Monetary Easing, Investment and Financial Instability*

Viral V. Acharya
New York University

Guillaume Plantin
Sciences Po

Pietro Reggiani
Cornerstone

Iris Yao
Cornerstone

August 29, 2023

Abstract

Low monetary policy rates lower the cost of capital for firms, thereby spurring productive investment. Low interest rates however can also induce the private sector to enter into risky carry trades when they imply that the earned carry more than offsets liquidity risk. Such

*We are grateful to seminar and workshop participants at the World Econometric Society Meetings in Montreal, CREDIT Greta conference in Venice, Micro Foundations of Macro Finance workshop at New York University, New York University (NYU) Stern School of Business, NYU Economics at the Graduate School of Arts and Sciences, European Central Bank conference on the Transmission of Monetary Policy, Bank for International Settlements, the Federal Reserve Board, Bank of Italy, Bank of Portugal, Banque de France, University of Mannheim, Université Paris-Dauphine, Aarhus University, CREST, London Business School, University of Geneva, the Einaudi Institute for Economics and Finance, Bank of Spain, and NYU – ETH Zurich Law and Finance conference, for helpful comments and discussions. Hae Kang Lee provided excellent research assistance.

carry trades and productive investment compete for funds, so much so that the former may crowd out the latter. Below an endogenous lower bound, monetary easing generates only limited capital expenditures that come at the cost of large and destabilizing financial risk-taking. Absent the ability to regulate carry trades, monetary easing must be complemented with a limited lender-of-last-resort (LOLR) policy in the form of higher lending rates so as to discourage risk-taking by relatively illiquid firms. Monetary easing, tepid investment response, and rollover risk for liquid firms then arise jointly (and optimally) in equilibrium.

Keywords: Monetary policy, lender of last resort, financial stability, financial fragility, shadow banking, carry trades, rollover risk
JEL: E52, E58, G01, G21, G23, G28

Introduction

Following the global financial crisis of 2007-08, most major central banks embarked upon so-called unconventional monetary policies. These policies featured 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. While these policies were associated with strong announcement effects in the form of a compression of term and risk premia (see, for instance, Krishnamurthy and Vissing-Jorgensen, 2011), several observers and policymakers have lamented the disappointing impact of this compression in the cost of capital for corporations on their capital expenditures.[1] In particular, investment did not return to its pre-2007 trends despite a large wedge between low interest rates and historically high realized rates of return on existing capital.[2]

Indeed, low borrowing costs for non-financial corporations appear to have fuelled an increase in leveraged payouts to their shareholders, notably in the form of debt-financed share repurchases (see Furman, 2015 and Acharya and

[1]See, for instance, an early concern raised in Rajan (2013): "If effective, the combination of the "low for long" policy for short term policy rates coupled with quantitative easing tends to depress yields. ... Fixed income investors with minimum nominal return needs then migrate to riskier instruments such as junk bonds, emerging market bonds, or commodity ETFs. ... [T]his reach for yield is precisely one of the intended consequences of unconventional monetary policy. The hope is that as the price of risk is reduced, corporations faced with a lower cost of capital will have greater incentive to make real investments, thereby creating jobs and enhancing growth. ... There are two ways these calculations can go wrong. First, financial risk-taking may stay just that, without translating into real investment. For instance, the price of junk debt or homes may be bid up unduly, increasing the risk of a crash, without new capital goods being bought or homes being built. ... Second, and probably a lesser worry, accommodative policies may reduce the cost of capital for firms so much that they prefer labor-saving capital investment to hiring labor."

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

Plantin, 2019, among others). The US corporate sector raised $7.8 trillion in debt over the 2010-2017 period, whereas net equity issuance was negative due to payouts to shareholders being at a high point compared with historical averages. As a result, corporate leverage during this monetary easing period rose to historical highs for large firms, and rose to levels exceeding those prevailing just before the global financial crisis (IMF 2017).[3]

Unconventional monetary policies also seem to have spurred risk-taking in the "shadow banking" sector. IMF GFSR (2016) documents that non-bank financial institutions, such as insurance companies and fund managers, increasingly engaged in (unregulated) maturity transformation, rolling over liabilities that were either short-term or sold with guarantees or redemption rights in order to channel flows into risky asset classes. These asset classes included bonds and collateralized leveraged loans and residential mortgage-backed assets (Stein 2013), as well as emerging-market government and corporate bonds (Acharya and Vij 2020, Bruno and Shin 2017, Feroli et al. 2014).

This financial risk-taking led to significant fragility at the onset of the pandemic in March 2020, as debt markets became stressed or frozen for even the relatively safer corporations and where the underlying assets were traditionally highly liquid[4]: (i) Leveraged trades in US Treasury markets by hedge funds experienced liquidation pressures (Schrimpf et al., 2020), contributing to fire sales and unexpected illiquidity (Duffie, 2020 and He et al., 2022). (ii) Investment-grade bonds suffered substantial liquidations and widening of spreads, leading to a breakdown in the no-arbitrage relationship

[3]There is significant heterogeneity across sectors and by firm ratings, but median net debt across S&P 500 firms was close to an all-time maximum.

