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MONETARY EASING, LEVERAGED PAYOUTS AND LACK OF INVESTMENT

Viral V. Acharya and Guillaume Plantin

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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 firms, thereby spurring productive investment. Low interest rates also induce firms to lever up so as to increase payouts to shareholders. Whereas such leveraged payouts privately benefit shareholders, they come at the social cost of reducing incentives to monitor firms, thereby degrading the quality of the assets that back corporate debt. In the presence of an unregulated shadow-banking system, the monetary authority has no choice but stimulating investment below first-best levels in order to contain such socially costly leveraged payouts.

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Introduction

Following the global financial crisis of 2007-08, most major central banks have embarked upon so-called unconventional monetary policies. These policies feature monetary easing aimed at keeping interest rates at ultra-low levels. Most notably, the Federal Reserve kept for over eight years interest rates at the zero lower-bound with large-scale asset purchases of Treasuries and mortgage-backed securities. European Central Bank followed suit with such purchases and so did the Bank of Japan.

These unconventional monetary policies have spurred debt issuance by both financial institutions and non-financial corporations.

In the financial sector, the size of the shadow-banking system now exceeds its 2008 peak. Non-bank financial institutions have increasingly engaged into (unregulated) maturity transformation, rolling over short-term liabilities in order to fund flows into risky asset classes that include junk bonds and collateralized leveraged loans, residential mortgage-backed assets (Stein 2013), and emerging-market government and corporate bonds (Acharya and Vij 2016, Bruno and Shin 2014, Feroli et al. 2014). IMF GFSR (2016) documents that the presence of such a “risk-taking channel” in the non-bank finance (insurance companies, pension funds and asset managers) implies that monetary policy remains potent in affecting economic and financial outcomes even when banks face strict macroeconomic regulation.

Non-financial corporations have also increasingly engaged into financial risk-taking. The US corporate sector has raised \$7.8 trillion in debt over the 2010-2017 period, whereas net equity issuance has been negative due to payouts to shareholders that are at a high point compared with historical averages. As a result corporate leverage is close to historical highs for large

firms¹, and has more broadly risen to levels exceeding those prevailing just before the global financial crisis, particularly so in the segment of leveraged loans (IMF GFSR 2017, 2018).

Several observers and policymakers lament the disappointing impact of such financial risk-taking on capital expenditures.² Investment has not returned yet to its pre-recession trends despite a large wedge between low interest rates and historically high realized rates of return on existing capital.³ These high returns on capital have fuelled an increase in firms' payout to their shareholders, notably in the form of share repurchases (Furman 2015).

Motivated by these facts, this paper develops a model in which monetary easing has a limited impact on productive investment. It spurs instead leveraged payouts that are socially costly because they negatively affect firms' incentives, thereby degrading the quality of their assets.

Gist of the argument. Suppose that an agent who values consumption at two dates 0 and 1 is endowed with a technology that converts date-0 consumption units into date-1 units with decreasing marginal returns. 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. One interpretation of this trade is indeed that the agent sets a corporation that operate her investment, and that this corporation issues bonds, using the proceeds net of investment outlay either to buy back shares

¹There is significant heterogeneity across sectors, but median net debt across S&P 500 firms is close to an all-time maximum.

²See, in particular, Rajan (2013).

³Return on capital measured as private capital income divided by the private capital stock as in Furman (2015).

from her or to pay her a special dividend.

Suppose now that the output from investment depends on costly private effort by the agent. Such moral hazard introduces a tension between investment and leveraged payouts as the interest rate decreases. On 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, thereby making investment less profitable and thus smaller. The agent sets her leverage at the level that optimally trades off consumption-smoothing and incentives.

The central feature of our setup is that there is in equilibrium a large wedge between this privately optimal trade-off and the socially optimal one. In our model with heterogeneous agents, the early consumption that the most impatient agents get out of such leveraged payouts is merely a welfare-neutral transfer that they receive in equilibrium from more patient ones, whereas their resulting reduced incentives are a pure social cost. This wedge induces the monetary authority to target lower investment levels than it would in the absence of moral hazard.

Our paper suggests a possible connection between two recent evolutions of the US financial system. On one hand, a large unregulated shadow-banking system has risen since the turn of the century. It now originates roughly as much credit as traditional banking. On the other hand, Gutiérrez and Philippon (2017) note among others that, starting also in the early 2000s, US fixed investment has been a decreasing fraction of firms' profits despite a high Tobin's q , and that this coincided with an increase in share buybacks.⁴ In our setup, the extent to which the public sector can regulate private leverage

⁴Gutiérrez and Philippon (2017) argue that this evolution owes to a decline in the degree of competition in US product markets. We view this explanation as complementary to ours.

drives the extent to which monetary easing spurs leveraged payouts instead of productive investment, or, in the language of the IMF (2017), favors financial risk-taking over economic risk-taking.

