Crises in the modern financial ecosystem[1]

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ABSTRACT

We build a moral hazard model to study incentives of financial intermediaries (shortly bankers) facing a leverage-insurance trade-off in their investment choice. We demonstrate that the choice is affected by two recent *transformations* of the financial ecosystem bankers inhabit: (i) the rise of institutional savers, such as treasurers of global corporations, whose huge balances are in need for parking space and (ii) the proliferation of underfunded insurance companies and pension funds (ICPFs) which allocate capital to bankers to reach for yield. Bankers supply parking space to institutional savers and deliver leverage-enhanced returns to ICPFs. When the demand for parking space and the mismatch which ICPFs must bridge are large, the equilibrium allocation is characterized by high leverage and financial crises. We show that post-crisis regulatory reforms, while improving the resiliency of the regulated banking sector, create room for bank disintermediation and do not unambiguously limit systemic risks which can build up in the asset management complex. Fiscal and structural reforms that directly address the real economy roots of the two transformations are then essential to complement financial and banking regulations and promote financial stability and balanced growth.

JEL classification: G01, G23, G28.

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1. Introduction

The financial intermediation mechanism changes and evolves mainly to accommodate developments and needs that originate outside the financial sphere and transform the financial ecosystem inhabited by financial intermediaries themselves. We focus on two key transformations. The first is the rise of *institutional savers* seeking parking space for their increasing balances. They include global corporations accumulating huge retained earnings offshore, amid factors that span globalization, technological progress and increasingly sophisticated strategies of arbitraging global tax regimes. At the end of 2016, the 150 firms in the S&P 500 (excluding financials) were investing 1$ trillion of retained earnings in money and bond markets, according to recent research by Credit Suisse.[4] On the other side of the spectrum, the second transformation is the growing need of *institutional investors* for high returns to meet promises made in the past to their clients. Main examples include asset-liability mismatches of life insurers and sponsors of defined-benefit pension plans, that have been growing large under the push of ageing population and low productivity trends.[5]

The need for parking space by institutional savers and the aggressive reach for yield by institutional investors shape the incentives of financial intermediaries, such as banks and asset managers, that stand in the middle of the global intermediation chain. The two transformations have been first-order drivers of several of the dynamics which culminated in the burst of the Global Financial Crisis (Pozsar, 2015). Even more relevantly, they both remain and evolve, therefore potentially posing systemic risks, although in a new fashion. Embracing the broader view that the financial intermediation mechanism mainly responds to needs stemming from the real economy also sheds a different light on policies aimed at safeguarding financial stability. In our view, the latter must encompass measures that go beyond financial and banking regulations, such as fiscal and structural policies that directly address the roots behind the two above-mentioned transformations.

This paper builds a theoretical model that incorporates essential features of modern financial intermediation into a modified version of the canonical framework of Holmström and Tirole (2011) to understand incentives of financial intermediaries to take systemic risks (section 2.1). The model is then enriched and used to study how the two transformations

[4] See Credit Suisse's Global Money Notes 11, *Repatriation, the Echo-Taper and the €/$ Basis.*

[5] See Chapter 2 of the IMF GFSR (2017) for a broader analysis of Insurance and Pensions in a Low-Natural-Rate Economy.

affect systemic risk-taking incentives (section 2.2). Finally, in section 3, we use the model to evaluate policy measures aimed at safeguarding financial stability and highlight potential future sources of systemic risk.

Similarly to the original Holmström and Tirole contribution, the economy is populated by financial intermediaries (henceforth, simply bankers) that implement investment projects. At the initial date, the banker has some equity A, borrows $i - A$, invests and her leverage is capped by the *pledgeability* ρ_0 of investment projects. At an interim date, all projects can be hit by an occasional aggregate liquidity shock (crisis), and δ units must be reinvested for each unit to be brought to completion. The continuation scale $j \leq i$ depends on the *liquidity* $\ell \leq \rho_0$ at the interim date of the claims on projects' future returns . Bankers exploit financial innovations (shadow banking technology, see below) to relax moral hazard and boost both pledgeability and liquidity of investment projects. In this way, they can also finance high-risk projects (e.g. subprime mortgages). We microfound the banker's choice between high-risk and low-risk projects. The former offers higher expected returns (z^r) and leverage, but becomes illiquid in a crisis ($\ell^r < \delta$), thereby forcing bankers to deleverage ($j^r = 0$ in a crisis). On the contrary, low-risk projects offer lower returns ($z < z^r$) and leverage but the claims on their future returns are liquid ($\ell \geq \delta$) and are brought to completion in all states of nature ($j = i$). We show that the banker optimally invests in high-risk projects when the cost of leverage is low enough. The model is then enriched with (non financial) firms that may need/seek to save. When firms save a fraction of their endowment, a demand for parking space arises. In the language of the paper, this is the rise of institutional savers. Pledgeable claims on the future returns of investment projects implemented by bankers represent natural parking space to firms. The larger the firms' savings, the lower the cost of leverage for bankers, and therefore, the stronger the incentives to invest in high-risk projects.

We then introduce ICPFs which manage an endowment A_p at the initial date and must meet a fixed return target $\bar{C}_p$ at the final date, reflecting promises previously made to their clients. They are attracted by leverage-enhanced returns delivered by bankers. ICPFs allocate funds to bankers under the assumption that the latter borrow (from households and/or firms) and invest in low- or high-risk projects to accomplish the mandate in exchange for a fee. ICPFs are also risk averse, in that they suffer a large utility loss when they fail to meet their target. Thus, generally, ICPFs dislike allocation to high-risk projects as the latter are abandoned in a crisis. We show that, for a given distribution of ICPFs heterogeneous with respect to $A_p/\bar{C}_p$, the lower the equilibrium cost of leverage, the higher the leverage-enhanced return that bankers can deliver to ICPFs by investing in low-risk projects, and the lower the aggregate allocation to high-risk projects. When projects' productivity is low and/or the cost of leverage is high, ICPFs with large mismatch (low $A_p/\bar{C}_p$) will simply maximise utility in the no crisis state and allocate to high-risk projects. More in general, when the allocation choice is aimed at meeting a fixed return target, leverage and liquidity risk become substitutes: either ICPFs can access cheap leverage and lever low-risk and liquid assets up, or they invest in high-risk and illiquid assets.