[4]For an overall description of the "dash for cash" in March 2020, see Kashyap (2020), Acharya and Steffen (2021), Acharya, Engle, Jager and Steffen (2021) and Vissing-Jorgensen (2021).

between credit default swap (CDS) and bond markets, in a scale that was more extreme than that for junk or speculative-grade bonds (Haddad et al., 2021); furthermore, several investment-grade firms, notably BBB-rated ones ("prospective fallen angels"), were downgraded by rating agencies by multiple notches (Acharya et al., 2022). (iii) Bond mutual funds, especially ones holding Treasuries and investment-grade bonds, faced investor redemptions and were forced to sell their most liquid asset holdings (Falato et al., 2021, Jiang et al., 2022, Kargar et al., 2022, Ma et al., 2021, and O'Hara and Zhou, 2021). (iv) Municipal bonds also faced significant selling pressures (Li et al., 2020). That the resulting financial fragility for relatively liquid assets was severe is confirmed by the unprecedented scale and scope of Federal Reserve stimulus, not just for Treasury markets, but extending to corporate bonds (especially investment-grade and fallen-angel firm bonds) and municipal debt markets.[5]

Motivated by these facts, we develop a simple general equilibrium model with price rigidity, with three key features: (i) a low policy rate lowers the cost of capital for firms that can offset the lack of flexible price signals and spur productive investment; (ii) a low interest rate, however, can also induce the private sector to enter into risky carry trades when this implies that the earned carry more than offsets liquidity risk or/and liquidation costs when debt cannot be rolled over; and, (iii) the possibility that such carry trades and productive investment compete for funds, so much so that the former may crowd out the latter. To relate to the empirical evidence closely, we consider firms with heterogeneous assets in terms of their liquidity risk or (conversely) liquidation values. Finally, we examine in such a setting the constrained-efficient public policy that faces imperfect enforcement in that

[5]See, e.g., Boyarchenko et al., 2022, Gilchrist, 2020, Logan, 2021, Quarles, 2020, and Vissing-Jorgensen, 2021.

carry trades cannot simply be ruled out by fiat,[6] but we allow policy to set a lender-of-last-resort (LOLR) rate which affects the liquidation outcomes ex post and thereby financial risk-taking ex ante.

Our principal result is that below an endogenous lower bound, monetary easing generates only limited capital expenditures that come at the cost of large and destabilizing financial risk-taking. Absent the ability to regulate carry trades, optimal policy faces a central tradeoff: at one extreme, not easing enough by lowering interest rates can discourage carry trades but also fails to stimulate investment; at the other extreme, adopting too high a LOLR rate also discourages carry trades but by keeping liquidation risk at high levels also fails to stimulate investment. Hence, constrained-efficient policy complements monetary easing with a limited LOLR policy in the form of higher lending rates so as to discourage the risk-taking by relatively illiquid firms, but it accepts the liquidation risk of more liquid firms in order to not sacrifice investments altogether. Monetary easing, tepid investment response, and rollover risk for liquid firms then arise jointly in equilibrium, as observed in our motivating remarks.

The paper is organized as follows. Section 1 discusses related literature. Section 2 sets up the model structure. Section 3 presents the first-best benchmark. Section 4 analyzes the model and derives the main result linking monetary easing, tepid investment response and financial fragility. Section 5 discusses some extensions. Section 6 presents the concluding remarks.

[6]In other words, it is not possible for policy to regulate private leverage. This can simply capture the existence of a large shadow-banking system that can fund corporate debt outside the scope of regulated bank credit.

1 Related literature

Even though the key feature that we model – that carry trades in the form of leveraged payouts crowd out investments – has amplified following the 2008 crisis, it could actually be discerned earlier on. For example, Gutiérrez and Philippon (2017) argue that starting 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. Gutiérrez 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. Taylor (2011, 2012) also traces the start of a "Great Deviation" around the same date, whereby monetary policy became relatively more accommodative than in the previous decades, and prudential regulation looser. Taylor argues that this has significantly contributed to the build-up of financial fragility leading to the 2008 crisis. To be sure, this latter point is contentious (see, e.g., Bernanke 2010 for an alternative viewpoint).

Turning to related models, Caballero and Farhi (2018) also build a model in which "disequilibrium" in the market for the risk-free asset plays a central role. Combined with borrowing constraints, it leads to an inefficiently low output in their setup. One important difference between their setting and ours is that disequilibrium in their model stems from an exogenous lower bound on the risk-free rate (the zero lower bound). By contrast, we exhibit an endogenous lower bound on the risk-free rate, below which leveraged share buybacks crowd out productive investment, leading it to collapse. Whereas the zero lower bound has arguably been the important binding constraint in the couple of years following the 2008 crisis, we believe that the endogenous lower bound that we obtain may have played a central role in the build-up of financial fragility leading to the 2008 crisis. This endogenous lower

bound may also help understand the current patterns of reduced investment rates, increased payouts to shareholders, and growing leverage and maturity transformation.

Other recent contributions that study the negative impact of low policy rates on financial stability rely on the lack of commitment of the public sector. 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 time-commitment problem; it finds low rates attractive up to a point for stimulating productive investment but lowering rates beyond triggers maturity transformation beyond socially useful levels, and crowds out productive real investment.