The paper is organized as follows. As a stepping stone, 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 and derives the main results. Section 3 discusses the results and presents concluding remarks.

Related literature

Our paper relates to recent contributions to three strands of literature.

First, Bolton et al. (2016) or Martinez-Miera and Repullo (2017) offer like us models in which a low cost of capital may be detrimental to incentives in the private sector. Whereas a low cost of capital is due to positive shocks on the supply of savings in their setup (“savings glut”), it stems from an endogenous and optimal monetary-policy decision in a closed economy 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. 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 corporate

payouts.

Finally, we show how monetary easing, even when optimal, may come with financial instability in the form of the socially useless issuance of debt backed by low-quality assets. Several recent contributions highlight like us the negative impact of low policy rates on financial stability. In Farhi and Tirole (2012), the central bank 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, 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. The crowding out of productive real investment by leveraged payouts is an ex-ante second-best.

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 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 the probability of success of his investment e at a private cost $e^2 f(I)/(2\pi)$ that is

subtracted from his date-0 utility over consumption, where $\pi \in (0, 1)$. The entrepreneur is risk neutral over consumption at dates 0 and 1 and does not discount date-1 consumption at date 0. He has a large date-0 endowment of the consumption good $W > 0$. He can trade securities with counterparties that require a gross expected return $r > 0$.

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 his (unit) discount rate.

Suppose first that $r \geq 1$. The entrepreneur in this case uses his own date-0 resources to fund the investment I in his technology f , and invests the residual $W - I$ in securities earning the expected return r . He selects the investment I and effort level e that solve

$$\max_{e, I} \left\{ \left(e - \frac{e^2}{2\pi} \right) f(I) + r(W - I) \right\} \quad (1)$$

maximized at

$$e = \pi, \frac{\pi}{2} f'(I) = r. \quad (2)$$

In this case $r \geq 1$, the probability of success π does not depend on the cost of capital r . Both investment I and expected output $\pi f(I)$ decrease with respect to r .

Leveraged payouts. Consider now the case in which $r < 1$. Given his unit discount factor, the entrepreneur would like to borrow at the rate r against the date-1 consumption that he can generate out of his 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 him a special dividend.⁵

Such borrowing backed by future output however distorts the entrepreneur's incentives to exert effort. The entrepreneur optimally trades off early consumption and incentives by selecting an investment level I , an effort level e , and a leverage $1 - x$ against his output, where $x \in [0, 1]$ is the fraction of the output against which he does not borrow—the “skin in the game”—that solve

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

s.t.

$$e = \arg \max_y \left\{ xy - \frac{y^2}{2\pi} \right\}. \quad (4)$$

Condition (4) is the incentive-compatibility constraint. The first-order conditions are

$$e = \pi x = \frac{\pi}{2-r}, \frac{\pi f'(I)}{2(2-r)} = r. \quad (5)$$

They imply that in this range, a lower cost of capital r induces an increase in leveraged payouts (a lower value of x). Furthermore, since a lower r induces both a lower probability of success $e = \pi/(2-r)$ and a higher investment $I = f'^{-1}(2r(2-r)/\pi)$, the overall impact of a reduction in r on expected output $ef(I)$ is ambiguous. Suppose for analytical simplicity that $f(I) = \gamma I^{1/\gamma}$, where $\gamma > 1$. We show in the appendix that the expected output actually increases in r for $r \in [2/(\gamma+1), 1]$, and decreases otherwise.

⁵Dividends and share buybacks are equivalent in this environment that abstracts from tax considerations.

The following proposition collects the above results.

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

$$e = \pi x = \frac{\pi}{2 - \bar{r}(r)}, \frac{\pi f'(I)}{2(2 - \bar{r}(r))} = r. \quad (6)$$

Thus,

- *For $r \in (1, +\infty)$, a reduction in the cost of capital r is irrelevant for corporate leverage, payout policy, and incentives. It spurs investment and expected output.*
- *For $r < 1$, 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 $r > 1$. Expected output actually increases with respect to r if $r \in [2/(\gamma + 1), 1)$.*

Proof. See the appendix. ■

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.⁶ In the case $r > 1$, fluctuations in the cost of capital only affect corporate investment I . When $r < 1$, by contrast, the cost of capital affects corporate leverage as well, even though the entrepreneur has all the internal liquidity W needed for investment. Leveraged payouts reduce incentives and thus shift the entire production function downwards, so much so that a reduction in the cost of capital actually comes with a reduction in expected output for $r \in (2/(\gamma +$

⁶The broad qualitative insights would clearly carry over under strict concavity.