The previous result has deep implications when it comes to policy measures to safeguard financial stability. Assume that a public authority (government, central bank) has the mandate to minimize deleveraging at the equilibrium. Consider first the setup with bankers, households and firms only. The simplest regulatory measure is to impose a cap on the leverage of bankers, in line with the Basel *Leverage Ratio Requirement* (LR). In the model, bankers face a leverage vs. insurance trade-off and their utility is a combination of investment scale i and continuation scale j. Intuitively, when i is capped, bankers will seek to exhaust borrowing capacity and increase utility by boosting j. Other policy options are based on the ability of the public authority to issue government bonds. In this class of models, the government can exploit its regalian taxation power and issue bonds backed by the promise to tax households at future dates. Sovereign bonds represent public parking space to firms and compete with the private parking space provided by bankers. Actively managing the supply of sovereign bonds to deal with financial stability concerns may be suboptimal as it mainly responds to exogenous and independent fiscal considerations. However, securities lending facilities, in line with the Federal Reserve *Reverse Repo Program* (RRP), can be actively used to repo out central bank's sovereign bonds' holdings. In the model, the authority can expand public parking space available to firms, increase the equilibrium cost of leverage and limit systemic risk. Another policy option centred around the issuance of sovereign bonds is liquidity regulation, in line with the Basel *Liquidity Coverage Ratio* (LCR). The concept is introduced in the model by requiring bankers to hold a minimum amount of sovereign bonds for each unit invested in high-risk projects. Sovereign bonds are liquid in all states of nature and can be used in a crisis to meet the reinvestment shock.

These policy options are effective when risk-taking incentives are determined by bankers that raise funding from households and firms. However, they generally perform poorly in the more general framework in which (a part of) risk-taking is driven by the need of ICPFs to meet the target. Indeed policies aimed at capping leverage (LR), making leverage more costly (RRP) and improving the liquidity of bankers (LCR) all have an adverse effect on the ability of ICPFs to grasp adequate returns and bridge their mismatch through portfolios built around combinations of low-risk projects and sovereign bonds. More specifically, the policies either entail lower leverage-enhanced returns associated to low-risk projects (LR and RRP) or, by increasing the aggregate demand for sovereign bonds, depress sovereign yields (LCR). We use the model to show that, in this scenario, ICPFs disintermediate regulated banks, that come with high cost of portfolio selection and disappointing returns. Alternative strategies include (i) allocation to asset managers that operate at lower leverage but charge low costs of portfolio selection, (ii) unlevered direct exposures to high-risk segments, such as emerging markets, infrastructure, etc.. Both alternatives are conducive to financial stability risks.

In the light of the above, financial stability requires a broader policy toolkit. Financial and banking regulations must be coupled with fiscal and structural policies that directly address real-economy drivers that fuel transformations of the financial ecosystem. These policies include tax reforms to address tax optimization strategies of global corporations. In this respect, the recent US tax reform - among other effects - will likely promote a simplification of the plumbing of global intermediation. The move from a global to a territorial tax system removes incentives for US global corporations to invest retained offshore earnings in the bond market and, at the same time, tap the onshore bond markets to raise cash to distribute dividends. On the other hand, the buildup of asset-liability mismatch of insurance companies and pension funds can be relaxed, for instance, by promoting a switch from defined-benefit to defined-contribution pension plans.

Relationship with the literature. Our contribution is related to the literature on financial intermediaries as producers of liquidity, in line with Diamond and Dybvig (1983) and Gorton and Pennacchi (1990). We share the general approach to the demand for and the supply of liquid assets of Holmström and Tirole (2011), henceforth HT. The two Nobel laureates explore conditions under which the private sector creates enough pledgeable income, the so-called inside liquidity, to support financial claims necessary for implementing a second-best, state-contingent production plan. We build on this framework and introduce two major novelties. First, we endow bankers, the "producers" of inside liquidity, with a *shadow banking technology* to boost projects' pledgeability at the initial date and their liquidity, at the intermediate date. This allows bankers to fund progressively riskier projects. We characterise this financial innovation as the backbone of money market funding of capital market lending (Mehrling et al., 2013). In line with Gorton and Metrick (2012) and Brunnermeier and Sannikov (2014), our shadow banking technology has to be intended as the wave of financial innovations, e.g. securitization and repo finance, that expand opportunities to hedge idiosyncratic risk. However, this may come at the cost of incentivising agents to take on more leverage and exposures to systemic risk. In Gennaioli et al. (2013), shadow banks pool their idiosyncratic risks, thereby increasing their systematic exposure, and use the safe part of these recombined portfolios to back the issuance of safe debt. This is conducive to financial instability when agents underestimate the tail of systematic risk. We instead consider the polar case of which aggregate shocks and exposures to systemic risk (i.e. investment in high-risk projects) can be fully rational. The second main deviation from HT is that our model explores how (i) the conditions in the market for parking space and (ii) liability-driven investing incentives by ICPFs affect the equilibrium allocation. Pozsar (2014) explains how dealer banks intermediated global funding flows between institutional cash pools searching for safety via collateralised cash investments and levered portfolio managers searching for yield via funded securities portfolios and derivatives. Pozsar (2015) provides a deeper analysis of investment strategies adopted by dealers and asset managers to satisfy the demand from return-hungry insurance companies and pension funds with structural asset-liability mismatches. We develop these concepts and propose a more comprehensive framework, that can also be adapted to the post-crisis environment. Our paper is also related to the broad literature which investigates how real economy developments affect the financial system. This includes contributions on different topics such as savings glut (Bernanke et al., 2005), macro imbalances (Rajan, 2010; Caballero and Krishnamurthy, 2009) and secular stagnation (Summers, 2015). Although these themes are not at the core of our paper, in many parts it tries to stick developments in the real economy to their manifestation within the financial system.

