would not be large enough to put the EPS on target.

This heterogeneous propensity to repurchase has implications for the dynamics of real variables. In fact, since the EPS adjustment is costly, we expect firms that need to repurchase to invest less in new capital and new hires compared with firms that do not need to repurchase. Figure 2 shows that this is indeed the case. The left- and

[10] As documented in Bartov, Givoly, and Hayn (2002), Kasznik and McNichols (2002), Kinney, Bargstahler, and Martin (2002), and Hribar, Jenkins, and Johnson (2006), missing the EPS negatively affects the market value of the firm, stock market returns, and the credibility of the firm's management.

right-hand side plot, respectively, the change in capital investment and employment (normalized by the value of assets) as a function of the pre-repurchase distance from the EPS forecast (normalized by the stock price). Firms that learn that they need to adjust their EPS tend to invest and hire less with respect to firms that are sure of meeting the EPS target.

In light of this evidence, now we want to study if monetary policy can influence the repurchase behavior of firms, and with what implications for real variables. Our strategy proceeds as follows. First, we focus on the right-hand side of Figure 1 and follow Calonico, Cattaneo, and Titiunik (2014) to define $[-0.018\$, +0.018\$]$ as the optimal (symmetric) interval of firms around the discontinuity. By doing so, the discontinuity in the probability to buy back allows to separate firms into two comparable groups: "repurchasers" and "non-repurchasers," i.e., firms below and above the cut-off. Then, we assess across both groups how exogenous changes in monetary policy affect repurchase expenditure and real variables through variations in the corporate cost of debt. Finally, we exploit our identification strategy to investigate the causal effect of repurchases, changes in the corporate cost of debt, and their interaction on investment and employment.

3.2 Results

Repurchases, EPS Distance from Forecast, and the Cost of Debt. Here we study how variations in the cost of debt due to innovations in monetary policy differently affect repurchasing behavior of firms around the discontinuity. First, for each firm we define the pre-repurchase distance from the EPS target with the variable *Distance*, i.e., the stock price normalized difference between the pre-repurchase EPS and the EPS forecast. Under this definition, a firm i is off (on) target before the repurchase if $Distance < 0$ ($Distance \geq 0$). Second, following Calonico, Cattaneo, and Tittunik (2014), we keep observations only for firms with $Distance_{i,t}$ in the $[-0.018\$, +0.018\$]$ bracket. Third, we extract the exogenous change in the firm-specific yield, by using monetary policy innovations (*Shock*) as an instrument for the firm-specific cost of debt ($\Delta Yield$). Then, we study how being off target and receiving an exogenous change in the cost of debt affects this level of repurchase. In order to do so, consider the following:

$$\begin{aligned}Repurchases_{i,t} &= \alpha + \beta_1 \mathbb{I}(Distance_{i,t} < 0) + \beta_2 \widehat{\Delta Yield}_{i,t} \\ &+ \beta_3 \mathbb{I}(Distance_{i,t} < 0) * \widehat{\Delta Yield}_{i,t} + \beta_4 Distance_{i,t} \\ &+ \beta_5 \mathbb{I}(Distance_{i,t} < 0) * Distance_{i,t} + \beta_6 Distance^2_{i,t} \\ &+ \beta_7 \mathbb{I}(Distance_{i,t} < 0) * Distance^2_{i,t} + \beta_8 Distance^3_{i,t} \\ &+ \beta_9 \mathbb{I}(Distance_{i,t} < 0) * Distance^3_{i,t} + X'_{i,t-1}\gamma + \theta_t + \epsilon_{i,t}, \quad (5)\end{aligned}$$

where $Repurchases_{i,t}$ is the level of positive net repurchase normalized by the level of assets in $t-4$, $\mathbb{I}(Distance_{i,t} < 0)$ takes value one when the firm i is off target with respect to the analysts' EPS forecast, $Distance_{i,t}$ is the pre-repurchase distance from the forecast, the square and the cube of this measure and its interaction with $\mathbb{I}(Distance_{i,t} < 0)$ control for non-linear behavior both at the left- and right-hand side of the discontinuity cut-off, and $\widehat{\Delta Yield}$ is the change in the 10-year corporate yield as predicted (instrumented) by monetary policy shocks. We estimate this equation with 2SLS.[11] Table 5 reports results. As from column 1, firms that are off target buy back 0.8 percent more than those already on target, since they want to tilt the EPS to market expectations. In column 2, we control for exogenous variation in the cost of debt due to monetary policy, but the effect is not significant across firms on both sides of the discontinuity. In column 3, we control for the interaction between the dummy variable $\mathbb{I}(Distance_{i,t} < 0)$ and the change in the cost of debt $\widehat{\Delta Yield}_{i,t}$. As a result, the average level of repurchase is now 2 percent higher for those off target. More interesting is the effect of the cost of debt across groups: if the change in the yield does not matter for those already on target, it does matter for those off target. In particular, if the cost of debt falls by 1 percent, repurchases increase by 0.5 percent only for those that need to buy back in the same quarter. In other words, if a firm in the position to launch an accretive repurchase faces an exogenous increase of the cost of debt, then its

[11] The initial stage for the instrumentation of the firm-level cost of debt with monetary policy innovations is reported in Appendix D.

Table 5. Repurchases, Distance from the EPS Forecast, and the Cost of Debt

	***Repurchases* (1)**	***Repurchases* (2)**	***Repurchases* (3)**	***Repurchases* (4)**
$\mathbb{I}(Distance < 0)$	0.008***	0.009***	0.021***	0.016***
	(0.002)	(0.002)	(0.005)	(0.004)
$\Delta \widehat{Yield}$		0.000	0.003	0.002
		(0.088)	(0.002)	(0.002)
$\mathbb{I}(Distance < 0) * \Delta \widehat{Yield}$			–0.005***	–0.005***
			(0.002)	(0.001)
Observations	44,419	30,738	30,738	30,738
Time FE	Yes	Yes	Yes	Yes
Industry FE	No	No	No	Yes
Controls (Polynomial, X)	No	No	No	Yes
Estimator	OLS	OLS	2SLS	2SLS

Note: This table reports 2SLS estimates of Equation (5). Standard errors are in parentheses, double-clustered at firm level and date. In columns 1 to 4, the unit of interest *Repurchases* is the difference between the value of stock purchases and stock issuances from the statement of cash flows. We consider only firms for which such difference is strictly positive, and we normalize it by total asset in $t - 4$. $\mathbb{I}(Distance < 0)$ is an indicator variable that takes value one if the firm is below the EPS forecast before EPS adjustment. $\Delta \widehat{Yield}$ is the exogenous change in the 10-year corporate yield as predicted by monetary policy shocks, i.e., when we instrument $\Delta Yield$ with the monetary innovations *Shock* as from an SVAR. In column 4, we control for a polynomial of the variable *Distance*, i.e., the difference between the EPS forecast and the pre-adjusted EPS of the firm, interacted with the indicator $\mathbb{I}(Distance < 0)$. X controls for return on assets, Q-value of investment, a dummy indicating whether the firm has redistributed dividends in the previous four quarters, a dummy indicating the quintile of asset the firms belong to. *, **, and *** indicate significance at the 90 percent, 95 percent, and 99 percent level, respectively.

action will be limited and its capability to buy back a larger amount of shares will be reduced. Conversely, if the yield on debt falls for a firm about to launch an accretive repurchase, then the lower cost of debt expands the quantity repurchased. Therefore, we conclude that the cost of debt causally affects the size of a repurchase program, and it matters for those managers that need to buy back their own shares to satisfy market expectations. Column 4 shows results when controlling for a polynomial of the variable *Distance* interacted with the indicator variable $\mathbb{I}(Distance < 0)$, and the set of covariates X. Estimates do not differ much.

Real Variables, EPS Distance, and the Cost of Debt. Here we study how variations in the cost of debt due to innovations in monetary policy differently affect capital investment and employment of firms around the discontinuity. To do so, consider the following:

$$\begin{aligned}\bar{Y}_{i,(t+1,t+4)} - \bar{Y}_{i,(t-4,t-1)} &= \alpha + \beta_1 \mathbb{I}(Distance_{i,t} < 0) + \beta_2 \widehat{\Delta Yield}_{i,t} \\ &+ \beta_3 \mathbb{I}(Distance_{i,t} < 0) * \widehat{\Delta Yield}_{i,t} + \beta_4 Distance_{i,t} \\ &+ \beta_5 \mathbb{I}(Distance_{i,t} < 0) * Distance_{i,t} + \beta_6 Distance^2_{i,t} \\ &+ \beta_7 \mathbb{I}(Distance_{i,t} < 0) * Distance^2_{i,t} + \beta_8 Distance^3_{i,t} \\ &+ \beta_9 \mathbb{I}(Distance_{i,t} < 0) * Distance^3_{i,t} + X'_{i,t-1}\gamma + \theta_t + \epsilon_{i,t}, \qquad (6)\end{aligned}$$

where the dependent variable is the difference between the mean value of Y in the next and previous four quarters, with Y being either capital investment or employment. This difference is normalized by the level of assets in $t - 4$.[12] All other variables are the same.

Table 6 reports results. As from column 1, firms that are off target and need to adjust the EPS reduce investments by 0.24 percent. When adding the instrumented change in the cost of debt $\widehat{\Delta Yield}$ and its interaction with the indicator $\mathbb{I}(Distance < 0)$ in column 2, we find that a 1 percent fall in the cost of debt leads to a 0.15 percent increase of investments for "non-repurchasing" firms, i.e., those above the EPS target. On the other hand, the same fall in the cost of debt leads to a smaller increase in investments for "repurchasing" firms, which is equal to $(0.15\% - 0.04\%) = 0.11\%$. As from column 3, firms off target cut employment by 27 percent. When considering the cost of debt in column 4, we find that a 1 percent fall in the cost of debt leads to a 6.6 percent increase of employees for "non-repurchasing" firms. On the other hand, the same change in the cost of debt leads to a smaller increase in employees for "repurchasing" firms, which is equal to $(6.66\% - 1.28\%) = 5.32\%$.

