Monetary Easing, Leveraged Payouts and Lack of Investment*

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Abstract

This paper studies a model in which a low monetary policy rate lowers the cost of capital for entrepreneurs, potentially spurring productive investment. Low interest rates, however, also induce entrepreneurs to lever up so as to increase payouts to equity. Whereas such leveraged payouts privately benefit entrepreneurs, they come at the social cost of reducing their incentives thereby lowering productivity and discouraging investment. If leverage is unregulated (for example, due to the presence of a shadow-banking system), then the optimal monetary policy seeks to contain such socially costly leveraged payouts by stimulating investment in response to adverse shocks only up to a level below the first-best. The optimal monetary policy may even consist of "leaning against the wind," *i.e.*, not stimulating the economy at all, in order to fully contain leveraged payouts and maintain productive efficiency. We provide preliminary evidence consistent with the model's implications.

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Introduction

The Federal Reserve has kept its policy rates at low levels following the 2008 global financial crisis. Since then, the financial structure of corporations in the United States (US) has experienced three remarkable evolutions.[1]

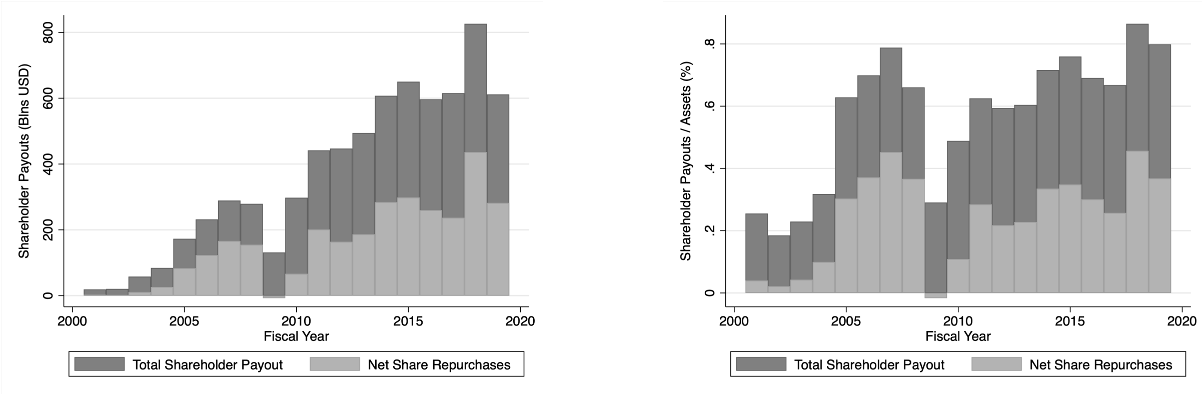
First, corporate leverage has significantly risen. Aggregate corporate debt to GDP has reached historically high levels, exceeding in particular those prevailing just before the global financial crisis. The share of corporate credit originated by non-banks—the so-called "shadow-banking" system—is also at an all-time high.

Second, this high leverage has been coincident with significantly large positive shareholder payouts, or in other words, negative net equity issuances, partly due to higher share buybacks (repurchases) than ever in the past.[2] Indeed, it was only in the past two decades that the aggregate importance of share repurchases has increased, especially so in the past decade. As Figure 1 shows, both net share repurchases and total shareholder payouts (the sum of net share repurchases and dividend payouts) have increased steadily since 2001 (in absolute terms as well as relative to assets), reaching a peak of more than $800 billion in 2018. One favored explanation has been that this recent buyback and payout rally has been sustained by leverage due to the expansion in corporate bond markets. With yields at historically low levels, it has been inexpensive for companies to raise new leverage.[3]

[1]These evolutions are described in detail in, e.g., IMF (2017, 2019) or Furman (2015), and suggested to be side-effects of ultra-accommodative policy in Rajan (2013) and Stein (2013).

[2]In 1982, the Security and Exchange Commission liberalized open market repurchase operations for corporations in the United States. These require approval of the board of directors, and have to respect some volume and timing limitations in order to avoid any fraud liability. For more detail on SEC rules on repurchases: https://www.investopedia.com/terms/r/rule10b18.asp

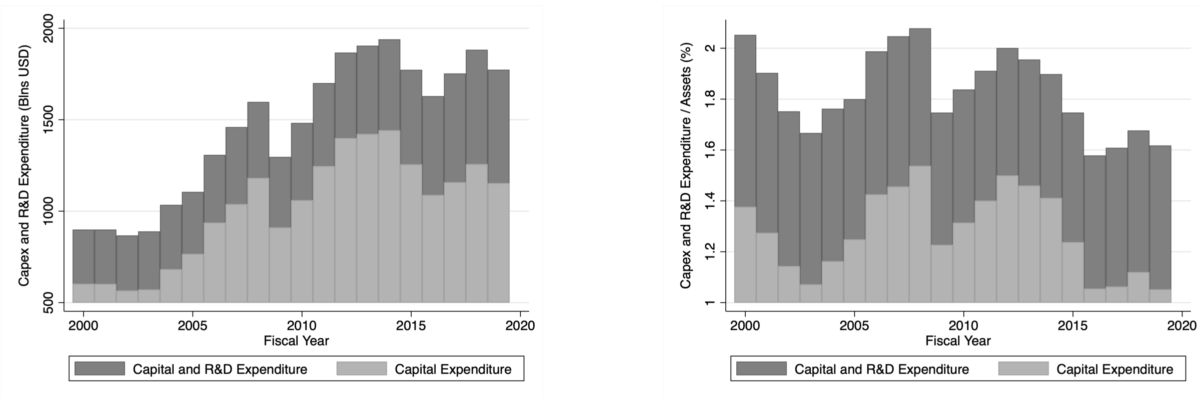
[3]The evolution of the US leveraged-loan market epitomizes these trends. This segment has doubled in size since 2010. Outstanding volumes now approach that of the high-yield bond market. The share of banks in their financing has plummeted to 8%. Nearly 70% of the proceeds fund "shareholder enhancements" such as dividends and buybacks, leveraged buyouts, or mergers and acquisitions.



(a) (b)

Figure 1: Total net share repurchases and shareholder payouts (defined as the sum of net share repurchases and dividend payouts). Panel (a) shows repurchases and payouts in levels, and panel (b) shows both repurchases and payouts normalized by firm assets in the prior quarter. Data from Compustat, 2001-2019 (inclusive).

Third, fixed business investment since the crisis remains below historical trends to date despite cheap funding, robust corporate profits and favorable tax reforms. Figures 2a and 2b show that while the level of investments has grown modestly over time, it has been relatively flat in absolute terms over the past decade; furthermore, the increase in capital and R&D expenditures have not been commensurate with firms' asset growth, as normalized investment has trended downwards over the last decade.



(a) (b)

Figure 2: Total capital and R&D expenditures. Panel (a) shows expenditures in levels, and panel (b) shows expenditures normalized by firm assets in the prior quarter. Data from Compustat, 2001-2019 (inclusive).

Indeed, in the wake of the COVID-19 outbreak, former Federal Reserve Chairman Janet Yellen has acknowledged that enormous debt loads of non-financial corporations reflected excessive borrowing, much of which was not spent on productive purposes like investments or expanding payroll but rather used for stock buybacks and to pay dividends to shareholders, and that the Federal Reserve did not have adequate tools to regulate such use of leverage in response to low interest rates.[4] This acknowledgement has lent weight to the possibility that the extraordinarily accommodative behavior of the Federal Reserve over the past decade has had a role in fueling the expansion of leveraged payouts. If true, this would imply that the target of monetary policy to sustain investment has possibly not been met, succeeding instead in raising dividend distributions in the form of leveraged buybacks.

Our paper offers a parsimonious model in which a low monetary policy rate leads to large leveraged payouts by firms that have a detrimental impact on capital expenditures, thereby leading to business investments that are too low from a social perspective. This adverse effect of low rates occurs only when the public sector is unable to regulate private leverage; conversely, an appropriate prudential regulation on leverage in combination with a low monetary policy rate can restore the first-best investment level. Thus we offer an equilibrium relationship between several salient features of the current corporate credit cycle: the significant involvement of a large unregulated shadow-banking sector, historically unprecedented levels of leveraged payouts, and disappointing capital expenditures.

Gist of the argument. Suppose that an agent who values consumption at two dates 0 and 1 is endowed with an investment technology that converts date-0 consumption units into date-1 units with decreasing marginal returns to scale. The agent is price-taker in a bond market. As the required return on bonds decreases, the agent (i) invests more in her technology until its marginal return equates the return on bonds, and (ii) borrows more against the resulting date-1 output until so does her marginal rate of intertemporal substitution. We deem such borrowing for consumption against future output a "leveraged payout." A natural interpretation of this trade is indeed that the agent sets

[4]See, in particular, https://finance.yahoo.com/news/us-economys-recovery-coronavirus-could-191344712.html: Former Federal Reserve Chairwoman Janet Yellen said the high level of corporate debt across Wall Street – aided in part by historically low interest rates and a lack of regulatory oversight – could make it more difficult for the U.S. economy to recover from the coronavirus pandemic. Although the banking and financial sector entered the economic crisis brought on by the novel coronavirus outbreak in "generally good shape, Yellen said Monday during a video broadcast hosted by the Brookings Institution that enormous debt loads were an existing vulnerability. "But nonfinancial corporations entered this crisis with enormous debt loads, and that is a vulnerability, Yellen said. "They had borrowed excessively. Much of that borrowing, Yellen said, was not spent on productive purposes like investments or expanding payroll but rather used for stock buybacks and to pay dividends to shareholders. The borrowing spree happened because regulators had "few, if any tools to rein it in and because low interest rates made it easier for companies to borrow, according to Yellen, who led the U.S. central bank between 2014 and 2018.

up a corporation that operates her investment, and that this corporation issues bonds, using the proceeds either to buy back shares from her or to pay her a special dividend.

Suppose now that the output from investment increases in costly private effort by the agent. Such moral hazard introduces a tension between investment and leveraged payouts as the interest rate decreases. On the one hand, the agent would like to enter into more leveraged payouts to front-load consumption. On the other hand, borrowing more against date-1 output reduces her incentives to increase this output, thereby making investment less profitable and thus smaller.[5] The agent sets her leverage at the level that optimally trades off consumption-smoothing and incentives. Very much like there is a trade-off between eliciting incentives and smoothing consumption across states of nature in the canonical moral hazard model of Holmström (1979), there is a tension here between producing an output and borrowing against it.

Such agents in our setup are entrepreneurs facing a (real) interest rate controlled by a benevolent central bank. The central bank aims at stimulating investment with a low interest rate in an economy in which rigid prices fail to send the proper signals to entrepreneurs to invest. Whereas such monetary easing would seamlessly work in the absence of moral hazard, the above mentioned moral-hazard problem creates a wedge between privately and socially optimal leverage as well as investment decisions by entrepreneurs. In the face of a lower rate, entrepreneurs optimally enter into more leveraged payouts at the expense of effort and investment. Whereas reduced effort and investment are deadweight social losses, entrepreneurs' private benefits from leveraged payouts at a distorted rate are a social wash because they must be paid for by other agents—in the form of taxes in our setup.

In sum, our parsimonious model offers a clear connection between monetary easing and the rise of leveraged payouts at the expense of capital expenditures and productivity. To be sure, neither payouts nor risky corporate debt are problematic *per se* in our model. Rather, leveraged payouts affect the capital structure of firms, and this affects their real decisions as in any model in which frictions invalidate the Modigliani-Miller theorem. We show that even when some leverage is socially optimal (due to wealth constraints on entrepreneurs), the incentive to undertake leveraged payouts implies that the privately optimal leverage is higher than the socially optimal one when the interest rate

[5]Unlike in the debt overhang problem of Myers (1977), debt is the optimal contract in this context as it maximizes incentives for a given raised amount of external funds.

is sufficiently low.[6]

Our setup has noteworthy implications for financial regulation and optimal monetary policy.

Implications for financial regulation. We show that the central bank can implement the first-best despite moral hazard if it has a free hand at regulating corporate leverage. We view the difference between a setting in which it can do so and one in which entrepreneurs lever up as they see fit as a stylized parallel between an economy in which corporate credit originates from regulated banks and one in which it also stems from non banks—the "shadow-banking" sector. We show that monetary easing entails more leveraged payouts at the expense of productive investment in the latter situation than in the former. Accordingly, our theory suggests that the existence of a large shadow-banking system may dramatically affect the transmission of monetary policy. Interestingly, as mentioned above, non banks have played an unprecedented central role in the US corporate credit boom that followed the 2008 crisis. Leveraged payouts during this boom have reached record high volumes whereas business investment has remained disappointing.

Implications for optimal monetary policy. We show that when it cannot regulate leverage, the central bank optimally targets a strictly smaller investment level than when it can regulate leverage. Stimulating investment with low rates comes at the cost of inducing leveraged payouts, which reduce entrepreneurs' incentives and thus productive efficiency. A smaller investment target compared to the first-best optimally trades off scale and productive efficiency. If the pass-through from monetary policy to investment level is rather muted, as observed recently,[7] then the optimal monetary policy may even consist of "leaning against the wind," *i.e.*, not stimulating the economy at all, in order to fully contain leveraged payouts and maintain productive efficiency.