2. The model

In section 2.1 we present the baseline model with bankers that have access to investment projects and to a shadow banking technology. We derive the optimal banker's choice and show that it is affected by the cost of leverage. In section 2.2.1 we introduce the supply of funding to bankers. In section 2.2.2 insurance companies and pension funds come into play.

2.1. The baseline setup

2.1.1. Agents

There is a single good used for consumption and investment, three dates: $t = 0, 1, 2$, and three classes of agents: households, firms and bankers.

Households are in a large number and collectively have endowments $Y_{c,t}$ at each date. They maximize utility $u_c = c_{c,0} + c_{c,1} + c_{c,2}$, where $c_{c,t}$ is consumption at date t. Households have a storage technology: one unit saved at date t yields one unit at $t + 1$. When lending out their endowment as market investors (see below), they require an expected return R_c.

Firms are in a continuum of unit mass. At $t = 0$ each firm has an endowment Y_f and maximises utility $u_f = \beta c_{f,0} + c_{f,1} + c_{f,2}$, where $\beta < 1$. Firms have access to investment opportunities and, differently from households, they cannot store their endowment. At $t = 0$, firms can then either consume, invest or lend at a rate R_f.

Bankers are in a continuum of unit mass and maximise utility $u_b = c_{b,0} + c_{b,1} + c_{b,2}$. They run banks and are protected by limited liability. They have equity A at $t = 0$, and can borrow and invest (see below).

We are interested in lending by corporations, or by a subset of them. Without loss of generality we assume firms do not borrow altogether.

2.1.2. Investment and shadow banking technology

In the initial period there are opportunities to invest (projects) that require a per-unit investment equal to 1. As in Holmstrom and Tirole (1997), the gross per-unit output of the investment at $t = 2$ is either Z, a success, or 0, a failure. The probability of success depends on an unobserved action (effort) taken by the banker. When exerting the effort, the probability of success is q; it declines to 0 when the banker shirks. Let $z \equiv qZ$ be the expected output when the banker behaves. Shirking guarantees per-unit private benefits B. As standard, the net return of the investment is positive only in the high effort case: $-1 + B \leq 0 \leq z - 1$.

Consider a banker which has equity A and implements a project of size i. She seeks to borrow and boost the investment scale $i > A$. Assume for now that the suppliers of funds (lenders, market investors) require a gross interest rate R and are paid contingent on the outcome of the project. Let Si (Fi) be the banker's wealth at $t = 2$ in case the project succeeds (fails). Limited liability implies that S and F cannot be negative. Investors receive $(Z - S)i$ in the case of success and $-Fi$ otherwise. Investors' participation constraint requires that $q(Z - S)i + (1 - q)(-F)i \geq (i - A)R$. In addition, the banker must be induced to provide high effort (incentive compatibility) $qSi + (1 - q)Fi \geq Fi + Bi$ or, rearranging terms, $S - F \geq B/q$. The banker earns a positive rent and it is optimal to set $F = 0$ and $S = B/q$. The pledgeable fraction of the future returns of the project, i.e. the maximum expected amount market investors can be promised when the banker is paid the minimum rent, is then $\rho_0 \equiv z - B$. The pledgeable fraction ρ_0 can be used by the banker to borrow and leverage up her equity.

As in Holmström and Tirole (1998), the banker faces an occasional liquidity shock before projects are brought to completion. The shock arrives with probability $1 - \alpha$ and is such that δ units must be reinvested for each unit of the project to be brought to completion. The project is abandoned and returns zero otherwise (see Figure 1). Consider the extreme case in which liquidity shocks are perfectly correlated across bankers (*crisis*), so that mutual insurance is not feasible. Each banker can only return to market investors and pledge claims on projects' returns to meet the reinvestment need. Let ℓ be the pledgeability of claims on future returns evaluated at $t = 1$. This is a key variable of our model, and in what follows we will refer to ℓ as *liquidity*. Notice that continuation requires $\ell \geq \delta$.

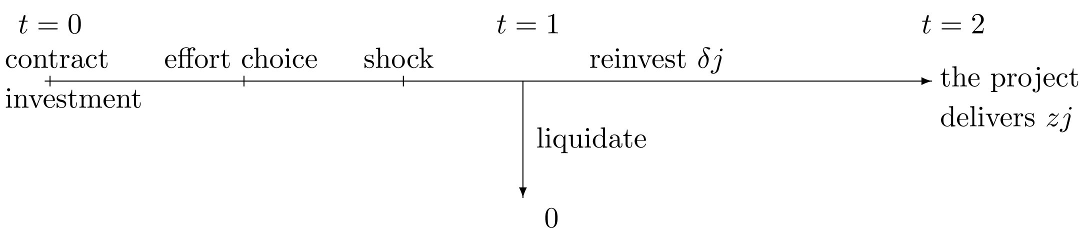

Figure 1: Investment and liquidity shock.

Before introducing shadow banking technology, assume the banker can also invest in *high-risk* projects. Let z^r and B^r be the expected output and private benefits associated riskier projects. We assume $z^r > z$ and $B^r > B$.[6] For the sake of expositional convenience, we refer to the other type of projects, characterized by expected return z and private benefits

[6]Riskier projects yield a higher expected output but are subject to more severe informational frictions.

B, as *low-risk* projects.