Several recent contributions suggest alternative channels for the limited impact of low interest rates on investment. Abadi, Brunnermeier and Koby (2023) show that this may stem from eroded lending margins in an environment of imperfectly competitive banks. Coimbra and Rey (2023) 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. Quadrini (2017) develops a model in which monetary easing in the form of private asset purchases may have a contractionary impact on investment. In his setup, firms use deposits to hedge productivity shocks. The claims of the public sector against private assets crowd out those of the corporate sector thereby reducing the corporate sector's ability to take on productivity risk. A distinctive feature of our approach is that we jointly explain low investment, high payouts, and the growth of maturity transformation within the shadow-banking sector.

Acharya and Naqvi (2012a, b) develop a model of internal agency problem in financial firms due to limited liability wherein liquidity shortfalls on maturity transformation serve to align insiders' incentives with those of outsiders. When aggregate liquidity at rollover date is abundant, such alignment is restricted accentuating agency conflicts, leading to excessive lending and fueling of asset-price bubbles. Easy monetary policy only exacerbates this problem. 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 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. The key difference between our model and these two papers is that excessive maturity transformation arises in our model not due to agency problems in the financial sector nor due to fire-sale externalities, but from monetary easing rightly aimed at stimulating aggregate output.

2 Setup

Time is discrete. There are two types of private agents, workers and entrepreneurs, and a public sector. The desirable goods are comprised of a perishable consumption good that serves as numéraire and of capital goods.

Capital goods. Capital goods can be in turn of two types, liquid or illiquid. One unit of capital good produced at date t generates one unit of the consumption good at date $t+2$ no matter its type. Alternatively, this unit of capital can be liquidated at date $t+1$, in which case it generates $1-\underline{\delta}$ units of consumption if liquid, and $1-\bar{\delta}$ units if illiquid, where $0<\underline{\delta}<\bar{\delta}<1$.

That the capital good need not be combined with labor in order to deliver the consumption good is for analytical simplicity. This also entails that the capital good can alternatively be interpreted as a durable good such as housing.

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. Each worker supplies inelastically one unit of labor when young. Each worker also owns a technology that transforms l units of labor into $g(l)$ contemporaneous units of the consumption good, where the function g satisfies the Inada conditions. Workers can either sell their labor in a competitive labor market, or apply it to their own technology.

Entrepreneurs. At each date, a unit mass of entrepreneurs are born and live for three dates. They value consumption at the initial and last dates of their lives, at which they are risk-neutral.[7] They discount late relative to early consumption at the rate R^2, where $1<R<1/(1-\underline{\delta})$. A fraction $\lambda\in(0,1)$ of entrepreneurs is endowed with a technology that transforms l

[7]Assuming that entrepreneurs do not value consumption when middle-aged slightly simplifies the exposition. Section 5 below explains how the introduction of interim consumption actually reinforces our results.

units of labor into $f(l)$ contemporaneous units of the liquid capital good, and the complement $1-\lambda$ produces the illiquid type with the same production function. The function f satisfies the Inada conditions.

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

Liquidity risk. An entrepreneur born at date t has access to the bond market at date $t+1$ with probability $1-q$ only, where $q \in (0,1)$. Market exclusions are independent across entrepreneurs of the same cohort. This simple modelling of liquidity risk follows Diamond (1997).

We will assume that in the relevant range for x,[8]

$$\frac{f(x)}{x} \geq R^2 f'(x). \tag{1}$$

Monetary policy. The public sector announces both a rate at which it is willing to trade in the bond market, and a rate at which it acts as a a lender of last resort (LOLR) or emergency lender, offering credit to the entrepreneurs who are excluded from the bond market. We deem the former rate the "policy rate" and the latter the "LOLR rate" in the balance of the paper:

- **Policy rate:** The public sector announces at each date an interest rate at which it is willing to trade one-period bonds in the bond market.
- **Lending-of-last-resort or emergency-lending rate:** The public sector can also act as a lender of last resort (LOLR) and lend to entrepreneurs excluded from the market at whichever LOLR rate it sees fit.

[8]This ensures that entrepreneurs' debt capacity exceeds their wage bill when the interest rate is (weakly) smaller than R.

Notice that these rates are real interest rates given the fixed-price model

Fiscal policy. The public sector can tax old workers as it sees fit. It can in particular apply lump-sum taxes. On the other hand, it cannot tax entrepreneurs nor regulate them. This latter assumption is made stark in order to yield a simple and clear exposition of our results.

Social-welfare function. The public sector seeks to maximize the present value of aggregate consumption at each date discounted at R.

