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Crises in the modern financial ecosystem

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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, which manage huge balances in need for parking space and (ii) the proliferation of balance sheets with asset-liability mismatch, like those of insurance companies and pension funds (ICPFs), which allocate capital to bankers to reach for yield and meet their liabilities offering guaranteed returns. 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. Both transformations indeed stem from real economy *developments* (e.g. population ageing, global imbalances, income and wealth inequality, increased sophistication of tax arbitrage). Fiscal and structural reforms that directly address the real economy roots of those secular developments 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

Financial stability issues have become increasingly relevant in the aftermath of the Global Financial Crisis. The latter culminated with the collapse of the shadow banking system (McCulley, 2007) - a web of non-bank financial institutions and markets supported by dealers and global banks - and had huge economic and social costs worldwide. Since then, several reforms to address financial stability risks have been put forward and a good number of them are fully effective. They include new regulations on banks' leverage, liquidity and involvement in shadow banking, rules to improve the resiliency of markets for derivatives and securities financing transactions and regulatory changes on non-bank institutions such as money market funds.[4] The wave of regulatory reforms and a reversal of market preference have brought about a deep rebalancing within the broad financial intermediation system. As a result, a progressive shift from a financial ecosystem centered around global banks and dealers towards one dominated by large asset managers is under way. Even less surprisingly, the international debate is now focusing on vulnerabilities and systemic risks associated with asset managers' activities.

This paper asserts the idea that the financial intermediation mechanism changes and evolves mainly to accommodate developments and needs that originate outside the financial sphere and that 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 huge idle balances. The second is the buildup of asset-liability mismatch in the balance sheets of entities, such as insurance companies and pension funds (ICPFs). They have large stocks of liabilities in fixed nominal amount and must reach for yield to bridge the mismatch. Institutional savers include treasurers of global corporations accumulating historically high balances amid structural developments that span globalization, technological progress and increasingly sophisticated strategies of arbitraging global tax regimes (section 2.1). On the other side of the spectrum, life insurers and sponsors of defined-benefit pension plans are in great need of high returns to meet promises made in the past to their clients, as their asset-liability mismatch grows larger under the push of ageing population and low productivity trends (section 2.2). The need for parking space and aggressive reach for yield have been first-order drivers of several dynamics which culminated in the burst of the Global Financial Crisis. Even more relevantly, they both remain, poten-

[4] For a comprehensive assessment of the full reform package, see (FSB, 2017).

tially 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.

The aim of this paper is threefold. First, it builds a theoretical model that incorporates essential features of modern financial intermediation into the canonical framework of Holmström and Tirole (2011) to understand incentives of financial intermediaries to take systemic risks (section 3.1). Second, after documenting in more details the two transformations (section 2), we incorporate these concepts into the model and study how they affect systemic risk-taking incentives (section 3.2). Finally, in section 4, we use the model to evaluate policy measures aimed at safeguarding financial stability and point at potential future sources of systemic risk.

Similarly to the original Holmström and Tirole contribution, our economy is populated by financial intermediaries (henceforth, simply bankers) that implement investment projects. Investment is subject to moral hazard and its future returns are only partially *pledgeable* to attract funding. In our model, bankers can invest in low and high-risk projects (e.g. subprime mortgages), with the latter characterized by relatively higher expected returns but also by more severe moral hazard problems. At the initial date, the banker borrows, invests in low and/or high-risk projects and her leverage is capped by limited *pledgeability*. At an interim date, all projects can be hit by an aggregate liquidity shock (crisis) which arrives with some exogenous probability. Bringing projects to completion depends on the *liquidity* of the claims on projects' future returns at the interim date. The first main novelty of our model is that bankers have access to a *shadow banking technology* that relaxes moral hazard problems and boosts pledgeability and liquidity. The technology has to be intended as the wave of financial innovations, ranging from securitization to repo finance (Gorton and Metrick, 2012), which essentially permit the manufacturing of marketable securities - generally accepted as collateral - out of historically illiquid assets. In her choice between low and high-risk projects, the banker faces then a trade-off between pledgeability (which boosts leverage and investment scale) at the initial date and liquidity (which guarantees insurance against crisis and boosts the continuation scale) at the interim date. High-risk projects offer higher returns and leverage but become illiquid in a crisis, forcing deleveraging. On the other extreme, low-risk projects offer lower returns and leverage but the claims on their future returns remain liquid in a crisis, so that low-risk projects are brought to completion in all states of nature. We show that the banker optimally invests in high-risk projects when the cost of leverage is low. The intuition is that the lower the cost of leverage, the more expensive is the insurance (i.e. investment in low-risk projects) in terms of utility, as the banker would obtain a large amount of (cheap) leverage by investing in high-risk projects.

The model is then enriched with (non financial) firms that may need/seek to save. When firms have access to abundant investment opportunities they invest their whole endowment in real projects and bankers raise funding exclusively from households. Funding conditions are then relatively tight, the price of leverage is high and bankers invest in low-risk projects. Conversely, when firms save a fraction of the endowment they manage at the initial date, a demand for parking space to postpone consumption (or investment) arises. In the language of our 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 (i.e. wholesale funding). The larger the firms' savings, the lower the cost of leverage for bankers, the stronger the incentives to invest in high-risk projects. We then introduce ICPFs which manage an endowment at the initial date and must meet a fixed return target at the final date. They are thus attracted by leverage-enhanced returns and allocate funds (equity capital) to bankers with a mandate to invest in low or high-risk projects. Bankers borrow, invest and (we assume) accomplish the mandate in exchange for a fraction of the profits (if any). ICPFs are also risk averse, in that they suffer a large utility loss when they fail to meet their target. Thus, in general, ICPFs dislike allocation to high-risk projects as the latter are abandoned and return zero in a crisis. We show that, *ceteris paribus*, 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, the higher the ICPFs' mismatch that can be closed in all states of nature. When instead low-risk projects fail to deliver a sufficiently high return in a crisis (low productivity, high cost of leverage), ICPFs simply maximize utility in the no crisis state and thus 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 (directly or indirectly) cheap leverage and lever low-risk and liquid assets up, or they seek to invest in high-risk and illiquid assets. Trivially, when the asset-liability mismatch is severe, no equilibrium cost of leverage can sustain allocation to low-risk projects.