1), 1]. Thus, the interplay of consumption smoothing and moral hazard with a standard investment problem simply generates the stylized facts described in the introduction.

Cost of capital and realized return on capital. Suppose that the economy may be at date 1 in two states, “normal times” or “crisis”. Whereas the entrepreneur’s project always succeeds in normal times, it may fail during a crisis. The entrepreneur has no control over the probability of occurrence of a crisis but can reduce his failure rate when it occurs by exerting effort. An econometrician interested in the gap between realized return on capital and interest rate would observe the ratio $f'(I)/r$ in normal times. This ratio $f'(I)/r = 2/\pi$ does not depend on r when $r \geq 1$, whereas it *decreases with respect to* r for $r < 1$ from (5). This latter situation is in line with the fact mentioned in the introduction that the gap between realized return on capital and interest rate has reached historical highs in the recent environment of historically low interest rates.

The next section embeds this partial-equilibrium model with exogenous cost of capital into a model in which a central bank with full fiscal backing controls the real rate and thus firms’ cost of capital. The central bank seeks to maximize a standard social welfare function, and sets its policy rate so as to mitigate the distortions induced by rigid wages.

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 at each date and do not discount future consumption. They are born with a large endowment W of the numéraire good.⁷ Each entrepreneur born at date t is 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. Entrepreneurs control the probability of success e at a private cost $e^2 f(l)/(2\pi)$ that is subtracted from their utility when young.

The technology f features a lag between production and delivery of consumption services. This technology thus stands in our stylized model for the

⁷We could endogenize this endowment as labor income at some additional complexity and without gaining insights.

most interest-sensitive sectors of the economy such as durable-good, housing or capital-good sectors.⁸ We accordingly deem firms using technology f the capital-good sector and that using g the consumption-good sector.

The functions f and g are increasing, strictly concave, twice differentiable over $[0, +\infty)$, and such that $\lim_0 f' = \lim_0 g' = +\infty$.

Public sector. The public sector does not consume. It maximizes the sum of the utilities of agents in the private sector, discounting that of future generations with a factor arbitrarily close to 1.

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

Monetary policy. The public sector announces at each date an expected 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. On the other hand, it cannot tax entrepreneurs. This latter assumption is made stark in order to yield a simple and clear exposition of our results.

Relationship to new Keynesian models. This setup can be described as a much simplified version of a new Keynesian model in which money serves only as a unit of account (“cashless economy”) and monetary policy consists in enforcing the short-term nominal interest rate. Such monetary policy has real effects in the presence of nominal rigidities. We entirely focus on these real effects, and fully abstract from price-level determination by assuming extreme nominal rigidities in the form of a fixed price level for the consumption good. This will enable us to introduce ingredients that are typically absent from mainstream monetary models in a tractable framework

⁸A 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.

in the following. In recent contributions, Benmelech and Bergman (2012), Caballero and Simsek (2017) or Farhi and Tirole (2012) also focus on the financial-stability implications of monetary policy abstracting from price-level determination as we do.

2.2 Steady-state

We first study steady-states in which the public sector announces a constant gross interest rate r at each date. We suppose that the public sector offsets its net position in the bond market at each date with a lump-sum tax or rebate on current old workers. We denote $w \geq 0$ the steady-state wage, and $l \in [0, 1]$ the steady-state quantity of labor used by entrepreneurs. The steady-state associated with a policy rate r can then be characterized as follows.

Entrepreneurs. Each entrepreneur's problem is identical to that in Section 1.⁹ As in Section 1, we denote x the skin in the game of an entrepreneur and $\bar{r}(r) = \min\{r; 1\}$. Each entrepreneur's objective is then

$$\max_{e,l,x} \left\{ (1 + r - \bar{r}(r)) \left[\frac{(1-x)ef(l)}{r} + W - wl \right] + \left(xe - \frac{e^2}{2\pi} \right) f(l) \right\} \quad (7)$$

s.t.

$$e = \arg \max_y \left\{ xy - \frac{y^2}{2\pi} \right\}. \quad (8)$$

Expression (7) for entrepreneurs' surplus subsumes (1) and (3), taking into account that $x = 1$ is optimal when $r \geq 1$. From Proposition 1, each en-

⁹Up to the change of variable $I = wl$.

