

# Financial Innovation for Rent Extraction

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## Abstract

This paper shows that financial innovation greatly increases the scope for rent extraction from public safety nets and may generate a large redistribution of wealth from the public purse to the financial sector. We develop a model in which it is optimal to have safety nets and show that such safety nets provide incentives to create new securities that crystallize risk-taking on states of nature in which bailouts will be obtained. Such financial innovation allows for rent extraction on a significantly larger scale. The incentives for rent extraction are mediated through market prices and do not require that the agents who engage in risk-taking are aware that they are extracting rents from public safety nets. In aggregate, the described behavior leads to large financial sector profits during good times, higher consumption volatility, greater economy-wide risk premia and stark misallocations in real investment.

**JEL Codes:** G28, E44, E25, G13, H23

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# 1 Introduction

In the recent financial crisis, governments around the world have provided unprecedented bailouts to failing financial institutions. In many instances, the magnitude of losses that were covered by bailouts was exacerbated by recent financial innovations such as subprime mortgages, credit default swaps, and repos. For example, AIG was rescued after accumulating large losses from selling credit default protection. The losses of Fannie Mae and Freddie Mac and many insured savings banks like Washington Mutual were accentuated by an explosion in their underwriting of subprime mortgages (see Acharya et al., 2011). The FDIC seized hundreds of failing banks and experienced losses that were magnified by innovative ways of structuring banking liabilities so as to maximize the value of deposit insurance (see e.g. Shibut, 2002). Investment banks developed financial innovations that allowed financial institutions to effectively circumvent capital adequacy requirements and increase the losses experienced by taxpayers when a financial institution was rescued. Examples include securitization without risk transfer (Acharya, Schnabl and Suarez, 2010) and structuring mortgage-backed securities such that they could be “rated at the edge,” i.e. they would only just obtain a favorable credit rating but be subject to the capital requirements reflecting the average riskiness of that credit rating (Brunnermeier, 2009).

The contribution of this paper is to explore the hypothesis that a significant number of recent financial innovations were designed to extract rents from public safety nets and bailouts. We develop a model in which bailouts arise endogenously: when financial sector capital is low, it is cheaper for the rest of the economy to provide a bailout than to suffer from a large credit crunch. It is well known that such bailouts distort incentives to invest in risky securities. This paper shows that bailouts also provide incentives to create new securities that crystallize risk-taking on states of nature in which bailouts will be obtained. Financial innovation allows for more efficient rent extraction on a significantly larger scale. The intuition is that bailouts can be viewed as state-contingent payoffs to the financial sector. If they are unregulated and/or underpriced, there is a strong incentive for the financial sector to create securities that arbitrage between the price at which the payoffs are obtained from government and the market value. Put differently, financial innovation allows financial institutions to monetize the put options implicit in government guarantees.

Our framework offers a number of novel insights: (1) Financial innovation may increase the distortions created by bailouts by an order of magnitude. (2) Although bailouts have an efficiency-enhancing role when they substitute for missing insurance markets, financial innovation destroys this role. (3) Financial innovation for rent ex-

traction entails massive wealth transfers that lead to large financial sector profits during good times and lower incomes for the rest of society. (4) When financial market participants engage in such rent extraction, they increase real economic volatility and allocate resources into risky real projects with negative NPV. (5) As a result, risk premia in the economy are increased. (6) We discuss regulatory measures to curtail financial innovation for rent extraction and conclude that enforcing limited liability during bailouts is the single most effective measure.

The paper develops a simple model with two sets of agents, bankers and households. Bankers are exposed to aggregate risk, and if an insurance market exists, they share this risk with households. This is desirable because the financial net worth of bankers plays an important role in the economy: it determines the level of financial intermediation, capital investment and, in turn, output and wages in the economy. The paper first describes the decentralized equilibrium if an insurance market to trade claims across the two states of nature exists. If such a market does not exist, then households find it optimal to provide transfers (or “bailouts”) to bankers whenever their net worth of bankers falls below a threshold, because the cost of the transfer is lower than the lost wages arising from a credit crunch. If an insurance market does not exist, bailouts are an optimal response of the household sector to the role of bankers as bottlenecks in the financial intermediation process. They are state-contingent transfers that substitute for market-provided insurance, and they are entirely time-consistent.

When there is a private market to trade insurance claims but bankers are simultaneously covered by bailout guarantees, then arbitrage possibilities arise – bankers can shift payoffs from bad states of nature to good states of nature, implying that they create losses in the bad states that are covered by bailouts. In good states of nature, by contrast, they obtain a large fraction of the aggregate income of the economy. Although the bailouts occur in the bad states, the rents are extracted in the good states of nature.

However, rent extraction can go further still: Under certain circumstances, bankers find it optimal to play mixed strategies in which they form two groups that bet against each other. In this type of equilibrium, bailouts occur no matter which group wins and which group loses. One group of bankers is set to fail and be bailed out; the other group obtains large payoffs from the winning bet. This maximizes the amount of rents that can be extracted from the rest of society. A practical example of such bets were the credit default swap transactions between Goldman Sachs and AIG.

When we introduce production into our framework, the quest for rent extraction leads to significant distortions in production decisions. Financial institutions only

care about maximizing payoffs in states of nature in which they will be intact and do so by minimizing their productive output in states in which they will be bailed out anyways. They will therefore invest in highly cyclical projects, which have negative net present value when valued at the pricing kernel of the household sector.

A number of economists have cast doubt on the view that bailout expectations led to increased risk-taking in the runup to the financial crisis by pointing to evidence that those bankers responsible for risk-taking either did not seem to be aware of the risks involved or did not seem to expect bailouts (see e.g. Cheng et al., 2014). However, our analysis makes clear that bailout expectations are mediated via market prices and do not need to be in the back of the mind of the actors engaging in risk-taking. The existence of explicit or implicit safety nets distorts market prices, which in turn pushes profit-maximizing financial sector participants to engage in behaviors that lead to bailout rent extraction.

Consider for example a banker who substitutes \$10bn of interbank loans by \$10bn of repo funding, which is 10 basis points cheaper.<sup>1</sup> Bank profits go up by \$10m because of the interest savings. The decision is rational based on publicly observable market signals, and the banker does not need to be aware of the fact that he has just increased the contingent liabilities of the deposit insurance fund by subordinating depositors, which cost the public an expected \$10m if valued at the market price of the default risk. Although the banker may not have consciously intended to engage in “moral hazard,” his actions have the same effect. We term the phenomenon more broadly bailout rent extraction. Similar considerations apply to the banker who found innovative ways of increasing risk-taking and profits in good times by minimizing the capital cushion that was set by regulators in order to limit risk-shifting in bad times, or to the banker who earned high profits from finding innovative ways of selling more tail risk in the housing market to Fannie Mae and Freddie Mac at favorable prices that included bailout rents. We discuss all three examples in more detail below.

Financial innovation for rent extraction was but one among several important factors contributing to the excessive risk-taking in the build-up to the financial crises and to the resulting large losses. Other factors included agency problems along every steps of the chain of financial intermediation, “animal spirits,” and externalities in financial markets (see e.g. Brunnermeier, 2009). However, regardless of the economic mechanism that led to large risk-taking, the financial sector earned significant bailout rents from the explicit and implicit guarantees that covered the financial sector.

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<sup>1</sup>This was the approximate spread on interbank loans over repos during the 2000s up until summer 2007. See Sengupta and Tam (2008).