The previous result has deep implications when it comes to policy measures to safeguard financial stability. Consider first the setup with bankers, households and firms only, and assume that a public authority (government, central bank) has the mandate to minimize deleveraging at the equilibrium. The simplest regulatory measure is to impose a leverage cap to bankers, in line with the Basel Leverage Ratio requirement: bankers' utility is a combination of investment scale (leverage) and continuation scale (insurance against the aggregate shock) and, intuitively, when investment scale is capped, bankers will seek to exhaust borrowing capacity and increase utility by boosting the continuation scale. Other policy options are based on the ability of the public authority to issue government bonds. The government can exploit its regalian taxation power and issue sovereign 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. Especially when the supply of sovereign bonds is sticky and/or responds to exogenous/independent fiscal considerations, the authority can actively manage the supply of public parking space by putting in place central bank facilities in line with the Fed Reverse Repo Program and repo out sovereign bonds' holdings and accommodate excess demand for parking space. Indeed, by expanding public parking space available to firms, the authority increases the equilibrium cost of leverage and induces bankers to switch from high to low-risk projects. Another policy option centred around the issuance of sovereign bonds is liquidity regulation, in line with the Basel Liquidity Coverage Ratio. In our model, that concept can be introduced 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, i.e. to raise market funding to bring high-risk projects to completion. All these policy options are successful to limit deleveraging at the equilibrium when risk-taking incentives are determined by bankers that raise funding from households and firms. However, they generally perform poorly when one accounts for the need of ICFPs to meet the target. The general point is that policies aimed at capping leverage (leverage regulation), making leverage more costly (supply of public parking space to institutional savers), improving the liquidity of bankers (liquidity regulation) have all an adverse effect on the ability of ICPFs to grasp adequate returns and bridge their mismatch through portfolios build around some combination of low-risk projects and sovereign bonds. More specifically, they either entail lower leverage-enhanced returns associated to low-risk projects or, by increasing the aggregate demand for sovereign bonds, depress sovereign yields, as in the case of liquidity regulation. In this case, one natural outcome is for ICPFs to push for disintermediation of regulated banks (high cost of portfolio selection, disappointing returns). Alternative strategies include (i) reallocations towards some asset managers (that operate at lower leverage levels but also at much lower costs of portfolio selection) or gaining unlevered direct exposures to high-risk projects (e.g. emerging markets, infrastructure, etc.). Both alternatives are conducive to financial stability risks. Therefore, the key message is that 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 behind the accumulation of high balance of institutional savers (e.g. international coordination to curb tax optimization strategies of global corporations) and the buildup of asset-liability mismatch of insurance companies and pension funds (e.g. mandatory 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 (Diamond and Dybvig, 1983; Gorton and Pennacchi, 1990). In particular, we share the general approach to the demand for/supply of inside (i.e. produced within the private sector) versus outside (i.e. public, sovereign bonds) liquidity comprehensively described in Holmström and Tirole (2011), and adapt it to the modern financial ecosystem. One novelty of our model with respect to HT is that bankers are endowed with a shadow banking technology which gives them additional room for their desired leverage/insurance mix. The choice affects the ability of bankers to find refinancing at the interim stage in the case of aggregate shocks and is intertwined with the conditions in the market for parking space. In Gorton and Metrick (2010), Gorton and Metrick (2012) and Krishnamurthy and Vissing-Jorgensen (2012), shadow banking is approached as a way to supply money-like claims and the whole intermediation process - with its weakness and vulnerabilities - is described. The focus of our paper is on the effects of aggregate shocks on the ability of the shadow banking to expand the inside liquidity, manufacturing private-label securities that serve as parking space: while the latter is money-like and joins the safe assets club in normal times, as aggregate shocks can disrupt its liquidity properties. Pozsar (2014) provides a comprehensive picture of what money and money-like claims are to different economic agents, including cash pools. Sunderam (2014) analyses the extent to which shadow banking liabilities constitute substitutes for high-powered money and finds that they respond to money demand. This finding is coherent with our view on shadow banking supplying an elastic private-sector alternative to public parking space. Moreira and Savov (2014) have a macro model in which intermediaries maximize liquidity creation by issuing securities that are money-like in normal times but become illiquid in a crash when collateral is scarce. This modeling device is in line with the one proposed earlier by Di Iasio and Pierobon (2013). 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. Similarly, interpretations of our shadow banking technology include risk-management techniques which permit the liquification of partially illiquid assets through diversification of idiosyncratic risks. We consider the polar case of aggregate shocks but, in contrast to Gennaioli et al. (2013), exposures to systemic risk (i.e. investment in high-risk projects) can be fully rational. The relevance of information-insensitive private collateral in the form of debt securities is the building block in Dang et al. (2010). Debt preserves the symmetric ignorance between counterparties and minimize the value of producing or learning public information about the payoff. Similarly to our model, a public signal (or a liquidity shock, as in our case) can cause debt to become information-sensitive. Gorton and Ordonez (2012) analyze the disruptive effects of a "collateral check" in a highly leveraged environment in which a large fraction of contracts are backed by private money-like instruments.

2. Transformations of the financial ecosystem

The financial ecosystem has undergone two main transformations in the last decades, mainly reflecting real economy developments on the global scale. In this section we briefly document the rise of institutional savers, with a focus on corporate treasurers, and the buildup of asset-liability mismatch in the balance sheets of ICPFs. We also describe the way the two transformations affect the financial intermediation mechanism and briefly connect them with real-economy, structural developments.

2.1. Institutional savers

The first transformation affected the funding side of financial intermediaries and is the rise of institutional savers. Main examples of institutional savers are multinational corporations, FX reserve managers, the central liquidity desk of asset managers and cash-collateral reinvestment of securities lenders. At the end of 2007 and 2014, they collectively managed funds earmarked for short term investment exceeding US$5 and US$6 trillion, respectively (Pozsar, 2015). At the same two dates, those of corporate institutional savers amounted to US$1.3 and US$1.9 trillion. Although more analysis is needed in this area, a range of developments can explain why corporate balances have been rising since early 2000. These include globalization, demographics, technological progress and increasingly sophisticated strategies of arbitraging global tax regimes. First, stagnant real wages in advanced economies and, by extension, greater profit margins for large corporations have much to do with the integration of China and other emerging market economies into the world labor market (Rajan, 2010). Second, corporations have been spending less of their cash inflows on investments due to secular demographic headwinds (Summers, 2016). Also, any investments large corporations decide to make, mostly to enhance the productivity of existing processes, cost progressively fewer nominal dollars due to technological tailwinds blown by Moore's law. Third, lower population and possibly lower technological growth means a reduction in the demand for new capital goods to equip new workers and lower priced capital goods means that a given level of corporate cash flow can purchase considerably more capital than was previously the case. The rise of the so-called weightless economy is adding momentum to trend: today's iconic, cutting-edge, technology, software and social media companies need little if any capital to expand, whereas iconic, cutting edge companies of yore needed to go to the market to support expansion. Last but not least, increasingly sophisticated tax avoidance strategies by global corporations have reduced corporate tax payments and inflated corporate idle balances, notably those offshore. The rise of institutional savers has reshaped the operating mechanism of a broad range of financial intermediaries. Over the years *before the crisis*, institutional savers poured the huge balances they manage into money markets, such as repos and money market funds (MMFs). Soon and unsurprisingly, they became a cheap and primary source of wholesale funding for banks, dealers and the broader shadow banking system (Pozsar, 2013). These financial intermediaries took charge of manufacturing private-label securities (e.g. mortgage-backed securities) out of historically illiquid credit claims towards real economy borrowers (e.g. subprime mortgages) and use them as collateral to raise funding. From the vantage point of institutional savers, repos backed by, and prime MMFs investing in, these private-label securities represented elastic private-sector parking space alternatives to T-bills and repos backed by Treasuries (i.e. public parking space).[5] *After the crisis*, the traditional comfort zone of institutional savers almost disappeared. Private repos issued by dealers' credit trading desks and collateralized by private assets shrank significantly under the regulatory push and sharp change of market preference.[6] On top of this, the unprece-