[12]Recall that employment data are available only at yearly frequency. As in Almeida, Fos, and Kronlund (2016), we replace the same value of employment for each quarter of the same year. Then, we proceed by calculating the four-quarter moving average of employment across time, and we normalize it by the value assets in $t - 4$. Within a year, the resulting ratio varies due to quarterly movements in the level of assets. Across years, the ratio varies due to changes of both employment and value of assets.

Table 6. Real Variables, Distance from the EPS Forecast, and the Cost of Debt

	Δ*Inv.* (1)	**Δ*Inv.* (2)**	**Δ*Emp.* (3)**	**Δ*Emp.* (4)**
$\mathbb{I}(Distance < 0)$	–0.0024***	–0.0022***	–0.2719***	–0.3018***
	(0.0004)	(0.0006)	(0.0286)	(0.0416)
$\Delta\widehat{Yield}$		–0.0015***		–0.0651***
		(0.0004)		(0.0215)
$\mathbb{I}(Distance < 0) * \Delta\widehat{Yield}$		0.0004**		0.0128**
		(0.0002)		(0.0057)
Observations	38,427	25,985	35,161	23,587
Time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Controls (Polynomial, X)	Yes	Yes	Yes	Yes
Estimator	OLS	2SLS	OLS	2SLS

Note: This table reports 2SLS estimates of Equation (6). Standard errors are in parentheses, double-clustered at firm level and date. In columns 1 and 2, the unit of interest Δ*Inv.* is the difference between the mean value of capital investments in the next four quarters and in the previous four quarters, normalized by total asset in $t - 4$. In columns 3 and 4, the unit of interest Δ*Emp.* is the difference between the mean level of employment in the next four quarters and in the previous four quarters, normalized by total asset in $t - 4$. $\mathbb{I}(Distance < 0)$ is an indicator variable that takes value one if the firm is below the EPS forecast before EPS adjustment. $\Delta\widehat{Yield}$ is the exogenous change in the 10-year corporate yield as predicted by monetary policy shocks, i.e., when we instrument $\Delta Yield$ with the monetary innovations *Shock* as from an SVAR. For both models, we control for a polynomial of the variable *Distance*, i.e., the difference between the EPS forecast and the pre-adjusted EPS of the firm, interacted with the indicator $\mathbb{I}(Distance < 0)$. X controls for return on assets, Q-value of investment, a dummy indicating whether the firm has redistributed dividends in the previous four quarters, a dummy indicating the quintile of asset the firms belong to. *, **, and *** indicate significance at the 90 percent, 95 percent, and 99 percent level, respectively.

This evidence corroborates results from Table 5: the way firms on and off target manage a liquidity shock is very different. In fact, "repurchasing" firms exploit the lower cost of debt to buy back more and invest and hire less. On the contrary, "non-repurchasing" firms exploit the lower cost of debt to invest and hire more. This proves that any unanticipated monetary policy shock that leads to a downward adjustment in the corporate cost of debt transmits to real variables in different ways, depending on whether the firm is about to repurchase or not.

Real Variables, Repurchases, and the Cost of Debt. Here we investigate the causal impact of share buybacks, changes in the cost of debt, and their interaction on capital investments and employment. The following regression quantifies these three effects:

$$\begin{aligned}\bar{Y}_{i,(t+1,t+4)} - \bar{Y}_{i,(t-4,t-1)} &= \alpha + \beta_1 Repurchases_{i,t} + \beta_2 \Delta Yield_{i,t} \\ &+ \beta_3 Repurchases_{i,t} * \Delta Yield_{i,t} + \beta_4 Distance_{i,t} \\ &+ \beta_5 \mathbb{I}(Distance_{i,t} < 0) * Distance_{i,t} + \beta_6 Distance^2_{i,t} \\ &+ \beta_7 \mathbb{I}(Distance_{i,t} < 0) * Distance^2_{i,t} + \beta_8 Distance^3_{i,t} \\ &+ \beta_9 \mathbb{I}(Distance_{i,t} < 0) * Distance^3_{i,t} + X'_{i,t-1}\gamma + \theta_t + \epsilon_{i,t}. \quad (7)\end{aligned}$$

Under this specification, the parameter β_1 and β_3 will tell us, respectively, the local average treatment effect (LATE) of repurchases and changes in the cost of debt on real variables. The interaction of these two variables will explain whether variation in the cost of debt exacerbates the effect of repurchases on real variables ($\beta_1 + \beta_3$), and whether share repurchases reduce the effect of a change in the cost of debt on real variables ($\beta_2 + \beta_3$). We estimate Equation (7) using 2SLS, where the endogenous variables *Repurchases*, $\Delta Yield$ and their interaction are instrumented, respectively, with the indicator variable $\mathbb{I}(Distance < 0)$, the monetary policy innovation *Shock*, and the interaction of these two instruments. Table 7 shows results. As from column 1, we find that a 1 percent repurchase program leads to a 5.9 percent decline in investments. A 1 percent decrease in the corporate cost of debt works in the opposite direction and leads to an increase in investments by 0.25 percent. However, launching a 1 percent repurchase program contemporaneously to a 1 percent fall of the cost of debt exacerbates the crowding out of repurchase on investments ($\beta_1 + \beta_3 > \beta_1$). At the same time, the same shock attenuates the positive effect of a lower cost of debt on investments ($\beta_2 + \beta_3 < \beta_2$). When in column 2 we repeat our estimation under further controls, we find similar results. As from column 3, a 1 percent repurchase program leads to a decline in the employment stock by 1.2 units per million of assets. On the other hand, a 1 percent decrease in the corporate cost of debt causes an increase in employment by 0.05 units per million of assets. Also in this case, launching a 1 percent repurchase program contemporaneously to

Table 7. Real Variables, Repurchases, and the Cost of Debt

	Δ*Inv.* (1)	**Δ*Inv.* (2)**	**Δ*Emp.* (3)**	**Δ*Emp.* (4)**
Repurchases	–0.0596***	–0.0615***	–1.2591***	–1.4266***
	(0.0151)	(0.0155)	(0.4489)	(0.4614)
Δ*Yield*	–0.0025**	–0.0027**	–0.0497***	–0.0486***
	(0.0012)	(0.0012)	(0.0180)	(0.0179)
Repurchases * Δ*Yield*	0.0255***	0.0301***	–0.2632*	–0.2812**
	(0.0084)	(0.0091)	(0.1431)	(0.1216)
Observations	25,985	25,985	23,587	23,587
Time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Controls (Polynomial, X)	No	Yes	No	Yes
Estimator	2SLS	2SLS	2SLS	2SLS

Note: This table reports 2SLS estimates of Equation (7). Standard errors are in parentheses, double-clustered at firm level and date. In column 1 and 2, the unit of interest Δ*Inv.* is the difference between the mean value of capital investments in the next four quarters and in the previous four quarters, normalized by total asset in $t - 4$. In columns 3 and 4, the unit of interest Δ*Emp.* is the difference between the mean level of employment in the next four quarters and in the previous four quarters, normalized by total asset in $t - 4$. *Repurchases* is the difference between the value of stock purchases and stock issuances from the statement of cash flows. We consider only firms for which such difference is positive, and we normalize it by total asset in $t - 4$. The endogenous variables *Repurchases*, Δ*Yield*, and their interaction are instrumented, respectively, with the indicator variable $\mathbb{I}(Distance < 0)$, the monetary policy innovation *Shock*, and the interaction of the two. We control for a polynomial of the variable *Distance*, i.e., the difference between the EPS forecast and the pre-adjusted EPS of the firm, interacted with the indicator $\mathbb{I}(Distance < 0)$. Control X includes return on assets, Q-value of investment, a dummy indicating whether the firm has redistributed dividends in the previous four quarters, a dummy indicating the quintile of asset the firms belong to. *, **, and *** indicate significance at the 90 percent, 95 percent, and 99 percent level, respectively.

a 1 percent fall of the cost of debt exacerbates the crowding out of repurchase on employment and—at the same time—it attenuates the positive effect of a lower cost of debt on this variable. Adding further controls in column 4 does not change significantly these results.[13]

[13]In Appendix E, we show how results change when using directly monetary policy shocks in Equation (7), instead of the (instrumented) corporate cost of debt. The difference between the results following this alternative identification

In light of this evidence, we conclude that a fall in the cost of debt does exacerbate the crowding-out effect of repurchase on real variables. Moreover, the repurchase channel attenuates the positive effect that a decline in the cost of debt has on investments and employment.

3.3 The Attenuation of Accommodative Monetary Policy on Real Variables Due to Repurchases

By how much do repurchases reduce the transmission of an accommodative monetary policy shock on real variables? For firms around the discontinuity, we compute a back-of-the-envelope calculation by using results from Sections 2.3 and 3.2. From Table 4, column 1, we know that a 1 percent exogenous innovation in the fund rate leads to a 0.61 percent increase of the 10-year yield. As from Table 5, column 4, we know that a 0.61 percent increase in the yield leads to a rise in repurchase by $0.5 \times 0.61 = 0.30\%$. Therefore, by using results from Table 7, we can write the expected change in real variables for a 1 percent accommodative monetary policy shock and its implied repurchase level equal to 0.30 percent as follows:

$$\mathbb{E}[\Delta Inv.|Shock_t = -1\%, Rep = 0.30\%] = -5.9 \times 0.3\% + 0.3 \times 0.61 - 2.5 \times 0.30\% \times 0.61 \approx 0.16$$

$$\mathbb{E}[\Delta Emp.|Shock_t = -1\%, Rep = 0.30\%] = -125.9 \times 0.3\% + 4.9 \times 0.61 - 26.3 \times 0.3\% \times 0.61 \approx 2.53.$$

In words, the overall effect of an expansionary monetary policy is positive and in line with what the basic macroeconomic theory predicts: investments grow by 160,000 dollars every million dollars of assets and employment grows by 2.53 employees every million dollars of assets. Yet, if we mute the repurchase channel, the transmission of

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and those from Table 7 is explained by firm-level heterogeneity in the cost of debt which—overall—amplifies the effect on real variables of the repurchase channel. Therefore, we believe that—by considering the firm-level cost of debt as in Equation (7)—we do a better job in measuring the firm-level effect of an exogenous monetary policy innovation on the managerial incentive to buy back.

monetary policy is going to be stronger. In fact, the expected change in real variables for a 1 percent accommodative monetary policy shock and a repurchase level equal to zero is

$$\mathbb{E}[\Delta Inv.|Shock_t = -1\%, Rep = 0\%] = 0.3 \times 0.61 \approx 0.18$$
$$\mathbb{E}[\Delta Emp.|Shock_t = -1\%, Rep = 0\%] = 4.9 \times 0.61 \approx 2.98,$$

meaning that—if the repurchase channel is muted—a 1 percent accommodative monetary policy shock would increase investments by 180,000 dollars every million dollars of assets and employment by 2.98 units every million dollars of assets. Therefore, in light of this simple back-of-the-envelope calculation, we can say that the repurchase channel attenuates the transmission of a 1 percent accommodative shocks on investments and employment, respectively, by $[1 - (0.16/0.18)] = 11\%$ and $[1 - (2.53/2.98)] = 15\%$.