Crucially, our paper points out that these rents are earned in good states of nature and do not require that an adverse shock occurs that triggers an actual bailout.

**Related Literature** This paper is related to the strand of literature on financial innovation. Allen and Gale (1988, 1991) analyze the efficiency effects of financial innovation in an incomplete market framework in which introducing new securities allows for better risk-sharing. More recently, Simsek (2011) shows that financial innovation may be driven by belief disagreements and may lead to greater volatility rather than better insurance. Gennaioli et al. (2011) analyze the possibility that financial innovation may be directed at hiding neglected risks from investors with imperfectly rational beliefs. Kondor and Koszegi (2015) analyze how financial institutions design new securities that allow them to take advantage of their information advantage compared to retail investors. We contribute to this literature by emphasizing rent extraction from public safety nets as a novel objective for financial innovation.

The second strand of literature to which our paper contributes is on the welfare effects of bailouts. Numerous economists, starting with Bagehot (1873), have observed that bailouts have positive efficiency effects when financial crises occur, but that they have adverse ex-ante incentive effects (‘moral hazard’ effects) since they encourage greater risk-taking. The positive efficiency effects of bailouts may include ruling out bad equilibria when there is multiplicity, e.g. in models of bank runs in the tradition of Diamond and Dybvig (1983), or relaxing binding financial constraints.<sup>2</sup> The tension between the ex-ante incentive effects and the ex-post efficiency effects also gives rise to a time consistency problem. A growing recent literature analyzes how the fashion in which bailouts are provided determines their incentive effects; see e.g. Acharya and Yorulmazer (2008), Jeanne and Korinek (2013), or Philippon and Schnabl (2013). Farhi and Tirole (2012) and Keister (2015) show that if bailouts are provided based on aggregate financial capital (‘systemic bailouts’) rather than based on an individual institution’s capital position, then the risk-taking decisions of individual actors become strategic complements because higher risk-taking by one actor increases the probability for other actors to receive bailouts, creating the possibility of multiple equilibria.

Our contributions to this strand of literature are threefold: First, we show that bailouts create incentives for socially undesirable forms of financial innovation. Secondly, such financial innovation massively deteriorates the trade-off between the

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<sup>2</sup>There is also a literature where the existence of bailouts is simply assumed so as to focus the analysis on their incentive effects. See e.g. a number of works on banking regulation surveyed by Freixas and Rochet (2008).

efficiency and incentive effects of bailouts. We provide an example of an economy in which there are only positive efficiency effects to bailouts before a market for risk is opened, but only rent extraction takes place after such a market is created through financial innovation. Thirdly, whereas most existing works on bailouts take it as given that financial institutions issue too much debt to take advantage of bailouts, we analyze which state-contingent assets allow financial institutions to extract bailouts in a more efficient manner.

Our methodological innovation is based on a simple observation: when economic agents can enter financial contracts contingent on states of nature in which their losses are covered by bailouts, then the equilibrium is determined by corner solutions. In a general equilibrium model, these corner solutions are either set by financial regulation, by solvency concerns if issuers have limited liability, or – if no other constraints are imposed – by the resource constraint of the economy, which represents a natural limit for rent extraction.<sup>3</sup>

Our paper is also related to a nascent literature that links developments in the financial sector to growing societal inequality (see e.g. Philippon and Reshef, 2012). We show in this paper that financial innovation for rent extraction leads to outcomes in which the financial sector can extract a large share of the surplus created by an economy in good times. Korinek and Kreamer (2014) expose an alternative mechanism through which financial deregulation increases inequality: deregulation increases financial sector profits in expectation but leads to higher volatility and a greater incidence of credit crunches, which hurts the real economy.

In the empirical literature, a number of recent papers provide evidence that financial institutions derive substantial benefits from safety nets. Noss and Sowerbutts (2011) distinguish two approaches used in the literature, one based on the funding advantage of banks due to government support and another based on valuing the contingent claims provided by government support. They employ a version of the latter approach to estimate the implicit subsidy to British banks at up to £120bn during 2010. Kelly et al. (2011) argue that the difference between the market price of put options on individual banks and on a banking index arises from a systemic bailout guarantee on the US banking system that was worth more than \$150bn during the recent financial crisis.

**Examples of Financial Innovation for Rent Extraction** In the following we discuss a number of examples in which (i) financial innovation led to increased profits among financial institutions during the run-up and increased losses during the

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<sup>3</sup>A possible example of the latter may be the Icelandic crisis of 2008, in which the financial system came close to extracting all the pledgeable resources of the economy.

ensuing crises and (ii) in which those losses led to increased expenses for the public sector in supporting or resolving the institutions in question. Although this does not establish a causal link between bailout rents and increased risk-taking, our examples are suggestive of our hypothesis that the described financial innovations were at least in part for rent extraction.

An important point about these examples, which we will develop further in our analytic model below, is that the actors who obtain bailout rents by creating financial innovations and engaging in higher risk-taking are not necessarily aware that the source of their profits is rent extraction. They simply follow the signals provided by market prices. The existence of explicit or implicit safety nets is reflected in market prices as long as at least a small fraction of the agents who take the other side of the trades expect that their claims on financial institutions are safe and will be honored, if necessary by transfers from the government. Bailing out any of the claimholders on financial institutions is therefore sufficient to allow for the described strategy of rent extraction. In fact, such distorted market prices push financial institutions to engage in financial innovation for rent extraction and take on higher risk – any other behavior would not maximize profits and should therefore lead to a shareholder revolt.

1. Deposit insurance: The FDIC insures the deposits of US banks against default and charges insurance premia that aim to reflect the riskiness of the operations of the insured banks. However, over time a large number of “financial innovations” have developed to structure banking liabilities in a way that maximizes the value of deposit insurance without a corresponding adjustment in premia (see e.g. Shibut, 2002): (i) Deposit brokers and splitters distribute the deposits of high net worth-individuals across large numbers of insured banks so as to keep the value of each account below the deposit insurance limit per individual per bank that is guaranteed by the FDIC. (ii) Replacing traditional interbank loans with repos has the effect of pushing the claims of FDIC-insured depositors down the seniority chain, since repos are secured with collateral and therefore senior. This change in priority has become especially important after the 1993 National Depositor Preference Act made deposits senior to interbank loans. (iii) Moreover, although short-term interbank liabilities are legally junior to FDIC-insured deposits they are typically withdrawn more quickly in the event of financial distress, rendering depositors and the FDIC effectively junior.

Between 2008 and 2011, the FDIC seized 423 failing banks and experienced

losses in excess of \$80bn.<sup>4</sup>

2. Mortgage markets: The underwriting guidelines for conforming mortgages by Fannie Mae and Freddie Mac required that home buyers make a downpayment of at least 20% in order to mitigate problems of adverse selection and moral hazard. Fannie and Freddie priced the default risk inherent in mortgages they held or insured based on this benchmark. In recent decades, banks increasingly offered mortgages to homebuyers who could not afford a 20% downpayment. However, loans to such home buyers were typically provided in two pieces: a first mortgage was originated and sold to Fannie or Freddie, and a second subordinated mortgage was held by the bank or later securitized in private securitization markets. Borrowers with lower home equity constituted worse risk pools and had worse incentives, but the pricing policies of Fannie and Freddie did not reflect this. Banks could therefore shift risks onto the books of Fannie and Freddie and share the gains with subprime borrowers (see Acharya et al., 2011).

The fiscal transfers after the government rescue of Fannie and Freddie were the largest in US corporate history, amounting to \$188bn by the first quarter of 2012.