3 First-best: Characterization and implementation

Let us denote $\underline{l}_t$ the labor used by entrepreneurs producing liquid capital at date t, $\underline{x}_t$ the fraction of liquid capital liquidated at date t, and $\bar{l}_t$ and $\bar{x}_t$ their counterparts for illiquid entrepreneurs and illiquid capital. Date-t aggregate consumption is equal to date-t aggregate income, and thus social welfare viewed from date-t, S_t, reads:

$$S_t = \sum_{s \geq t} \frac{1}{R^{s-t}} [g(1 - \lambda \underline{l}_s - (1-\lambda)\bar{l}_s) + \underline{x}_s(1-\underline{\delta})\lambda f(\underline{l}_{s-1}) + \bar{x}_s(1-\bar{\delta})(1-\lambda)f(\bar{l}_{s-1})$$
$$+ (1 - \underline{x}_{s-1})\lambda f(\underline{l}_{s-2}) + (1 - \bar{x}_{s-1})(1-\lambda)f(\bar{l}_{s-2})]. \qquad (2)$$

The first-term in the generic date-s income is the output from workers' technology g. The following two terms are the respective incomes resulting from the early liquidation of date-$(s-1)$ liquid and illiquid capital respectively. The last two terms are the outputs from the liquid and illiquid date-$(s-2)$ capital that has not been liquidated at $s-1$.

Given that $R < 1/(1-\underline{\delta})$, it is optimal to set $\underline{x}_s = \bar{x}_s = 0$. Differentiating

with respect to $\underline{l}_s$ and $\bar{l}_s$ yields $\underline{l}_s = \bar{l}_s = l^*$ such that

$$f'(l^*) = R^2 g'(1 - l^*). \tag{3}$$

Optimality condition (3) is straightforward: The marginal return on labor must be the same in all sectors.

Lemma 1. ***(First-best: Characterization)*** *The first-best is such that there is no asset liquidation, and that all entrepreneurs at all dates hire labor l^* such that $f'(l^*) = R^2 g'(1 - l^*)$.*

Proof. See discussion above. ■

We now show that a simple policy leads to a competitive equilibrium that implements this first-best. A first step consists in describing the optimal investment and consumption decisions of an entrepreneur when facing a liquidity parameter $\delta \in \{\underline{\delta}; \bar{\delta}\}$, a wage w, and monetary policy (r_P, r_E), where r_P is the policy rate and r_E the LOLR rate. In preparation for the subsequent analysis, we also add the possibility that her borrowing B be constrained to be smaller than some constant $\bar{B}$. The following lemma describes the resulting investment and consumption decisions.

Lemma 2. ***(Entrepreneurs' investment and consumption)*** *Let*

$$\hat{r} \equiv \min\{r_E; \frac{1}{1-\delta}\}, \tag{4}$$

$$\Delta \equiv \frac{1}{r_P^2}\left(1 - q + \frac{q r_P}{\hat{r}}\right). \tag{5}$$

If $\bar{B}$ is sufficiently large other things being equal, the entrepreneur hires labor l such that $\Delta f'(l) = w$. She borrows $B = wl$ if $\Delta R^2 < 1$, $B = \Delta f(l)$ if $\Delta R^2 > 1$, and is indifferent over all amounts within $[wl, \Delta f(l)]$ if $\Delta R^2 = 1$. Otherwise $B = \bar{B}$ and l is smaller than the solution to $f'(l) = R^2 w$.

Proof. If excluded from the market when rolling over debt, the entrepreneur faces two options, asset liquidation or emergency borrowing. Exercizing the best option amounts to borrowing at $\hat{r}$. Thus, $1/\Delta$ is the effective rate at which she borrows between t and $t+2$. This yields her program

$$\max_{B,l} C_Y + \frac{C_O}{R^2} \tag{6}$$

s.t.

$$C_Y + wl \leq B, \tag{7}$$

$$C_O + \frac{B}{\Delta} \leq f(l), \tag{8}$$

$$B \leq \bar{B}, \tag{9}$$

$$C_Y, C_O, l \geq 0. \tag{10}$$

Since (7) and (8) optimally bind, if (9) is slack then optimally $\Delta f'(l) = w$ and the entrepreneur borrows only wl if $\Delta R^2 < 1$, $\Delta f(l)$ if $\Delta R^2 > 1$, and any amount in between if $\Delta R^2 = 1$. Otherwise, $B = \bar{B}$ and either l solves $f'(l) = R^2 w$ and $C_Y > 0$, or $wl = B$ (and $C_Y = 0$). ■

Suppose now that the central bank announces a policy rate equal to R and an LOLR rate also equal to R—a monetary policy(R, R). That $R(1-\underline{\delta}) < 1$ implies that entrepreneurs, as in the first-best, never liquidate assets when excluded from the bond market and unable to rollover their debt: They prefer to tap instead the emergency-lending facility. From Lemma 2, facing a wage w_t, they hire labor l_t such that

$$f'(l_t) = R^2 w_t, \tag{11}$$

and they borrow at least $w_t l_t$ to finance their wage bill, which they can afford from (1). Workers facing the same wage w_t also maximize profits, and the associated first-order condition together with (11) and labor-market clearing yields the equilibrium investment wl and wage w as the (unique) solution to

$$\frac{f'(l)}{R^2} = g'(1-l) = w. \tag{12}$$

This implies in particular from (3) that the equilibrium labor used by entrepreneurs is equal to the first-best value l^*.

Workers save their income $g(1-l^*) + w^* l^*$ by lending to entrepreneurs who can pledge their entire capital income. Workers can lend the residual if any—that is, $(g(1-l^*) - f(l^*)/R^2)^+$— to the public sector. The public sector can use lump-sum taxes on old households to both fund LOLR lending and repay such bonds.