In light of these results, we conclude that—at least for firms around the discontinuity—share buybacks not only crowd out investments and employment but also represent a channel through which the transmission of an accommodative monetary policy shock is attenuated and the crowding-out effect on real variables exacerbates. This happens because firms that do repurchase exploit the lower cost of debt to finance these non-productive operations. As a consequence, they divert resources from the real economy.

4. Robustness Checks

4.1 Pre-existing Differences across Firms Above and Below the EPS Target

In order to validate our identification strategy, first we need to check whether firms around the discontinuity differ in major characteristics before the repurchase program is launched. This ensures that no other motive leads firms to repurchase their own share, but only the distance from the EPS forecast. Table 8 shows the difference in leverage, size, corporate yield, growth perspective (PE10), and financial constraint (measured following Hadlock and Pierce 2010) between firms below ($[-0.018\$, 0)$) and above the cut-off ($[0, 0.018\$]$). As

Table 8. Pre-repurchase Difference in Firm Characteristics

	Leverage **(1)**	***Size*** **(2)**	***Yield*** **(3)**	***PE*10** **(4)**	***Fin. Constraint*** **(5)**
Difference	–1.360 (2.920)	–0.009 (0.039)	–0.412 (0.513)	–0.866 (1.970)	–0.003 (0.004)

Note: The table reports the difference in characteristics between firms above and below the cut-off. Each difference is evaluated by regressing the firm characteristic on an indicator variable taking value one if the firm is below the cut-off. For each case, we control for time and firm's industry fixed effects. In column 1, the unit of interest *Leverage* is the ratio between the value of total corporate debt and equity. In column 2, the unit of interest *Size* is the logarithm of the total value of assets. In column 3, the unit of interest *Yield* is the yield for a 10-year-maturity corporate bond. In column 4, the unit of interest *PE*10 is the 10-quarter moving average of the price-earning ratio. In column 5, *Fin. Constraint* is a measure of the financial constraint of the firm built after Hadlock and Pierce (2010). Standard errors are in parentheses, clustered at firm level. *, **, and *** indicate significance at the 90 percent, 95 percent, and 99 percent level, respectively.

evident, firms on and off target are very homogeneous in these dimensions.[14]

Second, we need to check that there are no discontinuous differences in employment and investment dynamics for firms around the EPS cut-off before the repurchase takes place. Hence, for firms with $Distance_{i,t}$ in the $[-0.018\$, +0.018\$]$ bracket, we carry out this exercise for the four j quarters preceding the repurchase by running the following regression:

$$\Delta\bar{Y}_{i,(t-1,t-1-j)} = \alpha + \beta\mathbb{I}(Distance_{i,t} < 0) + \theta_t + \epsilon_{i,t}, \qquad (8)$$

where $\Delta\bar{Y}_{i,(t-1,t-1-j)}$ is the change of the dependent variable between $t-1$ and $t-1-j$ (normalized by total asset in $t-4$), with $j = \{1, 2, 3, 4\}$. As from Table 9, there are no systematic pre-existing differences between firms at the left and at the right of the discontinuity in terms of outcome variables. The pre-repurchase

[14]In Appendix D, we show that the EPS forecast is not correlated with monetary policy or the firm-level exogenous variation in the cost of debt, neither in the quarter in which the EPS forecast is released nor in the previous one.

Table 9. Pre-repurchase Trend in Outcome Variables

	Δ*Investment* (1)	**Δ*Employment* (2)**
Changes (t – 2 to t – 1)	–0.000	0.000*
$\mathbb{I}(Distance < 0)$	(0.000)	(0.000)
Changes (t – 3 to t – 1)	–0.001*	0.000
$\mathbb{I}(Distance < 0)$	(0.000)	(0.000)
Changes (t – 4 to t – 1)	–0.001	0.000
$\mathbb{I}(Distance < 0)$	(0.001)	(0.000)
Changes (t – 5 to t – 1)	–0.000	0.000
$\mathbb{I}(Distance < 0)$	(0.003)	(0.000)
Time FE	Yes	Yes
Industry FE	Yes	Yes
Controls (X)	No	No

Note: Standard errors are in parentheses, clustered at firm level. In column 1, the unit of interest Δ*Investment* is the difference between the mean value of capital investments measured in the four quarters before period t – 1 (included) and in the four quarters before period $t - 1 - j$ (included), with $j = \{1,2,3,4\}$. Each difference is normalized by total asset in t – 4. In column 2, the unit of interest Δ*Employment* is the difference between the mean value of employment measured in the four quarters before period t – 1 (included) and in the four quarters before period $t - 1 - j$ (included), with $j = \{1,2,3,4\}$. Each difference is normalized by total asset in t – 4. $\mathbb{I}(Distance < 0)$ is an indicator variable taking value one if the firm is currently below the EPS target. *, **, and *** indicate significance at the 90 percent, 95 percent, and 99 percent level, respectively.

common trend assumption holds. This validates our strategy such that the results of Section 3.2 can be interpreted as causal.

4.2 The Financing of Share Buybacks around the EPS Target

In this section, we check if indeed firms off target use debt to repurchase compared with firms on target. In order to do so, we propose the same accounting equation as in Section 2.2. Columns 1 and 2 of Table 10 show the contribution of debt to repurchases for the sample of firms off target (whose distance from target is in the [–0.018$,0$) bracket) while columns 3 and 4 show results for firms on target (whose distance from target is in the [0$,+0.018$]). For firms off target, every dollar of assets repurchased is financed with

Table 10. Financing Buybacks

	***Repurchases* (1)**	***Repurchases* (2)**	***Repurchases* (3)**	***Repurchases* (4)**
$\Delta Debt$	0.204*	0.185**	0.001	0.008
	(0.122)	(0.089)	(0.001)	(0.028)
Observations	21,261	15,733	20,102	17,175
Off-Target Sample	Yes	Yes	No	No
Time FE	No	No	No	No
Industry FE	No	No	No	No
Controls (Other Sources)	No	Yes	No	Yes

Note: Standard errors are in parentheses, clustered at firm level. In columns 1 to 4, the unit of interest *Repurchases* is the difference between the mean value of stock purchases and stock issuances from the statement of cash flows. We consider only firms for which such difference is positive, and we normalize it by total asset in $t-4$. $\Delta Debt$ is the change in the value of current total debt of the firm, normalized by total asset in $t-4$. When used, the control variables are all main other sources of the budget constraint of the firm: the change in firm money holding plus current net profit, capital expenditure, and the value of the dividends paid. *, **, and *** indicate significance at the 90 percent, 95 percent, and 99 percent level, respectively.

20 cents coming from new debt issuance (column 1); when controlling for other sources of financing and expenditures (column 2), the result does not change. For firms already on target (columns 3 and 4), the contribution of debt is not significant. As we learned from Section 3.2, firms below and above target manage their resources in different ways: the former devote more resources to repurchases rather than investing in new capital and new hires, whereas the latter use their resources for productive purposes. This validates our analysis, confirming that debt is an important source for firms that need to launch an accretive repurchase to bring the EPS on target. Firms already on target do not use debt issuance to finance repurchases, but to fund new investment and employment.[15]

[15]In Appendix F, we use our identification strategy to study if repurchases, the corporate yield, and their interaction can explain changes in corporate debt. In other words, we consider the model of Equation (7), but with $\Delta Debt$ as dependent variable. In this case, we find that repurchases cause an increase in debt issuance when the cost of debt is low. This corroborates the idea that debt is

4.3 EPS Accretion and Monetary Policy

Here we study how much an exogenous monetary policy innovation affects the capability of managers to conduct an accretive repurchase, i.e., a repurchase that is able to increase the EPS. In order to test it, consider the following:

$$\mathbb{I}(Accretion_{i,t} > 0) = \alpha + \beta Shock_t + X'_{i,t-1}\gamma + \theta_t + \epsilon_{i,t} \quad (9)$$

$$Accretion_{i,t} = \alpha + \beta Shock_t + X'_{i,t-1}\gamma + \theta_t + \epsilon_{i,t}, \quad (10)$$

where $\mathbb{I}(Accretion > 0)$ is an indicator variable taking value one if the firm was able to increase the EPS over the quarter through a share repurchase; *Accretion* is the price-normalized difference between the reported EPS at the end of the quarter and the one that would have prevailed without launching a repurchase program. Table 11 shows results. As from column 1, a 1 percent fall in the federal funds rate leads to an increase in the (linear) probability of conducting an accretive repurchase of 21 percent. In column 2 we consider the level of accretion, and we find that a 1 percent fall in the federal funds rate leads to an increase in accretion by 0.2 cents.

5. A Simple Model of EPS Maximization

The identification strategy of Section 3 is entirely based on the evidence that firms that need to adjust their EPS tend to repurchase more, particularly when the cost of debt is low. This section shows that this empirical fact can be reconciled with a simple theoretical framework of EPS maximization.