3. Capital adequacy requirements: Investment banks developed numerous financial innovations that allowed financial institutions to effectively circumvent capital adequacy requirements and increase both their profits on the upside and the losses experienced by taxpayers when a financial institution was rescued. An example was so-called securitization without risk transfer (Acharya et al., 2013), which allowed banks to fund close to a trillion dollars of mortgage-backed securities via conduits that enjoyed explicit or implicit guarantees while incurring minimal capital charges. Another example was the structuring of mortgage-backed securities such that they could be “rated at the edge,” i.e. they would only just obtain a favorable credit rating but be subject to the capital requirements reflecting the average riskiness of the credit rating (Brunermeier, 2009).
4. Euro-area break-up risk: In European capital markets, financial institutions have developed numerous innovative ways of offloading the exchange rate risk associated with a euro area break-up on the public sector, esp. the Eurosystem. For example, a number of peripheral banks have recently structured so-called

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<sup>4</sup>See <http://www.fdic.gov/bank/individual/failed/banklist.html> for details.



“retained covered bonds” that allowed them to access liquidity in euros in exchange for the (peripheral currency-denominated) collateral on their balance sheets without having to pay for the market price of the devaluation risk implicit in such collateral.<sup>5</sup> In mid-2012, the ECB’s exposure to such bonds was more than \$400bn.

The rest of the paper is structured as follows: Sections 2 and 3 introduce our benchmark model and solve the equilibrium, presenting our main results on financial innovation. Section 5.1 extends our setup to a production economy to study the implications of financial innovation for rent extraction for real investment decisions. Section 4 discusses a number of policy options to prevent welfare-reducing financial innovation. Section 6 concludes.

## 2 Model Setup

We consider an economy with two sets of atomistic agents of mass 1 called households and bankers, which we distinguish by the indices  $i \in \{h, b\}$ . There are three time periods  $t = 0, 1, 2$  and one homogenous consumption good. In period 1, a state of nature  $s \in \{L, H\}$  is revealed, where we assume that the probability for state  $L$  is  $\pi < 1/2$ . One interpretation of state  $L$  is that it represents a “crisis” state.

Both types of agents  $i \in \{h, b\}$  value consumption in period 2 according to the utility function

$$U_i = E [c_{is}]$$

where  $c_{is}$  is the consumption of the representative agent of type  $i$  in state  $s$ . We denote the state-contingent consumption vector of the representative agent of type  $i$  as  $c_i = (c_{iL}, c_{iH})'$ .

**Period 0** In period 0, bankers collectively decide whether to create a Walrasian market to trade securities that are contingent on the realization of the state  $s$  in period 1. The cost of creating such a market is  $f \geq 0$  units of consumption good for each banker  $j$ , which will be subtracted from her endowment in period 1. We capture the decision of bankers whether to create such a market by the indicator function  $1_M \in \{0, 1\}$ . If  $f$  is sufficiently low, the market will always exist so  $1_M = 1$ ; if  $f = \infty$  no market will exist so  $1_M = 0$ .

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<sup>5</sup>For example, a Barclays Research Report on “Retained covered bonds – implications for investors” notes that “in a number of countries, issuers were able to set up specific covered bond programmes for the sole purpose of creating ECB-eligible collateral.”

If bankers create a market, then all agents choose their optimal state-contingent allocations in period 0. We denote the market prices of the two states by a vector  $p = (p_L, p_H)$  and define the consumption good in state  $H$  as the numeraire so  $p_H = 1$ .

**Period 1** In period 1, the state of nature  $s$  is revealed, agents receive their endowments, any trades in the Walrasian market are executed, and households may provide transfers to bankers.

We assume w.l.o.g. that the endowment of households is constant in both states of nature and is denoted by the vector  $e_h = (e, e)'$  where  $e > 0$ . Bankers obtain state-contingent endowments that satisfy  $e_H > e_L > 0$ . We denote their endowment vector by  $e_b = (e_L, e_H)'$ . We collect the two vectors in an endowment matrix  $E = (e_h, e_b)$ .

After agents collect their endowments, trades in the Walrasian market are executed, if  $1_M = 1$ , i.e. if such a market exists. We denote the allocations chosen in the market by  $x_{is}$ , which we may call the interim wealth of agent  $i$  in state  $s$ . If no Walrasian market exists, then the interim wealth coincides with the endowments of agents,  $x_{is} = e_{is} \forall i, s$ .

Given the vector  $x_s^j$  of an individual banker  $j$ , households may collectively decide to provide a bailout transfer  $t_s^j = t_s(x_s^j) \geq 0$  to the banker, where the sum of all transfers satisfies  $t_s = \int_0^1 t_s^j dj \leq x_{hs}$ . Since transfers decisions are made collectively, the transfers appears like a lump-sum tax from the perspective of an individual household. For now, we assume that this decision is made in a time-consistent fashion, i.e. households cannot commit to a function  $t_s(x_s^j)$  in advance. We denote the resulting final period 1 wealth positions of the two agents by  $w_{hs} = x_{hs} - t_s$  and  $w_{bs}^j = x_{bs}^j + t_s^j$ . In an equilibrium in which all bankers are symmetric, we can summarize the final period 1 wealth positions in a square wealth matrix  $W$ .

At the end of period 1, each banker converts her wealth into productive capital using a linear technology  $k^j(w^j) = w^j$ . We assume that bankers have exclusive access to this technology. This captures the notion that bankers have a special role in intermediating capital to the real economy, and that this role cannot be replicated by other agents in the economy. (We will discuss the implications of relaxing this assumption below.) Households have access to a storage technology with zero net return in which they hold their wealth.

**Period 2** In period 2, the representative household competitively supplies one unit of labor  $\ell = 1$  at the prevailing market wage. Each banker  $j \in [0, 1]$  rents out her capital  $k^j$  to one-period entities called firms, which are also indexed by  $j \in [0, 1]$  and which are collectively owned by bankers. (In equilibrium, firms will make zero profits; therefore nothing would change if we assumed a different ownership

structure.) Each firm  $j$  competitively hires labor and rents capital. It combines the two factors in a production function  $F(k, \ell) = Ak^\alpha \ell^{1-\alpha}$ . Capital is fully used up in production. Firms pay out wages  $\omega \ell = (1 - \alpha) Ak^\alpha$  and gross interest  $Rk = \alpha Ak^\alpha$  after production has taken place. Finally, both sets of agents consume.

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|-----------------|---|
| <b>Period 0</b> | <ul style="list-style-type: none"> <li>• bankers collectively choose whether to create insurance market at cost <math>f</math></li> <li>• if market exists, agents determine state-contingent allocations <math>x_s</math></li> </ul>   |
| <b>Period 1</b> | <ul style="list-style-type: none"> <li>• nature picks a state <math>s \in \{1, 2\}</math></li> <li>• agents obtain endowments <math>e_s</math></li> <li>• if market exists, trades are executed</li> <li>• result is interim wealth <math>x_{i_s}</math></li> <li>• households collectively choose transfers <math>t_s^j</math></li> <li>• result is final period 1 wealth <math>w_s</math></li> <li>• bankers convert wealth into capital <math>k_s = w_{bs}</math></li> </ul> |
| <b>Period 2</b> | <ul style="list-style-type: none"> <li>• capital and labor are hired</li> <li>• production takes place</li> <li>• output is distributed and consumed</li> </ul>   |

**Table 1:** Time line

The time line of the model is summarized in table 1.

