# Leverage and the Central Banker's Put*

Emmanuel Farhi[†] and Jean Tirole[‡]

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**Abstract**

The paper elicits a mechanism by which that private leverage choices exhibit strategic complementarities through the reaction of monetary policy. The key ingredient is that monetary policy is non-targeted. The ex-post benefits from a monetary bailout accrue in proportion to the number amount of leverage, while the distortion costs are to a large extent fixed. This insight has important consequences. First, private interest-rate exposure is highly sensitive to macroeconomic conditions. Second, private borrowers may deliberately choose to *increase* their interest-rate sensitivity following bad news about future needs for liquidity. Third, optimal monetary policy is time inconsistent. Fourth, macro-prudential supervision is called for.

*Keywords*: monetary policy, funding liquidity risk, strategic complementarities, macro-prudential supervision

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## 1 Introduction

Among the many unusual aspects of the ongoing financial crisis features the unprecedented provision of backstop liquidity by central banks around the world. The Fed alone had committed $4,400 billion by mid-November 2008.[1] The Fed funds rate is almost equal to zero.

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[†]Harvard University, department of Economics, Littauer 318, 1875 Cambridge Street, Cambridge MA 02138, Tel: 617-496-1835, Fax: 617-495-8570, efarhi@fas.harvard.edu

[‡]Toulouse School of Economics, Manufacture des Tabacs, 21 allees de Brienne, F-31000 Toulouse, Phone: (33 5) 61 12 86 42, Fax: (33 5) 61 12 86 37, e-mail: tirole@cict.fr

[1]Source: Bloomberg.

These are extraordinary numbers.

This paper establishes a formal relationship between the recent monetary developments and the trends in private leverage and its structure. Over the last few years, some traditional institutions broker-dealers have relied more and more on markets (securitization, money market) for their funding. Some banks have also increased their dependence on markets; the standard illustration is Northern Rock, a UK mortgage bank, which prior to its bailout relied on short-term wholesale markets for 75% of its funding.

A second factor contributing to the reliance on wholesale markets is the overall shift from a bank-based system to a market-based one. The expanding so-called "shadow banking system" (conduits, hedge funds, investment banks, monolines) has engaged in substantial transformation, and unlike commercial banks, could not prevail itself of stable insured deposits. Mutual funds are under the threat of severe redemptions and may well face liquidity shortages as well.

Adding subprime borrowers, who are heavily dependent on high housing prices and, for those with ARMs, on low short-term interest rates, and highly leveraged corporations, the overall picture is one of a fragile economic environment that has become overly sensitive to interest rate risk.

The paper's key insight is that private leverage choices exhibit strategic complementarities through the policy reaction. Monetary policy, defined here as the public sector exerting a downward pressure on interest rates, is a prototypical non-targeted public policy. It rescues those who depend on low interest rates, but its other benefits and costs apply to the entire economy. As a consequence, the more economic actors exhibit a substantial interest-rate vulnerability, the more the state has to engage in active monetary policy. The lack of targeting implies that one is more likely to be rescued by monetary policy, the higher the overall economy's sensitivity to interest rate conditions.

This central insight has four immediate corollaries. First, private interest-rate exposure is highly sensitive to macroeconomic conditions. Second, private borrowers may deliberately choose to *increase* their interest-rate sensitivity following bad news about future needs for liquidity, a conclusion that runs afoul of the pattern predicted by standard modeling focusing on the microeconomics of corporate finance. Third, optimal monetary policy is time inconsistent, but not for the standard, inflation-bias reason; the central bank would like to commit not to lower the interest rates, but may ex post face the fait accompli of excessive short-term wholesale markets exposure. Fourth, and related to the previous point, macro-prudential supervision is called for.

# 2 The Model

The following stylized model illustrates the basic points. There are three periods, $t = 0, 1, 2$ and two groups of economic agents, of mass 1 each: entrepreneurs and consumers (investors).