[6] This view coincides with that of Cochrane in a recent blog post (https://johnhcochrane.blogspot.com/search?q=Airline+Bailouts+And+Capital+Regulation), although he focuses on a different moral-hazard problem: "Let's be clear. It is a myth that buybacks are bad because they reduce investment.(...). But buybacks do have a downside: they reduce equity and increase debt. Fine if you and the creditors are willing to take a bath in bad times. Not good if debt means taxpayers have to bail out in bad times. Too big to fail is spreading like a virus."

[7] Besides Furman (2015), see also the evidence presented for the United States by Wang (2019), who documents a weak pass-through of monetary policy to bank lending rates for the past two decades, especially so at low interest rates. See also the discussion and references in Wang (2019) for similar evidence of a weak pass-through of negative interest rates to the real economy in case of Europe and Japan.

Related literature

Our paper revisits the notion of "malinvestment" that has been prominent in Austrian economics (Hayek, 1931, for example). Malinvestment refers to the possibility that distortion of the real interest rate due to monetary easing subsidizes activities that are not socially desirable (but become privately profitable) at the expense of preferable investments. We are the first, to our knowledge, to connect the current fierce debate on the social optimality of leveraged share buybacks to this old idea of malinvestment.

Our paper also relates to three more recent strands of theoretical literature.

First, Bolton et al. (2016), Martinez-Miera and Repullo (2017) or Boissay et al. (2016) offer like us models in which a low cost of funds may be detrimental to incentives in the private sector. Whereas a low cost of capital is due to positive supply shocks in their setups, it stems from an optimal monetary policy decision aimed at stimulating the economy after a negative shock in our setup.

Second, we argue in this paper that this relation between cost of capital and incentives explains why low policy rates may fail to stimulate investment. Several recent contributions suggest alternative causes for this failure of monetary easing to spur investment. Brunnermeier and Koby (2018) show that this may stem from eroded lending margins in an environment of imperfectly competitive banks. Coimbra and Rey (2017) study a model in which the financial sector is comprised of institutions with varying risk appetites. Starting from a low interest rate, further monetary easing may increase financial instability, thereby creating a trade-off with the need to stimulate the economy. A distinctive feature of our approach is that we *jointly* explain low investment and high leveraged payouts by corporates.

Third, corporate debt becomes riskier in our model following leveraged payouts, and this is our point of contact with the literature on the role of monetary easing in creating financial instability. In Farhi and Tirole (2012), the central bank faces a commitment problem which is that it cannot commit not to lower interest rates when financial sector's maturity transformation goes awry. In anticipation, the financial sector finds it optimal to engage in maturity transformation to exploit the central bank's "put." In Diamond and Rajan (2012), the rollover risk in short-term claims disciplines banks from excessive maturity transformation, but the inability of the central bank to commit not to "bailing out" short-term claims removes the market discipline, inducing excessive illiquidity-seeking by banks. They propose raising rates in good times taking account of financial stability concerns, but so as to avoid distortions from having to raise rates when banks are distressed. In contrast to these papers, in our model the central bank faces no commitment problem; lowering rates triggers inefficient leveraged payouts that negatively affect productive efficiency and, ultimately, investment.

Finally, Stein (2012) explains that the prudential regulation of banks can partly rein in incentives to engage in maturity transformation that is socially suboptimal due to fire-sale externalities; however, there is always some unchecked growth of such activity in shadow banking. Hence, in line with the policy implications from our model, he argues that monetary policy that leans against the wind can be optimal as it raises the cost of borrowing in all "cracks" of the financial sector.

The paper is organized as follows. As a stepping stone to our main model, Section 1 presents a partial-equilibrium model of optimal investment and consumption-smoothing in the presence of moral hazard. Section 2 embeds it in a full-fledged equilibrium model to determine the optimal monetary policy and derives the main results. Section 3 offers extensions and alternative modelling choices. Section 4 presents descriptive empirical evidence for the model's implications linking monetary accommodation to payouts being financed with leverage from the regulated (bank debt) versus unregulated (bonds) financial system. Section 5 presents concluding remarks.

1 Cost of capital, investment, and leveraged payouts

Consider an economy with a single consumption good and two dates indexed by $t \in \{0; 1\}$. An entrepreneur is risk-neutral over consumption at dates 0 and 1 and discounts date-1 consumption at the gross rate $R > 1$. She has access to an investment technology that transforms I date-0 consumption units into a number of date-1 units equal to $f(I)$ with probability e, and to zero with the complementary probability, where f satisfies the Inada conditions. The entrepreneur controls e, the probability of success of her investment, at a private cost $e^2 f(I)/(2\pi R)$ that is subtracted from her utility over consumption when young, where $\pi \in (0, 1)$.[8] As is standard, this private cost stands for any time and resources that the entrepreneur devotes to maximizing the value of her investment—e.g.,

[8] The term $1/R$ in effort cost is just a normalization. The linearity of effort cost with respect to output size plays no other role than simplifying the algebra.

through screening projects or mapping and hedging risks—instead of devoting them to tasks that she finds more rewarding. The entrepreneur has a large date-1 endowment of the consumption good $W > 0$. She can trade securities with risk-neutral counterparties that require a gross expected return $r > 0$ between dates 0 and 1.

The rest of this section solves for the entrepreneur's utility-maximization problem, discussing in turn the cases in which the entrepreneur's cost of capital r is larger or smaller than her discount rate R.

Suppose first that $r \geq R$. The entrepreneur in this case is not interested in frontloading consumption (unless $r = R$ in which case she is indifferent between frontloading or not), and she borrows only to fund the investment I in the technology f. Restricting the analysis to the case in which $W > rI$, so that her debt is risk-free, she selects the investment level I and the effort level e that solve

$$\max_{e,I} \left\{ \frac{\left(e - \frac{e^2}{2\pi}\right) f(I) + W - rI}{R} \right\}. \tag{1}$$

The objective is maximized at $\left(\hat{e}, \hat{I}\right)$ such that

$$\hat{e} = \pi \quad \text{and} \quad \frac{\pi}{2} f'(\hat{I}) = r. \tag{2}$$

In this case $r \geq R$, the probability of success π does not depend on the cost of capital r. Both investment $\hat{I}$ and expected output $\pi f(\hat{I})$ decrease with respect to r.

Leveraged payouts. Suppose now that $r < R$. The entrepreneur would like in this case to frontload consumption. She borrows against her entire endowment W. She also contemplates borrowing against the date-1 consumption that she can generate out of the technology f. Such borrowing is akin to a leveraged payout, whereby the entrepreneur sets up a firm that runs the investment in the technology f at date 0, and then lets this firm borrow against its expected future cash flows to buy back shares from the entrepreneur or pay her a special dividend.[9]

More precisely, the timing is as follows. The entrepreneur announces an investment level I, an effort level e, and a leverage $(1 - x)$ against her output, where $x \in [0, 1]$ is

[9] Dividends and share buybacks are equivalent in this environment that abstracts from any informational or differential tax considerations relating to the two forms of shareholders' payouts.

the fraction of the output against which she does not borrow — her "skin in the game." Investors buy her bonds. The entrepreneur consumes and invests the proceeds and then exerts private effort. The entrepreneur selects (e, I, x) that maximizes her expected utility subject to the effort level e being incentive-compatible. Formally, she solves

$$\max_{e,I,x} \left\{ \frac{W + (1-x)ef(I)}{r} - I + \left(xe - \frac{e^2}{2\pi} \right) \frac{f(I)}{R} \right\} \tag{3}$$

s.t.

$$e = \arg\max_{y} \left\{ xy - \frac{y^2}{2\pi} \right\}. \tag{4}$$

Date-0 consumption is the sum of the present value of the endowment W/r net of investment I and of the present expected value of the fraction $(1-x)$ of output against which the entrepreneur borrows at the rate r. Date-1 expected consumption is the expected retained output $xef(I)$. Condition (4) is the incentive-compatibility constraint, stating that the announced effort e must maximize the entrepreneur's date-1 consumption net of effort costs. Simple algebra (see proof of Proposition 1 in Appendix A) yields the respective first-order conditions with respect to e, x, I:

$$x = \frac{R}{2R - r}, \tag{5}$$

$$e = \pi x = \frac{\pi R}{2R - r}, \tag{6}$$

$$\frac{\pi R f'(I)}{2(2R - r)} = r. \tag{7}$$

These conditions imply that in the case $r < R$, a lower cost of capital r induces an increase in leveraged payouts (a lower value of the skin in the game x). Furthermore, since a lower r induces both a lower probability of success $e = \pi R/(2R - r)$ and a higher investment $I = f'^{-1}(2r(2R-r)/(\pi R))$, the overall impact of a reduction in r on expected output $ef(I)$ is ambiguous. Suppose for example that $f(I) = I^{1/\gamma}$, where $\gamma > 1$. We show in Appendix A that the expected output increases in r for $r \in [2R/(\gamma+1), R]$, and decreases otherwise. The following proposition collects the above results.

Proposition 1. ***(Cost of capital, investment, and leveraged payouts)*** *Let* $\overline{r}(r) = \min\{r; R\}$. *The entrepreneur chooses skin in the game* x*, effort* e*, and investment* I*, such that*

$$x = \frac{R}{2R - \overline{r}(r)}, \quad e = \pi x = \frac{\pi R}{2R - \overline{r}(r)}, \quad \text{and} \quad \frac{\pi R f'(I)}{2(2R - \overline{r}(r))} = r. \tag{8}$$

Thus,

- *For* $r \in (R, +\infty)$*, a reduction in the cost of capital* r *is irrelevant for corporate leverage, payout policy, and incentives. It spurs investment and expected output.*
- *For* $r \leq R$*, a reduction in the cost of capital* r *spurs leveraged payouts that reduce the entrepreneur's incentives and thus degrade asset quality; investment is less sensitive to* r *than in the case* $r > R$*.*

Proof. See Appendix A. ■

The entrepreneur's linear preferences induce a sharp difference between the two cases discussed in Proposition 1. This permits a clear and simple exposition of the important intuition behind our results.[10] In the case $r > R$, fluctuations in the cost of capital only affect corporate investment I. When $r < R$, by contrast, the cost of capital affects the issuance of risky corporate bonds as well, *even though the entrepreneur has all the internal resources* W *needed to issue safe liquidity vehicles in order to fund investment.* Leveraged payouts reduce incentives and thus shift the entire production function downwards.

Section 2 embeds this partial-equilibrium model with exogenous cost of capital into a model in which a central bank has control over the real rate because of nominal rigidities. The central bank seeks to maximize a standard social welfare function, and sets its policy rate so as to mitigate the distortions induced by a downward-rigid wage.

[10] The broad qualitative insights would carry over under strict concavity.

2 Investment, leveraged payouts, and optimal monetary policy

2.1 Setup

Time is discrete. There is a single consumption good that serves as numéraire. There are two types of private agents, workers and entrepreneurs, and a public sector.

Workers. At each date, a unit mass of workers are born and live for two dates. They derive utility from consumption only when old, and are risk-neutral over consumption at this date. Each worker supplies inelastically one unit of labor when young in a competitive labor market. Each worker also owns a technology that transforms l units of labor into $g(l)$ contemporaneous units of the consumption good.

Entrepreneurs. At each date, a unit mass of entrepreneurs are born and live for two dates. Entrepreneurs are essentially identical to that in the previous section. They are risk-neutral over consumption when young and old, and discount future consumption at the rate $R > 1$. They receive a large endowment W of the numéraire good when old. Each entrepreneur born at date t is also endowed with a technology that transforms l units of labor at date t into $f(l)$ consumption units at the next date $t+1$ with probability e, and zero units with the complementary probability.[11] Entrepreneurs control the probability of success e at a private cost $e^2 f(l)/(2R\pi)$ that is subtracted from their utility when young.

The technology f features a one-period lag between production and delivery of consumption services. This technology thus stands in our stylized model for the most interest-sensitive sectors of the economy such as durable-good, housing or capital-good sectors. We accordingly deem technology f the *capital-good sector*, and technology g the *consumption-good sector*.[12] We also term *investment* the resources spent to produce the capital good.

The functions f and g satisfy the Inada conditions and f is twice continuously differentiable.

Bond market. There is a competitive market for one-period bonds denominated in the

[11] The joint distribution of entrepreneurs' outcomes is immaterial.

[12] A full-fledged model of f as a capital-good technology would require that the date-t investment be combined with labor at date $t+1$ in order to generate consumption. This would complicate the analysis without adding substantial insights.

numéraire good.

Public sector. The public sector implements monetary and fiscal policies.

- Monetary policy: The public sector announces at each date an expected rate of return at which it is willing to trade arbitrary quantities of bonds;
- Fiscal policy: The public sector can tax workers as it sees fit. It can in particular apply lump-sum taxes. However, it cannot tax entrepreneurs.

This latter assumption is made stark in order to yield a simple and clear exposition of our results. As detailed below, all that matters is that the public sector does not have a free hand at regulating entrepreneurs' behavior with appropriate tax schemes. In particular, it cannot use taxation as a substitute for prudential regulation. One possible reason entrepreneurs cannot be taxed is that they can operate in a different jurisdiction.

Social welfare function. The public sector seeks to maximize the sum of the present values of aggregate consumption net of effort costs at each date discounted at the rate R.