## 2.1 Assumptions

We introduce a financial friction in period 2 of our model to capture the notion that the net worth of bankers affects capital investment in the real economy. For simplicity, we impose the following assumption:

**Assumption 1** (Limited Commitment in Financial Markets). *Bankers and households cannot commit to repayments in period 2.*

This assumption implies that no borrowing and lending between bankers and households can be sustained between periods 1 and 2, and that capital investment in each state  $s$  of period 2 is determined by the financial net worth of bankers,

$$k_s^j = \min \{0, w_{bs}^j\}$$

where the minimum operator captures that bankers would default on any negative period 2 net worth  $w_{bs}^j < 0$ .

We make assumption 1 for analytical simplicity, but, more broadly, our results continue to hold as long as a financial friction is in place that keeps the marginal product of capital of bankers elevated when their financial net worth is low, for example because of a maximum leverage ratio. Micro foundations for such frictions are given, for example, by Stiglitz and Weiss (1981), Hart and Moore (1994) and Holmstrom and Tirole (1998).

We introduce an additional assumption that captures the notion that bank capital is specific and that bank relationships cannot be easily substituted:

**Assumption 2** (Specificity of Bank Capital). *Productive firms in period 2 are active in a unit mass of sectors indexed by  $j \in [0, 1]$ . The capital lent by a banker  $j \in [0, 1]$  is productive only in sector  $j$ .*

This assumption implies that the capital of each individual bank matters for households. This will be important when we derive the optimal bailout transfer policies of the household sector.<sup>6</sup> For a more detailed discussion of why bank capital is specific see e.g. Diamond and Rajan (2001). We will discuss the implications of relaxing this assumption along several dimensions below.

In order to study the adverse incentive effects of bailouts, we assume time-consistent behavior, which is a corner stone in much of the literature on the adverse incentive effects of bailouts:

**Assumption 3** (Time-Consistent Bailouts). *Households determine the optimal transfers  $t_s(x_s^j)$  in period 1 in a time-consistent manner.*

This assumption prevents households from committing to a no-bailout-policy if bankers misbehave. It is well known that, if households were able to make perfect commitments, then they could condition bailouts on good behavior and there would be no adverse incentive effects to bailouts (see e.g. Jeanne and Korinek, 2013).

Finally, we make the following assumptions about endowments:

**Assumption 4** (Endowments). *The endowments in the economy are sufficiently high to satisfy  $e + e_L \geq [\alpha(1 - \alpha)A]^{\frac{1}{1-\alpha}}$  and  $E_s[e_{bs}] \geq [\alpha(1 - \alpha)A]^{\frac{1}{1-\alpha}}$ .*

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<sup>6</sup>We perform our analysis under the assumption that bankers act competitively in the period 2 market for loans of capital. Given the specificity of bank capital, banks may face incentives to engage in monopolistic behavior in supplying loans to sector  $j \in [0, 1]$ . In appendix A.1 we show that the optimal allocations chosen by bankers who act monopolistically are identical to those of competitive bankers in our setup.

These are relatively weak technical assumptions. The first inequality guarantees that there are sufficient resources in the economy so that optimal bailouts in the low state do not surpass the aggregate endowment of the economy in state  $L$ . The second one captures that the expected net worth of bankers is sufficient so that they will not receive a bailout if they can optimally insure. Our insights still hold if these assumptions is violated, but we would have to analyze additional corner solutions.

## 2.2 Problem of Individual Households

A representative households takes the prices  $p_s$  and  $\omega$  as well as total transfers  $t_s = \int_0^1 t_s(x_s^j) dj$  as given. If  $1_M = 1$ , i.e. if the Walrasian market in period 1 exists, the optimization problem is

$$U_h = \max_{x_{hs}, w_{hs}, c_{hs}} E[c_{hs}] \quad (1)$$

$$\begin{aligned} \text{s.t.} \quad \sum_s p_s (x_{hs} - e_{hs}) &= 0 & (2) \\ w_{hs} &= x_{hs} - t_s \\ c_{hs} &= \omega_s \ell + \min \{w_{hs}, e + e_s\}, \end{aligned}$$

The period 0 budget constraint (2) is replaced by the identity  $x_{hs} = e_{hs} \forall s$  if no Walrasian market exists. The ensuing two constraints reflect that the end-of-period 1 wealth  $w_{hs}$  is determined by the interim wealth  $x_{hs}$  of households minus the transfer that they provide, and that household consumption consists of their wage earnings plus their financial wealth, which is limited by  $e + e_s$  because bankers default if households stake a claim on more resources than what is available in the economy.

## 2.3 Problem of Individual Bankers

An individual bankers  $j \in [0, 1]$  takes the prices  $p_s$  and  $R_s$  as given and internalize the transfer function  $t_s(x_s^j)$  that is collectively determined by households. If a Walrasian market in period 1 exists, the banker solves

$$U_b^j = \max_{x_{bs}^j, w_{bs}^j, k_s^j, c_{bs}^j} E[c_{bs}^j] \quad (3)$$

$$\begin{aligned} \text{s.t.} \quad \sum_s p_s (x_{bs}^j - e_{bs}^j) &= 0 & (4) \\ w_{bs}^j &= x_{bs}^j + t_s(x_s^j) \\ k_s^j &= \max \{0, w_{bs}^j\} \\ c_{bs}^j &= R_s k_s^j \end{aligned}$$

If no Walrasian market exists, we replace the period 0 budget constraint of the banker (4) by the identity  $x_{bs}^j = e_{bs}^j \forall s$ . The next three constraints indicate that final period-1 wealth is determined by interim wealth  $x_{bs}^j$  plus the transfer, that bankers transform their financial net worth into capital but default on negative financial net worth, and that they consume the returns on lending their capital to firms.

## 2.4 Determination of Bailouts

In this section, let us consider allocations in which bankers have chosen symmetric allocations, leading to interim banker wealth  $x_{bs}$ . (We will consider mixed strategies for bankers below.) Households collectively take the behavior of bankers as given. If bailouts are possible, they determine an optimal time-consistent transfer  $t_s$  in period 1 to maximize household welfare,

$$\begin{aligned} \max_{0 \leq t_s \leq x_{hs}} \quad & u(w_{hs} + (1 - \alpha) A(k_s)^\alpha) \\ \text{s.t.} \quad & w_{hs} = x_{hs} - t_s \\ & w_{bs} = x_{bs} + t_s \\ & k_s = \max\{0, w_{bs}\} \end{aligned} \tag{5}$$

where the three constraints capture that households collectively internalize that the transfer is taken from their interim net worth, but that it augments aggregate banker net worth, which in turn raises capital investment  $k_s$ . Collectively, households may find such a transfer advantageous since the wages they receive  $\omega = (1 - \alpha) A(k_s)^\alpha$  are an increasing function of capital investment, i.e.  $d\omega/dk_s = F_{kl} > 0$ .

## 2.5 Determination of Market Structure

In period 0, bankers collectively determine whether to pay a fixed cost  $f$  per banker to create a Walrasian insurance market that is contingent on the realization of the shock  $s \in \{L, H\}$  in period 1. They take the behavior of households as given and choose to create a market  $1_M = 1$  if the utility of bankers under such a market  $U_b^M$  is greater than with no market  $U_b^{NM}$ , i.e.

$$1_M = \{U_b^M \geq U_b^{NM}\}$$

where  $U_b = E[c_{bs}]$  as described above in (3) and will be determined in more detail below.