trepreneur chooses e , x , and l such that

$$x = \frac{1}{2 - \bar{r}(r)}, e = \pi x, \frac{\pi f'(l)}{2(2 - \bar{r}(r))} = rw. \quad (9)$$

Furthermore, taking again into account that $x = 1$ whenever $r \geq 1$, one can write an entrepreneur's net position in the bond market when young as:

$$\mathbb{1}_{\{r \geq 1\}}(W - wl) - \frac{(1 - x)ef(l)}{r}. \quad (10)$$

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

$$g'(1-l) = w. \quad (11)$$

Since they consume only when old, workers invest the resulting total income $g(1-l) + wl$ in the bond market thereby receiving a pre-tax income $r[g(1-l) + wl]$ when old. The government rebates as a lump-sum to old workers the investment in public bonds by contemporaneous young workers and entrepreneurs net of the repayment of maturing bonds.

Equations (9) and (11) uniquely determine the steady-state values of (x, e, l, w) for a given interest rate r . The surplus of a given cohort is for

such an interest rate:

$$\begin{aligned}
& \underbrace{(1 + r - \bar{r}(r)) \left(\frac{(1-x)ef(l)}{r} + W - wl \right) + \left(xe - \frac{e^2}{2\pi} \right) f(l)}_{\text{Entrepreneurs' surplus}} \\
& + \underbrace{rwl + rg(1-l)}_{\text{Old workers' pre-tax income}} \\
& + (1-r) \underbrace{\left[\mathbb{1}_{\{r \geq 1\}}(W - wl) - \frac{(1-x)ef(l)}{r} + g(1-l) + wl \right]}_{\text{Rebate to old workers}} \quad (12) \\
& = W + \left(e - \frac{e^2}{2\pi} \right) f(l) + g(1-l). \quad (13)
\end{aligned}$$

An important remark is in order before solving for the optimal steady-state interest rate. Note from expression (13) that the interest rate r affects social surplus only through its impact on the values of e and l that entrepreneurs choose in equilibrium. Entrepreneurs' surplus by contrast also directly depends on r from (8). In particular, when $r < 1$, entrepreneurs directly benefit from lower interest rates through higher leveraged payouts when young. Proposition 1 describes how they optimally trade off the benefits from such leveraged payouts with the costs of reduced incentives. Expression (13) shows that this trade-off is privately but not socially optimal, however. Reduced incentives are social costs whereas early consumption from early payouts are only transfers from old workers towards young entrepreneurs that are neutral given the assumed social welfare function. In short, leveraged payouts are in this model a form of inefficient rent extraction by entrepreneurs that is detrimental both to savers and to asset quality. The following quote by Andrew Sorokin (2010) reflecting on the monetary remedies to the 2008 crisis epitomizes this mechanism:

“It doesn't help that the economic medicine used by policymakers after a

crisis exacerbates those feelings of anger. The most efficient fix—lowering interest rates—helps the wealthy because they end up with cheaper mortgages and enjoy the benefits that low rates have on corporate growth. Those lower on the economic ladder, on the other hand, get little in interest on their savings. The gap between the haves and the have-nots widens. But that approach actually works, pulling everyone along with it, even if it is uneven and there are greater beneficiaries than others.”

We now solve for the optimal steady-state interest rate. Expression (13) implies that the public sector optimally seeks to implement (e^*, l^*) such that $e^* = \pi$ and $\pi f'(l^*)/2 = g'(1 - l^*)$. Given that profit maximization implies

$$g'(1 - l) = w \tag{14}$$

in the consumption-good sector and

$$\frac{\pi f'(l)}{2(2 - \bar{r}(r))} = rw \tag{15}$$

in the capital-good one, the public sector can reach (e^*, l^*) by setting the rate $r^* = 1$. The optimality of an interest rate equal to the (unit) growth rate of the population is of course akin to the “golden rule” maximizing steady-state utility in overlapping-generations models. Note that at this unit optimal rate, inflows and outflows in the bond market exactly offset each other so that the net rebate to old workers is zero.

2.3 Monetary easing

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 x units of labor into $\rho g(x)$ contemporaneous units of the consumption good, where $\rho \in (0, 1)$. We study the implications of such a time-varying productivity 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.

2.3.1 Flexible-wage benchmark

Proposition 2. (*Laissez-faire is optimal when the wage is flexible*)

If the wage is flexible, the public sector implements the first-best by setting the interest rate at the steady-state level $r^ = 1$ at each date. At this rate there is no need to regulate leverage.*

The cohort born at date -1 subsidizes that born at date 0 . There are no other transfers across cohorts.