EPS Adjustment and the Cost of Money. Consider the following definition for the earning-per-share ratio:

$$EPS = \frac{(1-\tau)[y - r^s nP]}{N - n},$$

where y is firm's profit at the net of production and financial costs, τ is the firm-specific taxation rate, P is the current stock price, n is the

important for the funding of repurchase programs—in particular, when the cost of debt is favorable.

Table 11. EPS Accretion and Monetary Policy Shocks

	$\mathbb{I}(\boldsymbol{Accretion} > 0)$ (1)	***Accretion*** (2)
Shock	–0.210*** (0.012)	–0.002*** (0.000)
Observations	44,419	44,419
Time FE	Yes	Yes
Industry FE	Yes	Yes
Controls (X)	Yes	Yes

Note: Standard errors are in parentheses, double-clustered at firm level and date. In column 1, the unit of observation is $\mathbb{I}(Accretion > 0)$, an indicator variable taking value one if the firm was able to boost the EPS through a repurchase program, i.e., if the difference between reported EPS and the EPS that would have prevailed without repurchasing is positive. In column 2, the unit of observation *Accretion* is the difference between reported EPS and the EPS that would have prevailed without repurchasing. *Shock* is an exogenous monetary innovation as from an SVAR (see Appendix A for details). Controls includes return on assets, Q-value of investment, a dummy indicating whether the firm has redistributed dividends in the previous four quarters, a dummy indicating the quintile of asset the firms belong to. *, **, and *** indicate significance at the 90 percent, 95 percent, and 99 percent level, respectively.

number of own shares repurchased, r^s is the return on a three-month government bond, and N is the number of outstanding shares.

Correction upward of the EPS can occur through two channels: (i) through profit management (y),[16] or (ii) through share buybacks (n).[17] However, share repurchases are not always effective in increasing the EPS ratio, i.e., they are not always accretive. In fact, since n appears in both the numerator and denominator, a repurchase

[16]As shown in Burgstahler and Dichev (1997), it is very unlikely for listed firms to report losses. In fact, they would rather adjust their cash flow or reduce operating costs and working capital than report earnings below market expectations. In this regard, see also Degeorge, Patel, and Zeckhauser (1999) and Burgstahler and Eames (2006), who demonstrate that distance from the analysts' EPS or sales forecast triggers managerial strategic behavior on profits in order to immediately please shareholders.

[17]Share buybacks are used not only to tilt the EPS to market expectations (as discussed in Section 3.1) but also to build credibility and reputation on capital markets (see Vermaelen 1981, Grullon and Ikenberry 2000, and Bens et al. 2003).

program is accretive only if the change in the denominator dominates the change in the numerator. In light of this, it is not trivial to say that EPS accretion is more feasible or bigger for a change in the interest rate r^s. In fact, an exogenous change in the value of money changes also managers' incentive to issue new debt, to buy new capital, and to change their leverage position. This endogenous adjustment in the capital structure will ultimately affect production and profits (y). This should be taken into account when considering launching an accretive repurchase program.

For these reasons, we introduce a simple static model to show under which conditions a negative change in the cost of debt allows for accretive repurchases. Following the work of Stein (1996), we imagine a firm characterized by a leverage ratio d, choosing today the level of capital K, debt B, and the quantity n of shares to be repurchased.[18] The firm is a price taker on the equity, bond, and capital markets such that the stock price P, the cost on newly issued debt r^B, and the unitary cost of capital are all observed at the beginning of the period and taken as given. Also, we assume that the firm-specific cost of debt is proportional to the minimum return r^s on a saving account, i.e., $r^B = \kappa r^s$, with $\kappa > 1$. Once the factors of production and the capital structure are chosen, the firm starts production with a final output equal to $f(K) = zK^\alpha$, with $\alpha \in (0, 1)$ and z being the productivity of the firm.

Given this setup, managers who are willing to launch an accretive repurchase face the following problem:

$$\max_{K,B,n} \ \Omega = \frac{(1-\tau)[f(K) - r^B B - r^s nP]}{N-n} - \frac{\theta}{2}[B - dK]^2.$$

In words, they maximize the EPS of the firm (the first element of the objective function Ω), taking into account the quadratic cost that arises due to deviations from the original leverage ratio d (the second element of Ω).[19] Under this formulation, earnings are defined as the after-tax income generated from production once the firm pays the

[18] If $n < 0$, then the firm is a net equity issuer.

[19] Note that, under this formulation, d is the targeted leverage of the firm. Hence, for a level of capital K, the debt issued B should be equal to dk. Deviation from the targeted leverage leads to a quadratic cost with weight θ, a proxy for capital structure flexibility.

interests on debt and reports the forgone earnings if the amount of money spent in the repurchase was instead kept on a saving account. The maximization problem is subject to the firm's budget constraint $K = B - nP$, such that capital is financed through debt at the net of the amount of money allocated to repurchases. Substituting the budget constraint into the objective function reduces the problem by one dimension and gives us the following first-order conditions.

LEMMA 1. *Managers maximize the EPS under quadratic capital adjustment costs if*

(i) $\frac{\partial \Omega}{\partial B} = 0$, *i.e.,* $(1-\tau)[f' - r^B] = \theta(1-d)[B(1-d)+dnP](N-n)$

(ii) $\frac{\partial \Omega}{\partial n} = 0$, *i.e.,* $EPS = (1-\tau)P[f' + r^s] + \theta d[(1-d)B + dnP]P(N-n)$,

where condition (i) states that the net marginal income from an extra unit of debt must be equal to the marginal cost of changing the capital structure through higher bond issuance, while condition (ii) states that the level of repurchase is optimal if the adjusted EPS is equal to the sum of the marginal loss in net income from diversion of resources from production and savings on a safe asset, and the marginal cost of changing the capital structure due to higher buybacks. The solution of the system of equations (i) and (ii) leads to the equilibrium B^*, n^* *and therefore* $K^* = B^* - n^*P$.

In order to understand how changes in the cost of money affect the optimal level B^*, n^* and EPS^*, we perturbate conditions (i) and (ii) of Lemma 1 by a marginal change in the interest rate r^s. This leads to the following.

PROPOSITION 1. *For* θ *small and* N *large, a marginal decrease in the interest rate leads to higher debt issuance* ($\partial B^*/\partial r^s < 0$)*, higher repurchase* ($\partial n^*/\partial r^s < 0$)*, and higher EPS* ($\partial EPS^*/\partial r^s < 0$)*. In other words—for firms with high level of outstanding shares and high flexibility in capital structure—debt issuance, share buybacks, and EPS are all negatively correlated with changes in the cost of money.*

Proof. See Appendix G.1.

Under Proposition 1, we gain two insights. First, launching a repurchase program affects mechanically more the denominator than the numerator of the EPS ratio: for an extra share repurchased, the fall in net income is smaller than the fall in the number of outstanding shares. Second, for a fall in the interest rate, the capital structure of the firm changes in favor of debt despite the quadratic cost of over-leveraging, and managers buy back more.

The theoretical result of Lemma 1 mimics well the empirical evidence of Tables 5 and 11: if a firm has to boost (maximize) the EPS—i.e., if a firm is off target—a fall in the interest rate helps the EPS accretion through a larger repurchase program.

Implications for Capital Expenditure. Analytically, we still do not know what the results of Proposition 1 imply for the derivative $\frac{\partial K^*}{\partial r^s}$. In fact, once perturbing the budget constraint at the equilibrium, we obtain

$$\frac{\partial K^*}{\partial r^s} = \frac{\partial B^*}{\partial r^s} - \frac{\partial n^*}{\partial r^s}P, \tag{11}$$

the sign of which depends heavily on the parametrization of the model.

Under the assumption of θ small and N large and a baseline calibration,[20] we find $\partial K^*/\partial r^s > 0$. In words, for a fall in the interest rate, EPS-maximizing firms increase repurchases at the expenses of capital investment. This theoretical result is in line with what is shown in Table 6: for an exogenous fall in the cost of debt, firms that need to boost (maximize) their EPS in order to meet market expectations invest less in new capital. Conversely, if repurchase behavior was insensitive to changes in the interest rate (i.e., $\partial n^*/\partial r^s = 0$), then firms would exploit the lower interest rate to issue more debt, which will be entirely used to finance new capital[21] (i.e., $\partial K^*/\partial r^s = \partial B^*/\partial r^s < 0$).

[20]Given the mean values of debt-on-asset and 10-year yield (see Table 1), and given knowledge of 10-year average risk-free rate, we set $r^B = 0.052$, $d = 0.23$, $\kappa = 1.3$. Then, we assume $\alpha = 0.5$, $\theta = 1$, $z = 1$, and $N = 1$. Finally, we calibrate P in order to obtain an equilibrium level $n^*/K^* = 0.03$, as observed in the data (see Table 1). See Appendix G.1 and G.2 for details.

[21]We explore this case from a theoretical point of view in Appendix G.2, where we compare the effect of a change in the interest rate r^s for firms that are allowed to repurchase and firms that are not (i.e., firms that maximize the EPS by

6. Conclusion

This paper documents how debt and the cost of debt are key deciding factors for a manager when launching a repurchase program. In particular, we show that if a firm benefits from an exogenous fall in the corporate yield—caused by an accommodative monetary policy shock—and needs to buy back its shares, the amount of shares repurchased from the stock market is going to be larger. This proves that the cost of debt determines the size of repurchase programs and that firms mostly rely on new and low-cost debt to finance this market operation. Moreover, when conducting a repurchase of their shares, the same firms tend to reduce investment and employment since they devote their resources to these programs at the expense of new capital or employees. Thus, we conclude that share buybacks represent a channel through which the transmission of an accommodative monetary shock is attenuated.