We assume that financial innovation is collectively determined by bankers as a group and that they each have to pay the fixed cost  $f$  of creating a Walrasian market.

In some of the literature, individual bankers decide on their own whether to create a market in which only they can trade claims with households (see e.g. Allen and Gale, 1988, 1991). This may give rise to equilibria in which only a subset of bankers engage in financial innovation, which requires keeping track of additional types of allocations but does not change our main insights.

## 2.6 Definition of Equilibrium

We define an equilibrium in the economy as a collection of wealth allocations  $(x_{is}, w_{is})$ , capital allocations  $(k_s)$ , consumption allocations  $(c_{is})$  together with a set of prices  $(p_s, R_s, \omega_s)$  as well as an indicator for the existence of the insurance market  $1_M \in \{0, 1\}$  and a transfer  $t_s$ , such that the allocations solve the individual optimization problems of bankers and households, the transfer  $t_s$  is an optimal time-consistent transfer from the collective perspective of households if bailouts are possible, the existence of the market  $1_M$  is optimally chosen by bankers, and all markets clear. (If  $1_M = 0$  then the prices  $p_s$  remain undefined.)

## 3 Equilibrium

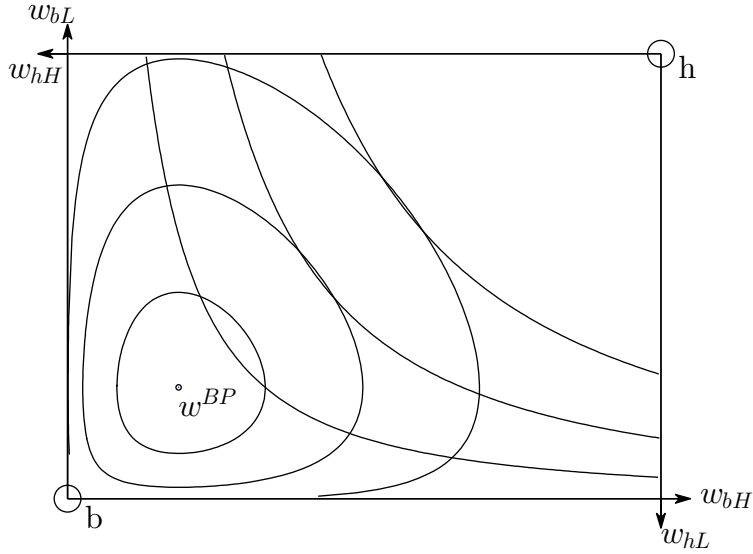
This section describes the equilibrium of the economy via backward induction. We start by analyzing the period 2 allocations as a function of the wealth positions  $w_s = (w_{bs}, w_{hs})$  of the two types of agents. Then we analyze the allocations of the economy for the cases in which an insurance market in period 0 is missing or is taken as given. Finally we determine the optimal choice of bankers regarding whether to create such an insurance market for claims contingent on the period 1 endowment shock.

### 3.1 Period 2 Allocations

At the end of period 1, the state of the economy is fully described by the vector of wealth positions  $w_s = (w_{bs}, w_{hs})$ . Given assumption 1, the capital investment of bankers satisfies

$$k_s = \min \{0, w_{bs}\}$$

Since factors are compensated competitively, the wage bill and the capital share satisfy  $\omega_s \ell = (1 - \alpha) A k_s^\alpha$  and  $R k_s = \alpha A k_s^\alpha$  respectively. We denote the resulting levels of utility of bankers and households in state  $s$  as a function of the vector



**Figure 1:** Indifference Curves in Modified Edgeworth Box

$w_s = (w_{bs}, w_{hs})$  as

$$\begin{aligned} V_b(w_{bs}) &= u_b (\alpha A (k_s)^\alpha) \\ V_h(w_{bs}, w_{hs}) &= u_h (w_{hs} + (1 - \alpha) A (k_s)^\alpha) \end{aligned}$$

We observe that if the wealth of bankers  $w_{bs}$  is low, capital investment is constrained and both labor and capital income decline.

Figure 1 illustrates the indifference curves of bankers and households as a function of their end-of-period-1 wealth positions  $w_{is}$  in a modified Edgeworth box.<sup>7</sup> For bankers, the origin is at the bottom left of the graph, the indifference curves are convex and welfare improves as we move up and to the right. For households, the origin is in the top right and utility increases as we move down and to the left, toward the bliss point  $w^{BP}$ , but decreases as their wealth grows beyond this point. The intuition is that if banker wealth is lower than this threshold, then capital investment, output, and wages are so low that households are worse off. The indifference curves of households are therefore concentric around their bliss point. This finding will be important in the following section when we determine the optimal bailout policy of households.

<sup>7</sup>The Edgeworth box is ‘modified’ because utility is expressed as a function of wealth not consumption. We describe the parameterizations used to generate all Figures in appendix B.



### 3.2 Symmetric Equilibrium without Insurance Market

Let us first analyze the allocations of an economy in which  $1_M = 0$ , i.e. in which no market for the period 1 endowment shock exists. We could interpret this as the fixed cost  $f$  being so high that bankers prefer  $1_M = 0$ . (A sufficient condition for this is  $f > e + e_H$ .) In that case, the interim wealth allocations in period 1 coincide with the endowment vectors,  $x_s = e_s$ .

Households collectively determine whether to provide a transfer  $0 \leq t_s(x_s) \leq x_{hs}$  to bankers after they observe the wealth level  $x_{bs}$  of bankers:

**Lemma 5** (Pareto-Improving Bailouts). *For given interim wealth  $x_s = (x_{bs}, x_{hs})$  in period 1, households find it collectively optimal to provide a time-consistent transfer to bankers that satisfies*

$$t_s = \begin{cases} 0 & \text{if } x_{bs} \geq \hat{k} \\ \hat{k} - x_{bs} & \text{if } x_{bs} \in (\hat{k} - x_{hs}, \hat{k}) \\ x_{hs} & \text{if } x_{bs} \leq \hat{k} - x_{hs} \end{cases} \quad (6)$$

where  $\hat{k}$  is the minimum Pareto-efficient level of bank capital defined by

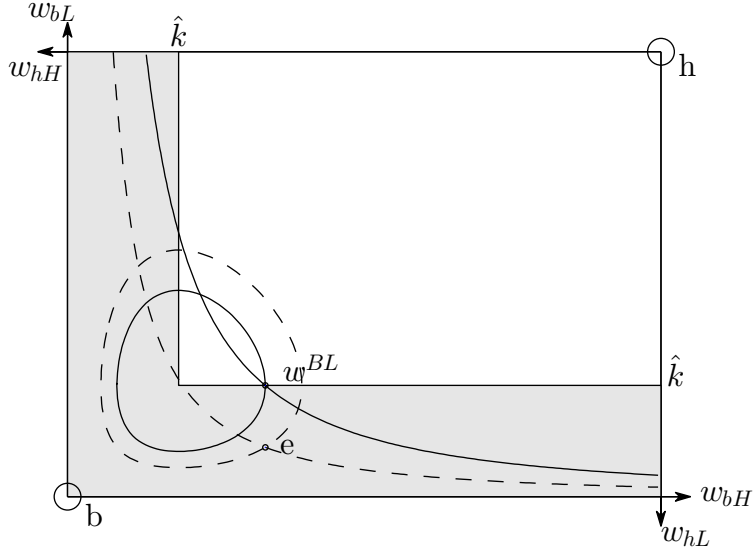
$$\frac{d\omega\ell}{dk} = F_{kl}(\hat{k}, 1) = \alpha(1 - \alpha)A\hat{k}^{\alpha-1} = 1 \quad (7)$$

If  $t_s > 0$ , this transfer generates a Pareto-improvement from the perspective of period 1.