Relationship to new Keynesian models. This setup can be viewed as a much simplified version of the new Keynesian framework, as it shares the following features with it: i) Money serves only as a unit of account ("cashless economy"), ii) the monetary authority controls the short-term nominal interest rate, and iii) sticky prices imply that it can affect real interest rates by doing so.

Assuming extreme nominal rigidities in the form of a fixed price level as we do enables us to abstract from price-level determination and to introduce ingredients that are typically absent from such mainstream monetary models.[13]

No model of monetary policy is complete without specifying how the central bank interacts with the fiscal authority: Monetary and fiscal policies are in general interdependent as they both contribute to shape the budget constraint of the government (e.g., Woodford 2001). In this paper, fiscal policy only serves to accommodate monetary policy ("Ricardian fiscal policy"), and we will see that it does so in a welfare-neutral fashion.

[13]In somewhat related setups, Benmelech and Bergman (2012), Caballero and Simsek (2019), Diamond and Rajan (2012), and Farhi and Tirole (2012) also abstract from price-level determination as we do. Their focus is, however, on the financial-stability implications of monetary policy.

2.2 Characterization of the first-best

Date-t aggregate consumption is equal to date-t aggregate income. Thus, denoting e_t the effort exerted by entrepreneurs born at date t and l_t the quantity of labor that they hire, date-t aggregate consumption net of effort costs reads:

$$\underbrace{W + e_{t-1} f(l_{t-1})}_{\text{Income generated by old entrepreneurs}} + \underbrace{g(1-l_t)}_{\text{Income generated by young workers}} - \underbrace{\frac{e_t^2 f(l_t)}{2\pi R}}_{\text{Young entrepreneurs' effort}} . \tag{9}$$

Social welfare viewed from date-t, S_t, is then

$$S_t = W + e_{t-1} f(l_{t-1}) + \sum_{t' \geq t} \frac{1}{R^{t'-t}} \left[\frac{W}{R} + g(1-l_{t'}) + \left(e_{t'} - \frac{e_{t'}^2}{2\pi} \right) \frac{f(l_{t'})}{R} \right] \tag{10}$$

Differentiating with respect to $e_{t'}$ and $l_{t'}$ yields:

Proposition 2. ***(First-best)*** *The first-best is such that for all t,*

$$e_t = \pi, \tag{11}$$

$$\frac{\pi f'(l_t)}{2R} = g'(1-l_t). \tag{12}$$

Proof. See discussion above. ■

Optimality conditions (11) and (12) are straightforward: The marginal effort cost must equate the resulting marginal expected increase in output, and labor must yield the same marginal return in both sectors, where future output is discounted at R in both cases.

2.3 Laissez-faire

We solve for the competitive equilibrium of this economy in the case in which the public sector is inactive.[14] The competitive equilibrium is characterized by a sequence $(r_t, e_t, x_t, l_t, w_t)$ where e_t and l_t are again entrepreneurs' effort and hired labor, x_t is the skin in the game of the entrepreneurs born at date t, w_t the date-t wage, and r_t the expected (gross) return on bonds due at date $t+1$. Such a sequence characterizes an

[14] As will be clear, laissez-faire may alternatively be interpreted as a monetary policy that consists in announcing an official rate R and a passive fiscal policy.

equilibrium if it is such that private agents optimize and markets clear.

Equilibrium interest rate. The bond market clears if entrepreneurs optimally borrow the amount saved by workers. Given their linear preferences, this requires that for all t,

$$r_t = R. \tag{13}$$

Workers. Young workers' income is comprised of labor income in the capital-good sector $w_t l_t$, labor income in the consumption-good sector $w_t(1 - l_t)$, and profits from the consumption-good sector $g(1 - l_t) - w_t(1 - l_t)$. These latter profits are maximum when

$$g'(1 - l_t) = w_t. \tag{14}$$

Since they consume only when old, young workers invest the resulting total income

$$g(1 - l_t) + w_t l_t \tag{15}$$

in the bond market, thereby receiving an income

$$R(g(1 - l_t) + w_t l_t) \tag{16}$$

when old.

Entrepreneurs. Up to the change of variable $I = w_t l_t$, each entrepreneur's problem is identical to that in Section 1. Since $r_t = R$, each entrepreneur is happy to borrow against her date-1 endowment W any amount above the investment $w_t l_t$ required to produce $e_t f(l_t)$, and sets $x_t = 1$. For brevity we suppose that W is always sufficiently large to repay (16) to old workers. From (2), optimal investment then implies:

$$e_t = \pi, \tag{17}$$

$$\frac{\pi}{2} f'(l_t) = r_t w_t = R w_t. \tag{18}$$

In sum, there exists a unique competitive equilibrium such that

$$(r_t, e_t, x_t, l_t, w_t) = (R, \pi, 1, l^*, w^*), \tag{19}$$

the wage w^* and labor supply to entrepreneurs l^* solve

$$\frac{\pi}{2R} f'(l^*) = g'(1 - l^*) = w^*, \tag{20}$$

and workers lend $g(1 - l^*) + w^* l^*$ to entrepreneurs.

Social welfare under laissez-faire. From Proposition 2, relations (17) and (20) ensure that laissez-faire implements the first-best. Date-t aggregate income (9) is split into consumption for the various agents as follows:

$$W + g(1 - l_t) + e_{t-1} f(l_{t-1}) - \frac{e_t^2}{2\pi R} f(l_t) = \tag{21}$$

$$\underbrace{g(1 - l_t) + w_t l_t - w_t l_t - \frac{e_t^2}{2\pi R} f(l_t)}_{\text{Young entrepreneurs' consumption net of effort cost}} \tag{22}$$

$$+ \underbrace{e_{t-1} f(l_{t-1}) + W - r_{t-1}(g(1 - l_{t-1}) + w_{t-1} l_{t-1})}_{\text{Old entrepreneurs' consumption}} \tag{23}$$

$$+ \underbrace{r_{t-1}(g(1 - l_{t-1}) + w_{t-1} l_{t-1})}_{\text{Old workers' consumption}} \tag{24}$$

Young entrepreneurs' consumption (22) is comprised of workers' loans net of wages paid and effort cost. Old entrepreneurs consume their output and endowment net of workers' loan reimbursement, which old workers in turn consume.

The following proposition collects these results.

Proposition 3. ***(Laissez-faire)*** *There exists a unique laissez-faire equilibrium in which the return on bonds is R. The wage w^* and labor supply to entrepreneurs l^* solve (20). There are no leveraged payouts, $e^* = \pi$, and workers lend $g(1-l^*)+w^*l^*$ to entrepreneurs. Laissez-faire implements the first-best.*

Proof. See discussion above. ■

Assuming a social welfare function that discounts aggregate consumption and effort at the "natural" rate of the economy R is not crucial to our results. It only has the convenient implication that laissez-faire is optimal in this benchmark model, and so any public intervention will solely result from the additional frictions that we now inject in this economy.

2.4 Monetary easing

Productivity shock. Suppose now that one cohort of workers — the one born at date 0, say — has a less productive technology than that of its predecessors and successors. Unlike the other cohorts, their technology transforms y units of labor into $\rho g(y)$ contemporaneous units of the consumption good, where $\rho \in (0, 1)$.

We study in turn the implications of such a negative (perfectly anticipated) productivity shock for optimal policy and welfare in three different contexts with incremental frictions:

1. The wage is flexible.

2. The wage is downward rigid and the public sector can regulate private leverage.

3. The wage is downward rigid and the public sector cannot regulate private leverage.

2.4.1 Flexible-wage benchmark

Proposition 4. ***(Laissez-faire is optimal when the wage is flexible)*** *If the wage is flexible, laissez-faire implements the first-best.*

Proof. The analysis in Section 2.3 carries over when the consumption-good technology is a time-dependent one $g_t(l)$. The welfare function reads in this case

$$S_t = W + e_{t-1} f(l_{t-1}) + \sum_{t' \geq t} \frac{1}{R^{t'-t}} \left[W + g_{t'}(1 - l_{t'}) + \left(e_{t'} - \frac{e_{t'}^2}{2\pi} \right) \frac{f(l_{t'})}{R} \right], \tag{25}$$

and is thus maximal when $e_{t'} = \pi$ and

$$g'_{t'}(1 - l_{t'}) = \frac{\pi f'(l_{t'})}{2R}. \tag{26}$$

This latter first-order condition is satisfied under laissez-faire because the equilibrium wage and labor supply solve

$$g'_{t'}(1 - l_{t'}) = w_{t'}, \tag{27}$$

$$\frac{\pi f'(l_{t'})}{2} = R w_{t'}. \tag{28}$$

At all dates $t \neq 0$, $g_t = g$, and wage and labor supply to entrepreneurs are w^* and l^* solving (20). Since $g_0 = \rho g < g$, (27) and (28) imply that the date-0 wage adjusts to a level $w_0 < w^*$ such that the employment level in the capital-good sector l_0 is above l^*.

For the remainder of the paper, we respectively denote $l_\rho > l^*$ and $w_\rho < w^*$ the first-best date-0 employment level and the associated date-0 market wage that arise in this case of a flexible wage. ■

2.4.2 Rigid wage and regulated leverage

We introduce for the remainder of the paper an additional friction in this economy in the form of a rigid wage:

Assumption. ***(Downward-rigid wage)*** *The wage cannot be smaller than the steady-state wage w^* at date 0.*

In other words, we suppose that the wage is too downward rigid to track the transitory negative productivity shock that hits the date-0 cohort, and that the public sector cannot regulate it in the short run.[15]

In preparation for our main result, we first suppose here that the public sector not only sets the interest rate at each date, but can also control entrepreneurs' leverage. It does so by imposing a prudential regulation on entrepreneurs that consists of a maximum fraction λ of their expected cash flows that entrepreneurs can pledge in the bond market.[16]

The following proposition shows that the combination of a reduction in the date-0 interest rate and of a prudential regulation implements the first-best allocation despite a downward-rigid wage.

Proposition 5. ***(Monetary easing and prudential regulation implement the first-best.)*** *The public sector reaches the first-best by:*

- *being inactive (or equivalently announcing a policy rate equal to R) at all other dates than 0;*

[15]We could also assume a partial wage adjustment without affecting the analysis. Note also that the analysis would be similar if the date-0 productivity shock was permanent ("secular stagnation"). All that would matter in this case would be the number of periods it takes for the wage to adjust to the level that is optimal given the productivity shock.

[16]To be sure, such a prudential regulation applies to banks, not to non-financial firms, in practice. We could accordingly split the capital-good sector into firms and financial intermediaries. Firms would by assumption have to borrow from financial intermediaries that would fund in turn their loans with workers' savings. It would be sufficient to subject such intermediaries to a prudential regulation in this case.

- *announcing a date-0 rate $r_\rho < R$ and imposing a prudential regulation λ_ρ on date-0 entrepreneurs, where (r_ρ, λ_ρ) solves:*

$$\pi \left(\frac{1-\lambda_\rho}{R} + \frac{\lambda_\rho}{r_\rho} \right) f'(l_\rho) = w^*, \tag{29}$$

$$\frac{\lambda_\rho}{r_\rho}(\pi f(l_\rho) + W) = \rho g(1-l_\rho) + w^* l_\rho. \tag{30}$$

Proof. See Appendix A. ■

An inspection of first-order conditions (14) and (18) shows that the capital-good sector is interest-rate sensitive whereas the consumption-good sector is not. The public sector can therefore make up for the absence of appropriate price signals in the date-0 labor market by distorting the date-0 capital market. Equation (29) pins down the investment l chosen by an entrepreneur facing a prudential constraint λ_ρ and a cost of external funds r_ρ. The term $[(1-\lambda_\rho)/R + \lambda_\rho/r_\rho]$ represents the inverse of her weighted cost of funds, increasing in allowed leverage λ_ρ when external funds are cheaper than internal ones ($r_\rho < R$). Equation (29) states that (r_ρ, λ_ρ) are set so that entrepreneurs optimally demand the socially optimal labor l_ρ. Each worker accommodates by applying in her own firm the residual quantity of labor that she cannot sell on the labor market at the disequilibrium wage w^*. She does so at a marginal return below wage ($\rho g'(1-l_\rho) = w_\rho < w^*$), and produces at the socially optimal level by doing so.

From Section 1, unregulated entrepreneurs would issue risky debt at such a cost $r_\rho < R$, thereby exerting a privately optimal effort level below the first-best π. The role of prudential regulation is to curb this behavior and ensure that entrepreneurs only issue sufficient risk-free debt to absorb young date-0 workers' savings $\rho g(1-l_\rho) + w^* l_\rho$, as formalized in (30). This way they exert the socially optimal effort level.

2.4.3 Rigid wage and unregulated leverage

Suppose now that the public sector no longer has the ability to regulate entrepreneurs' leverage. This corresponds to an economy in which a significant fraction of credit activity can be considered to take place in an unregulated shadow-banking system.