Proposition 3. ***(First-best: Implementation)*** *The policy (R, R) is such that the competitive-equilibrium outcome is the first-best.*

Proof. See discussion above. ■

4 Monetary easing and financial instability

Suppose now that one cohort of workers — the one born at date 0, say — has a less productive technology than that of the other cohorts. Unlike that of 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 first characterize the first-best in this case. We then check that, unsurprisingly, this productivity shock does not affect the optimal policy (R, R) when the wage is flexible. We then introduce a downward-rigid wage.

4.1 First-best

The determination of the first-best in Lemma 1 is verbatim when the production function g (and possibly f but it is irrelevant here) varies across cohorts. It is still optimal to never liquidate assets. All entrepreneurs born after date 1 use labor l^*. Date-0 entrepreneurs use $l_\rho > l^*$ implicitly defined as

$$f'(l_\rho) = R^2 \rho g'(1 - l_\rho), \tag{13}$$

and l_ρ is clearly decreasing with respect to ρ from this definition (13). Intuitively, as producing the capital good becomes relatively more efficient, more labor must be employed at that.

4.2 Flexible-wage benchmark

When the wage is flexible, the policy (R, R) still implements the first-best. Again it is easy to see that the proof of Lemma 2 is verbatim when g is time-varying. The date-0 wage adjusts to a level $w_\rho < w^*$ such that the employment level in the capital-good sector $l_\rho > l^*$ leads to more investment:

$$w_\rho = R^2 \rho g'(1 - l_\rho) = f'(l_\rho), \tag{14}$$

and w_ρ increases with respect to ρ as a lower ρ makes labor overall less productive and thus less compensated.

4.3 Rigid wage and monetary easing

We now introduce nominal rigidities in order to create room for monetary easing at date 0:

Assumption. ***(Downward rigid wage)*** *The wage cannot be smaller than* w^* *at any date.*

In other words, we suppose that the wage is too downward rigid to track the transitory productivity shock that hits the date-0 cohort, and that the public sector cannot regulate it in the short run. We could also assume a partial adjustment without affecting the analysis. Notice also that the analysis would be similar if the date-0 productivity shock was permanent. All that would matter in this case would be the number of periods it takes for the wage to adjust to the level w_ρ that is optimal given the productivity shock.

We now study the extent to which monetary policy can get the economy at or as close as possible to the first-best. We restrict the analysis to policies that affect only the date-0 cohort via the date-0 policy rate r_P and the date-1 LOLR rate r_E, leaving these rates at every other dates equal to R.

For every policy (r_P, r_E), let us define

$$\Gamma(r_P, r_E) = \frac{1}{r_P}\left[\frac{1-q}{R} + \frac{q}{r_E}\right]. \tag{15}$$

Proposition 4. ***(Monetary easing and financial instability)***

Suppose

$$f(l^*) \leq R^2 g(1-l^*), \tag{16}$$

and let

$$\underline{\rho} \in (0,1) \equiv \inf\left\{\rho \mid w^* f(l_\rho) \leq R^2 w_\rho g(1-l_\rho)\right\}. \tag{17}$$

Then monetary policy can implement the first-best for each $\rho \geq \underline{\rho}$ *by choosing*

a LOLR rate $1/(1-\underline{\delta})$ *and a policy rate* r_P *that solves*

$$\Gamma\left(r_P, \frac{1}{1-\underline{\delta}}\right) = \frac{w^*}{R^2 w_\rho}. \tag{18}$$

All date-0 entrepreneurs enter into carry trades against their entire future income, and use the emergency-lending facility when distressed. For $\rho < \underline{\rho}$ *the best possible policy is the same as that for* $\underline{\rho}$*, and the first-best is thus out-of-reach.*

Otherwise, if condition (16) *fails to hold, then some stimulation of investment is possible only if* λ *is sufficiently small. Still, it is only possible to stimulate investment by the most liquid entrepreneurs, who then are the only ones to enter into risky carry trades. They liquidate their assets when excluded from the market, however, thereby making stimulation less socially desirable than if they did not.*

Proof. A date-0 entrepreneur with asset liquidity δ such that $r_E \leq 1/(1-\delta)$ borrows effectively at the rate $1/\Gamma(r_P, r_E)$. Lemma 2 thus applies to entrepreneurs' investment and borrowing decisions with this rate in lieu of $1/\Delta$. Thus, if she is not constrained by a limited supply of funds, an entrepreneur will apply the quantity of labor l such that $\Gamma(r_P, r_E) f'(l) = w^*$. Thus monetary policy can induce the level l_ρ by choosing (r_P, r_E) such that $r_E \leq 1/(1-\underline{\delta})$—for example, $r_E = 1/(1-\underline{\delta})$—and $\Gamma(r_P, r_E) = w^*/(R^2 w_\rho)$. Since $\Gamma(r_P, r_E) > 1/R^2$ this implies that all entrepreneurs enter into carry trades against their entire future incomes. But then this implies that entrepreneurs may be rationed and, with the same reasoning as in the proof of Lemma 2 do not invest more than under policy (R, R). Rationing occurs at all values of ρ smaller than $\underline{\rho}$, the level at which entrepreneurs' demand for funds exactly matches workers' supply.