Shadow banking technology. One key novelty of our model is that we provide bankers with a shadow banking technology that lowers private benefits associated to projects from B and B^r down to b and b^r, respectively. It captures key features of financial innovation that permits the manufacturing of a broad range of securities, backed by future returns on historically illiquid assets, which are commonly accepted as collateral in money markets. In the terminology of the model, the pledgeable fractions of the two types of projects increase to $\rho_0 = z - b$ and $\rho_0^r = z^r - b^r$, for low and high-risk projects respectively. We make the following assumptions:

Assumption 1. $\rho_0^r > \rho_0$.

Assumption 1 states that one unit of the good generates more pledgeable returns if invested in high-risk projects.[7]

Assumption 2. $\ell^r < \delta$ *and* $\ell = \delta$.

Claims on future returns of high-risk projects become illiquid in a crisis.[8] Conversely, low-risk projects remain liquid and can be brought to completion in a crisis. Table 1 sums up relevant trade-offs.

Table 1: : Investment projects and shadow banking technology.

	$t = 0$ pledgeability	$t = 1$ liquidity	$t = 2$ expected return
Low-risk projects	$\rho_0 \equiv z - b$	$\ell \quad (= \rho_0 \equiv \delta)$	z
High-risk projects	$\rho_0^r \equiv z^r - b \quad (> \rho_0)$	$\ell^r \quad (< \delta)$	$z^r (> z)$

Discussion. As compared to the original HT framework, shadow banking techniques relax informational frictions and permit the liquification of historically illiquid assets. Bankers

[7]Consider the case of a banker that wants to hold assets worth 1 unit at $t = 2$ (in expectation). The banker can either invest $1/z$ in low risk projects or $1/z^r$ in high risk projects. She can leverage up its equity and raise ρ_0/z by pledging $1/z$ low risk projects and ρ_0^r/z^r by pledging $1/z^r$ high risk projects. Importantly, assumption 1 is perfectly compatible with a situation in which $\rho_0/z > \rho_0^r/z^r$. In other terms, we are not assuming that the equity needed to take a \$1 leveraged exposure on US Treasuries is higher than the equity needed to take a \$1 leveraged exposure on a residential mortgage-backed security.

[8]The banker cannot then return to market investors and raise the funding needed to accommodate the reinvestment shock.

can tap market investors to finance a larger fraction of their balance sheet. Assumptions 1 and 2 capture the idea that the shadow banking technology can be exploited either as a pure leverage-enhancing mechanism[9] or to generate liquidity to withstand aggregate shocks.[10] The setup is consistent with the findings of Gorton and Metrick (2012) for the US repo market.

2.1.3. The problem of the banker

In this section we describe the problem of a banker with equity A. She decides how much to borrow and which type of projects to implement. Consider for now a cost of leverage R, given and exogenous. The interest rate between $t = 1$ and $t = 2$, i.e. the rate at which the banker is able to finance the reinvestment shock (if any), is assumed to be 1 with no loss of generality. To make the problem tractable and interesting, we make the following standard assumptions.

Assumption 3. *(finite leverage)* $\rho_0^r < R/\alpha$ *and* $\rho_0 < R + (1-\alpha)\delta$.

Assumption 3 states that the pledgeability of investment projects is lower than their expected total cost.

Assumption 4. *(positive NPV in a crisis)* $z > 1 + \delta$.

Assumption 4 implies that the investment is always worth undertaking from a net-present-value point of view. Let $j^r \leq i^r$ and $j \leq i$ be the continuation scales of the two types of projects. The utility of a banker which invests i^r and i is:

$$u_b = \alpha[z^r i^r + zi] + (1-\alpha)[(z^r - \delta)j^r + (z-\delta)j] - R(i^r + i) \tag{1}$$

The banker maximises the utility subject to a borrowing and a liquidity constraint. The borrowing constraint is

$$R(i^r + i - A) \leq \alpha[\rho_0^r i^r + \rho_0 i] + (1-\alpha)[(\rho_0^r - \delta)j^r + (\rho_0 - \delta)j]. \tag{2}$$

[9] In the terminology of our model, this is the case of high-risk projects. These projects are intact in good states of nature and deliver relatively higher leverage and total returns. On the flip side, the liquidity of the claims on their future returns drops in those exact states of highest need (crisis). One may recall securities backed by subprime mortgages which suddenly became totally illiquid at the onset of the Great Financial Crisis.

[10] This is the case of low-risk projects. Shadow banking techniques help the banker to withstand liquidity shocks: at the cost of relatively lower total returns (and leverage), claims on low-risk projects' future returns remain liquid in a crisis so that these projects can always be brought to completion.

Continuation scales are derived from the liquidity constraints that, according to assumption 2, can be written as:

$$j^r = 0;\ j = i \tag{3}$$

The borrowing constraint stipulates that market investors must receive in expectations at least the amount lent to bankers times the required interest rate R. The repayment (left hand side of condition 2) cannot exceed total pledgeable resources (right hand side), which depend on the type of projects implemented by the banker and on the state of the economy at $t = 1$. With probability α, projects are intact and the banker optimally returns all pledgeable resources $\rho_0^r i^r + \rho_0 i$ to market investors. With probability $1 - \alpha$ the shock hits, high-risk projects are abandoned, the banker pledges ℓi and raises δi to meet the reinvestment shock to bring low-risk projects to completion.[11] The problem can be written as:

$$\max u_b = \alpha(z^r i^r + zi) + (1-\alpha)(z-\delta)i - R(i^r + i) \tag{4}$$

such that:

$$R(i^r + i - A) \leq \alpha(\rho_0^r i^r + \rho_0 i) \tag{5}$$

The banker's utility is increasing in investment scales and the borrowing constraint always holds with the equality. The Lagrangian of the problem is linear and the banker either chooses only low-risk or only high-risk projects. The optimal choice can then be simply determined by comparing utilities associated to the two policies, for any given R. The utility from investing in low-risk projects is:

$$u_b = [z - (1-\alpha)\delta - R]\, i \tag{6}$$

where the scale i is derived by imposing $i^r = 0$ into the borrowing constraint:

$$i = \frac{A}{1 - \alpha\rho_0/R} \tag{7}$$

and the quantity $1/[1 - \alpha\rho_0/R] > 1$ is the associated equity multiplier. The utility u_b^r from investing in high-risk projects is:

$$u_b^r = (\alpha z^r - R) i^r \tag{8}$$

[11] Also notice that, as in HT, initial investors are not repaid in a crisis, as $(\rho_0^r - \delta)j^r$ and $(\rho_0 - \delta)j$ are both zero.). Initial investors are fully diluted and, for this reason, do not expect any repayment in a crisis.