Suppose that the public sector seeks to stimulate investment by date-0 entrepreneurs by setting $r_0 < R$. From Section 1, date-0 entrepreneurs solve

$$\max_{e,l,x} \left\{ \frac{W + (1-x)ef(l)}{r_0} - w^* l + \left(xe - \frac{e^2}{2\pi} \right) \frac{f(l)}{R} \right\} \tag{31}$$

s.t.

$$e = \arg\max_{y} \left\{ xy - \frac{y^2}{2\pi} \right\} \tag{32}$$

yielding

$$x_0 = \frac{R}{2R - r_0} < 1, \tag{33}$$

$$e_0 = \pi x_0 = \frac{\pi R}{2R - r} < \pi, \tag{34}$$

$$\frac{\pi R f'(l_0)}{2(2R - r_0)} = r_0 w^*. \tag{35}$$

Such behavior by date-0 entrepreneurs has two implications: disequilibrium in the bond market and socially suboptimal effort.

Disequilibrium in the bond market. Entrepreneurs find it optimal to borrow against W, issue risky debt, and thus borrow a total amount

$$\frac{W + (1-x_0)ef(l_0)}{r_0} \tag{36}$$

larger by assumption than workers' savings,

$$\rho g(1 - l_0) + w^* l_0. \tag{37}$$

The public sector absorbs this excess private supply of bonds with the proceeds from taxing tax date-0 old workers the differential amount $[W + (1-x_0)ef(l_0)]/r_0 - (\rho g(1 - l_0) + w^* l_0)$.[17] Conversely, date-1 old workers receive a corresponding rebate out of the repayment from these public bonds. Appendix A details the subsidies from workers born at date -1 to entrepreneurs and workers born at date 0 when $r_0 < 1$ and leverage is

[17] We assume here that date-0 old workers can afford such a tax, and discuss the case in which they do not in Section 3.3. In the presence of an international capital market, this date-0 deficit could of course be financed with public debt issuance so as to spread the tax burden over several cohorts.

unregulated.[18] Note that these subsidies are welfare-neutral.

Socially suboptimal effort. Second, and more important, reduced skin in the game ($x_0 < 1$) implies in turn that date-0 entrepreneurs exert an effort level below π that is not socially optimal from Proposition 2. The resulting lower productive efficiency implies that they invest less than they would in the absence of moral hazard.

In sum, Proposition 1 describes how entrepreneurs facing $r_0 < 1$ optimally trade off the benefits from leveraged payouts with the negative impact of the resulting reduced incentives on their expected output. This trade-off is privately optimal, but not socially optimal. The reduced expected output due to weaker incentives is not only a private but also a social loss whereas the value that entrepreneurs extract from leveraged payouts holding effort fixed stems from a (welfare-neutral) transfer from old date-0 workers.

Leveraged payouts are in this model a form of inefficient rent extraction by entrepreneurs that is detrimental both to old date-0 workers, as it redistributes resources away from them, and to social welfare, as it results in a reduced expected output.[19]

The following proposition, where we employ the subscript u to denote outcomes under the rigid-wage and unregulated-leverage case, details this insight that monetary easing in this case not only induces leveraged payouts but also a lack of investment that puts the first-best out of reach.

Proposition 6. ***(Rigid wage and unregulated leverage)***

1. *The optimal interest rates are $r^* = R$ at all dates other than 0 and $r_u \leq R$ at date 0.*

2. *Social welfare is strictly lower when leverage is not regulated than when it is because date-0 investment is strictly lower: Entrepreneurs use a quantity of labor l_u strictly smaller than the first-best one l_ρ.*

3. *The cohort born at date -1 subsidizes the cohort born at date 0.*

Proof. See Appendix A. ■

In the absence of leverage regulation, the skin in the game of an entrepreneur x and thus her effort e (strictly) increase in r for $r < R$. As a result, attempts at spurring

[18] See proof of Proposition 6.

[19] Notice that if entrepreneurs' gains from leveraged payouts were compensated for by a lump-sum tax on them rather than on old workers, then this would eliminate the welfare-neutral redistribution from workers to entrepreneurs, yet this would leave unchanged the socially costly distortion in output.

investment/employment in the capital-good sector with a reduction in the date-0 interest rate boost leveraged payouts and degrade productive efficiency. This unintended consequence of monetary easing implies that social surplus is maximized at a lower date-0 use of labor in the capital-good sector l_u than in the presence of a prudential regulation imposing $x = 1$: $l_u < l_\rho$. In this sense, lack of investment relative to the first-best is part of a second-best policy in the absence of a strict prudential regulation.

The following proposition details how the size of the shock $1 - \rho$ affects monetary policy when leverage is unregulated.

Proposition 7. ***(Shock size and optimal interest rate)*** *There exists $\bar{\rho} \in [0, 1)$ such that*

- *If, ceteris paribus, $\rho \geq \bar{\rho}$, then it is optimal to ignore the shock ρ and leave the date-0 interest rate at its steady-state value: $r_u = R > r_\rho$. Investment is strictly below the first-best level but productive efficiency is at the first-best ($l_u < l^*$ but $e^* = \pi$).*
- *If $\bar{\rho} > 0$, then for $\rho \in (0, \bar{\rho})$ the optimal monetary policy is accommodative: $r_u < R$. Investment and productive efficiency are both strictly below their first-best levels ($l_u < l^*$ and $e^* < \pi$).*

Proof. See Appendix A. ■

Proposition 7 shows how the optimal interest rate trades off productive efficiency e and scale l in the capital sector. If ρ is sufficiently large (the shock is small), it is always optimal to avoid any leveraged payout by leaving the rate at $r^* = R$, thereby preserving productive efficiency $e^* = \pi$ at the cost of investing at a scale smaller than the first-best. It may be that this policy is actually optimal for all possible shocks (case $\bar{\rho} = 0$). Consider for example the limiting case in which the function f is constant. In this case, a reduction in the interest rate has only an adverse effect on productive efficiency and no impact on scale. It is thus undesirable to cut the interest rate below one no matter the size of the shock.

Stein (2012) argues that in the presence of some unchecked credit growth in the shadow-banking system, a monetary policy that leans against the wind can be optimal as it raises the cost of borrowing in all "cracks" of the financial sector. This resonates with our result that the optimal policy response to sufficiently small productivity shocks—and possibly for all shocks— consists in "leaning against the wind" this way, and setting $r_u = R$.

The proof of Proposition 7 offers formal examples in which $\bar{\rho}$ is either equal to zero or strictly positive. In this latter case, as ρ becomes smaller than $\bar{\rho}$, it becomes preferable to spur l even though this comes at an important cost for productive efficiency. In this case, there is aggressive monetary easing that still has a limited impact on investment, and generates instead a surge in leveraged payouts, that in turn induce degrade productive efficiency.

3 Extensions

This section presents several extensions and alternative modellings. Section 3.1 first discusses a version of the model in which risky corporate debt is not entirely socially undesirable, as is the case in the body of the paper. Section 3.2 then shows that the exact nature of the friction that creates a tension between leveraged payouts and productive efficiency is not important. Section 3.3 discusses the case in which disequilibrium in the bond market prevents the transmission of the policy rate to the corporate bond market. Section 3.4 shows that in the presence of a lower bound on feasible policy rates, the public sector can alternatively resort to the purchase of entrepreneurs' assets. Finally, Sections 3.5 and 3.6 briefly discuss richer modellings of the shadow-banking sector and of imperfect entrepreneurs' taxation.

3.1 Socially desirable risky corporate debt

The main model posits that entrepreneurs have enough safe collateral W to fund investment. Whereas this brings tractability, this implies that risky corporate debt that negatively affects incentives arises only when entrepreneurs enter into leveraged payouts. Risky corporate debt is thus always socially undesirable given the assumed welfare function. Here, we consider a setting in which some level of risky corporate debt is socially desirable, but the main conclusions of our model are robust in the sense that the privately optimal extent of leverage (and leveraged payouts) is inefficiently high relative to the socially optimally level.

First, note that if the date-1 collateral was a risky one $\tilde{W}$ with a possibly zero payoff realization, then all corporate debt would be risky, even though this would not affect incentives as long entrepreneurs borrow less than $E\tilde{W}$. More interesting is the case in which entrepreneurs are wealth-constrained. In particular, suppose that $W = 0$.

Proposition 8. ***("Good" and "bad" risky corporate debt)*** *In the partial-equilibrium model of Section 1, suppose that $W = 0$ and $f(I) = 2\sqrt{I}$.*

- *If $r \geq 2R/3$, then the entrepreneur borrows againt future output only to invest, with $x = 3/4$ and $\sqrt{I} = 3\pi/(8r)$.*
- *If $r < 2R/3$, then the entrepreneur borrows for consumption as well. As in the case $W > 0$, $x = R/(2R - r)$, and $\sqrt{I} = \pi R/[2(2R - r)r]$.*

Proof. See Appendix A. ■

With a binding wealth constraint, the entrepreneur has no choice but to borrow against output to fund investment and consumption. Leverage negatively affects incentives; whether leverage features constrained inefficiency or not depends upon the level of the interest rate, r:

- If $r \geq 2R/3$, the skin in the game is constant and the entrepreneur borrows only to fund investment I. The effort level $e = \pi x = 3\pi/4 < \pi$ is the socially constrained-efficient one that trades off efficiency e and scale I.
- However, if $r < 2R/3$, then risky corporate debt serves not only to make the investment but also to fund payouts. It is only this latter part of the risky debt issuance that is socially undesirable. Effort is below $3\pi/4$ and investment is less responsive to the interest rate than in the presence of such leveraged payouts.

3.2 Alternative frictions

The essential point this paper makes is that there is a tension between common macroeconomic wisdom stating that low rates spur both consumption and investment, and corporate-finance theory based on frictions that render capital structure relevant. The tension arises because these very frictions may create a tradeoff between leveraged payouts and productive efficiency in the presence of low rates. Whereas this tension is central to the paper, the nature of the friction at its roots is not important. Here we show that our results carry over when the hidden-effort friction is replaced either by rollover risk or by adverse selection. For simplicity, again, we carry out the analysis in the partial-equilibrium model of Section 1 in which we posit $W = 0$ and $f(I) = 2\sqrt{I}$.

Adverse selection

In the model of Section 1, suppose that there is no moral hazard: The probability of success of a project e is exogenously given, and there is no cost of effort ($\pi = +\infty$). The entrepreneur may be of two types, "good" or "bad". A good entrepreneur's project succeeds almost surely whereas that of a bad entrepreneur almost surely fails. The entrepreneur privately observes her type. Investors share the prior belief that she is good with probability q. All entrepreneurs' actions are publicly observed. The equilibrium is as follows:

Proposition 9. ***(Adverse selection, investment, and leveraged payouts)***

- *If $r \geq q^2 R$, then the entrepreneur borrows and invests $I = 1/r^2$ if good, and 0 if bad.*
- *If $r < q^2 R$, then the entrepreneur, regardless of her type, borrows $2q^2/r^2$, invests q^2/r^2, and consumes the residual.*
- *Debt is safe in the former case and subject to default with probability $1 - q$ in the latter one.*

Proof. See Appendix A. ■

A good entrepreneur may borrow only to invest, in which case a bad one does not mimic her and refrains from borrowing as she does not benefit from investment. The good entrepreneur may alternatively borrow beyond her investment needs in order to consume against future output. In this case a bad entrepreneur mimics her, and so the good entrepreneur incurs a lemons discount. If the interest rate is sufficiently low, however, the good entrepreneur does prefer to borrow for consumption despite this discount.

Overall, as in the moral-hazard case, lower rates trigger leveraged payouts, and debt becomes riskier because it is backed by a pool of assets of lower quality. Furthermore, aggregate investment decreases (holding r constant) to q^2/r^2 from q/r^2.

Note that the rate $q^2 R$ at which leveraged payouts arise is strictly below R. This is a consequence of the assumption that there are two types of entrepreneurs. With two effort levels instead of a continuum, we could also obtain maximum skin in the game and effort for a region of interest rates strictly below R in our baseline model with moral hazard.

Rollover risk

In the model of Section 1, suppose that the entrepreneur's project succeeds with probability $e = 1$ at date 1 at no cost. Suppose however that the entrepreneur incurs rollover risk when borrowing. She borrows at the rate r between $t = 0$ and an interim date $t = 0.5$. At this interim date, she must refinance her loan with risk neutral investors who do not discount date-1 cash flows. The entrepreneur has access to this interim market with probability q only. If excluded from the market, she must liquidate all or part of her assets to repay debt and this comes at a deadweight loss equal to a fraction $\eta \leq 0.5$ of the liquidated assets. We have in this case:

Proposition 10. ***(Rollover risk, investment, and leveraged payouts)***

- *If* $r \geq (1 - q\eta)^2[1 - \eta(1 - q)]R/(1 - \eta)$, *then the entrepreneur issues risk-free debt and invests the proceeds* $[(1 - \eta)/[1 - \eta(1 - q)]r]^2$.
- *Otherwise the entrepreneur issues risky debt, raising* $2(1 - q\eta)^2/r^2$, *invests* $[(1 - q\eta)/r]^2$, *and consumes the residual.*

Proof. See Appendix A. ■

The entrepreneur may decide to borrow only to fund investment, in which case asset liquidation following market exclusion is only partial and debt is risk-free. Facing sufficiently low interest rates, the entrepreneur prefers to borrow against its entire future output to consume early. Again, debt becomes risky, and leveraged payouts have a negative impact on investment.