**Consumers.** Consumers derive utility from consumption path $\{c_0, c_1, c_2\}$

$$V = c_0 + u(c_1) + c_2,$$

where $u$ is increasing and concave. They have "large" endowments $e_0$, $e_1$ at dates 0 and 1.

**Entrepreneurs.** Entrepreneurs have utility function

$$U = c_0 + c_1 + c_2$$

where $c_t$ is their date-$t$ consumption. Their only endowment is their wealth $A$ at date 0. Their technology set exhibits constant returns to scale. At date 0 they choose their investment scale $I$. If still productive at date 2 (see below), this investment then delivers $\rho_1 I$, of which $\rho_0 I$, is pledgeable to investors where $\rho_0 < 1$.[2]

[2] As usual, the "agency wedge" $\rho_1 - \rho_0$ can be motivated in multiple ways, including incentives to counter

In practice, an exposure to funding liquidity risk can stem from multiple factors: a reliance on securitization, a lack of hedging, or the failure to hoard liquid assets or to secure lines of credit. We here capture these various possibilities through a metaphor: The entrepreneur chooses at date 0 between a costly but safe technology, that never requires additional funds at date 1, and a cheaper but risky technology, that is vulnerable to liquidity shocks.

Under the safe technology, the entrepreneur is never exposed to a shock. The cost of investing at scale $i$ is $Ki$ where $K > 1$. The risky technology is cheaper. The date-0 investment cost is $I$ for investment scale $I$. However, with probability of "distress" $1 - \alpha$, one unit of reinvestment is needed per unit of initial investment in order for investment to be productive at date 2; otherwise the investment is discarded and there is no liquidation value. With probability $\alpha$, the firm is "intact" and needs no reinvestment at date 1. For simplicity, we will assume that the liquidity-need realizations are independent across firms choosing the risky technology. Finally we make the following assumption.

**Assumption 1**: $\frac{1}{\alpha} > K > 1 + (1 - \alpha)\rho_0$

This assumption will ensure that entrepreneurs find it preferable to opt for the safe technology if they anticipate that no monetary bailout will take place, and to opt for the risky technology if they anticipate that a monetary bailout will take place.

**Storage Technolgies.** There exists a linear storage technology that permits the transfer of resources between date 1 and date 2, with rate of return normalized to 1. There is no storage technology between date 0 and date 1.

**Markets and Contracts.** The only trades consumers and entrepreneurs can engage in are spot loan contracts. Both the technology choice and the level of investment of each entrepreneur are observable. By so restricting the set of contracts, we implicitly make the following two assumptions. First because there is no storage technology between date 0 and

moral hazard (see e.g., Holmström-Tirole 2008 for a discussion).

date 1 and because consumers cannot pledge at date 0 their endowment at date 1, there are no stores of value in the economy to carry wealth from date 0 to date 1. We could introduce stores of value, whose price would be determined by a date-0 clearing condition in the market for liquidity. Second, firms cannot pledge at date 0 funds for date 1 to other firms, contingent on their being intact (by design or by chance). That is, our model follows the lead of Caballero and Krishnamurthy (2003,a,b), and assumes that liquidity is not coordinated and therefore wasted. The results are robust to the relaxation of these two assumptions, but we deliberately focus on the simplest possible environment here.

**Central Bank.** The central bank sets monetary policy by controlling the real interest rate in the economy. In our environment, this amounts to assuming that investment in the linear storage technology between date 1 and date 2 is observable. Usage of this technology can then be taxed or subsidized, leading to a real (after-tax) interest rate equal to $R$. The proceeds are rebated lump sum to the consumers. The central bank maximizes a weighted average of consumer and entrepreneur welfare, with weight $\beta \leq 1$ on entrepreneurs:

$$W = V + \beta U$$

where the following assumption holds, which guarantees that reinvesting in distressed firm is socially optimal:

**Assumption 2**: $\beta(\rho_1 - \rho_0) > 1 - \rho_0$.

The potential costs and benefits of accommodative monetary policy can be understood as follows. On the one hand, lowering the real interest rate below one introduces a wedge between the intertemporal rate of substitution of consumers and the rate of return on the storage technology. On the other hand, it makes both investment in distressed firms at date 1 and investment in the risky technology more attractive at date 0 more attractive.