If however (16) fails to hold, then it is impossible to stimulate investment for all entrepreneurs as this would induce rationing. The only way to stimulate investment is therefore to ensure that some entrepreneurs do not enter into carry trades so that their demand for funds remains below supply. Since $\underline{\delta}$-entrepreneurs have cheaper refinancing options than $\bar{\delta}$-entrepreneurs through liquidation, it must be the latter type of entrepreneurs. Hence r_E must be lower than $1/(1-\bar{\delta})$ while $\Gamma(r_P, r_E) \geq 1/R^2$. It is then optimal to set r_E at $1/(1-\bar{\delta})$ to minimize r_P and let liquid entrepreneurs liquidate their assets conditionally on stimulating. If their carry trades exceed workers' savings then it fails, which occurs if λ is sufficiently large. Even when it is not the case, stimulating investment comes with asset liquidations that reduce social welfare. ■

The capital-good sector is interest-rate sensitive whereas the consumption-good one is not. Thus, by distorting and reducing the real rate, monetary policy can offset in principle the distortion induced by the fact that the date-0 wage is too high: $w^* > w_\rho$. Formally, policy must set entrepreneurs' effective interest rate at $\Gamma(r_P, r_E) = w^*/(R^2 w_\rho)$ so that profit-maximizing by entrepreneurs becomes:

$$\Gamma(r_P, r_E) f'(l) = w^* \Leftrightarrow f'(l) = R^2 w_\rho, \tag{19}$$

which generates the first-best. The reason this is not always feasible is that an effective rate smaller than R^2 induces carry trades by entrepreneurs. If their demand for funds exceeds workers' savings, then investment collapses to the non-stimulated level, as seen in Lemma 2. If condition (16) holds, then there is no such excess demand of funds for sufficiently small shocks (high values of ρ) and the first-best can be implemented for such shocks.

In the interesting case in which condition (16) fails to hold, it is not

possible to stimulate investment in such a way that all entrepreneurs enter into carry trades because there would immediately be excess demand in the credit market. Since liquid entrepreneurs can refinance when excluded at better conditions than illiquid ones through liquidation, the best monetary policy can achieve is to set the policy rate and the LOLR rate at a sufficiently high level that illiquid entrepreneurs are not tempted by carry trades, and to stimulate investment by liquid entrepreneurs who then inefficiently liquidate assets. Thus, in this case in which condition (16) fails to hold, the tension between stimulating investment and maintaining financial stability generates inefficient liquidity-risk taking in equilibrium.

5 Discussion

Discriminating emergency loans. An important assumption leading to inefficient liquidation in equilibrium is that the government cannot price-discriminate entrepreneurs when granting emergency loans. If it could do so, it would always find it optimal to avoid inefficient liquidations. Yet the rationing induced by carry trades and the resulting limited ability to spur investment would remain unchanged. Still, we consider the assumption that full price discrimination in emergency lending is out-of-reach to be realistic. Our elementary modelling of liquidity does not do justice to the fact that the actual liquidity of an asset or asset class depends on a plethora of time-varying factors that official lending facilities do not fully take into account in practice.

Limited commitment. We carry the analysis under the assumption that the public sector can fully commit to a policy. This makes clear that our results do not hinge on imperfect commitment. In fact, the presence of

inefficient liquidation in equilibrium owes to this assumption of perfect commitment. If the public sector could not commit to not bail out excluded entrepreneurs, then not only would such liquidations never occur, but the public sector would be unable to stimulate investment at all when condition (16) fails to hold, as ex-post bailouts would imply ex-ante attempts at carry trades by all entrepreneurs in turn leading to rationing.

Political-economy constraints. Aiming at developing the simplest possible framework with a minimum set of ingredients, we do not invoke any political-economy constraints on bailouts nor on workers' taxation. Such constraints would reinforce our results by further tying the hands of the public sector. If old workers could not be taxed without limits, this would reduce its ability to bail out distressed entrepreneurs, thereby creating more social costs of carry trades via inefficient liquidations.

Interim consumption by entrepreneurs. The assumption that entrepreneurs also value consumption when middle-aged would reinforce our results by increasing the demand for funds aimed at frontloading consumption rather than investing in the presence of date-0 monetary easing. To see this, note that the fraction $(1-q)$ of date-0 middle-aged entrepreneurs who are not excluded from markets at date 0 would borrow against their date-1 profit without taking any liquidity risk in the face of a date-0 interest-rate cut. This would suck more investable funds out of productive investment, and the public sector would have no way to prevent this with punitive emergency rates given the absence of liquidity risk. More generally, if entrepreneurs were living n periods and capital goods delivered consumption over the same horizon, then a stock of legacy assets produced by the $(n-1)$ previous cohorts would lend themselves to carry trades that are less risky than that against

newly produced (and thus longer-lived) assets at date 0. These carry trades would absorb a lot of date-0 savings and dramatically amplify the diversion of savings away from productive investment.