3.3 Financialized assets and crowding out of investment

Section 2.4.3 restricts the analysis to the case in which the public sector always has sufficient fiscal capacity to balance its budget given monetary policy. When entrepreneurs seek to borrow $[W + (1 - x_0)e_0 f(l_0)]/r_0$ whereas young workers lend only $\rho g(1 - l_0) + w^* l_0$, the public sector fills the gap $[W + (1 - x_0)e_0 f(l_0)]/r_0 - \rho g(1 - l_0) - w^* l_0$ with a lump-sum tax on old date-0 workers. Suppose otherwise that such taxation is not feasible:

$$R(g(1-l^*)+w^*l^*) < \frac{W+(1-x_0)e_0 f(l_0)}{r_0} - \rho g(1-l_0) - w^* l_0. \qquad (38)$$

This is so if W is sufficiently large other things being equal. This corresponds in practice to the case in which many of the assets in the economy are "financialized" and can be easily sold or borrowed against. In this case, denoting $\underline{r}$ the lowest interest rate such that (38) does not hold, entrepreneurs' cost of capital remains stuck at $\underline{r}$ even when the policy rate is below this value. In other words, borrowing against existing assets crowds out investment by creating a demand for funds that sustains a high hurdle for return on such investment.

3.4 Zero lower bound and asset purchases

In the face of a zero lower bound (ZLB) on policy rates, the Federal Reserve (and central banks of several developed economies) responded to the 2008 crisis or the Covid-19 one with unconventional policies that include the purchase of private claims such as mortgage-related securities and corporate debt. Suppose that the public sector is subject to a similar lower bound in our setup: It cannot set the date-0 rate below a given threshold.[20] The public sector can still enter into asset purchases, swapping date-0 entrepreneurs' claims to their date-1 output with public bonds, akin to remunerated excess reserves. Such swaps spur investment at date 0: if the public sector trades $1/r_0$ bonds for each date-1 consumption unit, then this amounts to granting a lower interest rate to date-0 entrepreneurs. Such asset purchases, however, have the same adverse implications for incentives as interest-rate reductions because they reduce entrepreneurs' skin in the game in the very same way as in our case of unregulated leverage.[21]

[20] For example, because the private sector can secretly store at some return.

[21] The possibility that quantitative easing can lead to leveraged payouts without real investments was reocgnized by Michael Spence and Kevin Warsh in the Wall Street Journal, Oct 2015 (available at https://search.proquest.com/docview/1727325243?accountid=12768): "In 2014, S&P 500 companies spent considerably more of their operating cash flow on financially engineered buybacks than real capital expenditures for the first time since 2007. During the pre-crisis period, by contrast, corporate spending on real assets averaged 10 percentage points higher than on financial assets. [...] We believe that Quantitative Easing (QE) has redirected capital from the real domestic economy to financial assets at home and abroad."

3.5 Shadow banking

We interpret the respective polar cases of regulated (Section 2.4.2) and unregulated (Section 2.4.3) leverage as respectively the situation in which the financial sector is mostly comprised of banks subject to prudential regulation and that in which a large shadow-banking sector operates. An interesting route for future research consists of studying the intermediate situation in which the regulation of leverage can only be imperfectly enforced, and examining the interplay of such imperfect enforcement with the crowding-out of investment by financial risk-taking highlighted here.[22]

3.6 Taxing entrepreneurs

Whereas we assume that entrepreneurs cannot be taxed at all for expositional simplicity, our results rely only on the assumption that the public sector does not have a free hand at taxing them. If entrepreneurial taxation were to be unbridled, then it would be easy to deter socially inefficient leveraged share buybacks, for example through the taxation of date-0 consumption by entrepreneurs or of risky corporate debt. An interesting route for future research consists in studying the situation in which such taxation is distortive or/and can only be imperfectly enforced.[23]

4 Empirical evidence

4.1 Related empirical literature

The linkages implied by our model between leveraged payouts, monetary policy and real investment have not yet been fully or rigorously established in the empirical literature on payouts and buybacks, which has primarily focused on issues relating to managerial private information and signaling, market timing across debt and equity markets, earnings management to meet analyst forecasts, and compensation practices.[24]

[22] Plantin (2015) develops a model of leverage regulation under imperfect enforcement.

[23] Landier and Plantin (2017) offer a model of optimal capital taxation under imperfect enforcement.

[24] See, in particular, Brav, John, and Campbell, Michaely (2005), Ikenberry, Lakonishok, Vermaelen (1995), Peyer and Vermaelen (2009), Brockman and Chung (2001), Vermaelen (1981) on private information and signaling; Baker and Wurgler (2002), Ma (2019) on market timing; Bens et al (2003), Hribar, Jenkins, and Johnson (2006), Almeida, Vyacheslay, and Kronlund (2016) on earnings management to meet analyst forecasts; and, Farre-Mensa, Michaely, and Schmalz (2018) on compensation and management incentives. Dittmar and Dittmar (2008) document evidence that buybacks happen in coordinated waves over the time-series; however, a convincing explanation for the cycle of buybacks is still missing.

Two recent inquiries, viz. Farre-Mensa, Michaely, and Schmalz (2018) and Elgouacem and Zago (2019) get more directly at the relation between buybacks, debt issuances, and the consequent effects on firm performance, especially in times of monetary policy accommodation. The former focuses on the source of funds that firms use to finance payouts; the latter follows a similar path but adds an identification strategy to try assess the impact of monetary policy on buybacks.

Farre-Mensa, Michaely, and Schmalz (2018) study corporate payouts over the period from 1989 to 2012. The authors break down the total payout of firms in two components: the non-discretionary component, which is the minimum of regular dividends in the current and the prior year, and the discretionary component, which is equal to the sum of regular dividend increases, special dividends and share repurchases. They document that firms that pay discretionary payouts also raise capital during the same year, mostly in the form of debt, and that cash flows generated by the firms' operations are not sufficient to sustain the observed level of payouts. The authors also provide suggestive evidence that share repurchases may be spurred not only through lower borrowing costs due to loose monetary policy, but also through possible substitution towards corporate debt resulting from a lower supply of government debt in the wake of the Federal Reserve's quantitative easing program.

Elgouacem and Zago (2019) examine the relationship between share buybacks, monetary policy and the cost of debt over the period 1985 to 2016.[25] They find that net repurchases are correlated with net debt issuances and lower investment. In order to measure the *causal* effect of monetary policy on repurchases, the authors employ a regression discontinuity design, inspired by Hribar, Jenkins, and Johnson (2006) and Almeida, Vyacheslay, and Kronlund (2016). In particular, they exploit the fact that managers whose firms happen to be right below the Earnings Per Share (EPS) forecast by analysts tend to buy back shares more frequently than those above the cutoff. They document that a fall in corporate bond yield due to monetary policy shocks results in a greater increase in repurchases among firms below the cutoff relative to those just above. They also find that investments and employment fall with a drop in yields only for firms below the cutoff, suggestive of a crowding-out of real activity by share repurchases.

[25]The authors define repurchases as in Ma (2014) as the firm's net position in the equity market. This is the difference between the value of the shares repurchased and the value of the newly issued shares normalized by total assets in the previous period.

Together, Farre-Mensa, Michaely, and Schmalz (2018) and Elgouacem and Zago (2019) suggest that share buybacks and discretionary payouts are increasingly financed by leverage; accommodative monetary policy shocks drive this behavior in part; and, such leveraged buyback activity is not coincident with investments in spite of monetary accommodation.[26] Our model provides a theoretical rationale for these results. It also derives the additional novel implication for the source of leveraged buybacks at low interest rates being from regulated finance (bank debt) versus unregulated financial system (for example, bond financing). Next, we present descriptive evidence supporting this implication.

4.2 Summary statistics and sample partitions

We analyze data from 2000 to present, extract firm fundamentals from Compustat, and calculate bank debt as a proportion of total firm debt from Capital IQ. We begin by examining differences between firms based on their net repurchasing activity. We split firms by average net repurchasing activity and compare median firm characteristics in Table 2 (Appendix B). We note that negative and zero net repurchasers are relatively more comparable, particularly in terms of total assets and reliance on bank debt. By contrast, positive net repurchasers are meaningfully larger in terms of assets, more liquid, and rely much more heavily on non-bank debt (mostly bonds).

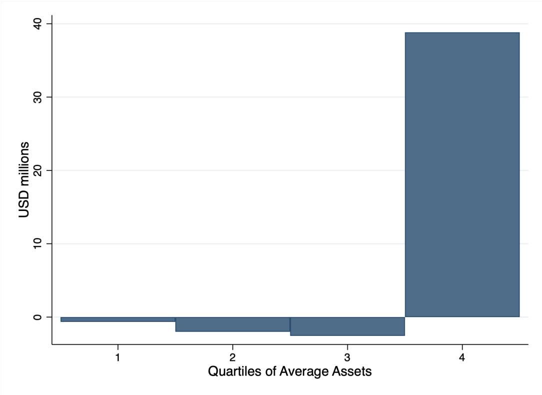
Based on the observation above, we focus further on firms within the largest asset quartile, as they account for a significant majority of the positive net repurchasing activity (Figure 3a) and rely largely on non-bank debt (Figure 3b).

Within this quartile, we consider only firm-quarter observations where Romer and Romer (2004) interest-rate "shocks" were high (in the top quartile in the entire time-series) as in monetary tightening, or low (bottom quartile) as in monetary accommodation.[27] This leaves us with approximately 40,000 firm-quarter observations, split between high and low interest rate shocks. As Table 1 (Appendix B) shows, the top quartile of firms by asset size is indeed the quartile that engages in net repurchases in both high and

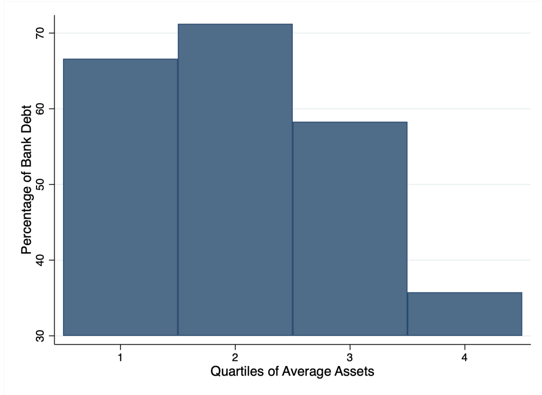
[26]In addition to these papers, Lazonic (2014) underlines the potentially harmful consequences of buybacks on investment, employment and human capital formation, and Almeida, Vyacheslay, and Kronlund (2016) also provides suggestive evidence that buybacks crowd out investment and employment growth, but these papers do not focus on issues related to leverage.

[27]Romer and Romer (2004) methodology to identify interest-rate shocks is explained in Appendix C. As explained therein, presently available data from the Federal Reserve needed for the methodology limit our quarterly time-series of interest-rate shocks to the period 1985–2012.

low interest-rate shocks, with this quartile's net repurchase activity being significantly larger in times of low interest-rate shocks.



(a) Average net repurchases (mln USD) by asset quartile. Asset quartiles are based on average assets over the entire sample for each firm.



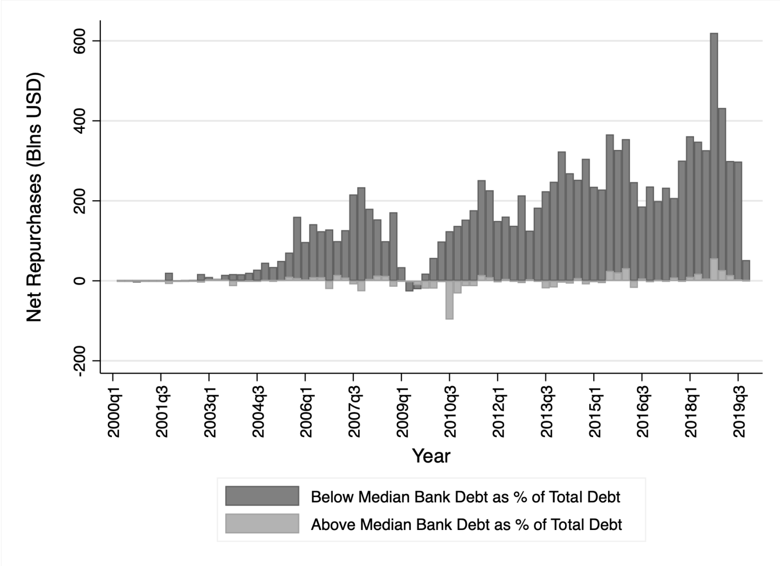
(b) Average proportion of bank debt (%) by asset quartile. Asset quartiles are based on average assets over the entire sample for each firm.