The main contribution of the paper is that we are able to measure the causal impact of monetary policy on share buyback programs, to quantify the extent to which the crowding-out effect of repurchases on investment and employment is due to an accommodative monetary policy shock, and, finally, to assess by how much share buybacks reduce the effectiveness of an expansionary monetary policy. This is an empirical challenge that we solve by exploiting a discontinuity in the data triggered by managerial consideration over the EPS index. We use an information shock based on the distance of a firm's EPS from the analysts' forecast to split the sample in firms more prone to buy back their own shares, i.e., those below the analyst EPS forecast, and those that are less prone to buy back, i.e., those above the forecast. Then we show that a negative change in the cost of debt, as explained by an accommodative monetary policy shock, affects only managers below the target and allows them to launch a larger repurchase program and to easily adjust their EPS in order to meet market expectations. Through this instrumentation, we show that such repurchase behavior has a causal and negative impact on investments and employment and that an expansionary

choosing only the optimal level of debt). In the same appendix, we discuss in depth these theoretical results and we link them to the empirical evidence of Section 3.2.

monetary policy exacerbates this effect such that the overall transmission of an accommodative shock on real variables is attenuated. In particular we find that, if the repurchase channel was muted, the transmission of a 1 percent accommodative shock on investments and employment would be, respectively, 11 percent and 15 percent stronger.

Appendix A. An SVAR for Monetary Shocks

We follow Rossi and Zubairy (2011) and Ramey (2016) to extract monetary policy shocks from an SVAR. In particular, for a time-window spanning from 1985:Q1 to 2016:Q4, we consider this model:

$$Z_t = K + \Gamma_1(t) + \Gamma_2(t)d_t + A(L)Z_{t-1} + B(L)u_t^R + \epsilon_t,$$

where $Z_t = [G_t, Y_t, h_t, C_t, I_t, w_t, \pi_t, r_t]$, i.e., a vector containing series for government spending (G_t), real GDP (Y_t), hours worked in the non-farm business sector (h_t), non-durable and service consumption (C_t), gross private investments and durable consumption (I_t), wages in the non-farm business sector (w_t), GDP deflator inflation (π_t), and the three-month rate on government bonds. $\Gamma_1(t)$ and $\Gamma_2(t)$ are both a fourth-degree polynomial time trend, d_t is a dummy variable taking value equal to one for periods after the beginning of the Great Recession (2008:Q1–2016:Q4), and zero otherwise. In this way, not only do we control for a non-linear trend, but we also take into account the structural change that occurred to the economy with the Great Recession. Moreover, with u^R we include also a "narrative" measure of government spending shocks, based on defense news-shocks as from Ramey (2009). $A(L)$ and $B(L)$ are set to be lag polynomials of degree four, consistently with the existing literature on fiscal a monetary policy shocks. All variables, with the exception of the interest rate, are in logs. The monetary shocks are identified using a Cholesky decomposition.

Appendix B. The Financing of Share Buybacks

In Section 2.2, we show that newly issued debt is important for the financing of buyback programs. Here we corroborate this idea

Table B.1. Financing Buybacks

	Repurchases **(1)**	***Repurchases*** **(2)**
$\Delta Debt$	0.35***	0.35***
	(0.08)	(0.08)
$\Delta Money$	–0.09***	–0.09***
	(0.03)	(0.03)
Profits	0.48***	0.48***
	(0.06)	(0.06)
Investments	–0.19***	–0.19***
	(0.06)	(0.06)
Dividends	0.00	0.00
	(0.03)	(0.03)
Observations	144,858	144,858
Time FE	No	Yes
Industry FE	No	Yes
Controls (X)	No	No

Note: Standard errors are in parentheses, clustered at firm level. The unit of observation *Repurchases* is the difference between the value of stock purchases and stock issuances from the statement of cash flows. $\Delta Debt$ is the change in the value of current total debt of the firm. $\Delta Cash$ is the change in firm money holding. *Profits* is the value of firm profit at the net of taxes. *Investments* is equal to capital expenditure. *Dividends* is equal to the value of the dividends paid. All variables are in levels, and expressed in U.S. dollars. The sample is composed of firms that are net repurchasers, i.e., firms for which *Repurchases* > 0. *, **, and *** indicate significance at the 90 percent, 95 percent, and 99 percent level, respectively.

by considering the same specification of Section 2.2, but with variables expressed in levels and both cash holdings and profits on the right-hand side:

$$Repurchases_{i,t} = \beta_1 \Delta Debt_{i,(t,t-1)} + \beta_2 \Delta Money_{i,t} + \beta_3 Profits_{i,t} + \beta_3 Investments_{i,t} + \beta_4 Dividends_{i,t} + \epsilon_{i,t}.$$

Table B.1 reports results when the sample is composed of firms that conduct a positive net repurchase. As from column 1, each dollar spent in repurchases is financed with 35 cents of newly issued debt, 10 cents from a reduction of cash holdings, 48 cents from current profits, and 20 cents from a reduction of investments. The level of dividend payments is not significantly correlated with the level of repurchases. These magnitudes do not change when controlling for time and industry fixed effects (column 2).

Appendix C. Monetary Policy Shocks and EPS Surprise

Here, we check that the probability of being below the EPS forecast is not influenced anyhow by the (contemporaneous or lagged) monetary policy shock and the (contemporaneous or lagged) exogenous change in the firm' cost of debt (as explained by the monetary policy shock itself). In practice, we consider the following specifications for $j = \{0, 1\}$:

$$\mathbb{I}(Distance_{i,t} < 0) = \alpha + \beta Shock_{t-j} + X'_{i,t-1}\gamma + \theta_t + \epsilon_{i,t} \quad \text{(C.1)}$$

$$\mathbb{I}(Distance_{i,t} < 0) = \alpha + \beta \Delta\widehat{Yield}_{i,(t-j,t-j-1)} + X'_{i,t-1}\gamma + \theta_t + \epsilon_{i,t}, \quad \text{(C.2)}$$

where $\mathbb{I}(Distance < 0)$ is the indicator variable that takes value one if the firm is currently below the EPS forecast, *Shock* is the monetary policy innovation out of an SVAR (see Appendix A for details), $\Delta\widehat{Yield}$ is the exogenous change in the 10-year corporate yield as predicted by monetary policy shocks, i.e., we use the variable *Shock* as instrument for the cost of debt. X controls for firm-level characteristics such as return on assets, Q-value of investment, a dummy indicating whether the firm has redistributed dividends in the previous four quarters, a dummy indicating the quintile of asset the firms belong to, θ controls for year fixed effects, and quarter fixed effects separately.

Table C.1 shows results (errors are doubled-clustered at firm level and date). From columns 1 and 2 we find that the monetary policy shock has no contemporaneous or lagged effect on the probability for the firm to be off target. From columns 3 and 4, we find the same when considering the exogenous change in the cost of debt (as explained by a monetary policy shock). These results validate our identification strategy: the two instruments used in the first-stage analysis of Section 3.2 are not significantly correlated.

Table C.1. Monetary Policy Shocks and EPS Surprise

	$\mathbb{I}(Distance < 0)$ (1)	$\mathbb{I}(Distance < 0)$ (2)	$\mathbb{I}(Distance < 0)$ (3)	$\mathbb{I}(Distance < 0)$ (4)
$Shock_t$	0.003 (0.005)			
$Shock_{t-1}$		−0.004 (0.004)		
$\Delta\widehat{Yield}_{(t,t-1)}$			0.483 (0.376)	
$\Delta\widehat{Yield}_{(t-1,t-2)}$				0.586 (0.394)
Observations	44,419	42,214	30,738	29,401
Time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Controls (X)	Yes	Yes	Yes	Yes
Estimator	OLS	OLS	2SLS	2SLS

Note: Standard errors are in parentheses, double-clustered at firm level and date. The unit of observation $\mathbb{I}(Distance < 0)$ is an indicator variable that takes value one if the firm is currently below the EPS forecast. *Shock* is an exogenous monetary innovation as from an SVAR (see Appendix A for details). $\Delta\widehat{Yield}$ is the exogenous change in the 10-year corporate yield as predicted by monetary policy shocks, i.e., when we use *Shock* to instrument the firm-level cost of debt. Control X includes return on assets, Q-value of investment, a dummy indicating whether the firm has redistributed dividends in the previous four quarters, a dummy indicating the quintile of asset the firms belong to. *, **, and *** indicate significance at the 90 percent, 95 percent, and 99 percent level, respectively.

Appendix D. Share Buybacks, Monetary Policy, and the Cost of Debt: The First Stage

As explained in Section 3.2, we instrument the cost of debt $\Delta Yield$ with the variable *Shock*, i.e., the monetary policy innovations extracted from an SVAR. As in any two-stage least-squares regression, this implies that the endogenous variable will be regressed over all instruments, exogenous variables, and controls. In other words the initial stage is

$$\begin{aligned}\Delta Yield_{i,t} &= \zeta + \mu_1\mathbb{I}(Distance_{i,t} < 0) + \mu_2 Shock_t \\ &\quad + \mu_3\mathbb{I}(Distance_{i,t} < 0) * Shock_t + \mu_4 Distance_{i,t} \\ &\quad + \mu_5\mathbb{I}(Distance_{i,t} < 0) * Distance_{i,t} + \mu_6 Distance^2_{i,t} \\ &\quad + \mu_7\mathbb{I}(Distance_{i,t} < 0) * Distance^2_{i,t} + \mu_8 Distance^3_{i,t} \\ &\quad + \mu_9\mathbb{I}(Distance_{i,t} < 0) * Distance^3_{i,t} + X'_{i,t-1}\xi + \theta_t + \eta_{i,t},\end{aligned}$$

Table D.1. First Stage

	Δ *Yield* (1)	**Δ *Yield* (2)**	**Δ *Yield* (3)**	**Δ *Yield* (4)**
$\mathbb{I}(Distance < 0)$	–0.000	–0.000	–0.000	–0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Shock		0.522**	0.528**	0.528**
		(0.254)	(0.250)	(0.252)
$\mathbb{I}(Distance < 0) * Shock$			–0.108	–0.098
			(0.103)	(0.115)
Observations	44,419	30,738	30,738	30,738
Time FE	Yes	Yes	Yes	Yes
Industry FE	No	No	No	Yes
Controls (Polynomial, X)	No	No	No	Yes