Regulating quantities (leverage). In our stylized model, the same type of agents, "entrepreneurs," aggregate both non-financial firms and the financial sector. Whereas the leverage of firms and that of a number of financial institutions is not regulated, the government on the other hand can curb the leverage of commercial banks through prudential regulation, thereby also indirectly controlling that of firms that primarily depend on bank funding. It is easy to see that full control of entrepreneurs' leverage would enable the government to implement the first-best when combined with monetary easing because entrepreneurs are never rationed when they borrow only to fund investment and not carry trades.

An interesting route for future research consists in studying the intermediate situation in which the regulation of leverage can only be imperfectly enforced—for example due to the rise of a large shadow-banking system in the US over the last two decades or so—and examining the interplay of such imperfect enforcement with the crowding out of investment by financial risk-taking highlighted here.[9]

Inflationary consequences of excessive stimulation. The goal of this paper is to offer a model in which monetary stimuli generate material financial instability in the form of inefficient asset liquidation even when optimally designed. We do so in the simplest possible framework with a minimum set of ingredients. In particular, we analyze a fixed-price model. With less extreme price rigidity, we conjecture that financial instability and price-level

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

instability would presumably be substitute. In the face of a lower policy rate, more rigid prices would both correspond to lower inflation and a lower real rate leading in turn to a larger demand of funds by entrepreneurs.

6 Concluding remarks

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 study an economy in which i) the intertemporal rate of substitution of agents with the highest borrowing capacity in the economy exceeds the policy rate, ii) the public sector has limited control over maturity transformation by the private sector. Under these circumstances, monetary easing triggers a large amount of financial risk-taking at the expense of capital expenditures. Financial risk-taking is a socially costly rent extraction by entrepreneurs. The model gives a compact explanation for the increase in maturity transformation and share buybacks that has accompanied the recent phases of monetary easing, together with limited investment despite a wedge between the marginal return on capital and interest rate.

There are many directions in which we could extend our analysis fruitfully. For example, we could introduce uncertainty to the duration of the productivity shock experienced by the economy over time (instead of a one-period shock) whereby monetary easing may continue for several periods and then be tightened at the cost of unwinding of financial sector carry-trades. Carry trades 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 (Feroli et al. 2014).

References

Acharya, Viral V., and Hassan Naqvi. 2012a. "The Seeds of a Crisis: A Theory of Bank Liquidity and Risk Taking over the Business Cycle," *Journal of Financial Economics* 106 (2).

Acharya, Viral V. and Hassan Naqvi. 2012b. "Bank Liquidity and Bubbles: Why Central Banks Should Lean against Liquidity," In *New Perspectives on Asset Price Bubbles: Theory, Evidence and Policy*, edited by Douglas Evanoff, George Kaufman and A.G. Malliaris. New York: Oxford University Press.

Acharya, Viral V. and Guillaume Plantin. 2019. "Monetary Easing, Leveraged Payouts and Lack of Investment," Working Paper, New York University Stern School of Business.

Acharya, Viral V., Ryan Banerjee, Matteo Crosignani, Tim Eisert and Renée Spigt. 2022. "Exorbitant Privilege? Quantitative Easing and the Bond Market Subsidy of Prospective Fallen Angels," Working Paper.

Acharya, Viral V. and Siddharth Vij. 2020. "Foreign Currency Borrowing of Corporations as Carry Trades: Evidence from India," Working Paper.

Bernanke, Ben S. 2010. "Monetary Policy and the Housing Bubble," Speech at the Annual Meeting of the American Economic Association,

Atlanta, Georgia.

Boyarchenko, Nina, Anna Kovner, and Or Shachar. 2022. "It's what you say and what you buy: A holistic evaluation of the corporate credit facilities," *Journal of Financial Economics* 144(3), 695-731.

Abadi, Joseph, Markus K. Brunnermeier and Yann Koby. 2023. "The Reversal Interest Rate," *American Economic Review* Vol. 113, No. 8, 2084–2120.

Bruno, Valentina and Hyun-Song Shin. 2017. "Global Dollar Credit and Carry Trades: A Firm-level Analysis," *Review of Financial Studies,* Vol.30, Issue 3, 703-749.

Caballero, Ricardo J. and Emmanuel Farhi. 2018. "The Safety Trap," *Review of Economic Studies,* Vol. 85, Issue 1, 223-274.

Coimbra, Nuno and Hélène Rey. 2023."Financial Cycles with Heterogeneous Intermediaries," *Review of Economic Studies.*

Diamond, Douglas W. 1997. "Liquidity, Banks, and Markets," *Journal of Political Economy* 105 (5).

Diamond, Douglas W. and Raghuram G. Rajan. 2012. "Illiquid Banks, Financial Stability, and Interest Rate Policy," *Journal of Political Economy* 120 (3).

Duffie, Darrell. 2020. "Still the world's safe haven? redesigning the U.S. Treasury market after the Covid-19 crisis", Working Paper, 2020

Falato, Antonio, Itay Goldstein, and Ali Hortacsu. 2021. "Financial fragility in the COVID-19 crisis: The case of investment funds

in corporate bond markets.," *Journal of Monetary Economics*, 123:35-52.