where the scale i^r is

$$i^r = \frac{A}{1 - \alpha\rho_0^r/R} \tag{9}$$

Investing in high-risk projects guarantees a higher leverage but the banker is forced to fully deleverage in a crisis. To make the banker's problem non trivial, we consider only the case when $z - (1-\alpha)\delta \geq \alpha z^r$, otherwise investing in high-risk projects is always optimal. The relevant result of this section is that the cost of funding R is a key determinant of the banker's choice.

Proposition 1. *Bankers invest in high-risk projects when the cost of leverage is lower than $\bar{R}$ and in low-risk projects otherwise.*

Proof. By comparing utilities u and u^r, $u^r \geq u \; \forall R \leq \bar{R}$, where with simple algebra and using $\delta = \rho_0$:

$$\bar{R} \equiv \frac{\alpha}{1-\alpha}(\rho_0^r - \alpha\rho_0) \tag{10}$$

■

The banker obtains utility from a combination of leverage and insurance. When the price of leverage R is low, obtaining insurance (i.e. investing in low-risk projects) is particularly costly in terms of utility, as the banker would otherwise obtain a large amount of (cheap) leverage by investing in high-risk projects.

2.2. Equilibrium

This section enriches the model with institutional savers and institutional investors. We first model the supply of funds to bankers by institutional savers. Firms save when investment opportunities available to them fall short of the endowment at their disposal. By affecting the funding mix available to bankers and the equilibrium cost of leverage, the demand for parking space by institutional savers ultimately affects the banker's choice and the balance between leverage and insurance.

2.2.1. Firms as institutional savers

Bankers can raise funding from both households and firms. For simplicity, we assume that each class of market investor is repaid according to its own outside option. Households have a storage technology and therefore require a gross expected return equal to $R_c = 1$. Firms have access to a limited amount T of investment opportunities and dislike consumption at

$t = 0$. When $T \geq Y_f$, firms invest their whole endowment. Conversely, for $T < Y_f$, we assume each firm faces a positive probability $(Y_f - T)/Y_f$ not to have access to investment opportunities. In the aggregate, only a fraction of the firms' endowment can be invested, while the remaining $Y_f - T$ is either consumed at $t = 0$ or lent out to bankers. Firms' opportunity cost of consumption at $t = 0$ is β, so that those in need for parking space will lend to bankers at a rate β. The equilibrium cost of funding for bankers thus depends on the relative share of funding raised from households and firms.

Result 1. *The higher the demand for parking space by firms the stronger the incentives for bankers to invest in high-risk projects.*

Proof. In general, the worse the firms' access to profitable investment projects, the higher the fraction of banks' funding that is sourced from firms, and therefore, the lower the average cost of leverage. Let's divide the problem in two cases.

1. When $T < Y_f$, there are two sub-cases:
   (a) $i^r + i - A \leq Y_f - T$, i.e. the demand for funding from bankers is not higher than the demand for parking space from firms. Bankers prefer first to exhaust the cheapest source of funding and thus borrow uniquely from firms. In this case, the equilibrium interest rate is $R = \beta$.
   (b) $i^r + i - A > Y_f - T$. Bankers raise $Y_f - T$ from firms and the remainder from households. The equilibrium (average) cost of funding is:
   $$R = \frac{\beta[Y_f - T] + [i^r + i - A - Y_f + T]}{i^r + i - A} \equiv 1 - (1 - \beta)\frac{Y_f - T}{i^r + i - A} \qquad (11)$$
   where $R \in (\beta, 1)$.
2. When $T \geq Y_f$, firms will not lend at the equilibrium and $R = 1$.

Clearly, $Y_f - T$ affects the cost of leverage and, according to result 1, the banker's choice. In cases 1.a and 2, equilibrium quantities and the banker's choice depend uniquely on $\bar{R} \equiv \frac{\alpha}{1-\alpha}(\rho_0^r - \alpha\rho_0)$ being lower than β and 1, respectively. The choice is fully determined by the probability of the crisis α and technological parameters. In case 1.b instead, any additional unit of funding raised from firms increases the parameters' space where the banker optimally invests in high-risk projects. ■

Discussion. This section sketches out a close link between (i) the availability of investment opportunities to firms (T), the initial distribution of wealth among households (Y_c), firms (Y_f) and bankers (A) and (ii) the intermediation system which emerges at the equilibrium. Lack of investment opportunities and/or excess savings from non financial firms exert a downward pressure on the cost of leverage, creating incentives for bankers to take on systemic risk.

2.2.2. Insurance companies and pension funds in need for returns

While in sections 2.1.3 and 2.2.1 the cost of leverage is the only driver of the banker's choice, the introduction of ICPFs modifies incentives in risk-taking. In this section we consider an economy populated by ICPFs, bankers, households and firms. ICPFs have an endowment A_p at $t = 0$ and commit to deliver $\bar{C}_p$ to their clients at $t = 2$. Let C_p denote ICPFs' assets at $t = 2$. ICPFs maximise the following utility function:

$$u_p = \begin{cases} C_p - \bar{C}_p & \text{if} \quad C_p \geq \bar{C}_p \\ \\ -M & \text{if} \quad C_p < \bar{C}_p \end{cases} \tag{12}$$

where M is positive and large. The utility is linear when ICPFs meet the target but drops sharply when realised returns fall short of the commitment. For the sake of simplicity, we assume bankers have no equity on their own ($A = 0$). ICPFs allocate their endowment to bankers, the latter borrow from households and firms and invest in high or low-risk projects to maximise the utility of ICPFs in exchange for a fee w.[12] In what follows, we then say ICPFs allocate to low or high-risk projects; $\bar{c}_p \equiv \bar{C}_p/A_p$ is a measure of ICPFs' asset-liability mismatch, or underfundeness, at $t = 0$. Also, it represents the required return to meet the target.