Our modelling of monetary policy deserves some comments. To simplify the exposition and focus on our specific contribution, we have built a real model with no money balances in our model, no sticky prices and no imperfect competition. Yet we argue that our modelling of monetary policy captures a key feature of monetary policy in New-Keynesian models. There, the nominal interest rate is controlled by the central bank. Prices only adjust gradually according to the New-Keynesian Phillips Curve, and the central bank can therefore control the real interest rate. The real interest rate regulates aggregate demand through a version of the consumer Euler equation – the dynamic IS curve – by determining the slope of the intertemporal consumption profile – the intertemporal rate of substitution. Without additional frictions, the central bank can achieve the allocation of the flexible price economy by setting nominal interest rates so that the real interest rate equals to the "natural" interest rate. Deviating from this rule introduces unnecessary distortions. Our model shares the assumption that monetary policy acts by affecting the real interest rate or equivalently the intertemporal rate of substitution of consumers. However, the specific nature of the distortion imposed by monetary policy is different: a wedge between the intertemporal rate of substitution of consumers and the return on the storage technology in our model versus dispersion in relative prices in New-Keynesian model.

Note also that we are ruling out other forms of policy intervention. For example, we do not consider subsidies to reinvestment. This extreme assumption is just meant to rule out direct bailouts and thus to focus on monetary policy. This restriction could be derived from explicit but extreme information constraints, assuming that types – consumer versus investor – are private information and that technology choice, investment by entrepreneurs and trades between consumers and entrepreneurs are hidden from the central bank, who only observes aggregate variables and investment in the storage technology.

# 3 Monetary Policy under Commitment

In this Section, we analyze the equilibrium under commitment where monetary policy is passive. Under the other assumptions of this model, the interest rate will never fall below $\rho_0$. This is the interest rate that allows distressed firms to be refinanced. For this reason, we refer to the event $\{R = \rho_0\}$ as a monetary bailout. We denote by $y \equiv \Pr(R = \rho_0)$ the exogenous probability of such a monetary bailout. Let $x$ denote the fraction of entrepreneurs who choose the risky technology.

**Safe Technology.** Consider the case of an entrepreneur investing in the safe technology at date 0. The entrepreneur's borrowing capacity is determined by

$$Ki - A = \rho_0 i.$$

Letting

$$i^* \equiv \frac{A}{K - \rho_0},$$

the entrepreneur's net utility is

$$U = (\rho_1 - \rho_0)i^*. \tag{1}$$

**Risky Technology.** Consider now the case of an entrepreneur investing in the risky technology. A firm in distress at date 1 is fully dependent on funding liquidity, namely its ability to raise new funds on the market. Such funds can be raised only if (one plus) the interest rate, $R$, between dates 1 and 2 is low enough, namely $R \leq \rho_0$. A risky firm's borrowing capacity is determined by

$$I - A = \alpha\rho_0 I$$

since $R \geq \rho_0$ implies that initial investors never make a return when the firm is in distress.

Letting

$$I^* \equiv \frac{A}{1 - \alpha\rho_0},$$

the entrepreneur has utility

$$U = (\rho_1 - \rho_0)[\alpha + (1 - \alpha)y]I^* \tag{2}$$

when choosing the risky technology.