*Proof.* Households collectively solve the optimization problem (5). If the solution to this problem is interior to the constraint  $0 \leq t_s \leq x_{hs}$ , then the first-order condition yields equation (7) and the optimal transfer ensures that  $w_{bs} = \hat{k}$ . If the interim net worth of bankers is greater than the threshold  $x_{bs} > \hat{k}$ , then the transfer is set at the lower bound  $t_s = 0$  and  $w_{bs} = x_{bs}$ . If the transfer necessary to achieve the capital level  $\hat{k}$  exceeds the interim net worth of households, then the transfer is determined by the corner solution  $t_s = x_{hs}$  and the wealth allocations satisfy  $w_{bs} = x_{bs} + x_{hs}$  and  $w_{hs} = 0$ .

If  $t_s > 0$ , we observe that such a transfer generates a Pareto improvement since it increases the consumption of both households and bankers.  $\square$

Intuitively, the cross-derivative  $F_{k\ell}$  captures how much the wage  $\omega = F_\ell$  rises in response to a marginal increase in bank capital. For low  $k$ , there are large payoffs to additional capital investment since  $\lim_{k \rightarrow 0} F_{k\ell}(k, 1) = \infty$ . As long as  $F_{k\ell} > 1$ ,



**Figure 2:** Bailout Equilibrium

households are better off if they coordinate to transfer some of their wealth to bankers who will use it for capital investment, thereby benefiting both agents. The cross-derivative  $F_{k\ell}$  is declining in  $k$ , i.e. the more capital bankers have already invested, the smaller the marginal benefit of additional investment. The threshold  $\hat{k}$  is the level of capital at which the wage increase derived from a marginal unit of wealth transferred to bankers equals the cost of the transfer, i.e.  $F_{k\ell} = 1$ .

An important feature of the lemma is that households find it optimal to provide the transfer (6) even if the interim net worth of bankers is negative  $x_{bs} < 0$ . Assumption 1 about the limited commitment of bankers implies that bankers would default if they enter period 2 with negative net worth  $w_{bs} < 0$ . Collectively, households do not care if they incur losses because of default or because of bailouts. As long as  $w_{bs} + t_s < 0$ , an additional dollar of bailout does not affect the consumption of households because it increases the bailout but reduces losses from default by an equal amount. However, once the threshold  $w_{bs} + t_s = 0$  has been crossed, a marginal increase in the bailout raises  $k_s$  and increases the wages that households receive, generating a Pareto improvement. We will discuss alternative bankruptcy frameworks to deal with  $x_{bs} < 0$  in section 4.

In figure 2, the level of  $\hat{k}$  is indicated by grey bars in both states of nature. In the figure, we assume that the endowments of bankers satisfy  $e_{bL} < \hat{k} < e_{bH}$ . It is therefore ex-post optimal for households to provide a bailout transfer  $\hat{k} - e_{bL}$  in state

$L$  to bankers, leading to the point  $w^{BL}$  in the figure and moving both sets of agents to higher indifference curves.

**Remark** We could generalize our results to the case where the transfer  $t_s$  is determined by a planner who maximizes a weighted sum of the welfare of bankers and households. This would increase the threshold value  $\hat{k}$ , but would no longer guarantee a Pareto improvement. However, the main point of our analysis is to show that bailout transfers from households to bankers are ex-post desirable even if we care exclusively about the welfare of households. It is not surprising that the desirability of such transfers increases as we place a greater welfare weight on bankers.

### 3.3 Equilibrium with Insurance Market

Next we analyze the allocations of an economy in which we take the existence of an insurance market for claims contingent on the state of nature  $s \in \{L, H\}$  as given so  $1_M = 1$ . In period 0, households choose a state-contingent allocation of interim wealth  $x_h = (x_{hL}, x_{hH})'$  to maximize the optimization problem (1). Their optimality condition implies

$$p_L = \frac{\pi}{1 - \pi} \quad (8)$$

Since they are risk-neutral, households are willing to hold any wealth allocation  $x_h$  at a market price that corresponds to the relative probabilities of the two states.

We can formulate the optimization problem of bankers (3) as

$$\max_{x_b} E [V_b(x_{bs} + t(x_s))] \quad \text{s.t.} \quad p(e_b - f - x_b) = 0$$

where they internalize that households will provide transfers as described in (6). The associated optimality condition with respect to  $x_{bL}$  can be written as

$$\pi V'_b(w_{bL}) \cdot [1 + t'(x_L)] - (1 - \pi) p_L V'_b(w_{bH}) \cdot [1 + t'(x_H)] = 0 \quad (9)$$

We again start the analysis of the problem of bankers by focusing on symmetric equilibria. In a second step we will analyze non-symmetric equilibria.

#### 3.3.1 Symmetric Equilibrium

Bankers recognize that the transfer function  $t(x_{bs})$  has a kink when  $x_{bs}$  falls below the bailout threshold  $\hat{k}$ . This makes the objective function of bankers non-concave in the neighborhood of the threshold since  $t'(x_s) = 0$  for  $x_{bs} > \hat{k}$  but  $t'(x_s) = 1$

for  $x_{bs} < \hat{k}$ . We separate the choice set of bankers for  $x_{bs}$  into two regions that we call the *insurance region* (with  $x_{bs} \geq \hat{k} \forall s$ ) and the *rent extraction region* ( $\exists s$  s.t.  $x_{bs} < \hat{k}$ ). We solve for the local maximum in each of the two regions and observe that bankers will choose whichever allocation yields higher utility for them.

**Lemma 6** (Insurance Allocation). *The wealth allocation of the two sets of agents in the insurance allocation is given by the matrix*

$$W^{Ins} = \begin{pmatrix} w_{hL} & w_{bL} \\ w_{hH} & w_{bH} \end{pmatrix} = \begin{pmatrix} e + e_L - E[e_{bs}] & E[e_{bs}] - f \\ e + e_H - E[e_{bs}] & E[e_{bs}] - f \end{pmatrix} \quad (10)$$

The utility levels of the two agents are  $U_h^{Ins} = e + (1 - \alpha) A \bar{k}^\alpha$  and  $U_b^{Ins} = \alpha A \bar{k}^\alpha$  where  $\bar{k} = E[e_{bs}] - f$  is the expected wealth of bankers net of the cost of creating the market. This allocation constitutes a Pareto improvement over the autarky allocation  $W^{Aut} = E$ .