Proposition 2. *ICPFs allocate to high-risk projects if* $\bar{c}_p > \frac{z-\delta-R}{1-\alpha\rho_0/R} - w$ *and to low-risk projects otherwise.*

Proof. The utility from high-risk projects is:

$$u_p^r = \alpha \left\{ \left[\frac{z^r - R}{1 - \alpha\rho_0^r/R} - w \right] A_p - \bar{C}_p \right\} + (1 - \alpha)(-M) \tag{13}$$

In the good state, high-risk projects guarantee relatively high returns z^r and leverage $1/(1 - \alpha\rho_0^r/R)$. However, in a crisis, high-risk projects are abandoned, ICPFs miss the target and face the utility loss $-M$. The utility from low-risk projects is

[12] In a sense, bankers are redundant in this section. We prefer this representation and not to change terminology during the presentation of the different parts of the model. Bankers here are nothing more than vehicles which can deliver different combination of leverage and insurance.

$$u_p = \alpha \left\{ \left[\frac{z-R}{1-\alpha\rho_0/R} - w \right] A_p - \bar{C}_p \right\} + (1-\alpha)\Upsilon \tag{14}$$

where $\Upsilon = \left\{ \left[\frac{z-\delta-R}{1-\alpha\rho_0/R} - w \right] A_p - \bar{C}_p \right\}$ if $\frac{z-\delta-R}{1-\alpha\rho_0/R} - w \geq \bar{c}_p$ and $\Upsilon = -M$ otherwise. ICPFs strictly prefer allocation to low-risk projects when their leverage-enhanced return is a crisis is not lower than the required return: $\bar{c}_p \leq \frac{z-\delta-R}{1-\alpha\rho_0/R} - w$. In this way, ICPFs would avoid the utility loss $-M$ associated to high-risk projects in a crisis. On the contrary, when both high and low-risk projects fail to deliver the required return to meet the target in a crisis, ICPFs simply seek to maximise the return in the no crisis state and allocate to high-risk projects. ■

Discussion. Conditions in the market for parking space still play a role when the allocation choice is driven by the need for ICPFs to meet the target. Unsurprisingly, the cost of leverage (R), pledgeability parameters (ρ_0 and ρ_0^r) and projects' returns (z and z^r) affect equilibrium allocations. Risk averse ICPFs naturally dislike allocations to high-risk projects. A low cost of leverage R incentivises ICPFs to allocate to low-risk projects. Indeed $\frac{z-\delta-R}{1-\alpha\rho_0/R}$ is a decreasing function of R, in the relevant set of parameters. *Ceteris paribus*, the lower the cost of leverage, the higher the mismatch $\bar{c}_p$ that can be bridged. Generally, when the allocation choice is aimed at meeting a fixed return target, leverage and liquidity risk become substitutes: either ICPFs can access cheap leverage and lever lower risk/yield assets up, or they seek to invest in high-risk and illiquid assets. In a more general setting, equilibrium quantities are determined by the shares of capital allocation driven by ICPFs and bankers. In the next section we expand the analysis to include banking/financial regulation and also introduce sovereign bonds, a parking space alternative available to institutional savers.

3. Financial stability

Credit rationing models raise conceptual problems for welfare analysis. Even when agents are all risk neutral, Pareto optimal allocations cannot simply be determined by total surplus maximisation. To circumvent this problem, we introduce a public authority (government, central bank, ...) with a financial stability mandate. We introduce this concept into the model assuming that the authority seeks to minimise deleveraging in a crisis. The authority has no direct control on the bankers' private choice and can only implement measures and/or impose regulatory constraints to achieve its mandate. In what follows, we consider the case of bankers investing in high-risk projects in the market equilibrium (i.e. without any intervention by the authority). We analyse different sets of policies, which mainly mirror post-crisis regulatory reforms. First, we evaluate these policies within the setup with exclusively bankers, households and firms (section 3.1). We then consider the effects of these policies when ICPFs come into play (section 3.2).

3.1. Banks and institutional savers

The first policy consists of a regulatory constraint on the maximum leverage of bankers: when bankers face a trade-off between leverage and insurance, capping leverage induces bankers to exhaust borrowing capacity by obtaining more insurance, i.e. switch from high to low-risk projects. The second and the third policy measure are both based on the ability of the government to issue sovereign bonds. Specifically, the government exploits its regalian taxation power and issues debt obligations backed by the promise to tax households at future dates. Sovereign bonds are issued at $t = 0$, come with a supply X, cost 1 at $t = 0$ and return R_X with certainty at $t = 1$. At $t = 0$ the government sells the bonds and distributes the revenues from the sale to households; at $t = 1$ the authority imposes taxes to households and redeems the bonds. In order to rule out the possibility for sovereign bonds to redistribute wealth from taxpayers to bondholders, we consider $R_X \leq 1$.[13] Generally, when R_X is high enough, sovereign bonds can be attractive to ICPFs and can also represent *public parking space* to institutional savers. However, R_X must not be lower than β, otherwise not even firms in need for parking space would be willing to buy sovereign bonds at $t = 0$. The second policy option is a liquidity regulation, much in line with the Basel Liquidity Coverage Ratio. In this scenario, besides issuing bonds, the government requires bankers to hold a minimum amount of sovereign bonds for each unit invested in high-risk projects. Finally, the authority can supply public parking space to institutional savers. Sovereign bonds can indeed crowd out private parking space supplied by bankers and increase the equilibrium cost of leverage. When X is large enough, bankers can eventually switch from high to low-risk projects. Along this line, central banks with large sovereign bond portfolios can play an active role in managing the supply of parking space to institutional savers, by implementing securities lending facilities.