[5]Institutional savers were indeed stuck between a rock and a hard place when it came to investing their balances, funds earmarked for short-term investments. Bank deposits are insured only up to a limited amount, far below the billions institutional savers seek to invest. Other alternatives include facing the sovereign in two ways: T-bills, which represent no credit and duration risk but come with an insufficient and inelastic supply, and repos backed by Treasury bonds collateral and issued by the government-desk of dealers, which provide a good proximity to the sovereign but often come at unfavorable yield conditions.

[6]For instance, constant NAV shares issued by prime MMFs and backed by private bills, such as commercial paper, have been banned by regulatory reforms.

dented decline of yields, also fuelled by global QEs, has forced institutional savers to look for other parking space alternatives and invest in longer maturities. Institutional savers have then started to pour an increased fraction of the trillion they manage into (i) capital markets to fund banks' HQLA portfolios and bank's needs for TLAC and NSFR compliance and (ii) ETFs and the broader asset management complex, which is eager of liquidity.

2.2. Insurance companies and pension funds

The second transformation affected the lending side of financial intermediaries and is driven by the reach for yield of insurance companies and pension funds. A closer look at what happened *before the crisis* is illustrative and also constitutes useful guidance to understand current dynamics. In the decade before 2008, dealers have been using less than 20 per cent of their repo funding to finance their own securities inventories, while the remaining was allocated to fund their matched book money dealing activity (Mehrling et al., 2013). More specifically, dealers lend in the capital market and usually use the same collateral to borrow in money markets, i.e. re-hypothecate the securities pledged by cash-borrowers to raise funding from cash-lenders. Besides the central role of global banks, the ultimate users of wholesale funding raised in money markets (including funds lent out by institutional savers) and securities financing extended by dealers via matched repo books include an assorted universe of levered bond portfolio managers such as hedge funds, mutual funds (i.e. total return funds) and index funds. These portfolio managers, that once exclusively managed the private funds of wealthy individuals, have been receiving increased allocations by insurance companies and pension funds since early 2000. The main explanation for this portfolio allocation, away from long term low-yielding sovereign bonds and towards riskier strategies, can be traced back to the build-up of an asset-liability mismatch (IMF, 2017). Having indeed a considerable fraction of liabilities and future obligations expressed in fixed nominal amount, ICPFs reached for yield by looking for leverage-enhanced returns. Asset-liability mismatch widened also amid substantial downward pressure on yields of assets in which ICFPs were historically invested into, such as Treasuries, due to the increased appetite of institutional savers for dollar-denominated safe assets (the so-called global savings glut). Main examples of entities with increasing asset-liability mismatch are life insurance companies offering products with guaranteed returns and defined-benefits pension funds. Interestingly, key drivers behind both the accumulation of hard to meet promises and diminishing yields on Treasuries, are real and not financial phenomena, such as population ageing and global imbalances. *After the crisis*, asset-liability mismatches rose even further as rates fell, lowering the duration of ICPFs' assets but increasing the duration of their liabilities. Also, the mechanism that helped to reduce their mismatch became less popular. This was because it failed to perform (e.g. hedge funds) due to the collapse in market volatility and because dealers' balance sheet became increasingly difficult to come by due to the Basel-driven shrinkage of matched repo books. What emerged in its place instead were ICPFs with (i) an increase tendency to engage in synthetic leverage via derivatives, (ii) a massive relocations towards lower-leverage credit exposures, which are also illiquid, through the rampant asset manager complex lead by few big names and (iii) direct investments in credit illiquid investments such as infrastructures.

3. The model

In section 3.1 we present the baseline model with bankers that have access to investment projects and to a shadow banking technology to liquify illiquid credit claims. We derive the optimal banker's choice and show that it is affected by the cost of leverage. In section 3.2.1 we introduce the supply of funding to bankers. In particular we show how firms' demand for parking space affects the cost of leverage and the bankers' choice in equilibrium. In section 3.2.2 we introduce insurance companies and pension funds that must meet a fixed target and analyze how this influences the equilibrium allocation.

3.1. The baseline setup

3.1.1. Agents

There is a single good used for consumption and investment, and three dates: $t = 0, 1, 2$. There are 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. They have access to a storage technology to postpone consumption: 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 maximize utility $u_f = \beta c_{f,0} + c_{f,1} + c_{f,2}$, where $\beta < 1$. Firms have access to investment opportunities. Differently from households, they do not have a storage technology and at $t = 0$ the endowment Y_f can be either consumed, invested or lent out at a rate R_f.

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

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

3.1.2. Investment and shadow banking technology

To single out the contribution of our paper, we first describe the standard HT moral hazard problem. Then we introduce our 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 agent implementing the project (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: $-1 + B \leq 0 \leq z - 1$. This is the basic moral hazard problem.

A key assumption in this class of models is that all financial commitments must be backed up by claims on pledgeable asset (see below). Consider a banker which has an endowment worth A, implements a project of size i and is protected by limited liability. She seeks to borrow and boost the investment scale $i > A$. For now, assume 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 at $t = 1$, i.e. before projects are brought to completion. More in detail, 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). We consider the extreme case in which liquidity shocks are perfectly correlated across bankers (the shock is then also called crisis), so that mutual insurance is not feasible and each banker can only return to market investors and pledge claims on projects' return 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 $l \geq \delta$.

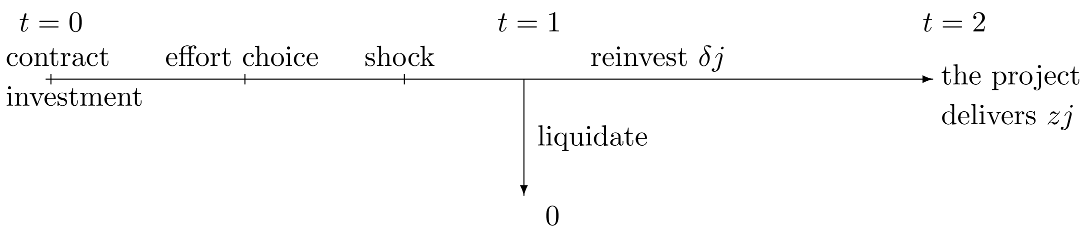

Figure 1: Investment and liquidity shock.