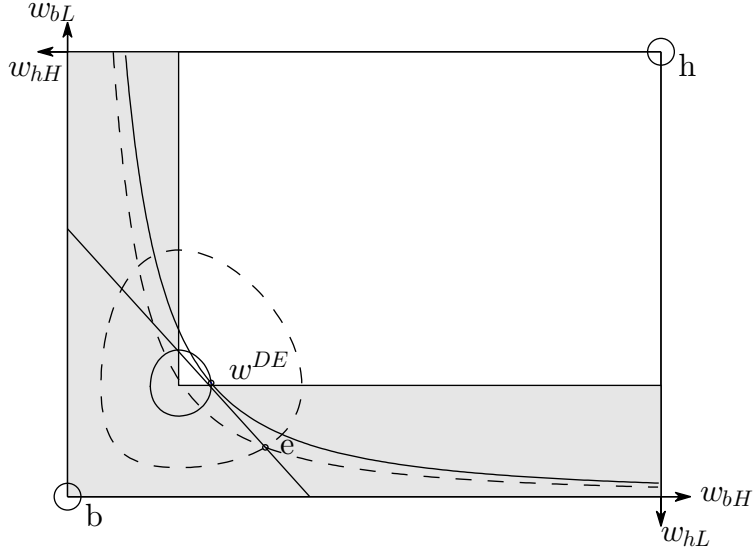
*Proof.* If the allocation of bankers satisfies  $x_{bs} \geq \hat{k}$  in both states of nature  $s$ , then they do not receive transfers so  $t_s = 0 \forall s$  and  $w_{is} = x_{is}$ . The terms  $t'(x_s)$  in the first-order condition (9) drop out. The behavior of bankers is then driven by the standard insurance condition

$$\frac{\pi}{1 - \pi} \cdot \frac{V'_b(w_{bL})}{V'_b(w_{bH})} = p_L$$

Given the equilibrium market price (8), the marginal valuation of wealth of bankers in the two states of nature is equated and equilibrium requires  $w_{bL} = w_{bH} = E[e_{bs}] - f$ . Households take on the endowment risk  $e_s - E[e_{bs}]$ . The resulting wealth allocation is given by the matrix  $W^{Ins}$ . Substituting  $k_s = w_{bs} = E[e_{bs}] - f = \bar{k}$  determines the wages and capital income as captured by the utility functions  $U_h^{Ins}$  and  $U_b^{Ins}$ . Agents are better off than under the autarky wealth allocation since the economy's production function is concave in capital so  $F(\bar{k}, 1) > E[F(e_{bs} - f, 1)]$  and the average wage earnings and capital income are increased.  $\square$

In short, households provide insurance to bankers against their endowment shock, ensuring a Pareto efficient allocation of capital in the economy. An example of such an equilibrium is illustrated in Figure 3. Bankers and households trade along a budget line that has slope  $1/p_L$  and reach an equilibrium in which both of them have higher utility.

If the equilibrium is in the rent extraction region so that  $x_{bs} < \hat{k}$  for some  $s$ , then bankers choose the corner solution that maximizes the value of the transfer.



**Figure 3:** Decentralized Equilibrium

**Lemma 7** (Rent Extraction Allocation). *In a symmetric rent extraction equilibrium, bankers extract all the economy's resources in state  $H$  and obtain a bailout that guarantees the minimum efficient level of capital  $\hat{k}$  in state  $L$ . The equilibrium period 2 wealth levels of the two agents are given by the matrix*

$$W^{RE} = \begin{pmatrix} e + e_L - \hat{k} & \hat{k} \\ 0 & e + e_H \end{pmatrix}.$$

*Proof.* Let us first assume that bankers choose their allocations such that the bailout takes place in state  $L$  so  $x_{bL} < \hat{k}$ . (We will prove next that they indeed prefer a bailout in state  $L$  to a bailout in state  $H$ .) Then the term  $[t'(x_L) + 1] = 0$  vanishes in equation (9) and the remaining expression is negative for any  $x_{bL} < \hat{k}$ , implying that the optimum is given by the corner solution in which  $x_{bL}$  takes on the minimum possible value or, conversely,  $x_{bH}$  takes on the maximum possible value.

Let us consider the two candidates for a corner solution. First,  $x_{bL}$  may be limited from below by the households' interim wealth – the transfer obtained by bankers has to satisfy  $t_s \leq x_{hs}$  since households cannot transfer more resources than they have (lemma 5). This constraint is never binding in equilibrium because, by assumption 4, the resource constraint implies that  $x_{bL} + x_{hL} > \hat{k}$  holds – the only way for bankers to reduce  $x_{bL}$  is for households to increase  $x_{hL}$ . The second candidate is determined by the maximum  $x_{bH}$  that is in the choice set of bankers. This is given by the point

where households have sold all their goods in state  $H$  to bankers, i.e.  $x_{bH} = e + e_H$  and  $x_{hH} = 0$ . The resulting allocation features a bailout in state  $L$  so that  $w_{bL} = \hat{k}$  and  $w_{hL} = e + e_L - \hat{k}$  and no bailout in state  $H$  so  $w_{iH} = x_{iH}$ . This is the allocation that constitutes the solution to the optimization problem of bankers, resulting in the wealth matrix given in the lemma.

If bankers were to extract a bailout in state  $H$  rather than state  $L$ , then the corresponding allocation would be given by  $w_b = (e + e_L, \hat{k})'$ . Bankers strictly prefer the bailout in the low state, both because the amount of resources extractable in the high state is higher,  $e + e_H > e + e_L$ , and because the high state is more likely,  $1 - \pi > \pi$ .  $\square$

Intuitively, bankers choose to go for broke in the low state of nature in order to extract the maximum possible bailout, and they shift the market value of this bailout from the low into the high state of nature. Since we assumed that households provide the bailout in a time-consistent fashion and cannot commit to limits on bailouts, this allows bankers to extract the entire net worth of the economy  $w_{bH} = e + e_H$  in the high state of nature and households obtain  $w_{hH} = 0$ .

Given the described institutional setup, households are willingly going along at every step of the process: In the Walrasian market in period 0, individual households are willing to accumulate claims contingent on the low state at the prevailing market price, which allows bankers to shift their payoffs into state  $H$ . Households rationally anticipate that they will provide a large lump-sum bailout  $t_L = \hat{k} - x_{bL}$  in the low state of nature. (If they were risk-averse, they would additionally have a very strong motive to accumulate such claims for insurance purposes.) They rationally anticipate that all their claims on bankers in state  $L$  will be honored because of the bailouts. Furthermore, if state  $L$  materializes in period 1, households are collectively willing to provide the bailout in order to avoid a costly collapse in output. We will discuss how to modify this institutional setup in order to reduce rent extraction in section 4.

**Remark** A noteworthy feature of the described rent extraction allocation is that bankers reap the main benefits of bailouts in state  $H$  not state  $L$  in which the actual bailout transfer occurs. The existence of state-contingent markets allows banker to efficiently extract enormous bailouts in the low state  $L$ , and shift their bounty into the high state  $H$ , in which their share of the economy's resources is only bounded by the aggregate resource constraint. If the good state  $H$  occurs, then all that can be observed from an outside perspective is that bankers make enormous profits – it seems like they are very smart and productive. If the probability of the low state is

small and the described setup is played over many consecutive periods in which only high shocks materialize, the financial sector will earn large profits for long periods of time without actually receiving any bailout transfers in equilibrium.

Bankers choose the insurance or rent extraction allocation depending on which one delivers the higher level of expected utility.

**Proposition 8** (Determination of Equilibrium).

1. Bankers choose the rent extraction regime over the insurance regime if and only if  $U_b^{RE} > U_b^{Ins}$  or

$$(1 - \pi) \underbrace{[(e + e_H - f)^\alpha - \bar{k}^\alpha]}_{\text{rent extracted on upside}} > \pi \underbrace{[\hat{k}^\alpha - \bar{k}^\alpha]}_{\text{insurance lost on downside}} \quad (11)$$

2. This condition is satisfied if (i) the expected wealth  $\bar{k}$  of bankers is sufficiently low compared to the bailout threshold  $\hat{k}$ , (ii) the probability  $\pi$  of state  $L$  is sufficiently low, (iii) the extractable endowment of households  $e$  is sufficiently high.
3. For parameter values for which bankers choose the rent extraction regime, the rent extraction increases banker welfare at the expense of households welfare and of introducing greater output and wage volatility in period 2.