Leverage Ratio requirement. In the context of the setup described in Section 2.2.1, the simplest policy to rule out deleveraging at the equilibrium is a cap on leverage of bankers.

[13]No distortion from taxation is considered.

The highest investment scale, which is also compatible with bankers implementing low-risk projects, is derived by substituting $R = \bar{R}$ into the equation 7:

$$i_{LR} = \frac{\rho_0^r - \alpha\rho_0}{\rho_0^r - \rho_0} A \tag{15}$$

The associated Leverage Ratio requirement is $LR \equiv i_{LR}/A = \frac{\rho_0^r - \rho_0}{\rho_0^r - \alpha\rho_0}$. The LR requirement is binding when high-risk projects are implemented in the market equilibrium.

Liquidity Regulation. Sovereign bonds are assumed to be liquid in all states of nature and, if purchased in a sufficient amount by bankers at $t = 0$, can be used to accommodate the liquidity shock. The minimum amount of sovereign bonds which would guarantee no deleveraging at the equilibrium is $x = \delta/R_X$ per each unit invested in high-risk projects. Sovereign bonds also represent a lower-yield technology and depress the investment scale. Even more relevantly, when firms in need for parking space bid for sovereign bonds $R_X = \beta$ in equilibrium, and bankers' cost to hedge the liquidity shock is extremely costly. The banker can invest in low-risk projects and obtain utility defined in equation 6; alternatively, she can implement high-risk projects and purchase sovereign bonds. The borrowing constraint for a banker implementing i^r high-risk project is:

$$R(i^r - A + \delta i^r/\beta) = \alpha(\rho_0^r + \delta)i^r \tag{16}$$

Rearranging terms, the investment scale is:

$$i^r_{LCR} = \frac{A}{1 + \delta\left(\frac{1}{\beta} - \frac{\alpha}{R}\right) - \frac{\alpha\rho_0^r}{R}}$$

and utility:

$$u_{LCR} = [z^r - (1-\alpha)\delta - R]i_{LCR} \tag{17}$$

Notice that i_{LCR} and u_{LCR} are decreasing in β. The banker invests in high-risk projects when $R^* \leq \bar{R}(\beta)$ and $\bar{R}(\beta)$ is lower than $\bar{R}$. Liquidity regulation forces expected redistribution from bankers to households and is always an effective policy tool, even when $\bar{R} > 1$.

Public parking space. Sovereign bonds represent parking space supplied by the official sector which is available to firms. They compete with parking space supplied by bankers and increase the equilibrium cost of leverage. An adequate supply of sovereign bonds can thus induce bankers to switch to low-risk projects. However, that is an effective policy tool only when $\bar{R} \leq 1$.[14] The amount X_{pps} that induces bankers to invest in low-risk projects is:

$$X_{pps} = Y_f - T - (i_{pps} - A)\bar{R}$$

The equilibrium investment scale i_{pss} is equal to i_{LR} derived above. Sovereign bonds force expected redistribution from bankers to firms and/or households, depending on R_X.[15] In addition, the supply of sovereign bonds is usually driven by fiscal considerations and can hardly be adjusted within a short time frame to respond to financial stability concerns. However, central banks that hold large amounts of sovereign bonds can actively manage the supply of public parking space by implementing securities lending programs, in line with the Federal Reserve Reverse Repo Program. Opening up - directly and indirectly - securities lending programs to institutional savers would at least partially crowd out parking space supplied by bankers.

3.2. ICPFs and asset managers

In this section we discuss the effects of post-crisis regulations when capital allocation is driven by ICPFs, as in section 2.2.2. The key result is that regulatory changes, besides undiscussed merits in safeguarding the solidity and resilience of regulated banks, create room for banks' disintermediation and can shift systemic risk towards the less supervised and regulated asset manager complex, which in our admittedly simplified model, can be interpreted as "bankers" which access lower leverage levels and charge lower intermediation costs w, but can nonetheless guarantee large exposures to illiquid and credit risky assets.

Consider the economy of section 2.2.2. Bankers can source leverage from households and firms, and may receive allocations from ICPFs. ICPFs can also purchase sovereign bonds. Let R^* be the cost of leverage for bankers and R_X be the return of sovereign bonds at $t = 1$. We capture the effects of regulation assuming that leverage is capped: the equity multiplier must be then lower than $1/\lambda > 1$.[16] ICPFs maximise the utility expressed by equation 12. Finally, consider the case of a continuum of unit mass of ICPFs, each endowed with A_p at

[14] When $\bar{R} > 1$ bankers invest in high-risk projects even when the equilibrium cost of funding is higher than 1. Sovereign bonds, whose return is $R_X \leq 1$ to avoid redistribution from taxpayers to bondholders, fail to compete with private parking space delivered by bankers. In other terms, bankers raise funding at a rate $R \in (1, R_X)$ and optimally invest in high-risk projects.

[15] When $R_X = 1$, firms grasp the whole benefit obtaining a higher remuneration $R_X > \beta$; when $R_X = \beta$, firms get the same utility, while households, which will be taxed $R_X = \beta < 1$ for each unit of additional consumption obtained at $t = 0$, enjoy the whole surplus.

[16] Notice that λ actually reflects both technological/pledgeability parameters and regulatory constraints.

$t = 0$, and heterogeneous with respect to their mismatch $\bar{c}_p \equiv \bar{C}_p/A_p$. Let $\bar{c}_p$ be distributed over the support $(0, \bar{c}_p^{\max}]$ with cumulative distribution function $F(\bar{c}_p)$.