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 $B^r > B$ so that riskier projects yield a higher expected output but are plagued by more severe informational frictions.[7] For the sake of expositional convenience, we refer to the other type of projects, characterized by expected return z and private benefits B as *low-risk* projects.

Shadow banking technology. One key novelty of our model is that we provide bankers with a shadow banking technology to relax informational frictions and the associated limited

[7]Examples of high-risk projects span from subprime mortgages to credit card receivables, from emerging market bonds to infrastructure investments.

pledgeability problem. In the model, the technology is an ensemble of financial innovations which lower private benefits and boost pledgeable income. More in detail, we make the following assumptions:

Assumption 1. *The shadow banking technology lowers private benefits associated to projects from B and B^r down to $b < B$.*

This assumption captures key features of financial innovation, e.g. securitization and repo finance, at the core of the surge of money market funding of capital market lending. The rise of shadow banking indeed permitted the manufacturing of a broad range of securities, backed by future returns on historically illiquid assets, which have been commonly accepted as collateral in money markets. In the terminology of the model, the pledgeable income associated to the two types of projects increases to $\rho_0 = z - b$ and $\rho_0^r = z^r - b$, for low and high-risk projects respectively. Note that, by construction, $\rho_0^r > \rho_0$.[8]

Assumption 2. *In a crisis, the liquidity of high-risk projects is $l^r < \delta$, while that of low-risk projects is $l = \rho_0 = z - b = \delta$.*

This assumption defines the liquidity features of the two types of investment. While delivering higher pledgeability, the claims on future returns of high-risk projects become illiquid in a crisis ($l^r < \delta$) in the sense that banker cannot return to market investors and raise the funding needed to accommodate the reinvestment shock by pledging l^r. Conversely, $l = \delta$, low-risk projects remain liquid in a crisis and can be brought to completion. In our view, this capture a second feature of financial innovations associated to shadow banking. Indeed the liquidity of low-risk projects without the shadow banking technology would be $z - B$, which is lower than δ. Low-risk projects would be illiquid in a crisis. Therefore, assumptions 1 and 2 capture the idea that the technology can be exploited in two opposite manners: a pure leverage-enhancing mechanism (when applied to high-risk projects) or a way to create liquidity and withstand aggregate shocks (low-risk projects). Table 1 sums up relevant trade-offs.

Table 1: : Investment projects and shadow banking technology.

	Pledgeability at $t = 0$	Liquidity at $t = 1$	Expected return at $t = 2$
Low-risk projects	$\rho_0 \equiv z - b$	$l \quad (= \rho_0 \equiv \delta)$	z
High-risk projects	$\rho_0^r \equiv z^r - b \quad (> \rho_0)$	$l^r \quad (< \delta)$	$z^r (> z)$

[8] We only need $\rho_0^r > \rho_0$, so that b being identical for both types of projects is not essential. Any b^r such that $z^r - b^r > z - b$ would do the job.

Discussion. As compared to the original HT framework, shadow banking techniques relax informational frictions and permit the liquification of historically illiquid assets. Bankers can tap market investors to finance a larger fraction of their balance sheet, thereby either boosting leverage or improving the ability to withstand liquidity shocks. We take the open view that financial innovations supporting shadow banking can be used in different ways. On the one hand, the banker can simply boost leverage. 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. On the other hand, when investing in low-risk projects, the shadow banking technology is helping the banker to withstand liquidity shocks: at the cost of relatively lower total returns (and leverage), claims on low-risk projects' future returns remain liquidity in a crisis so that these projects can always be brought to completion.

3.1.3. The problem of the banker

In this section we describe the problem of a banker with equity A. She decides how much to borrow (leverage) and which type of projects to implement. Consider for now a cost of funding 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 (see below). To make the problem tractable and interesting, we make the following assumptions.

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

Assumption 3 states that pledgeability is lower than the expected cost of the project and guarantees that banker's leverage is finite.

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:

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

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

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

Continuation scales are derived from the liquidity constraints that, according to Assumptions 1 and 2, can be written as:

$$j^r = 0; \ j = i \quad (3)$$

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) 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 return to market investors all pledgeable resources $\rho_0^r i^r + \rho_0 i$. With probability $1 - \alpha$ the shock hits, high-risk projects are abandoned ($j^r = 0$), the banker pledges li to raise exactly δi to meet the reinvestment shock for low-risk projects and bring them to completion.[9] The problem can be written as:

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

such that:

$$R(i^r + i - A) \leq \alpha(\rho_0^r i^r + \rho_0 i) \quad (5)$$

Banker's utility is increasing in the investment scales. Then, 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:

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

[9] 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: high-risk projects are abandoned and do not produce any output; low-risk projects are brought to completion ($j = i$) but, however, the pledgeable fraction ρ_0 is used by the banker to raise fresh funding at $t = 1$ and meet the shock ($\rho_0 - \delta = 0$). Initial investors are fully diluted and, for this reason, do not expect any repayment in a crisis.

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 (leverage). The utility u_b^r from investing in high-risk projects is:

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

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 it is always optimal to invest in high-risk projects, as they guarantee both a higher per-unit expected output and higher leverage. The relevant result of this section is that the cost of funding R is a key determinant of the banker's choice.

Proposition 1. *Banker 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 intuition is that 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.

3.2. Equilibrium

This section enriches the model with the two transformations we are interested in, namely the rise of institutional savers and the proliferation of balance sheets with liabilities in fixed nominal amounts, such as those of insurance companies and pension funds (ICPFs). More in detail, we first model the supply of funds to bankers and this is where institutional savers, i.e. firms in need for parking space, come into the play. 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. We then introduce ICPFs as ultimate drivers for the demand of returns. In that setup, ICPFs have an equity endowment they seek to allocate to bankers (that will simply maximize ICPFs' utility) in exchange for leverage-enhanced returns. ICPFs are risk averse and must meet a commitment with their clients to deliver a fixed return at $t = 2$.

3.2.1. 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 the its own outside option. Households have a storage technology and require a gross expected return equal to $R_c = 1$. As far as firms are concerned, we assume they have access to a limited amount T of investment opportunities. Firms dislike consumption at $t = 0$ and, as a first option, will try to invest as much as possible. When $T \geq Y_f$, firms can 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 demand for parking space by firms boosts 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 sourced from firms (say: wholesale funding), the lower the average cost of leverage. Let's analyze 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. 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 will 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 remaining part from households. The equilibrium (average) cost of funding is:

$$R = \frac{\beta[Y_f - T] + [i^r + i - A - Y_f + T]}{i^r + i - A} \equiv 1 - (1-\beta)\frac{Y_f - T}{i^r + i - A} \tag{11}$$

where $R \in (\beta, 1)$.