Figure 3

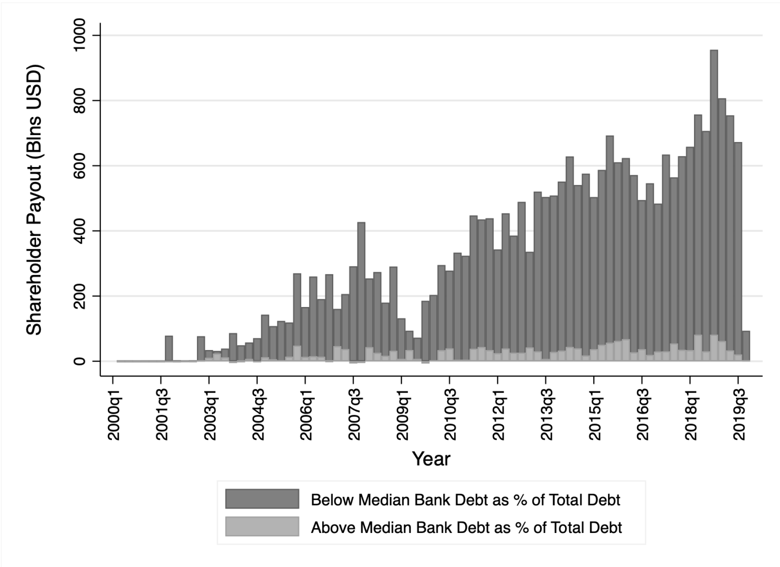
For both levels of interest rate shocks, we further divide firms into five bins of increasing proportion of bank debt over total debt. In summary, we partition our data in three successive steps – first by asset size, then by the level of monetary policy shock, and finally, by the proportion of bank debt.

4.3 Repurchasing activity and bank debt versus market debt

We wish to examine how the source of financing – regulated as in bank debt versus unregulated as in bond financing – influences the repurchasing activity of firms. As a first pass, we note that the aggregate volume of net repurchasing activity is largely driven by firms with a relatively low reliance on bank debt throughout the time-series (Figure 4a). We define non-bank debt as total debt (current and long term debt, per COMPUSTAT) less bank debt. Figure 4a below shows annualized net repurchasing behavior, split by firms above and below the median proportion of bank debt to total debt. Most of the repurchasing activity is driven by firms that are below the median level of bank debt. This could be due to a number of factors – in particular, larger firms tend to conduct more share repurchases and also tend to be less reliant on bank debt. The same observation holds if we consider total shareholder payout (the sum of net share repurchases and dividend payouts) in Figure 4b.

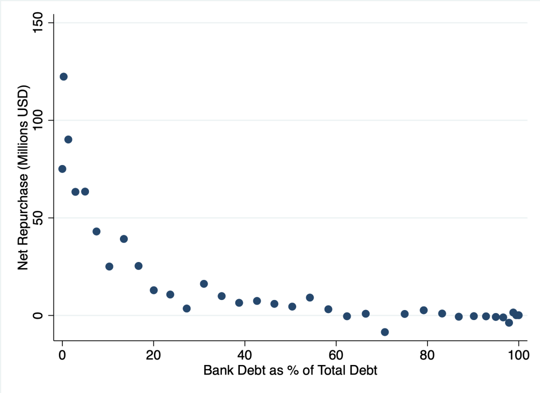


(a) Net share repurchases (billions USD), split by above and below median proportion of bank debt to total debt.

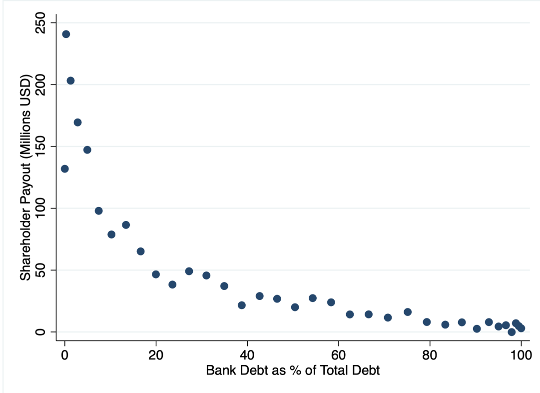


(b) Total shareholder payout (billions USD), defined as the sum of net share repurchases and dividend payouts, split by above and below median proportion of bank debt to total debt.

Figure 4



(a) Binscatter of net repurchasing volume against bank debt as a proportion of total debt.



(b) Binscatter of shareholder payouts (defined as the sum of net share repurchases and dividend payouts) against bank debt as a proportion of total debt.

Figure 5

To explore the impact of the nature of financing on repurchasing activity, we first consider some aggregate directional relationships between net repurchasing activity and different types of debt. Total debt levels tend to covary positively with net repurchases – firms with higher debt tend to spend more on repurchases. However, firms with a higher proportion of bank debt relative to total debt tend to repurchase less (Figure 5a). This relationship persists after we control for firm asset size (figure available upon request). This evidence suggests that the volume of share repurchases is more sensitive to non-bank debt, which is typically financed in the form of bonds from unregulated (or weakly regulated) parts of the financial sector. Furthermore, the repurchase activity is driven by firms that do not rely heavily on financing from banks which are more heavily regulated in terms of leverage provision to firms. Finally, we note that these patterns remain similar if we consider the relationship between total shareholder payout and bank debt (Figure 5b).

4.4 Monetary policy, market debt, and repurchase activity

Having suggested that share repurchases are more sensitive to non-bank debt, we test if this dependence is more responsive to the price of non-bank debt, proxied by Romer-Romer interest-rate shocks.

Below, we examine the difference in net repurchasing volume and net repurchasing volume normalized by market value between low and high monetary shocks for the set of firms in the highest quartile of assets. In general, we find that firms tend to repurchase more (both in levels and normalized by market value) when monetary policy shocks are lower. This is in line with our conjecture that firms may be financing repurchases with debt issuances; as the cost of debt decreases, net repurchases increase from leverage raised from weakly regulated parts of the financial system. Furthermore, we expect this difference to be less significant for firms whose cost of borrowing does not co-move closely with the market cost of debt and which borrow more from heavily regulated parts of the financial system.

We see in Figure 6a that this difference does indeed decrease for firms that rely more on bank debt and less on market debt. Further evidence can be seen in Figure 6c, which shows that net repurchase volume are consistently higher for lower interest rate shocks, the difference between the trendlines being substantial for firms with high reliance on non-bank debt and compressed as reliance on bank debt is increased. As above, we see very similar trends in Figures 6b and 6d when we consider total payout rather than net share repurchases.

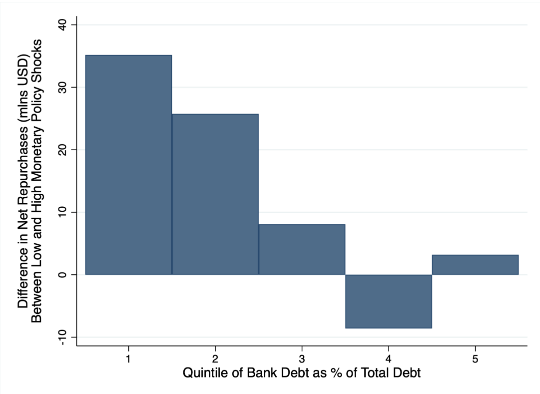
Additionally, as a robustness check, we considered monetary policy shocks as constructed in Kuttner (2000) and analyzed the difference in net repurchasing volume across quintiles of percentage bank debt for different interest rate environments as in Figure 6. We find that similar trends persist in particular, that differences in net repurchases between low and high monetary shock periods are most pronounced for firms which rely more on non-bank debt.[28]

While far from being conclusive, this is suggestive evidence that looser monetary policy and associated lower cost of debt leads firms to increase leveraged share repurchases funded by debt raised from bond markets, *i.e.*, from the lightly regulated parts of the financial system.

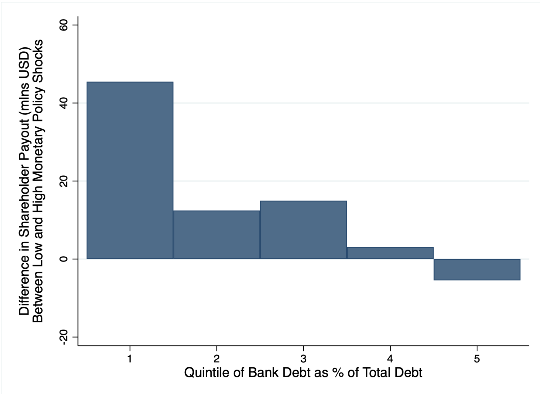
4.5 Repurchasing activity and real investments

So far, we have have provided some evidence that loose monetary policy leads to increased share repurchases (and investor payouts). In this section, we focus on the investment outcomes which result from these payout policies. We control for investment opportunities using Tobin's Q, defined as the market value of assets over their replacement value. We

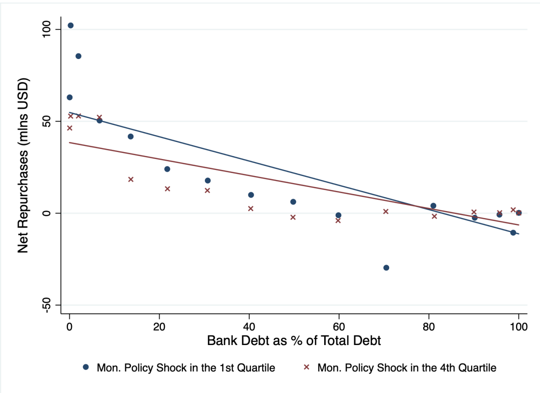
[28]See Appendix C for details on the Kuttner (2000) methodology and figures analogous to Figure 6 using the Kuttner monetary policy shocks.



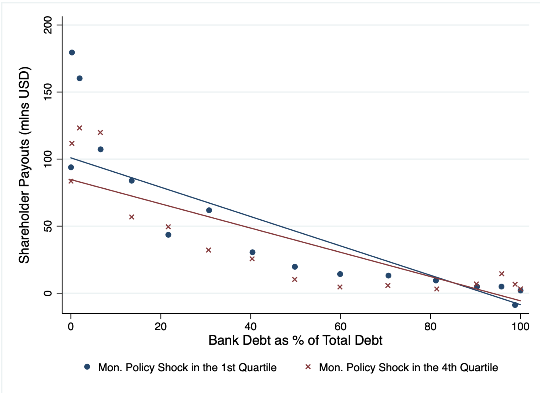
(a) Difference in net repurchasing volume (mlns USD) conducted during low (bottom quartile) and high (top quartile) monetary policy shocks.



(b) Difference in total shareholder payout (sum of net repurchases and dividends) during low (bottom quartile) and high (top quartile) monetary policy shocks.



(c) Binscatter of net repurchase volume against bank debt as a proportion of total debt, by low/high monetary policy shocks.



(d) Binscatter of total shareholder payout (sum of net repurchases and dividends) against bank debt as a proportion of total debt, by low/high monetary policy shocks.

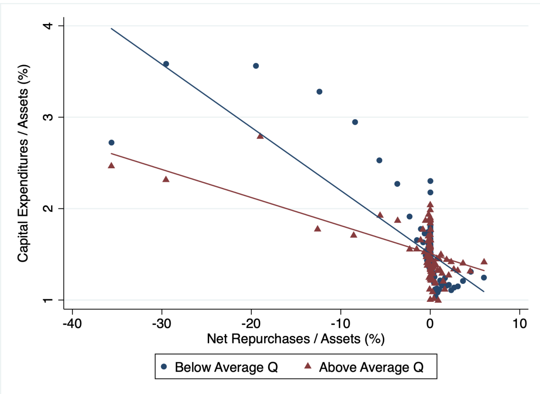
Figure 6

proxy for this value by assuming that the market value of debt is equal to the book value, and that the replacement value of assets is equal to the book value.

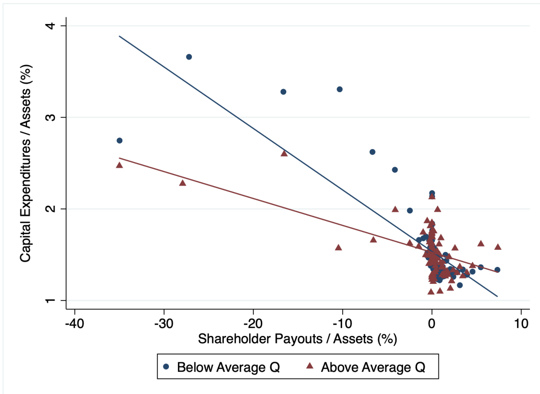
Figure 7 plots binscatters of capital expenditures against net repurchases (Figure 7a) and total shareholder payout (Figure 7b), where all variables are normalized by firm assets in the prior quarter. We show similar trends persist when examining total shareholder payouts in Figure 10 (Appendix D).

We note the negative relationship in Figure 7 suggests that net repurchases (and total shareholder payouts) may detract from capital expenditures; a similar trend emerges when we include R&D expenditures in our metric of real investments (Figure 10).

Combining the results from the current and prior sub-sections, we conclude that firms relying on non-bank financing tend to increase repurchases (and shareholder payouts) during easy monetary policy, and such increase in leveraged payouts is associated with lower real investment levels. Much remains to be done to establish these empirical links with rigorous econometric methods.



(a) Binscatter of capital expenditures against net repurchases for firms with below and above average Q. Both capex and repurchases are normalized by assets in the prior quarter.



(b) Binscatter of total shareholder payouts against net repurchases for firms with below and above average Q. Both capex and shareholder payouts are normalized by assets in the prior quarter.