Assumption 5. $R_X < \min[\alpha z^r - 1, \alpha(z-1) + (1-\alpha)(z-\delta-1)]$

To simplify the analysis, we assume that the expected unlevered returns of high and low-risk projects are higher than the return of sovereign bonds, even when $R^* = 1$.

Proposition 3. *The optimal ICPF's choice is:*

- *Allocation to low-risk projects if* $\bar{c}_p \leq \frac{z-\delta-R^*}{\lambda} - w$*;*
- *Sovereign bonds if* $\bar{c}_p \in (\frac{z-\delta-R^*}{\lambda} - w, R_X]$*;*
- *Allocation to high-risk projects if* $\bar{c}_p > \max[R_X, \frac{z-\delta-R^*}{\lambda} - w]$*.*

Proof. ICPFs normally dislike allocation to high-risk projects and their ideal portfolio is the one that delivers a return higher than, or equal to, $\bar{c}_p$ in a crisis. When $\bar{c}_p \leq \frac{z-\delta-R^*}{\lambda} - w$ the ICPF allocates the whole endowment to low-risk projects (higher expected return than sovereign bonds). Alternatively, the ICPF buys sovereign bonds, provided their yield is high enough, i.e. $\bar{c}_p \leq R_X$. In the case neither low-risk projects nor sovereign bonds deliver the required return in a crisis, the ICPF allocates to high-risk projects (highest return in no crisis states). ■

Discussion. Before the crisis, the increasing demand for parking space from institutional savers, coupled with the relative scarcity and lack of flexibility of public parking space alternatives, compressed both R_X and R^*. Market valuations of the pledgeability of high-risk projects were incredibly buoyant (high ρ_0^r). Regulatory constraints on leverage were relatively less tight (low λ). ICPFs with limited or no asset-liability mismatch invested in sovereign bonds (possibly long term) and low-risk projects. Bankers (e.g. proprietary trading desks) and ICPFs running a large mismatch preferred instead high-risk projects. Since then, the financial intermediation mechanism has undergone deep changes. Firstly, recognising that the ground zero of the crisis was letting high-risk private-label assets get into the plumbing of the system, reforms and a broad change of market sentiment have essentially cleaned up the plumbing and nearly-exclusively government securities are used as collateral (lower ρ_0^r). Secondly, recognising the risks of banks business model, Basel III has been limiting the ability to issue short-term instruments, running large matched repo books and engaging in very high leverage (higher λ) in various ways. Thirdly, the US Money Market Fund reform in 2016 turned institutional-class prime money funds from a liquidity to a credit vehicle, effectively cutting the system's menu for par on demand options available to institutional savers (lower $Y_f - T$ available to bankers, higher R^*). As time passed, other corners of the ecosystem responded: in the US, the sovereign increased its supply of Treasury bills and short-term Treasury coupons, whilst the Federal Reserve started a Reverse Repo Program to lend out a fraction of its large holdings of safe assets to a wide set of non-bank counterparties. These responses have increased the supply of public parking space available to institutional savers (higher X, see previous section). On top of that, the move from a global to a territorial tax system promoted by the recent US Tax Reform is expected to further cut the demand for parking space by US global corporations which, since early 2000, have accumulated large balances of offshore retained earnings (eliminate the fraction of $Y_f - T$ driven by fiscal optimisation strategies). The net effect of this long list of developments has been a massive reduction in dealer banks' repo volumes and, with it, a transformation of the pre-crisis habitat of institutional savers. However, while banks today are certainly more and better capitalised, more liquid and resolvable, post-crisis developments are bad news for insurance companies and pension funds. Capping aggregate leverage also means constraining the effectiveness of banks' matched repo books, an intermediation mechanism based on the re-hypothecation of collateral to deliver parking space to institutional savers and leverage-enhanced returns to ICPFs at the same time. Furthermore, by forcing banks to pile up High Quality Liquid Assets, liquidity regulation exerts a downward pressure on sovereign yields. These factors depress yields on portfolios of sovereign bonds and low risk projects and increase the fraction of ICPFs that invest in high-risk projects (proposition 3). Structural transformations of the financial system are under way too. Banks fail to deliver satisfying leverage-enhanced returns and the push for bank disintermediation gains momentum as ICPFs try to economise on costs associated with portfolio selection. A number of recent trends can be understood within the lenses of the model. The popularity of global banks and dealers, intermediaries based on high $1/\lambda$ but also high w is decreasing, with asset managers and mutual funds taking their place (cheaper w). Within the asset management complex itself, hedge funds (high $1/\lambda$ and high w) are retrenching, while bond funds investing in corporate and emerging markets and passive and low-cost strategies (e.g. ETFs, low w) are on the rise in the world of fixed income. In the same spirit, direct unlevered exposures of ICPFs to highly illiquid and credit risky assets, e.g. infrastructure in the form of public-private partnership, are on the rise.

4. Conclusions

This paper builds a simple model to understand how the financial intermediation mechanism adapts and evolves to accommodate demands and needs stemming into a global financial ecosystem heavily influenced by the rise of institutional savers and by asset-liability mismatches of insurance companies and pension funds. We show that these two recent transformations are key to understand past, present and possible future financial stability risks. Relevantly, both these transformations share real-economy roots, which include population ageing in advanced economies, income and wealth distribution, globalisation and increased sophistication in tax arbitrage by multinational corporations.

In light of the above, a more comprehensive approach to financial stability and balanced growth may require policymakers to tackle the very structural and fundamental macro developments to which financial intermediaries provide private-sector - sometimes grossly inefficient - responses. This paper argues that financial stability risks can be inherent in income/wealth inequality, global imbalances and other macro factors that create demands and need financial intermediaries accommodate. In this respect, the benefits of redistributive policies – including global currency and corporate tax reforms – may also have relevant financial stability benefits. Similarly, the possibility to renegotiate promises made in the past - like those of defined benefit pension plans - when real returns fall short of expected returns in a structural way would be beneficial for financial stability.

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