Proof. Let us introduce $\rho_t = 1 + (\rho - 1)\mathbb{1}_{\{t=0\}}$. We use the subscripted notation $(e_t, x_t, l_t, w_t, r_t)$ to denote the values of (e, x, l, w, r) for the cohort born at date t out of the steady-state.

The social welfare function assigns the same weight to every unit of consumption no matter who consumes it and when, and to private costs of effort no matter when they are incurred. The first-best is thus reached when

$$\left(e_t - \frac{e_t^2}{2\pi} \right) f(l_t) + \rho_t g(1 - l_t) \tag{16}$$

is maximum for all t , or

$$e_t = \pi, \rho_t g'(1 - l_t) = \pi f'(l_t)/2. \quad (17)$$

With a flexible wage, setting $r_t = 1$ for all t implements the first-best because this induces $x_t = 1$, and profit maximization in both sectors and labor-market clearing imply

$$e_t = \pi, \quad (18)$$

$$\rho_t g'(1 - l_t) = w_t = r_t w_t = \pi f'(l_t)/2, \quad (19)$$

which characterizes the first-best from (17).

The proof that the only transfer across cohorts is that from the date-(-1) cohort towards the date-0 one is in the appendix. ■

When the wage is flexible, the steady-state unit interest rate $r^* = 1$ is unsurprisingly still optimal at all dates in the presence of time-varying productivity. From (19), the date-0 wage adjusts to a level $w_0 < w^*$ such that the employment level in the capital-good sector $l_0 > l^*$ leads to more investment, and this maximizes the contribution of the date-0 cohort to total output. For the remainder of the paper, we respectively denote l_ρ and w_ρ this first-best date-0 employment level and the associated market wage in this case of a flexible wage.

Time-varying productivity only has a redistributive effect across the cohorts born at -1 and 0 that is immaterial given our social welfare function. The savings of agents born at date 0 and thus facing a less productive economy do not suffice to repay the bonds of old date-(-1) agents that are due at date 0 , and so these latter old agents must pay a tax. Workers born at date 0 conversely receive a matching rebate once old at date 1 , as savings from

date-1 born agents are back to the higher steady-state value.

2.3.2 Rigid wage and regulated leverage

We now introduce a friction in this economy in the form of nominal rigidities:

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.¹⁰

We also suppose here that the public sector not only sets the interest rate at each date and taxes workers, but can also control entrepreneurs' leverage.¹¹ The following proposition shows that in this case, the combination of a reduction in the date-0 interest rate and of a prudential regulation enforcing that entrepreneurs do not borrow at this date implements the first-best, albeit through higher date-0 transfers from old to young agents than under a flexible wage.

Proposition 3. (*Monetary easing and prudential regulation implement the first-best*) *The public sector implements the first-best outcome with the following policy:*

- *It sets $r^* = 1$ at all other dates than 0 (and thus need not regulate leverage at these dates)*

¹⁰We 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.

¹¹We could alternatively assume that the public sector can tax capital income at no cost and without restrictions.

- It sets $r_\rho = w_\rho/w < 1$ at date 0 and imposes $x_\rho = 1$ to young date-0 entrepreneurs.

The cohort born at date -1 subsidizes that born at date 0, more so than under flexible wage. There are no other transfers across cohorts.

Proof. First-order conditions for profit maximization (14) and (15) show that the capital-good sector is interest-rate sensitive whereas the consumption-good sector is not. The public sector can accordingly make up for the absence of appropriate price signals in the date-0 labor market by distorting the date-0 capital market. By setting the date-0 policy rate at

$$r_\rho = \frac{w_\rho}{w^*} < 1, \quad (20)$$

and imposing $x_\rho = 1$ at date 0, the public sector implements the flexible-wage outcome in the labor market. Entrepreneurs invest up to the optimal level l_ρ since they face under this policy the same first-order condition as when the wage is flexible and $r^* = 1$:

$$\frac{\pi}{2} f'(l_\rho) = r_\rho w^* = w_\rho. \quad (21)$$

Each worker accommodates by applying in his own firm the residual quantity of labor that he cannot sell on the labor market at the disequilibrium wage w^* . He 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. ■

Note that the combination of date-0 monetary easing and leverage regulation maximizes the social welfare function, but that it implies more subsidy to young date-0 entrepreneurs from contemporaneous old workers. This owes to the fact that such young entrepreneurs, facing a rate $r_\rho < 1$, prefer to con-

sume their endowment when young rather than saving it, and the public sector must make up for this lower demand for bonds with higher date-0 taxes on old workers.