Figure 7

5 Concluding remarks

This paper studies a model of the interest-rate channel of monetary policy in which low official rates aim at spurring investment. Firms take advantage of such low rates in two ways. They invest, but also frontload consumption by means of leveraged payouts. If a standard friction (moral hazard, adverse selection, or rollover risk) creates a tension between leveraged payouts and productive efficiency, then firms undertake a privately optimal tradeoff. Their choice is socially suboptimal though, as reduced efficiency is a social loss whereas early consumption is a welfare-neutral transfer. Controlling overall leverage in the private sector suffices to restore the first-best, but is out of reach in the presence of a large shadow-banking sector. We provide descriptive evidence that is in line with our prediction that leveraged payouts in response to monetary easing are funded in the least regulated corners of the financial system.

There are several promising directions along which our model can be extended. While low interest rates are associated with a growth in unregulated leverage or shadow banking, this growth can also have equilibrium effects on the nature of risks undertaken by banks and other regulated entities. Modelling the impact of monetary easing with risk heterogeneity across firms and featuring co-existence of regulated and unregulated leverage appears to be an interesting line of research for further inquiry.

Similarly, the recently witnessed fallout of the pandemic begs the question as to how leveraged payouts interact with shocks to firm profitability to create rollover risk. Answering this question requires a natural extension of our framework to aggregate risks with embedding of fire-sale externalities, which would create a tension between ex-post monetary measures such as the lender-of-last-resort policies of a central bank and its ex-ante decision whether to accommodate in order to stimulate investment.

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Appendix A Proofs

Proof of Proposition 1

The case $r \geq R$ is straightforward and derived in the body of the paper. In the case $r < R$, in order to derive the conditions in (7), notice first that (4) implies $e = \pi x$. Plugging this into (3), the objective becomes

$$\pi x \left(\frac{1-x}{r} + \frac{x}{2R} \right) f(I) + \frac{W}{r} - I, \tag{39}$$

and first-order conditions with respect to x and I yield the two remaining conditions in (7).

Suppose $f(I) = I^{1/\gamma}$. When $r < R$, the expected output is

$$ef(I) = \left(\frac{\pi R}{2R - r} \right)^{\frac{\gamma}{\gamma - 1}} \left(\frac{1}{2\gamma r} \right)^{\frac{1}{\gamma - 1}}, \tag{40}$$

and standard derivation yields its variations with respect to r. ■

Proof of Proposition 5

At all dates other than 0, the rigid wage w^* coincides with the flexible one, and so laissez-faire is optimal. At date 0, suppose first that effort is observable, and so $e_0 = \pi$. Facing a prudential regulation $\lambda \in [0, 1]$ and $r \leq R$, a date-0 entrepreneur borrows B and hires l that solve:

$$\max_{B,l} \left\{ c_0 + \frac{c_1}{R} \right\} \tag{41}$$

s.t.

$$c_0 + w^* l \leq B, \tag{42}$$

$$c_1 + rB \leq \pi f(l) + W, \tag{43}$$

$$rB \leq \lambda(\pi f(l) + W), \tag{44}$$

$$c_0 \geq 0. \tag{45}$$

Inequalities (42) and (43) clearly bind at the optimum, and so does (44) since $r < R$. Injecting these equalities in the objective and differentiating w.r.t. l yields a first-order condition:

$$\pi\left(\frac{1-\lambda}{R}+\frac{\lambda}{r}\right)f'(l)=w^*. \tag{46}$$

Ensuring that $l = l_\rho$ and that date-0 entrepreneurs can borrow sufficiently to absorb workers' savings $\rho g(1-l_\rho)+w^*l_\rho$ yields two equations that uniquely define λ_ρ and r_ρ:

$$\pi\left(\frac{1-\lambda}{R}+\frac{\lambda}{r}\right)f'(l_\rho)=w^*, \tag{47}$$

$$\frac{\lambda}{r}(\pi f(l_\rho)+W)=\rho g(1-l_\rho)+w^*l_\rho. \tag{48}$$

If date-0 entrepreneurs find it optimal to issue only safe debt under (λ_ρ, r_ρ) in the absence of moral hazard, then they find it a fortiori desirable when their effort is not observable; this is because moral hazard only adds an incentive-compatibility constraint to their problem that reduces the benefits from issuing risky debt. ■

Proof of Proposition 6

Proof of points 1. and 2. Laissez-faire is optimal for all $t \neq 0$ because the wage is at its flexible level. Regarding the date-0 cohort, the optimal rate $r \leq 1$ maximizes:

$$\Sigma_\rho(r)=\left(e(r)-\frac{e(r)^2}{2\pi}\right)\frac{f\left(l(r)\right)}{R}+\rho g(1-l(r)), \tag{49}$$

where relations (34) and (35) implicitly define $e(r)$ and $l(r)$, which are obviously differentiable with respect to r, respectively increasing and decreasing. For r' such that $l(r')=l_\rho$, we have:

$$\Sigma_\rho'(r')=\underbrace{e'(r')\left(1-\frac{e(r')}{\pi}\right)}_{>0}\frac{f\left(l(r')\right)}{R}+\underbrace{l'(r')}_{<0}\underbrace{\left[\left(e(r')-\frac{e(r')^2}{2\pi}\right)\frac{f'\left(l(r')\right)}{R}-\rho g'(1-l(r'))\right]}_{<0}>0. \tag{50}$$

The last negative sign stems from the fact that by definition of l_ρ, $\pi f'(l(r'))/2R = \rho g'(1-l(r'))$ and $e(r') < \pi$. Then, the fact that surplus is strictly increasing at r' such that $l(r') = l_\rho$ implies in turn points 1. and 2. in the proposition ($l_u < l_\rho$).

Proof of point 3. Aggregate income is split as follows across agents at dates 0 and 1 .

- Date-0 aggregate income (net of effort cost)

$$W + \pi f(l^*) + \rho g(1 - l_u) - \frac{e_0^2 f(l_u)}{2\pi R} \tag{51}$$

  is split into the consumptions of

  - Old workers: $R(g(1 - l^*) + w^* l^*) - \left[\frac{W+(1-x_0)e_0 f(l_u)}{r_u} - \rho g(1 - l_u) - w^* l_u\right]$
  - Old entrepreneurs: $\pi f(l^*) + W - R(g(1 - l^*) + w^* l^*)$
  - Young entrepreneurs: $\frac{W+(1-x_0)e_0 f(l_u)}{r_u} - w^* l_u - \frac{e_0^2 f(l_u)}{2\pi R}$

- Date-1 aggregate income (net of effort cost)

$$W + e_0 f(l_u) + g(1 - l^*) - \frac{\pi^2 f(l^*)}{2R} \tag{52}$$

  is split into the consumptions of

  - Old workers: $r_u(\rho g(1-l_u)+w^* l_u)+[W + (1 - x_0)e_0 f(l_u) - r_u(\rho g(1 - l_u) + w^* l_u)]$
  - Old entrepreneurs: $x_0 e_0 f(l_u)$
  - Young entrepreneurs: $g(1 - l^*) + w^* l^* - w^* l^* - \frac{\pi^2 f(l^*)}{2R}$

Overall, old date-0 workers are taxed $[W + (1 - x_0)e_0 f(l_u)]/r_u - \rho g(1 - l_u) - w^* l_u$, allowing young entrepreneurs to consume the equivalent amount on top of what they receive from young workers ($\rho g(1 - l_u) + w^* l_u$). Date-1 old workers in turn receive a rebate of $[W + (1 - x_0)e_0 f(l_u) - r_u(\rho g(1 - l_u) + w^* l_u)]$ on top of the proceeds from their loans to entrepreneurs. The difference between the tax on date-0 workers and the value of this rebate to date-1 workers discounted at R accrues to date-0 entrepreneurs. ■

Proof of Proposition 7

Step 1. It is optimal to set $r_u = R$ for ρ sufficiently large.

Differentiating

$$\frac{\pi R f'(l(r))}{2(2R - r)} = r w^* \tag{53}$$

w.r.t. r for $r \in (0,1)$ yields

$$l'(r) = \frac{4w^*(R-r)}{\pi R f''(l(r))}, \tag{54}$$

and so one can write

$$\Sigma'_\rho(r) = (R-r)\left[\underbrace{\frac{\pi f(l(r))}{(2R-r)^3}}_{A} + \frac{4w^*}{\pi R f''(l(r))}\left[\underbrace{\frac{\pi(3R-2r)f'(l(r))}{2(2R-r)^2} - \rho g'(1-l(r))}_{B}\right]\right] \tag{55}$$

We have $\lim_{r\to R} l(r) = l^*$, and so for (ρ, r) sufficiently close to $(1, R)$, term B becomes arbitrarily close to 0 from the first-best condition $\pi f'(l^*)/(2R) = g'(1-l^*)$. Term A on the other hand stays bounded away from 0 for (ρ, r) in the neighborhood of $(1, R)$, and thus $\Sigma' > 0$ in this neighborhood. Furthermore, a standard continuity argument implies that $\lim_{\rho\to 1} r_u = R$. As a result, $\Sigma'(r_u)$ must be strictly positive for ρ sufficiently close to 1, implying that (r_u, l_u) is actually equal to (R, l^*) for ρ sufficiently close to 1.

Step 2. Existence of $\bar{\rho}$.

Let $\underline{r}$ denote the value of r such that (53) yields $l(\underline{r}) = 1$. Let Ω denote the subset of values of $\rho \in (0,1)$ such that the maximum of $\Sigma_\rho(r)$ over $r \in [\underline{r}, R]$ is interior, that is, such that it is reached at some $r \in (\underline{r}, R)$. We know from Step 1 that $r_u = R$ for ρ sufficiently large. This implies that $\Omega \neq (0,1)$, and therefore that $\bar{\rho}$, if it exists, is strictly smaller than 1.

If $\Omega = \emptyset$, this means that $\Sigma_\rho(r)$ is maximum at $r = R$ for every $\rho \in (0,1)$ because Σ'_ρ is strictly positive in the right-neighborhood of $\underline{r}$ (in turn because $g'(1-l(r))$ is unbounded in this neighborhood) and thus the maximum of Σ_ρ, if not interior, cannot be at $\underline{r}$. It must therefore be at $r = R$. This implies that $\bar{\rho}$ exists and is equal to 0 in this case.

Suppose otherwise that $\Omega \neq \emptyset$. We show that Ω must be of the form $(0, \bar{\rho})$. To see this, notice that for any $\rho \in \Omega$, the envelope theorem implies that

$$\frac{d\Sigma_\rho}{d\rho} = g(1-l_u). \tag{56}$$

The output net of effort costs of the date-0 cohort when the interest rate is $r_u = R$ reads:

$$\frac{\pi f(l^*)}{2R} + \rho g(1 - l^*). \tag{57}$$

Expression (57) is linear in ρ, with a slope $g(1 - l^*)$ larger than $g(1 - l_u)$ since $l_u > l^*$ when $r_u < R$ from (53). This means that if $\rho \in \Omega$, then the left-neighborhood of ρ is also within Ω because Σ_ρ admits a local extremum that is strictly larger than its value for r in the neighborhood of R. This establishes that Ω is an interval of the form $(0, \bar{\rho})$.

Step 3. Examples such that $\bar{\rho} = 0$ and $\bar{\rho} > 0$.

Suppose that $f(l) = \frac{2Rg'(0.5)}{\pi} l^{\frac{1}{\gamma}}$ for $\gamma > 1$.

We have

$$\frac{\pi R f'(l_u)}{2(2R - r_u)} = r_u w^*, \tag{58}$$

$$\frac{\pi f'(l_\rho)}{2} = \frac{R w_\rho}{w^*} w^*, \tag{59}$$

implying

$$r_u(2R - r_u) = \frac{R^2 w_\rho}{w^*} \left(\frac{l_u}{l_\rho}\right)^{\frac{1}{\gamma} - 1}. \tag{60}$$

l_u and l_ρ remain bounded and bounded away from 0 for as $\gamma \to 1$ because they are smaller than 1 and larger than l^* which tends to 0.5 as $\gamma \to 1$. Thus, letting $\gamma \to 1$ in (60) yields

$$\frac{R w_\rho}{w^*} \simeq r_u \left(2 - \frac{r_u}{R}\right), \tag{61}$$

and this implies

$$r_u < \frac{R w_\rho}{w^*} < R. \tag{62}$$

Note that we have actually established that $\lim_{\gamma \to 1} \bar{\rho} = 1$.

We have

$$\Sigma'_\rho(r) = (R-r)\left[\frac{2Rg'(0.5)l^{1/\gamma}}{(2R-r)^3} - \frac{2w^*(3R-2r)\gamma}{R(2R-r)^2(\gamma-1)}l + \frac{\rho g'(1-l)\gamma^2 2w^*}{g'(0.5)(\gamma-1)R^2}l^{2-1/\gamma}\right] \quad (63)$$

There exists l^0 sufficiently small such that the first term dominates the second one for all values of $(r,l) \in [0,R] \times (0,l^0)$ for γ sufficiently large. The third term dominates the second term for γ sufficiently large and all $(r,l) \in [0,R] \times (l^0,1)$. Thus $\Sigma'_\rho > 0$ for γ sufficiently large which implies $\bar{\rho} = 0$. ■

Proof of Proposition 8

The entrepreneur solves

$$\max_{e,I,x}\left\{\frac{(1-x)ef(I)}{r} - I + \left(xe - \frac{e^2}{2\pi}\right)\frac{f(I)}{R}\right\} \quad (64)$$

s.t.

$$\frac{(1-x)ef(I)}{r} \geq I, \quad (65)$$

$$e = \arg\max_y\left\{xy - \frac{y^2}{2\pi}\right\}. \quad (66)$$

If (65) is not binding, it must be that $r \leq R$, and the solution is given by conditions (8) with $f(I) = 2\sqrt{I}$, yielding the expressions in the proposition. Writing that (65) binds with I and x as such functions of r yields that it binds for $r \geq 2R/3$.