Note: Standard errors are in parentheses, double-clustered at firm level and date. In columns 1 to 4, the unit of interest is Δ *Yield*, the change in the firm-level 10-year corporate yield. $\mathbb{I}(Distance < 0)$ is an indicator variable that takes value one if the firm is below the EPS forecast before EPS adjustment. *Shock* is an exogenous monetary innovation as from an SVAR (see Appendix A). In column 4, we control for a polynomial of the variable *Distance*, i.e., the difference between the EPS forecast and the pre-adjusted EPS of the firm, interacted with the indicator $\mathbb{I}(Distance < 0)$. X controls for return on assets, Q-value of investment, a dummy indicating whether the firm has redistributed dividends in the previous four quarters, a dummy indicating the quintile of asset the firms belong to. *, **, and *** indicate significance at the 90 percent, 95 percent, and 99 percent level, respectively.

where $\Delta Yield_{i,t}$ is the change in the 10-year corporate yield, $\mathbb{I}(Distance_{i,t} < 0)$ takes value one when the firm i is off target with respect to the analysts' EPS forecast, *Shock* is the monetary policy innovation as from an SVAR (see Appendix A), $Distance_{i,t}$ is the effective distance from the EPS forecast, the square and the cube of this measure and its interaction with $\mathbb{I}(Distance_{i,t} < 0)$ control for non-linear behavior both at the left- and right-hand side of the discontinuity cut-off. Table D.1 shows results (errors are doubled-clustered at firm level and date).

The fact that the coefficient on the indicator variable $\mathbb{I}(Distance < 0)$ is always insignificant proves that there is no difference in terms of cost of debt for firms around the EPS cut-off. Also the coefficient on the interaction term between the indicator variable and the monetary policy shock confirms that the information shock (the variable $\mathbb{I}(Distance < 0)$) does not have any impact on the cost of debt for both firms above and below the discontinuity. On the other hand, the monetary shock has a significant effect on the cost of debt across both groups. Notice finally that the effect of the monetary policy shock on the change in the cost of debt, estimated here for the sample in the $[-0.018, +0.018]$ bracket, is comparable in magnitude to what is found in Section 2.4.

Appendix E. Challenging our Identification Strategy

Here, we want to challenge what was done in Section 3 in order to understand to what extent our identification strategy is rigorous. In particular, we want to check whether using directly monetary policy shocks (*Shock*) instead of the changes in the cost of debt ($\Delta Yield$) in Equation (7) leads to similar results to those from Table 7 of Section 3.2.

First Stage: EPS Distance from Forecast and Monetary Policy Shocks. Here we study how monetary policy innovations affect repurchasing behavior of firms around the discontinuity. Similarly to what we do in Section 3.2, we consider only firms with $Distance_{i,t}$ in the $[-0.018\$, +0.018\$]$ bracket, and estimate the following first-stage regression:

$$\begin{aligned} Repurchases_{i,t} &= \alpha_0 + \beta_1 \mathbb{I}(Distance_{i,t} < 0) + \beta_2 Shock_t \\ &+ \beta_3 \mathbb{I}(Distance_{i,t} < 0) * Shock_t + \beta_4 Distance_{i,t} \\ &+ \beta_5 \mathbb{I}(Distance_{i,t} < 0) * Distance_{i,t} + \beta_6 Distance^2_{i,t} \\ &+ \beta_7 \mathbb{I}(Distance_{i,t} < 0) * Distance^2_{i,t} + \beta_8 Distance^3_{i,t} \\ &+ \beta_9 \mathbb{I}(Distance_{i,t} < 0) * Distance^3_{i,t} + X'_{i,t}\gamma + \theta_t + \epsilon_{i,t}, \end{aligned}$$

where $Repurchases_{i,t}$ is the level of net repurchase normalized by the level of assets in $t-4$; $\mathbb{I}(Distance_{i,t} < 0)$ takes value one when the firm i is off target with respect to the analysts' EPS forecast; *Shock* is the monetary policy innovation as from an SVAR (see Appendix A); $Distance_{i,t}$ is the effective distance from the EPS forecast, and the square and the cube of this measure and its interaction with $\mathbb{I}(Distance_{i,t} < 0)$ control for non-linear behavior both at the left- and right-hand side of the discontinuity cut-off. $X_{i,t-1}$

Table E.1. EPS Surprise as Unique IV

	***Repurchases* (1)**	***Repurchases* (2)**	***Repurchases* (3)**	***Repurchases* (4)**	***Repurchases* (5)**
$\mathbb{I}(Distance < 0)$	0.008***	0.009***	0.013***		
	(0.002)	(0.002)	(0.004)		
Shock		–0.001	–0.001		
		(0.002)	(0.001)		
$\mathbb{I}(Distance < 0)$ * *Shock*			–0.004***		
			(0.001)		
Repurchases				–0.047***	–1.276**
				(0.014)	(0.541)
Shock				–0.002***	–0.031**
				(0.000)	(0.015)
Repurchases * *Shock*				0.017***	0.158*
				(0.006)	(0.095)
Observations	44,419	44,419	39,778	38,427	35,161
Time FE	Yes	Yes	Yes	Yes	Yes
Industry FE	No	No	Yes	Yes	Yes
Controls (Polynomial, X)	No	No	Yes	Yes	Yes
First Stage	Yes	Yes	Yes	No	No
Second Stage	No	No	No	Yes	Yes

Note: Standard errors are in parentheses, double-clustered at firm level and date. In columns 1 to 3, the unit of observation *Repurchases* is the difference between the value of stock purchases and stock issuances from the statement of cash flows. We consider only firms for which such difference is positive, and we normalize it by total asset in $t - 4$. $\mathbb{I}(Distance < 0)$ is an indicator variable that takes value one if the firm is currently below the EPS forecast. *Shock* is an exogenous monetary innovation as from an SVAR (see Appendix A for details). In column 4, the unit of observation $\Delta Inv.$ is the difference between the mean value of capital investments in the next four quarters and in the previous four quarters, normalized by total asset in $t - 4$. In column 5, the unit of interest $\Delta Emp.$ is the difference between the mean level of employment in the next four quarters and in the previous four quarters, normalized by total asset in $t - 4$. Column 3 is the first-stage regression where the endogenous variable *Repurchases* is instrumented with $\mathbb{I}(Distance < 0)$, *Shock*, and their interaction. Columns 4 and 5 report the second-stage regression when the dependent variable is, respectively, the change in investments and employment. We control for a polynomial of the variable *Distance*, i.e., the difference between the EPS forecast and the pre-adjusted EPS of the firm, interacted with the indicator $\mathbb{I}(Distance < 0)$. X controls for return on assets, Q-value of investment, a dummy indicating whether the firm has redistributed dividends in the previous four quarters, a dummy indicating the quintile of asset the firms belong to. *, **, and *** indicate significance at the 90 percent, 95 percent, and 99 percent level, respectively.

controls for firm-level characteristics such as Q-value of investment, return (profit) on assets, a dummy indicating whether the firm has redistributed dividends in the previous four quarters, and a dummy indicating the quintile of asset to which the firms belong.

Table E.1 shows results (errors are doubled-clustered at firm level and time). Firms off target repurchase 1 percent more (column 1). When we control for the monetary policy shock, we find no significant impact on the size of the repurchase program (column 2). When we control for the interaction term $\mathbb{I}(Distance_{i,t} < 0) * Shock_t$ and further controls, we find a negative and significant impact of monetary policy among firms off target. In other words, if a firm needs to buy back to adjust the EPS in the same quarter in which a negative shock realizes, then the firm will be able to repurchase more. How much more? For a 1 percent negative innovation on the federal funds rate, firms off target buy back 0.4 percent more. Is this result comparable with the one from Table 5? There we found that 1 percent decrease in the corporate cost of debt among firms off target leads to an increase of repurchases by 0.5 percent. The difference is explained by heterogeneity in the firm-level cost of debt.

Second Stage: Repurchases, Monetary Shocks, and Real Variables. Here we complete our analysis by investigating the impact of share buybacks, monetary shocks, and their interaction on capital investments and employment. The following regression quantifies this effect:

$$\begin{aligned}\bar{Y}_{i,(t+1,t+4)} - \bar{Y}_{i,(t-4,t-1)} &= \alpha_1 + \xi_1 Repurchases_{i,t} + \xi_2 Shock \\ &+ \xi_3 Repurchases_{i,t} * Shock_t + \xi_4 Distance_{i,t} \\ &+ \xi_5 \mathbb{I}(Distance_{i,t} < 0) * Distance_{i,t} + \xi_6 Distance^2_{i,t} \\ &+ \xi_7 \mathbb{I}(Distance_{i,t} < 0) * Distance^2_{i,t} + \xi_8 Distance^3_{i,t} \\ &+ \xi_9 \mathbb{I}(Distance_{i,t} < 0) * Distance^3_{i,t} + X'_{i,t-1}\omega + \theta_t + \epsilon_{i,t},\end{aligned}$$

where the dependent variable is the difference between the mean value of Y in the next four quarters and in the previous four quarters, with Y being either capital investments or employment. All variables are normalized by the level of assets in $t-4$.

Columns 4 and 5 of Table E.1 report two-stage least-squares estimates when the variable $Repurchases$ and $Repurchases * Shock$ are instrumented, respectively, with the variable $\mathbb{I}(Distance < 0)$ and $\mathbb{I}(Distance < 0) * Shock$. Errors are doubled-clustered at firm level and date. From this estimation we find that the crowding-out effect of 1 percent increase in repurchase on investment is 5 percent, while on employment it is 127 percent. When looking at the direct effect of the monetary policy shock, we find that a 1 percent accommodative shock leads to 0.2 percent (3.1 percent) increase in investments (employment). When looking at the interaction term, we find that conducting a 1 percent repurchase in coincidence of a 1 percent accommodative shock leads to 1.7 percent (15.8 percent) decrease in investments (employment) such that the crowding-out effect of repurchases on investments (employment) exacerbates. With respect to the results of Table 7 of Section 3.2, this different identifying equation gives slightly smaller coefficients. The difference is due to the fact that—here—we are not taking into account firm-level heterogeneity in the cost of debt. Since there is heterogeneous adjustment of the corporate yield across firms, not considering this dimension will under-estimate the effects of monetary policy and its interaction with repurchases.