2.3.3 Rigid wage and unregulated leverage

Suppose now that the public sector no longer has the ability to regulate entrepreneurs' leverage. As detailed below, this corresponds to an economy in which a significant fraction of credit activity takes place in an unregulated shadow-banking system. The following proposition shows that this induces a lack of investment that puts the first-best out of reach.

Proposition 4. (*Rigid wage and unregulated leverage*)

1. *The optimal interest rates are $r^* = 1$ at all other dates than 0 and $r_u \leq 1$ at date 0.*
2. *Surplus is strictly lower and date-0 entrepreneurs use a quantity of labor l_u strictly smaller than that in the case of flexible wage l_ρ .*
3. *If ρ is sufficiently close to 1 other things being equal then $r_u = 1 > r_\rho$.*
4. *Suppose $f(l) = \gamma l^{1/\gamma}$ where $\gamma > 1$. If ρ and γ are sufficiently small other things being equal then $r_u < r_\rho$.*
5. *The cohort born at date -1 subsidizes that born at date 0, more so than under rigid wage and regulated leverage. There are no other transfers across cohorts.*

Proof. See the appendix. ■

From (9), in the absence of leverage regulation, the skin in the game of an entrepreneur x and thus his effort e (strictly) increase in r for $r < 1$. As

a result, attempts at spurring investment/employment in the capital-good sector with a reduction in the date-0 interest rate boost leveraged payouts and degrade asset quality. This unintended consequence of monetary easing implies that social surplus is maximized at a lower date-0 use of labor l_u in the capital-good sector 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.

Interestingly, whether the optimal date-0 interest rate r_u —the one that leads entrepreneurs to choose l_u —is lower or higher than the optimal date-0 rate in the presence of regulated leverage r_ρ is unclear. On the one hand, employment in the capital-good sector is less sensitive to the interest rate when leverage is unregulated, which implies setting a lower interest rate when leverage is unregulated than when it is in order to reach a given target level for l .¹² We just stated on the other hand that the target for employment in the capital-good sector should be lower in the absence of leverage regulation— $l_u < l_\rho$, which goes in the direction of setting $r_u > r_\rho$ as less stimulation is needed. The latter effect is dominant in the case of small productivity shocks (large values of ρ , point 3. in the proposition) whereas the former one prevails for large shocks provided f is not too concave (point 4. in the proposition).

Finally, monetary easing is anti-redistributive in the sense that date-0 leveraged payouts by young entrepreneurs lead to an issuance of corporate debt that crowds out public bonds and forces the public sector to raise more taxes on old workers than under regulated leverage.

Overall, these results suggest that the rise of a large unregulated shadow-

¹²In the absence of leverage regulation l is reached by setting r such that $\pi f'(l) = 2w^*r(2-r)$ whereas r is such that $\pi f'(l) = 2rw^*$ for $x = 1$.

banking sector can significantly affect the impact of monetary easing on the mix of financial risk taking and investment, as well as on redistribution.

3 Discussion and concluding remarks

Zero lower bound and asset purchases

In the face of a zero lower bound (ZLB) on policy rates, the Federal Reserve has responded to the 2008 crisis with unconventional policies that include the purchase of private claims such as mortgage-related securities. Suppose that the public sector is subject to a similar ZLB in our setup: It cannot set the date-0 rate below $r^* = 1$.¹³ 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 grant 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.

Shadow banking

As mentioned in the introduction, both non-financial corporations and the financial sector have responded to post 2008 monetary easing with large debt issuances. The size of the shadow-banking sector in particular, after a sharp contraction in 2007-8, now exceeds pre-crisis levels.

There is no room for financial intermediation in our setup, and so we

¹³For example, because the private sector can secretly store with a unit gross return.

aggregate for conciseness financial and non-financial firms into one single private sector.¹⁴ In this context we interpret the respective polar cases of regulated (Section 2.3.2) and unregulated (Section 2.3.3) 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 in 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.¹⁵

Although the mechanism in his setup differs from ours,¹⁶ Stein (2012) explains that the prudential regulation of banks can partly rein in incentives to engage in socially suboptimal financial risk-taking; however, there is always some unchecked growth of such activity in shadow banking, and 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 small productivity shocks consists in being passive and setting $r^* = 1$.

Our attempt in this paper has been to embed financial-stability concerns in a workhorse model of the interest-rate channel of monetary policy. We show that a standard-moral hazard problem combined with loose prudential regulation creates a very natural link between the recently observed lack of real investment and surge in leveraged payouts. There are many directions in

¹⁴We could introduce financial intermediaries in a two-tiered incentives problem as in Holmström and Tirole 1997.

¹⁵Plantin (2015) develops a model of leverage regulation under imperfect enforcement.