2. When $T \geq Y_f$, firm will not lend at the equilibrium and $R = 1$.

Clearly, $Y_f - T$ affects the the cost of leverage and, according to result 1, the banker's choice. Cases 1.a and Case 2 are the simplest ones, with equilibrium quantities and the banker's choice depending uniquely on $\bar{R} \equiv \frac{\alpha}{1-\alpha}(\rho_0^r - \alpha\rho_0)$ being lower than β and 1, respectively. The choice between low and high-risk projects is fully determined by the probability of the crisis α and technological parameters. Case 1.b is more interesting as every additional unit of funding raised by bankers from firms increase the parameters' space where the former optimally invest in high-risk projects. ■

See Appendix A for the analytical derivation of equilibrium quantities in the three cases.

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) on the one hand and (ii) the intermediation system which emerges at the equilibrium. Lack of investment opportunities and/or excess savings from non financial firms determine the need for parking space and exert a downward pressure on the cost of leverage, creating incentives for bankers to take on systemic risk.

3.2.2. Insurance companies and pension funds in need for returns

In this section, the framework is augmented with ICPFs that have a fixed-return target. While in sections 3.1.3 and 3.2.1 the cost of leverage (and thus the demand for parking space by institutional savers) is the only driver of the choice between high and low-risk projects, this section introduces a demand for returns by ICPFs which modifies incentives in risk-taking. The economy is populated by ICPFs, bankers, households and firms. The framework is modified in two ways. First, we adapt the concept of ICPFs having commitments in fixed amount towards their clients assuming that ICPFs have an endowment A_p at $t = 0$ and must deliver $\bar{C}_p$ to their clients at $t = 2$. Let C_p denote ICPFs' assets at $t = 2$. ICPFs maximize 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 realized returns fall short of the commitment. Second, to further simplify the presentation, we assume bankers have no equity on their own ($A = 0$). When ICPFs allocate their equity endowment to bankers, the latter can borrow from households and firms and choose to invest in high or low-risk projects to simply maximize the ICPFs' utility in exchange for a fee w.[10] In what follows, we then say ICPFs allocate to low or high-risk projects. Define $\bar{c}_p \equiv \bar{C}_p/A_p$ a measure of ICPFs' asset-liability mismatch at $t = 0$.

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

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

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. Allocation to low-risk projects allows ICPFs to meet the target in a crisis if $\bar{c}_p \leq \frac{z-\delta-R}{1-\alpha\rho_0/R} - w$, i.e. when the leverage-enhanced return delivered by low-risk projects net of the reinvestment cost and banker's fee is high enough to meet the target. When this is the case, ICPFs strictly prefer allocation to low-risk projects to avoid the utility loss $-M$. 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 maximize 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

[10] 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 (return) and insurance.

equilibrium allocations. Having risk averse ICPFs that must meet a fixed target exerts two different effects. First, risk averse ICPFs naturally dislike allocations to high-risk projects, as the latter return zero in a crisis. Second, a lower cost of leverage R helps ICPFs to meet their fixed target in a crisis when allocating to low-risk projects. Notice indeed that $\frac{z-\delta-R}{1-\alpha\rho_0/R}$ is a decreasing function of R, in the relevant set of parameters. Ceteris paribus, the lower the cost of leverage, the higher the leverage-enhanced return delivered by low-risk projects, the higher the mismatch $\bar{c}_p$ that can be closed. 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, the final mix between high and low-risk projects will be then determine 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.

4. 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 maximization. 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 minimize 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 analyze different sets of policies, which mainly mirror post-crisis regulatory reforms. We first evaluate these policies within the setup with exclusively bankers, households and firms (section 4.1). We then consider the effects of these policies when ICPFs come into play (section 4.2).

4.1. Banks and institutional savers

The first policy consists in a regulatory constraint on the maximum leverage of bankers: when bankers face a trade-off between leverage and insurance within the limits of the investment and the shadow banking technologies, capping leverage forces bankers to exhaust borrowing capacity by obtaining more insurance. In the language of the model, bankers 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 $R_X \leq 1$.[11] Generally, when R_X is high enough, sovereign bonds can be attractive to ICPFs and they also represent *public parking space* to institutional savers. However, R_X must not be lower than β, otherwise no agent in the economy would be willing to buy sovereign bonds at $t = 0$, not even firms in need for parking space. 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 3.2.1, the simplest policy to rule out deleveraging at the equilibrium is a cap on leverage of bankers. As mentioned above, banker's utility is a combination of investment scale (leverage) and continuation scale (insurance against the aggregate shock). When investment scale is capped, bankers will seek to exhaust borrowing capacity and increase utility by boosting the continuation scale. In the language of our model, when the government imposes a limit on the investment scale i_{LR}, bankers will seek to implement low-risk projects. The maximum investment scale which is compatible with bankers implementing low-risk projects is derived by substituting $R = \bar{R}$ into the equation 7:

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

[11]No distortion from taxation is considered.

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 and resembles the spirit of Basel regulation on banks' leverage.

Liquidity Regulation. The authority can accomplish its mandate by imposing a liquidity requirement to bankers. In our framework, 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. However, sovereign bonds represent a lower-yield technology and its purchase, by consuming banker's borrowing capacity, depresses the investment scale. Even more relevantly, when firms are in need for parking space they will bid for sovereign bonds and $R_X = \beta$ in equilibrium. This downward pressure on sovereign yields makes sovereign bonds extremely costly for bankers as a hedge against the liquidity shock. Liquidity regulation is always an effective policy tool, that is also when $\bar{R} > 1$.

Under liquidity regulation, the banker can seek to invest in low-risk projects, with utility and investment scale defined in equations 6 and 7; alternatively, she can still implement high-risk projects and, to meet the regulatory requirement, 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:

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

Banker's utility from investing in i_{LCR} high-risk projects and $\delta i_{LCR}/\beta$ sovereign bonds is:

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

Note that i_{LCR} and u_{LCR} are decreasing in β. When β is low, firms aggressive bid drives down sovereign yields considerably. This makes liquidity regulation particularly costly for bankers and would materially depress the investment scale in high-risk projects, also eventually pushing the banker to switch to low-risk projects. The banker seeks to invest in high-risk projects when $R^* \leq \bar{R}(\beta)$ with $\bar{R}(\beta)$ lower than $\bar{R}$ as defined in the previous section.