In this binding case, it is still the case that $e = \pi x$, and I given x results from the binding condition (65). Injecting this value for I in the objective and maximizing it over x yields $x = 3/4$. ■

Proof of Proposition 9

If a good entrepreneur borrows only to invest, her utility $(f(I) - rI)/R$ is maximum at $I = 1/r^2$, equal to $1/(Rr)$, whereas if she borrows against her entire output her utility is $qf(I)/r - I$, maximum at $I = q^2/r^2$ and equal in this case to q^2/r^2, which yields the results. ■

Proof of Proposition 10

If the entrepreneur borrows only to invest, assuming she can always repay her debt, her utility $[f(I) - [1 - q + q/(1 - \eta)]rI]/R$ is maximum at $I = [[1 - \eta]/[1 - \eta(1 - q)]r]^2$ and equal to $[1 - \eta]/[[1 - \eta(1 - q)]Rr]$. Furthermore, $\eta \leq 1/2$ ensures that debt is indeed risk-free, as straightforward shows that $(1 - \eta)f(I) \geq rI$ as soon as $\eta \leq 1/[2(1 - q)]$. If the entrepreneur borrows against her entire output her utility is $(1 - \eta q)f(I)/r - I$, maximum at $I = [(1 - q\eta)/r]^2$, equal in this case to $[(1 - q\eta)/r]^2$, which yields the results. ■

Appendix B Summary Statistics

	Net Repurchases	Net Repurchases (W)	Assets
Quartile 1	-871	-871	20
Quartile 2	-3006	-3002	136
Quartile 3	-3233	-2547	630
Quartile 4	46169	29791	11774

	Net Repurchases	Net Repurchases (W)	Assets
Quartile 1	-978	-978	22
Quartile 2	-2670	-2595	136
Quartile 3	-4271	-2745	648
Quartile 4	66651	40688	12082

Table 1: The top (bottom) table shows cumulative net repurchases and average assets for firms across all four asset quartiles during periods with high (low) monetary policy shocks, 2000 - 2012 (inclusive). A '(W)' indicates that that the variable was winsorized at the 1% level. All values are in millions of USD.

	Negative Net Repurchases (Median)	Zero Net Repurchases (Median)	Positive Net Repurchases (Median)
Net Repurchases (mlns)	-0.17	0.00	2.11
Market Value (mlns)	361.15	58.76	2170.02
Market/Book	2.00	1.14	2.28
Assets (mlns)	399.80	162.84	2319.65
Total Debt (mlns)	71.75	35.14	605.02
Total Bank Debt (mlns)	23.25	17.38	85.00
Total Bank Debt/Total Debt	68.43	76.33	35.65
Total Debt/Assets	0.24	0.28	0.26
Total Bank Debt/Assets	0.10	0.15	0.07
Cash/Assets	0.06	0.04	0.06
Capex/Assets	0.02	0.01	0.02
Current Ratio	14.36	6.68	19.43
Interest Coverage Ratio	2.16	1.07	6.84
Altman Z-score	2.89	1.41	3.43
Observations	32995	13662	30754

Table 2: Median values for firms conducting negative, zero, and positive annual net repurchases. Observations are at the firm-quarter level, 2000-2019 (inclusive). Current ratio is short term assets / short term liabilities; interest coverage ratio is operating income / interest expense.

Appendix C Monetary Policy Shocks

For the results in the paper, we use Romer and Romer (2004) methodology to construct monetary policy shocks. The idea is to construct an exogenous shock to account for the fact that the level of nominal interest rates also embeds other factors–notably, aggregate market conditions–which also impact the likelihood of share repurchases.

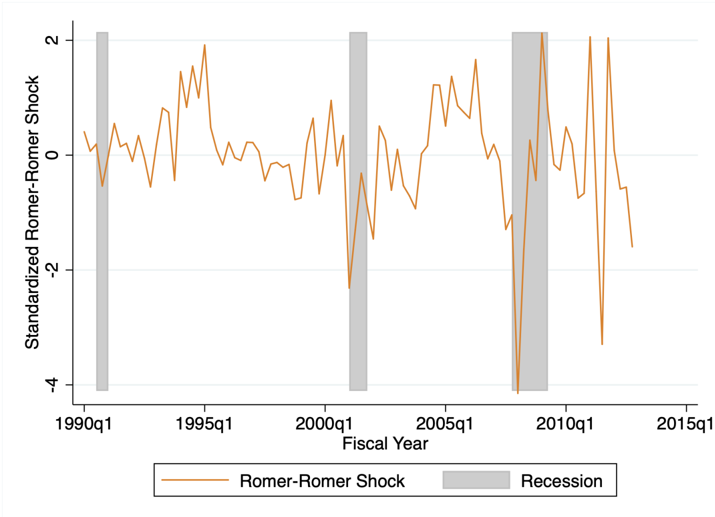


Figure 8: Standardized Romer-Romer shocks, 1990 - 2012 (inclusive). The data is extended from the original sample from December 1996, per Breitenlechner (2018).

Romer-Romer shocks are the changes in the federal funds rate which are not explained by the Federal Reserve's own internal (Greenbook) forecasts of real GDP, inflation and unemployment. This construction assumes that the Federal Reserve has superior information about the economy and attempts to purge the change in federal funds rate which is directly in response to the levels of real GDP, inflation, and unemployment. Specifically, Romer-Romer methodology runs the following regression:

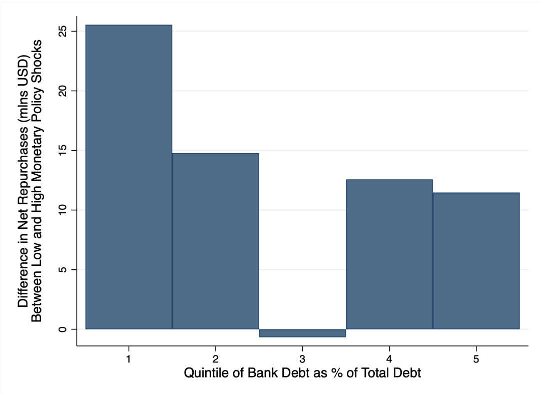
$$\Delta ff_m = \alpha + \beta \cdot ff_m + \sum_{i=-1}^{2} \gamma_i \widetilde{\Delta y}_{m,i} + \sum_{i=-1}^{2} \lambda_i (\widetilde{\Delta y}_{m,i} - \widetilde{\Delta y}_{m-1,i})$$
$$+ \sum_{i=-1}^{2} \phi_i \widetilde{\pi}_{m,i} + \sum_{i=-1}^{2} \theta_i (\widetilde{\pi}_{m,i} - \widetilde{\pi}_{m-1,i}) + \rho \widetilde{u}_{m0} + \epsilon_m$$

where Δff_m is the intended Federal Funds rate change to occur at meeting m; ff_m is the current interest rate target going into the meeting, $\widetilde{\Delta y}_{m,i}$, $\widetilde{\pi}_{m,i}$, $\widetilde{u}_{m,i}$ are Greenbook forecasts of real output growth, inflation, and unemployment for quarter i (where $i = 0$

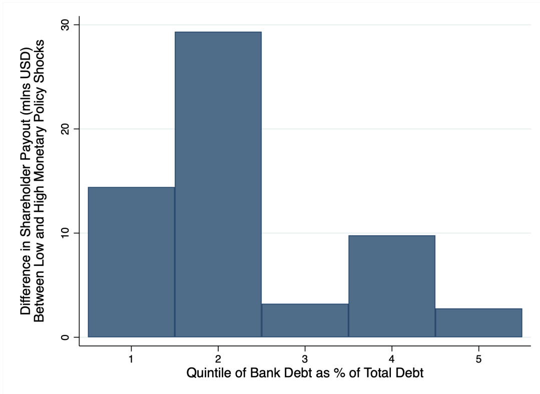
is the quarter of meeting m). The series of estimated innovations $\hat{\epsilon}_m$ forms the series of policy shocks that we use in our analysis.

Our time-series of shocks is quarterly, from 1985–2012. Our time series is truncated due to data limitations associated with obtaining current Greenbook data. Public releases of Federal Reserve forecasts are subject to a five year lag, and further, the lagged data are released only once per year. At the time of our writing, publicly available data is available only up to 2013. From 2009 onwards, interest rates approached the zero lower bound and the Federal Reserve began a series of asset purchases. Since the zero lower bound may not adequately capture the intended policy target, the updated series uses a shadow short rate constructed in Krippner (2015), which is not bounded by zero and is estimated based on longer maturity interest rates.

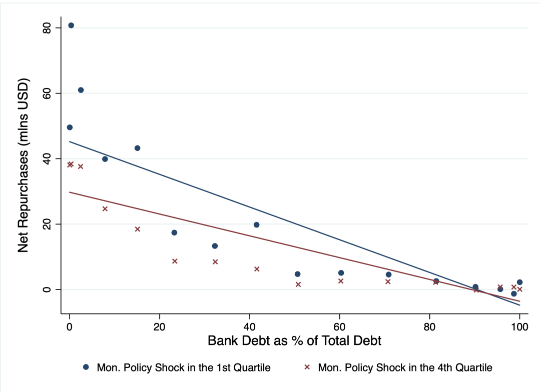
We verify the robustness of our results by also employing Kuttner (2000), which yields a series of monetary policy shocks based upon the movement in the Fed Funds futures. The core idea is as follows. Given a monetary policy committee meeting on date t, the day $t-1$ futures embed the expected change in interest rates on, or after, date t. Therefore, any deviation from this expectation on the day of the meeting represents the 'surprise' in the monetary policy change. We replicate Figure 6 with Kuttner shocks and find similar trends as with Romer-Romer shocks.



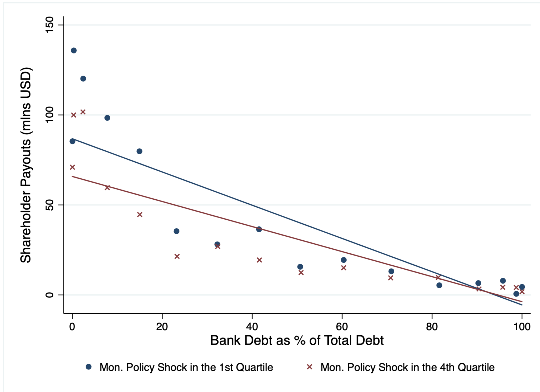
(a) Difference in net repurchasing volume (mlns USD) conducted during low (bottom quartile) and high (top quartile) monetary policy shocks.



(b) Difference in total shareholder payout (sum of net repurchases and dividends) during low (bottom quartile) and high (top quartile) monetary policy shocks.



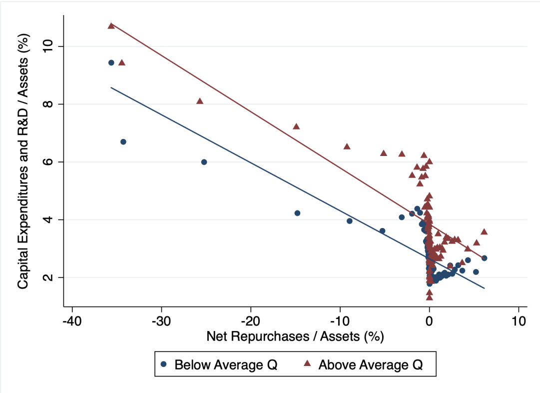
(c) Binscatter of net repurchase volume against bank debt as a proportion of total debt, by low/high monetary policy shocks.



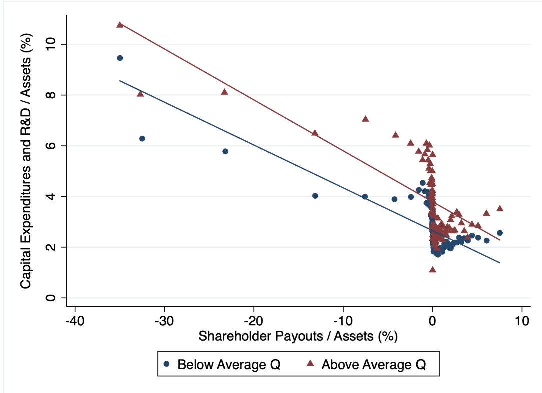
(d) Binscatter of total shareholder payout (sum of net repurchases and dividends) against bank debt as a proportion of total debt, by low/high monetary policy shocks.

Figure 9

Appendix D Repurchasing activity and real investments



(a) Binscatter of capex and R&D expenditures against net repurchases for firms with below and above average Q. Both capex and R&D as well as net repurchases are normalized by assets in the prior quarter.



(b) Binscatter of capex and R&D expenditures against shareholder payouts for firms with below and above average Q. Both capex and R&D as well as net repurchases are normalized by assets in the prior quarter.

Figure 10