¹⁶Banks in his paper engage in maturity transformation that is socially suboptimal due to fire-sale externalities

which we could extend our analysis fruitfully. For example, we could introduce long-term projects and incomplete bond markets in order to generate maturity transformation. “Carry trades”—the rollover of short-term debt to fund long-term cash flows— would then potentially build up in the economy over an extended period of monetary easing and face an endogenous rollover risk when rates rise. Adding such a feature to the model would allow us to relate in a better fashion to phenomena in asset markets and financial flows as observed during the “taper tantrum” in 2013 (Feroi et al. 2014).

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Appendix

Proof of Proposition 1

The case $r \geq 1$ is straightforward and derived in the body of the paper. In the case $r < 1$, in order to derive the conditions in (5), notice first that (4) implies $e = \pi x$. Plugging this into (3), the objective becomes

$$\frac{\pi x[2 - (2 - r)x]}{2r} f(I) + W - I, \quad (22)$$

and first-order conditions with respect to x and I yield the two remaining conditions in (5).

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

$$ef(I) = \left(\frac{\pi}{2 - r} \right)^{\frac{\gamma}{\gamma-1}} \left(\frac{1}{2r} \right)^{\frac{1}{\gamma-1}}, \quad (23)$$

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

Proof of Proposition 2

The only result that is not established in the body of the paper regards transfers across cohorts. For any t , in the absence of leverage regulation, the surplus of a date- t cohort is

$$\begin{aligned} & (1 + r_t - \bar{r}(r_t)) \left[\frac{(1 - x_t)e_t f(l_t)}{r_t} + W - w_t l_t \right] + r_t w_t l_t + r_t \rho_t g(1 - l_t) + \\ & \mathbb{1}_{\{r_{t+1} \geq 1\}} (W - w_{t+1} l_{t+1}) - \frac{(1 - x_{t+1})e_{t+1} f(l_{t+1})}{r_{t+1}} + w_{t+1} l_{t+1} + \rho_{t+1} g(1 - l_{t+1}) \\ & - r_t \left[w_t l_t + \rho_t g(1 - l_t) + \mathbb{1}_{\{r_t \geq 1\}} (W - w_t l_t) - \frac{(1 - x_t)e_t f(l_t)}{r_t} \right] \end{aligned} \quad (24)$$

The first line in (24) is the consumption of entrepreneurs plus old workers' pre-tax income. The next two lines are the lump-sum rebated to old workers, comprised of the net savings of the next cohort (second line) minus the repayment of outstanding bonds to the private sector (third line). Note that we implicitly assume throughout the paper that the rebate to old workers, when it is negative, can be financed by their pre-tax income. It is easy to see that this is so as long as workers earn a sufficiently large amount of total income at each date.

From (24), straightforward computations show that under the optimal policy, the surplus of each cohort born at any date $t \notin \{-1; 0\}$ is given by

$$W + \frac{\pi f(l^*)}{2} + g(1 - l^*), \quad (25)$$

whereas that of cohort -1 is

$$W + \frac{\pi f(l_\rho)}{2} + \rho g(1 - l_\rho), \quad (26)$$

and that of cohort 0 equals

$$W + \frac{\pi f(l_\rho)}{2} + g(1 - l^*). \quad (27)$$

Cohort -1 thus pays a subsidy equal to $g(1 - l^*) - \rho g(1 - l_\rho)$ to cohort 0 . ■

Proof of Proposition 3

From (24), and accounting for leverage regulation, straightforward computations show that the surplus of each cohort born at any date $t \notin \{-1; 0\}$ is

given by

$$W + \frac{\pi f(l^*)}{2} + g(1 - l^*), \quad (28)$$

whereas that of cohort -1 is

$$w^* l_\rho + \frac{\pi f(l^*)}{2} + \rho g(1 - l_\rho), \quad (29)$$

and that of cohort 0 equals

$$W + \frac{\pi f(l_\rho)}{2} + g(1 - l^*) + W - w^* l_\rho. \quad (30)$$

Cohort -1 thus pays a subsidy equal to $g(1 - l^*) - \rho g(1 - l_\rho) + W - w^* l_\rho$ to cohort 0 , larger than under flexible wage. This is due to the fact that young date-0 entrepreneurs are unwilling to save $W - w^* l_\rho$ at the rate $r_\rho < 1$, and prefer instead to consume this when young. This forces the public sector to collect this additional amount from old date-0 workers. ■

Proof of Proposition 4

Proof of points 1. and 2. Setting $r_t = 1$ maximizes (16) for all $t \neq 0$.