Appendix F. Debt Issuance, Repurchases, and the Cost of Debt

From Section 4.2, we know that firms off target issue more debt to finance the required repurchases to tilt the EPS to market expectations. Here we move a step forward and study if repurchases do cause an increase in debt. For this, we consider again Equation (7), but with the change in debt ($\Delta Debt$) as dependent variable:

$$\begin{aligned}\Delta Debt_{i,t} &= \alpha + \beta_1 Repurchases_{i,t} + \beta_2 \Delta Yield_{i,t} \\ &+ \beta_3 Repurchases_{i,t} * \Delta Yield_{i,t} + \beta_4 Distance_{i,t} \\ &+ \beta_5 \mathbb{I}(Distance_{i,t} < 0) * Distance_{i,t} + \beta_6 Distance^2_{i,t} \\ &+ \beta_7 \mathbb{I}(Distance_{i,t} < 0) * Distance^2_{i,t} + \beta_8 Distance^3_{i,t} \\ &+ \beta_9 \mathbb{I}(Distance_{i,t} < 0) * Distance^3_{i,t} + X'_{i,t-1}\gamma + \theta_t + \epsilon_{i,t}.\end{aligned} \tag{F.1}$$

Table F.1 reports results of 2SLS estimates when the endogenous variables $Repurchases$, $\Delta Yield$ and $Repurchases * \Delta Yield$ are instrumented, respectively, with $\mathbb{I}(Distance < 0)$, $Shock$ and $\mathbb{I}(Distance < 0) * Shock$. Errors are doubled-clustered at firm level and date.

Despite a positive estimate, there is no significant evidence that repurchases cause per se a direct increase in debt. Yet, for an exogenous decline in the cost of debt, an increase of repurchases does cause

Table F.1. Debt, Repurchases, and the Cost of Debt

	Δ*Debt* (1)	**Δ*Debt* (2)**
Repurchases	0.0183	0.0183
	(0.0114)	(0.0114)
Δ *Yield*	–0.0061**	–0.0059**
	(0.0029)	(0.0028)
Repurchases * Δ *Yield*	–0.0066**	–0.0054*
	(0.0031)	(0.0029)
Observations	28,560	28,560
Time FE	Yes	Yes
Industry FE	Yes	Yes
Controls (Polynomial, X)	No	Yes

Note: This table reports 2SLS estimates of Equation (F.1). Standard errors are in parentheses, double-clustered at firm level and date. The unit of interest Δ*Debt* is the change in debt, normalized by total asset in $t - 4$. *Repurchases* is the difference between the value of stock purchases and stock issuances from the statement of cash flows. We consider only firms for which each difference is positive, and we normalize it by total asset in $t - 4$. The endogenous variables *Repurchases*, Δ *Yield*, and their interaction are instrumented, respectively, with the indicator variable $\mathbb{I}(Distance < 0)$, the monetary policy innovation *Shock*, and the interaction of the two. We control for a polynomial of the variable *Distance*, i.e., the difference between the EPS forecast and the pre-adjusted EPS of the firm, interacted with the indicator $\mathbb{I}(Distance < 0)$. Control X includes return on assets, Q-value of investment, dummy indicating whether the firm has redistributed dividends in the previous four quarters, a dummy indicating the quintile of asset the firms belong to. *, **, and *** indicate significance at the 90 percent, 95 percent, and 99 percent level, respectively.

a significant increase in debt issuance. This evidence corroborates the idea that the cost of debt is strategic for repurchase behavior: when the cost of debt is low, repurchases leads to an increase of debt issuance. Such result is line with Ma (2019), who shows that the relative change in the price of equity with respect to the cost debt is important to rationalize corporate decisions over capital structure and repurchase behavior. Almeida, Fos, and Kronlund (2016) and Wang, Yin, and Yu (2021) do not take into account how variations in the cost of debt interact and affect decisions over repurchases and debt issuance. For this reason, they put more emphasis on the role of internal resources for the financing of share buybacks.

Appendix G. Theoretical Model and Mapping with the Empirical Strategy

G.1 Proof of Proposition 1

Assume for simplicity that the tax rate is zero (i.e., $\tau = 0$). Then, consider the system of equation pinned down by condition (i) and (ii) of Proposition 1 and evaluate it at the equilibrium:

$$\begin{cases} [f'(B^* - n^*P) - r^B] = \theta(1-d)[B^*(1-d) + dn^*P](N - n^*) \\ EPS(B^*, n^*) = P[f' + r^s] + \theta d[(1-d)B^* + dn^*P]P(N - n^*). \end{cases}$$

Perturbate the latter for a small change in the interest rate r^s. Then we obtain the following:

$$\begin{cases} a\frac{\partial B^*}{\partial r^s} + b\frac{\partial n^*}{\partial r^s} = \kappa \\ c\frac{\partial B^*}{\partial r^s} + d\frac{\partial n^*}{\partial r^s} = \frac{\kappa B^* + NP}{N - n^*}, \end{cases} \tag{G.1}$$

where

$$\begin{aligned} a &= [f'' - \theta(1-d)^2(N - n^*)] \\ b &= \theta(1-d)[B^*(1-d) - dP(N - 2n^*)] - Pf'' \\ c &= -\frac{Pf''}{N - n^*} - \theta dP(1-d)(N - n^*) \\ d &= f''P^2 - \theta dP[dP(N - 2n^*) - (1-d)B^*]. \end{aligned}$$

Then, by using Cramer's rule, we can find the solution of system (G.1):

$$\begin{aligned} \frac{\partial B^*}{\partial r^s} &= \frac{\kappa d - b\frac{\kappa B^* + NP}{N - n^*}}{ad - cb} \\ \frac{\partial n^*}{\partial r^s} &= \frac{a\frac{\kappa B^* + NP}{N - n^*} - \kappa c}{ad - cb}. \end{aligned}$$

To understand the sign of $\frac{\partial B^*}{\partial r^s}$ and $\frac{\partial n^*}{\partial r^s}$, analyze first the sign of the denominator. For simplicity, we consider the case in which $\theta = 0$. Therefore we can write

$$ad - cb = \frac{(f'')^2P^2[N - n^* - 1]}{N - n^*}.$$

Assuming concavity of the production function $\alpha \in (0,1)$, $N - n^* > 1$ and θ small is sufficient for $ad - cb$ to be positive. Under these normative assumptions, which, respectively, imply decreasing returns to capital, an amount of outstanding shares bigger than $1 + n^*$, and low cost in leverage change, we can write

$$\kappa d - b\frac{\kappa B^* + NP}{N - n^*} < 0$$

and

$$a\frac{\kappa B^* + NP}{N - n^*} - \kappa c < 0.$$

Therefore, under these normative assumptions, we conclude that

$$\frac{\partial B^*}{\partial r^s} < 0 \tag{G.2}$$

$$\frac{\partial n^*}{\partial r^s} < 0. \tag{G.3}$$

In light of these results, we can take a first-order Taylor expansion around the equilibrium EPS, and study how the latter changes for a small variation of the interest rate Δr^s:

$$\Delta EPS^* = [f' - \kappa^B B^*]\Delta B^* - P[f' + r^s]\Delta n^* - [\kappa B^* + Pn^*]\Delta r^s + EPS^*\Delta n^*.$$

Under the simplifying assumption of $\theta = 0$, and by making use of condition (i) and (ii) of Proposition 1, we can write

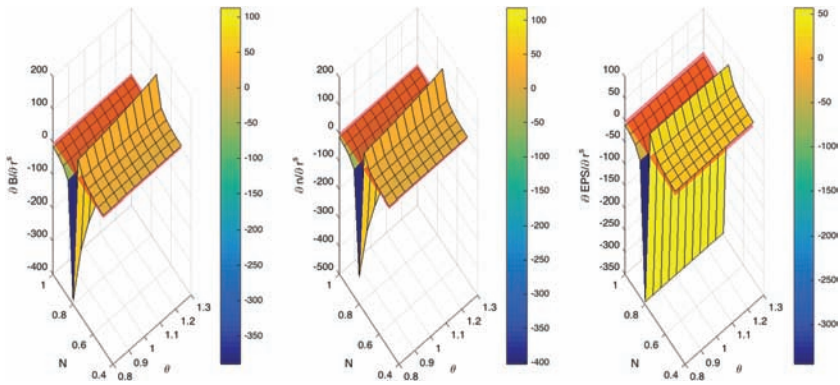
$$\Delta EPS^* = -[\kappa B^* + Pn^*]\Delta r^s,$$

which is negative for a positive increase in the interest rate r^s. Hence, we can approximate this result as

$$\frac{\partial EPS^*}{\partial r^s} = -[\kappa B^* + Pn^*] < 0. \tag{G.4}$$

Yet, these results are not general since they are based on the assumption that $\theta = 0$, which requires $\alpha \in (0,1)$ and N large for the derivatives of Equations (G.2), (G.3), and (G.4) to be negative. Conversely, for high level of θ, α and a small level of N, the sign of

Figure G.1. The Role of θ and N for the Sign of $\frac{\partial B^*}{\partial r^s}$, $\frac{\partial n^*}{\partial r^s}$, and $\frac{\partial EPS^*}{\partial r^s}$