As compared to the market equilibrium, liquidity regulation forces large redistribution from bankers to households when bankers seek to invest in high-risk projects. Alternatively, when liquidity regulation simply discourages bankers to invest in high-risk projects by making low-risk projects relatively more attractive, sovereign bonds are not traded at the equilibrium and no redistribution towards households take place.

Public parking space. Sovereign bonds can represent parking space supplied by the official sector and available to firms. They compete with parking space supplied by bankers and whenever their supply increases, the average cost of funding for bankers increases. Through this channel, an adequate supply of sovereign bonds can induce bankers to switch to low-risk projects. Notice that public parking space is an effective policy instrument only when $\bar{R} \leq 1$. Indeed if $\bar{R} > 1$, 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. The amount X_{pps} which has to be supplied to induce 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. As compared to the market equilibrium with high-risk projects, sovereign bonds force redistribution from bankers (which will pay a higher cost of funding) to firms and/or households, depending on R_X.[12]

In general, the supply of sovereign bonds is driven by fiscal considerations and can hardly be adjusted within a short time frame to respond to financial stability concerns. However, central banks usually hold large amounts of sovereign bonds which can be lent out actively managing 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.

[12] When $R_X = 1$, firms grasp the whole benefit obtaining a higher remuneration $R_X > \beta$; on the polar opposite, 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.

4.2. ICPFs and asset managers

The financial intermediation mechanism has undergone deep changes amid post crisis regulatory reforms. First, recognizing that the ground zero of the crisis was letting private-label securities manufactured by the shadow banking system get into the plumbing of the system, reforms have focused on cleaning up the plumbing and using near-exclusively government securities as collateral. Second, recognizing the risks of the pre-crisis global banks business model, Basel III has been limiting in various ways the ability of banks to issue short-term instruments, run large matched books and engage in very high leverage. The net effect has been a massive reduction in dealer banks' repo volumes and, with it, a reduction in the habitat of institutional savers. 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 and the Federal Reserve started a Reverse Repo Program, opened to a wide set of nonbank counterparties, to lend out a fraction of its large post-QE holdings of safe assets. These responses have increased the supply of "public" parking space available to institutional savers, the shortage of which, by compressing the cost of leverage, elicited the creation of securities with poor liquidity properties in adverse market scenarios and was one of the roots of the crisis. Also, liquidity and leverage regulation of banks have limited dealers' balance sheet capacity and also the leverage-enhanced returns that the shadow banking system can deliver to insurance companies and pension funds which, however, are struggling with widening asset-liability mismatch. In this section we discuss the effects of these regulations in the case that the ultimate driver of the reach for yield in the economy are ICPFs in need of meeting their target, as in section 3.2.2. The main result of what follows is that these regulatory changes, besides undiscussed merits in safeguarding the solidity and resilience of regulated banks, creates room for banks' disintermediation and can spur systemic risk shifting towards the less supervised and regulated asset manager complex, which in our admittedly simplified model, can be interpreted as "bankers" which access lower leverage levers, charge lower intermediation costs w, but in some cases can guarantee to their clients large exposures towards illiquid and credit risky assets.

Consider the economy of section 3.2.2. Bankers can source leverage from households and firms, when the latter must save. Also, bankers may receive equity allocation from ICPFs with the mandate to invest in low or high-risk projects. Also, we consider here ICPFs that can invest in sovereign bonds. Let R^* be the equilibrium cost of leverage for bankers which, as above, reflects the relative shares of wholesale and retail funding. R_X is the return of sovereign bonds at $t = 1$. We capture the effects of banking regulations assuming that banking leverage capacity is capped. The equity multiplier must be then lower than $1/\lambda > 1$; λ reflects then both technological parameters (i.e. the ability of banks to create collateral from claims on future returns of investment projects) and regulatory constraints. ICPFs assign a mandate to bankers and maximize the utility function expressed by equation 12.

Finally, consider the case of a continuum of unit mass of ICPFs, each endowed with A_p at $t = 0$, 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, Assumption 5 states 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. *Consider an ICPF with mismatch $\bar{c}_p$. The optimal portfolio is: allocation to low-risk projects if $\bar{c}_p \leq \frac{z-\delta-R^*}{\lambda} - w$, investment in sovereign bonds if $\bar{c}_p \in (\frac{z-\delta-R^*}{\lambda} - w, R_X]$ and allocation to high-risk projects if $\bar{c}_p > \max[R_X, \frac{z-\delta-R^*}{\lambda} - w]$.*

Proof. ICPF's ideal portfolio is the one that delivers a return higher than or equal to $\bar{c}_p$ also in a crisis (ICPFs normally dislike allocation to high-risk projects). When $\bar{c}_p \leq \frac{z-\delta-R^*}{\lambda} - w$ the ICPF allocates the whole endowment to low-risk projects, which deliver a higher expected return than sovereign bonds. In the case the previous condition is not met, ICPF seeks to close the mismatch buying 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 maximizes the utility simply by seeking the allocation which delivers the highest return in no crisis states, i.e. high-risk projects. ■