**Equilibrium Technology choice.** Entrepreneurs therefore prefer to invest in the safe technology if and only if

$$(\rho_1 - \rho_0)i^* \geq (\rho_1 - \rho_0)[\alpha + (1 - \alpha)y]I^*. \tag{3}$$

The second inequality in Assumption 1 ensures that choosing the risky technology allows for a larger scale $I^* > i^*$. The higher the cost disadvantage $K - 1 - (1 - \alpha)\rho_0$ of the safe technology, the larger the investment scale disparity. The entrepreneurs trades off this larger scale against the lower probability of success $\alpha + (1 - \alpha)y$ involved in the risky technology. The latter depends on the stance of monetary policy. The higher the probability $y$ of a monetary bailout, the larger the probability of success of a risky project, and the more attractive the risky technology.

The equilibrium is entirely pinned down by this condition. If (3) holds with a strict inequality, then entrepreneurs invest in the safe technology. If (3) is violated, then entrepreneurs invest in the risky technology, and distressed projects are continued only in the case of a monetary bailout. Entrepreneurs never consume at date 0 and 1. At date 2, they consume $(\rho_1 - \rho_0)\, i^*$ if they invest in the safe technology, and $(\rho_1 - \rho_0)\, I^*$ if they invest in the risky technology and their project was safe or bailed out. Consumers lend the funds necessary for investment at date 0 and consume the residual $c_0$. Their consumption at date 1, 1 and 2 is determined by $u'(c_1) = R$. Finally, their consumption at date 2 is determined by the budget constraint $c_0 + c_1 + c_2 = e_0 + e_1$.

**Optimal Policy under Commitment.** The case of a passive, laissez-faire monetary policy is an important benchmark. The rate of interest between dates 1 and 2 is then

$$R = 1 > \rho_0$$

so that $y = 0$. Conditions (1) and (2), together with the first inequality in Assumption 1, imply that the entrepreneurs opt for the safe technology. Thus the equilibrium features $x = 0$.

Another important benchmark is the case where a monetary policy bailout occurs with probability $y = 1$. The first inequality in Assumption 1 then ensures that entrepreneurs choose the risky technology so that $x = 1$.

Optimal monetary policy under commitment involves either laissez-faire or systematic monetary bailouts. To rescue distressed firms, the state must bring the interest rate $R$ down to $\rho_0$. The following objects are useful to compare welfare under both policies. Let $I_1$ the amount of reinvestment in distressed firms desired at date 1. Define

$$\hat{V}(R) \equiv u(e_1 + \widehat{X}) - \widehat{X} \quad \text{with} \quad u'(e_1 + \widehat{X}) = R,$$

and consumer welfare

$$V(R; I_1) = \hat{V}(R) - (1 - R)I_1 \text{ for } R \leq \rho_0 \text{ and } V(R; I_1) = \hat{V}(R) \text{ for } \rho_0 < R \leq 1.$$

The difference between welfare under laissez-faire $W^{\ell f}$ and under systematic monetary bailouts $W^{mb}$ is given by

$$W^{\ell f} - W^{mb} = [V(1; 0) + \beta(\rho_1 - \rho_0)i^*] - [V(\rho_0; (1 - \alpha)I^*) + \beta(\rho_1 - \rho_0)I^*].$$

The optimal policy under commitment is laissez-faire if and only if $W^{\ell f} > W^{mb}$. This occurs when the welfare loss resulting from the distortion of the interest rate $\hat{V}(1) - \hat{V}(\rho_0)$ is greater than the net gain from a greater investment scale $\beta(\rho_1 - \rho_0)(I^* - i^*)$ due to the choice of the risky technology, net of the reinvestment cost $(1 - \rho_0)(1 - \alpha)I^*$ from rescuing distressed firms:

$$\hat{V}(1) - \hat{V}(\rho_0) > \beta(\rho_1 - \rho_0)(I^* - i^*) - (1 - \rho_0)(1 - \alpha)I^* \tag{4}$$

# 4 Limited Commitment and Monetary Bailouts

In the previous Section, we assumed that the central bank committed to monetary policy at date 0. In this Section, we depart from this assumption. Rather, we assume that monetary policy is set at date 1, without commitment. Without commitment, our environment has the following structure. We can represent the policy of central bank as a programming problem. There is a single state variable. This state variable is a simple transformation of the average action taken by firms at date 0. The relative expected payoffs to firms from the different actions depend on the anticipated policy by the central bank.