Farhi, Emmanuel and Jean Tirole. 2012. "Collective Moral Hazard, Maturity Mismatch, and Systemic Bailouts," *American Economic Review* 102 (1): 60–93.

Feroli, Michael, Anil K. Kashyap, Kermit Schoenholtz, and Hyun Song Shin. 2014. "Market Tantrums and Monetary Policy," U.S. Monetary Policy Forum.

Furman, Jason. 2015. "Business Investment in the United States: Facts, Explanations, Puzzles, and Policies," Council of Economic Advisers. Remarks at the Progressive Policy Institute.

Gilchrist, Simon, Bin Wei, Vivian Yue, and Egon Zakrajsek. 2020. "The fed takes on corporate credit risk: An analysis of the efficacy of the SMCCF," BIS Working paper.

Gutiérrez, Germán and Thomas Philippon. 2017. "Investmentless Growth: An Empirical Investigation," *Brookings Papers on Economic Activity,* Fall.

He, Zhiguo, Stefan Nagel and Zhaogang Song. 2022. "Treasury inconvenience yields during the COVID-19 crisis", *Journal of Financial Economics,* Vol. 143, issue 1, 57-79.

Haddad, Valentin, Alan Moreira, and Tyler Muir. 2021. "When Selling Becomes Viral: Disruptions in Debt Markets in the COVID-19 Crisis and the Fed's Response", *The Review of Financial Studies,* 34(11), 5309-5351.

International Monetary Fund. 2016. "Monetary Policy and the Rise of Nonbank Finance," In *Global Financial Stability Report, October 2016.*

International Monetary Fund. 2017. "Getting the Policy Mix Right," In *Global Financial Stability Report, April 2017.*

Jiang, Hao, Yi Li, Zheng Sun and Ashley Wang . 2022. "The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy." *Journal of Financial Economics*, Vol. 143, issue 1, 277-302.

Kargar, Mahyar, Benjamin Lester, David Lindsay, Shuo Liu, Pierre-Olivier Weill, and Diego Zuniga. 2021. "Corporate bond liquidity during the COVID-19 crisis." *Review of Financial Studies*, 34(11), 5352-5401.

Krishnamurthy, Arvind and Annette Vissing-Jorgensen. 2011. "The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy." *Brookings Papers on Economic Activity.*

Landier, Augustin and Guillaume Plantin. 2017. "Taxing the Rich," *Review of Economic Studies* 84 (3), 1186-1209.

Li, Yi, Maureen O'Hara, and Xing (Alex) Zhou. 2020. "Mutual fund fragility, dealer liquidity provisions, and the pricing of municipal bonds," Working Paper.

Logan, Lorie K. 2021. "Liquidity Shocks: Lessons Learned from the Global Financial Crisis and the Pandemic". *Remarks at the 2021 Financial Crisis Forum, Federal Reserve Bank of New York.*

Ma, Yiming, Kairong Xiao, and Yao Zeng. 2022. "Mutual fund liquidity transformation and reverse flight to liquidity," *Review of Financial Studies* 35(10), 4674-4711.

O'Hara, Maureen and Xing (Alex) Zhou. 2021. "Anatomy of a liquidity crisis: Corporate bonds in the COVID-19 crisis," *Journal of Financial Economics* 142(1), 46-68.

Plantin, Guillaume. 2015. "Shadow Banking and Bank Capital Regulation," *Review of Financial Studies* 28 (1), 146-175.

Quadrini, Vincenzo. 2017. "Interest Rate Policies, Banking and the Macro-economy," working paper.

Quarles, Randal K. 2020. "What happened? What have we learned from it? Lessons from COVID-19 stress on the financial system," speech at the *Institute of International Finance*, Washington D.C. .

Rajan, Raghuram G. 2013. "A Step in the Dark: Unconventional Monetary Policy after the Crisis," Andrew Crockett Memorial Lecture, Bank for International Settlements.

Schrimpf, Andreas, Hyun Song Shin, and Vladyslav Sushko. 2020. "Leverage and margin spirals in fixed income markets during the COVID-19 crisis", BIS Working Paper.

Stein, Jeremy C. 2012. "Monetary Policy as Financial-Stability Regulation," *Quarterly Journal of Economics* 127 (1).

Stein, Jeremy C. 2013. "Overheating in Credit Markets: Origins, Measurement, and Policy Responses," Speech delivered at the "Restoring Household Financial Stability after the Great Recession: Why

Household Balance Sheets Matter" research symposium sponsored by the Federal Reserve Bank of St. Louis, St. Louis, Missouri.

Taylor, John. 2011. "Macroeconomic Lessons from the Great Deviation," in Daron Acemoglu and Michael Woodford (Eds.) NBER Macroeconomics Annual, Vol. 25, The University of Chicago Press, 25.

Taylor, John. 2012. "Monetary Policy Rules Work and Discretion Doesn't: A Tale of Two Eras," *Journal of Money Credit and Banking* 44 (6).

Vissing-Jorgensen, Annette. 2021. "The treasury market in spring 2020 and the response of the federal reserve," *Journal of Monetary Economics*, 124:19-47.