Regarding the date-0 cohort, the optimal rate $r \leq 1$ maximizes

$$\Sigma(r) = \left(e(r) - \frac{e(r)^2}{2\pi} \right) f(l(r)) + \rho g(l(r)), \quad (31)$$

where relations (9) implicitly define $e(r)$ and $l(r)$. These functions are obviously differentiable with respect to r , respectively increasing and decreasing,

and straightforward computations yield:

$$\Sigma'(r) = \frac{\pi(1-r)f(l(r))}{(2-r)^3} + \left[\frac{\pi(3-2r)f'(l(r))}{2(2-r)^2} - \rho g'(1-l(r)) \right] l'(r). \quad (32)$$

For r'_ρ such that $l(r'_\rho) = l_\rho$, we have by definition of l_ρ that $\pi f'(l(r'_\rho))/2 = \rho g'(1-l(r'_\rho))$, which implies

$$\Sigma'(r'_\rho) = \frac{\pi(1-r'_\rho)f(l(r'_\rho))}{(2-r'_\rho)^3} - \frac{\pi}{2} \left(\frac{1-r'_\rho}{2-r'_\rho} \right)^2 f'(l(r'_\rho))l'(r'_\rho) > 0, \quad (33)$$

implying in turn points 1. and 2. in the proposition ($l_u > l_r$).

Proof of point 3. Using

$$l'(r) = \frac{4w^*(1-r)}{\pi f''(l(r))}, \quad (34)$$

one can write

$$\Sigma'(r) = (1-r) \left[\underbrace{\frac{\pi f(l(r))}{(2-r)^3}}_A + \frac{4w^*}{\pi f''(l(r))} \left[\underbrace{\frac{\pi(3-2r)f'(l(r))}{2(2-r)^2} - \rho g'(1-l(r))}_B \right] \right] \quad (35)$$

For (ρ, r) sufficiently close to $(1, 1)$, B becomes negligible relative to A and so $\Sigma' > 0$ over $[r, 1)$. Furthermore, standard continuity arguments imply that $\lim_{\rho \uparrow 1} (r_u, l_u) = (1, l^*)$. That $\Sigma'(r_u)$ must therefore be strictly positive for ρ sufficiently close to 1 implies that (r_u, l_u) is actually equal to $(1, l^*)$ for ρ sufficiently close to 1. \blacksquare

Proof of point 4. If $f(l) = \gamma l^{1/\gamma}$ then $f''(l) = (1/\gamma - 1)l^{1/\gamma-2}$. Thus, for any fixed $(r, l) \in (0, 1)^2$, there exists γ sufficiently close to 1 and ρ sufficiently

close to 0 such that

$$\frac{\pi f(l)}{(2-r)^3} + \frac{4w^*}{\pi f''(l)} \left[\frac{\pi(3-2r)f'(l)}{2(2-r)^2} - \rho g'(1-l) \right] < 0. \quad (36)$$

It is easy to see that this implies that l_u must become arbitrarily close to 1 for ρ and γ sufficiently small. It is also clearly the case that l_ρ is arbitrarily close to 1 for ρ and γ sufficiently small. We have

$$\frac{\pi f'(l_u)}{2(2-r_u)} = r_u w^*, \quad (37)$$

$$\frac{\pi f'(l_\rho)}{2} = r_\rho w^*, \quad (38)$$

and so it must also be that $r_u < r_\rho$ for ρ and γ sufficiently small.

Proof of point 5. From (24), straightforward computations show that the surplus of each cohort born at any date $t \notin \{-1; 0\}$ is given by

$$W + \frac{\pi f(l^*)}{2} + g(1-l^*), \quad (39)$$

whereas that of cohort -1 is

$$w^* l_u + \frac{\pi f(l^*)}{2} + \rho g(1-l_u) - \frac{\pi(1-r_u)f(l_u)}{r_u(2-r_u)^2}, \quad (40)$$

and that of cohort 0 equals

$$W + \frac{\pi f(l_\rho)}{2} + g(1-l^*) + W - w^* l_u + \frac{\pi(1-r_u)f(l_u)}{r_u(2-r_u)^2}. \quad (41)$$

Cohort -1 thus pays a subsidy equal to $g(1-l^*) - \rho g(1-l_u) + W - w^* l_u + \pi(1-r_u)f(l_u)/[r_u(2-r_u)^2]$ to cohort 0, larger than under rigid wage and regulated leverage. This is due to the fact that young date-0 entrepreneurs

consume an additional $\pi(1 - r_u)f(l_u)/[r_u(2 - r_u)^2]$ when young borrowed against their date-1 output, which forces the public sector to collect this additional amount from old date-0 workers. ■