The state variable $I_1 \equiv x(1 - \alpha)I^*$ is the aggregate reinvestment need of distressed firms. The policy of the central bank is the date 1 interest rate. The action taken by firms at date 0 is to invest in a safe technology or a risky technology. The aggregate reinvestment need $I_1$ of distressed firms at date 1 is increasing in the number of firms investing in the risky technology at date 0.

**The Central Bank's decision.** At date 1, the central bank either sets the interest rate at the laissez-faire level of 1 or at the monetary bailout level $\rho_0 < 1$. Ex-post, it is optimal to set $R = \rho_0$ if and only if the welfare gains of a monetary bailout on entrepreneurs $\beta(\rho_1 - \rho_0)(1 - \alpha)I_1$ exceed the welfare losses on consumers $V(1;0) - V(\rho_0;(1 - \alpha)I_1)$. This condition can be rewritten as

$$\hat{V}(1) - \hat{V}(\rho_0) \leq [\beta(\rho_1 - \rho_0) - (1 - \rho_0)]I_1 \tag{5}$$

The left hand side of condition (5) corresponds to the "fixed cost" of the non-targeted policy: the interest rate is distorted, creating a welfare loss equal to $\hat{V}(1) - \hat{V}(\rho_0)$. The right hand side is the net gain (Assumption 2 guarantees that this term is positive) of rescuing distressed firms. This monetary bailout costs $1 - \rho_0$ per unit to consumers, but yields per unit benefit $\rho_1 - \rho_0$ to entrepreneurs. The higher the aggregate reinvestment need $I_1$ of distressed firms, the more likely a monetary bailout. Therefore, leverage decisions exhibit strategic complementarities. The higher the fraction of entrepreneurs investing in risky technologies, the higher the aggregate reinvestment need $I_1$ of distressed firms, the more likely a monetary bailout. This in turn makes the risky technology more desirable for entrepreneurs.

An intuition that accords with our title is that the central banker's put is closer to the money, the more leveraged the economy. As a result, the entrepreneurs' payoff is more convex, reinforcing the incentives for risk-taking and leverage.

**Equilibrium.** Note, first, that if the entrepreneurs opt for the safe technology, then $I_1 = 0$ and it is optimal for the central bank to set $R = 1$. Hence the laissez-faire equilibrium with $y = 0$ and $x = 0$ analyzed in Section 3 is still an equilibrium under no commitment. Under a stronger condition than Assumption 2, namely,

$$\hat{V}(1) - \hat{V}(\rho_0) \ \leq [\beta(\rho_1 - \rho_0) - (1 - \rho_0)](1 - \alpha)I^*, \tag{6}$$

then the systematic monetary bailout equilibrium with $y = 1$ and $x = 1$ analyzed in Section 3 is also an equilibrium.[3]. Furthermore, this equilibrium *Pareto-dominates* the safe strategy equilibrium from the point of view of entrepreneurs. We will henceforth assume that when

[3]There is then also an unstable, mixed equilibrium with $0 < x < 1$.

multiple equilibria coexist, the (entrepreneurs') Pareto superior one prevails.

**Sensitivity to Macroeconomic Conditions.** The possibility of multiple equilibria, one with $y = 0$ and $x = 0$, and one with $y = 1$ and $x = 1$ underscores that equilibrium risk-taking, leverage and monetary policy can be very sensitive to aggregate macroeconomic conditions ($\alpha$).[4]

Exposure to funding liquidity risk and monetary bailouts thus arise if condition (6) is satisfied. We therefore conclude that they are more likely when: (i) the corporate sector receives more weight in the state's objective function ($\beta$ high) and (ii) liquidity shocks are more likely ($\alpha$ low).