Discussion. When reach for yield is ultimately driven by the mismatch between promises made in the past ($\bar{c}_p$) and market returns and productivity of the present ($(z-\delta-R^*)/\lambda$ and R_X), a close link between the severity of the mismatch and incentives in risk-taking emerges. From Proposition 3, a mass $1 - F(\max[R_X, \frac{z-\delta-R^*}{\lambda} - w])$ of ICPFs invest in high-risk projects. Note that the fraction is non increasing in R_X and $1/\lambda$, so that liquidity and leverage regulations of banks have ambiguous financial stability implications. On the one hand $1/\lambda$ represents both an individual and aggregate cap on leverage. Less leverage trivially implies less deleveraging associated to high-risk projects in a crisis. On the other hand, as described in section 2, banks' matched repo books, a mechanism to deliver at the same time parking space to institutional savers and leverage-enhanced returns to ICPFs, is based on leverage and on the possibility to re-hypothecate collateral: capping leverage means constraining the efficiency and the scale of the mechanism. In light of the above, the pre-crisis period can be interpreted as a situation with a huge and increasing demand for parking space from institutional savers that, coupled with the relative scarcity and lack of flexibility of public parking space alternatives, compressed both R_X and R^*. Also, the market valuation of the pledgeability of high-risk projects (ρ_0^r) was incredibly buoyant. Regulatory constraints on leverage were relatively soft (high $1/\lambda$). As mentioned above, the allocation between low and high-risk projects is driven by the relative share of capital coming from bankers and ICPFs. Therefore, in the pre-crisis period, ICPFs with limited or no asset-liability mismatch still seeked portfolios of sovereign bonds (possibly long term) and allocation to low-risk projects. Bankers (e.g. proprietary trading desks) and those ICPFs running a large mismatch turned instead to high-risk projects. The burst of the crisis and regulatory reforms deeply reshaped this environment. With new regulations jeopardizing the effectiveness of dealers matched repo books mechanism, the system had to adapt. Needless to say, curbing leverage was an intended first-order effect of new regulations. However, several adjustments have taken place, some of which may partially reduce financial stability gains of the post-crisis regulatory wave. First, on the bigger scale, regulatory tightening and a widespread mistrust in their business model have compressed banks' profitability and consequently the fraction of global capital managed by bank intermediaries, which now include almost all investment banks (dealers). Second, lower aggregate leverage means that banks can (i) absorb a smaller fraction of wholesale funding from institutional savers and (ii) deliver lower leverage-enhanced returns to ICPFs. Furthermore, liquidity regulation and the need for banks to build HQLA portfolios add up on the large unsatisfied demand for parking space from institutional savers and exert additional (read: on top of global QEs) downward pressure on sovereign yields. According to proposition 3, all these effects increase the fraction of ICPFs allocating to high-risk projects. In a medium to long term perspective, these effects are changing the structure of the financial intermediation system itself. As banks fail to deliver satisfying leverage-enhanced returns, the push for bank disintermediation has been gaining momentum. ICPFs also try to economize on costs associated to portfolio selection. In the language of the model, when the balance between $1/\lambda$ and w becomes unfavorable, ICPFs migrate away from banks, eventually seeking returns through exposures to high-risk projects with no or little leverage. A number of recent trends can be understood within this context. The popularity of global banks and dealers, intermediaries based on high $1/\lambda$ and w, is decreasing while asset managers and mutual funds, with few big names taking the lead, are becoming more and more attractive for ICFPs. Through the lens of the model, asset managers are indeed an intermediation mechanism which delivers returns through diversified exposures with lower $1/\lambda$ and w. Within the asset management complex, hedge funds (intermediaries based on high $1/\lambda$ and high w) are retrenching while bond funds investing in corporate and emerging markets and passive low-cost strategies delivered by - sometimes also leveraged - ETFs (low w) are acquiring relevance 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.

5. 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 dominated by institutional savers on the one side, and balance sheets with asset-liability mismatches, like those of insurance companies and pension funds, on the other. We show that these two recent transformations are key to understand past, present and possible future financial stability risks. Relevantly, both these transformations are secular and share real-economy roots, which include population ageing in advanced economies, income and wealth distribution, globalization and increased sophistication in tax arbitrage by multinational corporations.

In the years before the crisis, institutional savers such as global corporations flooded money markets with unprecedented high balances in need for parking space. Banks, dealers and the broader shadow banking system (for simplicity called bankers throughout the paper) absorbed these savings in the form of wholesale funding, commonly secured by collateral manufactured out of credit claims to real economy borrowers. As the demand for parking space grew larger, more and more illiquid and risky credit claims were packaged into marketable and, surprisingly, high-rating collateral. This set the stage for the credit boom of the US real estate market. Cheap wholesale funding meant cheap leverage for global banks, but a relevant fraction of it was passed on through dealers' matched repo books to an assorted universe of portfolio managers, such as hedge funds, that used securities financing transactions and other cash-absorbing investment strategies to generate leverage-enhanced returns. Finally, a substantial fraction of these returns fed return-hungry insurance companies and pension funds (ICPFs). The latter, having large stocks of liabilities offering guaranteed returns and facing historically low yields on their traditional asset portfolios, have been looking for alternative investment strategies to close the mismatch between the promises made in the past to their clients and the market returns of the present. The greater the reach for yield from ICPFs, the greater the need for leverage and leverage-enhanced returns, the higher the demand for dealers' balance sheet capacity, the greater the appetite of dealers for wholesale funding for their matched books, the larger the volume of repos (and derivatives) absorbing the cash provided by institutional savers. This mechanism based on the two-sided balance sheet of dealers collapsed when the US real estate market crashed.

We model this complex web of interlinkages building a quite simple moral hazard model. In the baseline model there are bankers who borrow and invest in projects of two types. High-risk projects guarantee high leverage/output at the cost of exposure to an aggregate shock (crisis) while low-risk projects offer insurance against the crisis at the expense of lower leverage/output. We show that the higher the supply of wholesale funding from institutional savers, the lower the price of leverage, the stronger the incentives of bankers to invest in high-risk projects, the higher the output volatility across states, as high-risk projects entail large deleveraging in a crisis. Similarly, the larger the asset-liability mismatch insurance companies and pension funds must close, the stronger their incentives to allocate capital (directly, i.e. through bankers, or directly) to high-risk projects.

In this setup, we evaluate several post-crisis responses by regulators and central banks. Absorbing the demand for parking space of institutional savers on the "one-sided" balance sheet of a central bank through reverse repo facilities, as opposed to a "two-sided" balance sheet such as that of dealer's matched repo book, means that, in the aggregate, financial intermediaries operate with less leverage. However, on the other side of the spectrum, asset-liability mismatches still and firmly remain in a prolonged low yield environment, and notably so. Therefore, while dealing with problems in wholesale funding markets via reverse repo facilities solves one half of the problem, risk-taking can materialize in different corners of the system, in new ways and forms. For instance, the reach for yield from entities with asset-liabilities mismatch may migrate even more towards activities which deliver synthetic leverage via derivatives and absorb relatively less cash than securities financing transactions. Similarly, the new Basel liquidity and leverage regulations, while promoting a much more stable banking system, have ambiguous effects on systemic risk-taking incentives once one accounts for potential banks' disintermediation. On the one hand, by making banks more and better capitalized, less leveraged and more liquid, regulatory reforms have limited financial stability risks stemming within the regulated banking sector. On the other hand, in the language of our model, by limiting the ability of bankers to deliver leverage-enhanced returns that let ICPFs to bridge their mismatch in all states of nature and by depressing yields on sovereign bonds, they boost "gamble-for-resurrection" incentives and increase the relative convenience to invest in high-risk projects. Ultimately, beyond a threshold, tight leverage and liquidity regulations push ICPFs to disintermediate banks and seek exposures to illiquid and credit risky assets either indirectly, through intermediaries with lower intermediation costs, or directly.

In light of the above, financial and banking regulations seem to be second best policies when systemic risk is fuelled by transformations of the financial ecosystem which closely mirror developments taking place in the real economy. 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 – usually examined from a demand management perspective, may also have relevant financial stability benefits, through their impact on the size of wholesale funding markets. Similarly, promises made in the past - like those of defined benefit pension plans - should be renegotiated whenever real returns fall short of expected returns in a structural way.