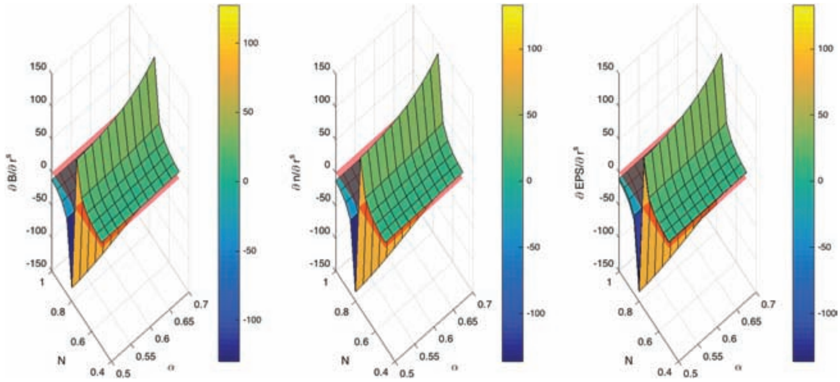


Note: This figure plots the derivative $\frac{\partial B^*}{\partial r^s}$, $\frac{\partial n^*}{\partial r^s}$, and $\frac{\partial EPS^*}{\partial r^s}$ on the (N, θ)-space.

the derivative could potentially change. Here we check this fact by studying how $\frac{\partial B^*}{\partial r^s}$, $\frac{\partial n^*}{\partial r^s}$, and $\frac{\partial EPS^*}{\partial r^s}$ behave in the parameter space of α, θ, and N. First, we numerically solve the model. The initial parameterization is $r^B = 0.052$, as the mean yield on a 10-year corporate bond (see Table 1), $r^s = 0.04$ as the mean 10-year Treasury bill observed in the 1985–2016 period (which implies $\kappa = 1.3$), $d = 0.23$ as the observed mean leverage, $\theta = 1$, $z = 1$, $N = 1$, and $\alpha = 0.50$. Then, we compute a grid search for P in order to obtain an equilibrium level n^*/K^* close to the ratio of repurchase on assets observed on average in the data (and equal to 0.03). The calibrated P is equal to 1.195, which implies a 10-year return on equity equal to 19 percent. Under this set of parameters the equilibrium levels of the endogenous variables are $EPS^* = 0.88$, $n^* = 0.023$, $B^* = 0.85$, $K^* = 0.82$. Hence, we evaluate Equations (G.2), (G.3) and (G.4) and study how each derivative behaves for values of θ, α, and N around their initial (pre-set) levels.

Figure G.1 plots the sign of each derivative in the (θ, N)-space. As shown, the sign of each derivative flips from negative to positive for low levels of N. In fact, if the number of outstanding share is above (below) a certain threshold, any increase in the interest rate will decrease (increase) also debt, the level of repurchase, and the

Figure G.2. The Role of α and N for the Sign of $\frac{\partial B^*}{\partial r^s}$, $\frac{\partial n^*}{\partial r^s}$, and $\frac{\partial EPS^*}{\partial r^s}$



Note: This figure plots the derivative $\frac{\partial B^*}{\partial r^s}$, $\frac{\partial n^*}{\partial r^s}$, and $\frac{\partial EPS^*}{\partial r^s}$ on the (N, α)-space.

EPS. Moreover, each derivative is an increasing function of θ. For example, if we consider the set of parameters for which the derivative is negative, we find that the higher is the cost of leverage change, the less negative is each derivative.[22] In other words, the optimal levels B^*, n^*, and EPS^* become less sensitive to variation in the interest rate r^s if the cost of changing the capital structure is too high.

In Figure G.2, we study the behavior of each derivative in the (α, N)-space and we reach similar conclusions. The derivative is a positive function of the parameter α,[23] and there is a portion of the parameter space for which the sign of each derivative flips from negative to positive. This happens for low levels of N.

In light of this argument, we conclude that the results of Proposition 1 hold true for firms that can adjust easily their capital structure, that have a large number of outstanding shares, and that exhibit decreasing returns to scale. Moreover, assuming a high N, a

[22]In the portion of parameter space where the derivative is negative, the limit of each derivative is zero for $\theta \to \infty$.

[23]For example, in the portion of parameter space where the derivative is negative, the limit of each derivative is zero for $\alpha \to \infty$.

relatively small θ and $\alpha \in (0, 1)$ is realistic, since this parameterization grants the normative negative relationship between the interest rate and the level of debt.

G.2 Implications for Capital Expenditure: Theory vs. Empirical Results

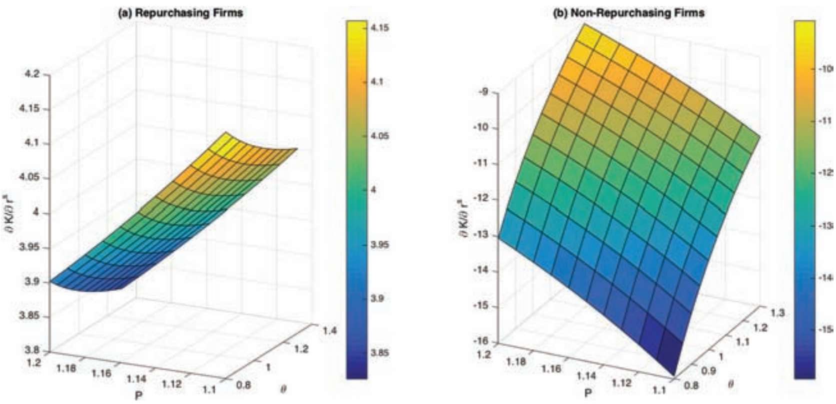
Since $K^* = B^* - n^*P$, we can immediately write

$$\frac{\partial K^*}{\partial r^s} = \frac{\partial B^*}{\partial r^s} - \frac{\partial n^*}{\partial r^s}P, \tag{G.5}$$

which can be either positive or negative depending on the value of $\frac{\partial B^*}{\partial r^s}$ and $\frac{\partial n^*}{\partial r^s}P$ at the equilibrium. For example—for a negative change in the interest rate r^s—if the extra expenditure in share buybacks $\frac{\partial n^*}{\partial r^s}P$ is higher (lower) than the the amount of money raised through debt issuance $\frac{\partial B^*}{\partial r^s}$, the level of capital K^* will decrease (increase). Overall, the sign of the derivative heavily depends on initial parameterization and equilibrium levels. Under the current parameterization and initial equilibrium, we find $\frac{\partial K^*}{\partial r^s} > 0$, i.e., for a decrease in the interest rate, debt alone cannot finance the optimal level of repurchase such that capital expenditure must be cut.

As we can understand from Equation (G.5), if N is large and $\alpha \in (0, 1)$, the value of $\frac{\partial K^*}{\partial r^s}$ evaluated at the equilibrium depends mostly on the stock price and the capability of the firm to adjust its capital structure. Therefore, here we study how the derivative behaves for changes in θ and P. As shown in Figure G.3(A), the derivative is bigger for low levels of P and θ. In words, for a common fall in the interest rate r^s, firms facing a relatively lower stock price and lower capital adjustment cost choose a higher optimal level of repurchase. By doing so, the same firms can increase the EPS by more. However, such increase in share repurchase is also more than proportional to the increase in debt. Therefore, in order for the firms' budget constraint to hold, the equilibrium level of capital must decrease relatively more for these firms. On the other hand, if the stock price and cost of changing capital structure are both too high, there is little the firm can do to increase the EPS, since it cannot easily change the level of debt and the cost of adjusting the EPS through repurchase is already too big. As a result, the effect

Figure G.3. The Sign of $\frac{\partial K^*}{\partial r^s}$: Repurchasing vs. Non-repurchasing Firms



Note: This figure plots the derivative $\frac{\partial K^*}{\partial r^s}$ on the (P, θ)-space for two types of firms. In Figure G.3(A), the firm can use repurchases to maximize the EPS. In Figure G.3(B), the firm is not allowed to use repurchases to maximize the EPS.

on the optimal level of capital will be smaller for the same change in r^s.

How does the derivative $\frac{\partial K^*}{\partial r^s}$ change if we mute the repurchase channel? Say that the economy is split into two group of firms. The first group is the one described so far: it is composed of firms that maximize the EPS by choosing the optimal level B^* and n^*. On the other hand, the second group of firms is not allowed to repurchase and therefore it maximizes the EPS by choosing B^* only. Under this assumption, the EPS maximization problem introduced in Section 5 becomes a simple profit-maximization problem for these (non-repurchasing) firms.

For comparability between the two groups, the optimal level n^* for the repurchasing firms is assumed as an exogenous parameter ($\bar{n} = n^*$) for the group of non-repurchasing firms. Hence, $\bar{n}P$ is a sunk cost for non-repurchasing firms. All other parameters are in common such that the equilibrium level EPS^* and B^* will be identical for both types of firms. In light of this, we can study how the derivative of K^* with respect to the interest rate r^s differs between the two groups and for different parameterization of θ and P.

Figure G.3(B) shows results for the non-repurchasing group. Differently from repurchasing firms, the derivative $\frac{\partial K^*}{\partial r^s}$ is strongly negative for this group. In other words, these firms exploit the lower interest rate to issue debt which is entirely used to finance capital investment. A higher level of capital allows the firm to increase profits and—consequently—the EPS. This effect is stronger for lower level of θ and P, when the non-repurchasing firm can easily adjust the capital structure and the sunk cost $P\bar{n}$ is small.

These results map well to what found in our empirical analysis. As shown in the right-hand side of Figure 1 of Section 3.1, only firms below and very close to the EPS forecast (left-hand side of the discontinuity) have the incentive to buy back since this maneuver allows to boost (maximize) the EPS and to put it on target. As the empirical evidence of Section 3.2 suggests—and consistently with the predictions of the model—the level of repurchase is very sensitive to variation in the cost debt only for firms off target: a lower interest rate incentivizes them to launch a bigger buyback program since this will allow them to boost the EPS by more and to out-beat market expectations. As also shown in Section 3.2—and consistently with the theoretical framework of this section—the same firms divert more resources towards the repurchase program at the expenses of capital investment, which declines.

Conversely, firms on target (right-hand side of the discontinuity) have no incentive to buy back since their EPS is already at the optimal level. Hence, it is plausible to assume—as we do in this theoretical section—that they are operating just under profit maximization. Consequently, they exploit the same lower interest for purposes different from share buybacks: they issue debt to finance capital expenditure.

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