While (i) is rather obvious, (ii) deserves more comments. Note that under commitment to laissez-faire, the safe technology is more likely to be chosen ($1 > \alpha K$) if $\alpha$ is small. Nonetheless, without commitment, the policy reaction implies that the firms may take on more risk ($x = 1$) when bad news accrue ($\alpha$ decreases). When macroeconomic condition deteriorate ($\alpha$ decreases), the central banker's put is closer to the money. As a result, the entrepreneurs' payoff is more convex, inducing further risk-taking.

**Time-Inconsistency.** We can also comment on time consistency. When both (4) and (6) hold, the optimal policy under commitment is laissez-faire while under no commitment, systematic monetary bailouts occur. In this case, the optimal policy features a form of time-inconsistency. Welfare is higher when the central bank commits at date 0 not to lower interest rates at date 1. This deters entrepreneurs from engaging in risky-projects, which is socially optimal as long as (4) holds. When the central bank lacks commitment, instead, entrepreneurs anticipate a monetary bailout and invest in the risky technology at date 0. Many firms are then distressed at date 1, and the central bank finds it optimal to lower interest rates.

[4]Multiple equilibria can be seen as a convenient exposition tool to illustrate the general conclusion that the equilibrium can be very sensitivity to parameters.

The interaction between technology choice and monetary policy runs as follows. On the one hand, lower anticipated interest rates make the risky technology more attractive. On the other hand, the policy function for the interest rate is decreasing in the number of distressed firms. This interaction results in strategic complementarities in technology choice. When (6) holds, the laissez-faire equilibrium and the systematic monetary bailout equilibrium coexist. This equilibrium is selected and is inefficient.

**Regulating Leverage.** The perverse effects from leverage to the likelihood of monetary bailouts can be neutralized if technology choice can be regulated by the central bank. Thus, in our simple model, there is a role for macro-prudential supervision. Note that in our model, there is no role for such supervision under commitment. The reason is twofold. First, it is sub-optimal, both from the entrepreneurs' private perspective and from a social perspective of the central bank, to undertake a risky project that will be discontinued in case of distress. Second, in case a monetary bailout takes place, it is always optimal, both privately and socially, to undertake a risky project.

Indeed, it is enough for supervision to ensure that the aggregate amount of investment in the risky technology is capped by $\bar{I}$ where

$$\bar{I} \equiv \frac{\hat{V}(1) - \hat{V}(\rho_0)}{[\beta(\rho_1 - \rho_0) - (1 - \rho_0)](1 - \alpha)}.$$

This ensures that the benefits of implementing a monetary bailout are always less than its costs, which in turn induces the entrepreneur to limit their leverage by opting for the safe technology.

# 5 Conclusion

The paper elicits a mechanism by which that private leverage choices exhibit strategic complementarities through the reaction of monetary policy. The key ingredient is that monetary policy is non-targeted. The ex-post benefits from a monetary bailout accrue in proportion to the number amount of leverage, while the distortion costs are to a large extent fixed. We showed that this insight has important consequences. First, private interest-rate exposure is highly sensitive to macroeconomic conditions. Second, private borrowers may deliberately choose to *increase* their interest-rate sensitivity following bad news about future needs for liquidity. Third, optimal monetary policy is time inconsistent. Fourth, and related to the previous point, macro-prudential supervision is called for.

These insights are not specific to interest rate policy. The less targeted the policy under consideration, the more relevant our analysis. For example, some of the various facilities recently introduced by the Fed can be seen as a forms of subsidies, which are not targeted to the extent that they can be partly appropriated by agents who are not distressed or carry a lower weight in the central bank's welfare function. An important empirical question to interpret the recent events in the light of our model is whether these facilities are more targeted than the Fed funds rate. On the theoretical front, it is worth enriching the model to allow for a finer determination of the trade-offs underlying the choice between different policy instruments.

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