Appendix A. Equilibrium allocation with bankers and institutional savers

In Case 1.a if $1 < \bar{R}$ bankers invest in high-risk projects. The investment scale is

$$i^r_{T \geq Y_f} = \frac{A}{1 - \alpha \rho^r_0}$$

If otherwise $1 \geq \bar{R}$, low-risk projects are implemented and the investment scale is

$$i_{T \geq Y_f} = \frac{A}{1 - \alpha \rho_0}$$

Case 2 is quite similar and the banker's choice fully depends on $\bar{R}$ being lower or higher than β. In Case 1.b, bankers implement high-risk projects when

$$1 - (1 - \beta)\frac{Y_f - T}{i^r - A} < \bar{R}$$

(Figure A.2).

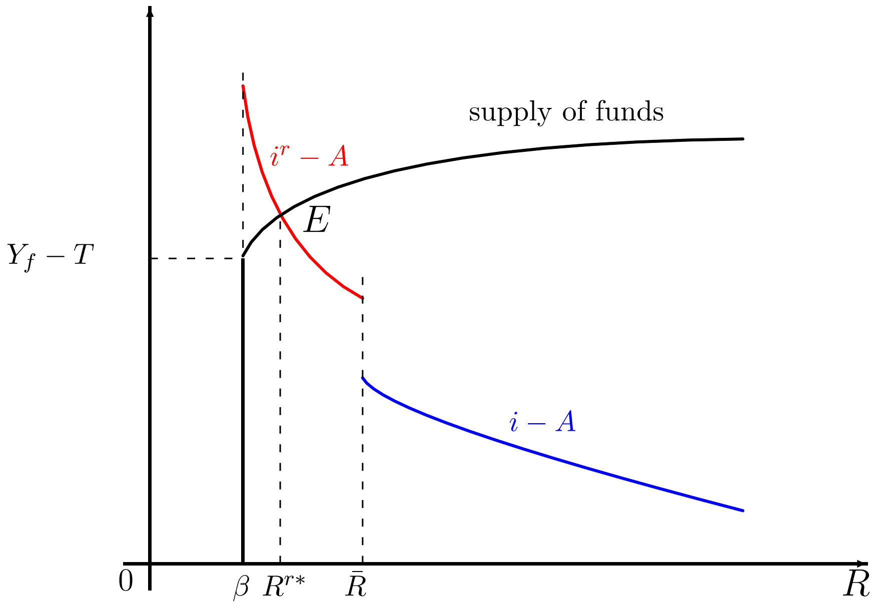

Figure A.2: **Equilibrium with high-risk projects.** Banker's demand for funds when implementing high-risk projects (red curve) and low-risk projects (blue curve). Black curve: supply of funds.

Equilibrium allocation can be derived from the system of equations:

$$\begin{cases} i^r = \frac{A}{1-\alpha\rho_0^r/R} \\ R = 1-(1-\beta)\frac{Y_f-T}{i^r-A} \end{cases} \tag{A.1}$$

The equilibrium investment scale is

$$i^r = \frac{A+(1-\beta)[Y_f-T]}{1-\alpha\rho_0^r}$$

and the equilibrium cost of funding

$$R^* = \alpha\rho_0^r \frac{A+(1-\beta)[Y_f-T]}{\alpha\rho_0^r A+(1-\beta)[Y_f-T]}$$

Bankers implement low-risk projects (see Figure A.3) when

$$1-(1-\beta)\frac{Y_f-T}{i^- A} > \bar{R}$$

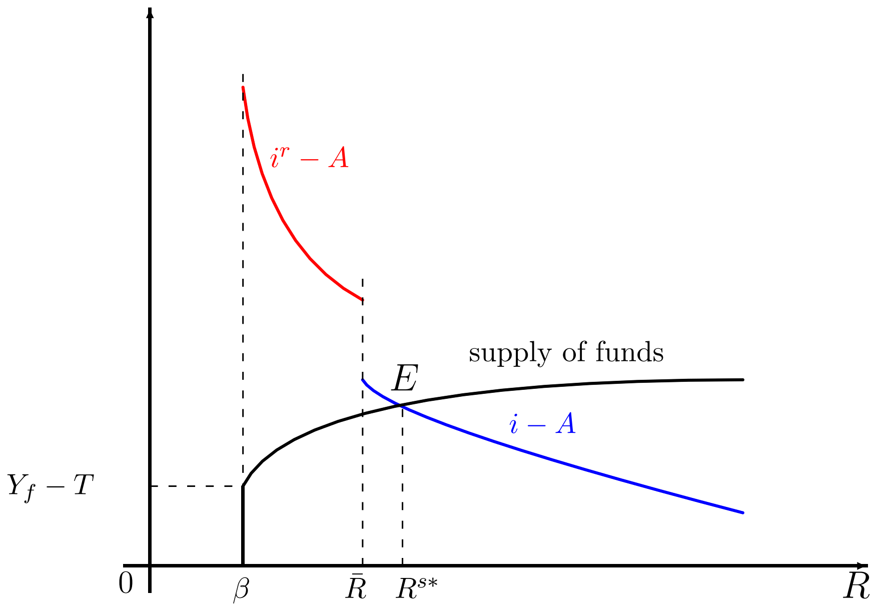

Figure A.3: **Equilibrium with low-risk projects.** Banker's demand for funds when implementing high-risk projects (red curve) and low-risk projects (blue curve). Black curve: supply of funds.

By solving the system:

$$\begin{cases} i = \frac{A}{1-\alpha\rho_0/R} \\ R = 1-(1-\beta)\frac{Y_f - T}{i-A} \end{cases} \tag{A.2}$$

we obtain the equilibrium investment scale

$$i = \frac{A + (1-\beta)[Y_f - T]}{1-\alpha\rho_0}$$

and the equilibrium cost of funding

$$R^* = \alpha\rho_0 \frac{A + (1-\beta)[Y_f - T]}{\alpha\rho_0 A + (1-\beta)[Y_f - T]}$$

Finally, the case where the supply of funds curve intersects the dotted line connecting the red and the blue curve. Notice that the equilibrium cost of funding is a negative function of the demand for parking space $Y_f - T$. For $Y_f - T \geq D^H$, the equilibrium is the one of Figure A.2. For $Y_f - T \leq D^L$, only low-risk projects are implemented at the equilibrium (Figure A.3). For $Y_f - T \in (D^L, D^H)$, bankers are indifferent between the two types of projects[13] and we assume a fraction γ of bankers implement high-risk projects and the remaining $1-\gamma$ invest in low-risk projects, with γ such that:

$$R^* = \bar{R} = 1-(1-\beta)\frac{Y_f - T}{\gamma i^r + (1-\gamma)i - A} \tag{A.3}$$

[13] In Figure A.3 it would be the case when the supply of funds intersects the dotted line connecting the red and blue curves.

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