*Proof.* 1. The comparison follows directly from the utility maximization problem of bankers. We obtain inequality (11) by substituting for  $U_b^{RE}$  and  $U_b^{Ins}$  and simplifying.

2. The conditions in the proposition derive from inequality (11). The left-hand side is always strictly positive since  $\bar{k} < e_H - f$ . If  $\bar{k}$  is close to  $\hat{k}$  or if  $\pi$  is close to zero then the right hand side is arbitrarily close to zero. Furthermore, for given  $\hat{k}$  and  $\bar{k}$ , increasing the endowment  $e$  of households makes the left hand side arbitrarily large whereas the right-hand side remains constant.

3. Since the insurance regime was Pareto efficient and bankers are better off under the rent extraction regime, it follows immediately that households are worse off under the rent extraction regime. Under the insurance regime, the variance of output and wages is zero since  $k_s = \bar{k}$ ; under the rent extraction regime, both variances are strictly positive since  $k_H > k_L$ .  $\square$

### 3.3.2 Mixed-Strategy Equilibrium

In this section we investigate non-symmetric mixed-strategy equilibria in which bankers form two groups to bet against each other and households so as to maximize bailouts in both states of nature.<sup>8</sup> We denote the bankers that extract a bailout in state  $\sigma \in \{L, H\}$  by  $b(\sigma)$  and the mass of such bankers by  $n_\sigma$  where  $n_L + n_H = 1$ . Households continue to be homogenous because they are identical and earn labor income from all segments of the market  $j \in [0, 1]$ .

Following the same arguments as in lemma 5, we describe the optimal transfer policy of households as  $t(x_{b(s)s})$  as in equation (6). The budget constraint of households now implies that the transfer is limited by  $t(x_{b(s)s}) \leq x_{hs}/n_s$ .

If bankers choose the insurance allocation, then all their allocations are identical and correspond to Walrasian equilibrium described above, yielding a level of utility  $U_b^{Ins}$  for bankers. Otherwise bankers chose the following allocation:

**Lemma 9** (Mixed-Strategy Rent Extraction Allocation). *In a mixed-strategy rent extraction regime, bankers split into two groups  $\sigma \in \{L, H\}$  of mass  $n_\sigma$  with  $n_L + n_H = 1$  and  $n_L > n_H$  that each go for broke in state  $s = \sigma$ . They achieve wealth allocations described by the matrix*

$$W^{MRE} = \begin{pmatrix} w_{hL} & w_{b(L)L} & w_{b(H)L} \\ w_{hH} & w_{b(L)H} & w_{b(H)H} \end{pmatrix} = \begin{pmatrix} 0 & \hat{k} & \frac{e+e_H-f-\hat{k}n_L}{n_H} \\ 0 & \frac{e+e_L-f-\hat{k}n_H}{n_L} & \hat{k} \end{pmatrix}$$

Observe that households obtain a wealth allocation  $w_h = (0, 0)$ .

*Proof.* Following the logic of lemma 7, bankers of type  $b(L)$  sell claims contingent on state  $L$  and buy up claims contingent on state  $H$  until they exhaust the bailout capacity of households, i.e.  $n_L(\hat{k} - x_{b(L)L}) = x_{hL}$  or  $x_{b(L)L} = \hat{k} - x_{hL}/n_L$ , and bankers  $b(H)$  do likewise for claims contingent on state  $H$  so that  $x_{b(H)H} = x_{hH}/n_H$ . The fractions  $n_L$  and  $n_H$  adjust so as to ensure that bankers are indifferent between the two strategies.  $\square$

In the described non-symmetric rent extraction allocation, bankers in aggregate extract the maximum possible bailout in both states of nature and leave households with zero financial net worth. The intuition is that bankers bet with each other knowing that one of the two groups will go bankrupt and receive a bailout whereas the other group will make record profits. In expectation, this maximizes the payoff received by bankers.

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<sup>8</sup>We thank AIG and Goldman Sachs for their creative financial contracting, which served as an inspiration for this subsection.



**Proposition 10** (Mixed-Strategy Equilibrium).

1. Bankers under unlimited liability choose the non-symmetric strategy rent extraction regime over the insurance regime if and only if  $U_b^{MRE} > U_b^{Ins}$ , or

$$\pi V_b u(\hat{k}) + (1 - \pi) V_b \left( e + e_L - \hat{k} \frac{n_H}{n_L} \right) > U_b^{Ins}$$

2. This condition is more likely to be satisfied the higher  $\hat{k}$  and  $\pi$  and the lower  $e_L$
3. If bankers choose the mixed-strategy rent extraction regime, they push down the level of household consumption to  $c_h = (0, 0)$  and split the bounty across states  $L$  and  $H$  among strategy  $L$  and  $H$  players.

*Proof.* The proof follows the same steps as the proof of the previous proposition.  $\square$

### 3.4 Financial Innovation for Rent Extraction

In this section we solve for the market structure chosen by bankers to analyze how the existence of bailouts affects the incentive for financial innovation. We follow Allen and Gale (1988, 1991) in assuming that bankers can create a market between the two states of nature  $s = L, H$  at a fixed cost  $f$  that has to be paid w.l.o.g. in period 2.

In the absence of bailouts, bankers decide whether to create a market by comparing their expected utility under autarky with the utility level from trading with households if the market is introduced. The maximum price  $\bar{f}$  that they are willing to pay is given by the equation

$$E[V_b(e_{bs})] = \pi V_b(x_{bL}) + (1 - \pi) V_b(x_{bH}) - \bar{f}$$

It is clear that the maximum  $\bar{f}$  is an increasing function of the gains from trade, i.e. it is higher the greater the disparity of endowments between bankers and households.

However, when we introduce bailouts, the incentives to create a market between the two states of nature change. In particular, we find that bailouts introduce two types of distortions into the decision of whether to engage in financial innovation, depending on whether the new market leads to the insurance allocation or the rent extraction allocation, as described in Proposition 8:

**Proposition 11** (Bailouts and Financial Innovation). *Bailouts affect the maximum price  $\bar{f}$  that bankers are willing to pay to create an insurance market as follows:*

*(i) **Suppressing Desirable Insurance Markets:** If the resulting equilibrium is the insurance allocation, bailouts reduce  $\bar{f}$ .*

*(ii) **Financial Innovation for Rent Extraction:** If the resulting equilibrium is the rent extraction allocation, bailouts increase  $\bar{f}$ .*

*Proof.* For point (i), the welfare of bankers under bailouts is higher than under autarky,  $U^{BL} \geq U^A$ , and strictly so if  $e_L < \hat{k}$ . This implies that  $\bar{f} = U^{Ins} - U^{BL} \leq U^{Ins} - U^A$  and the stated result immediately follows.

For point (ii), the rent extraction allocation is chosen if  $U^{RE} > U^{Ins}$ . This implies that  $\bar{f} = U^{RE} - U^{BL} > U^{Ins} - U^A$ , proving the stated result.  $\square$

Under point (i), bankers have reduced incentives to create a costly market for private insurance since they can benefit from free public insurance in the form of bailouts in the low state of nature. This highlights that bailouts act as a substitute to insurance markets. In some situations, bankers would even prefer to actively suppress markets that allow them to buy costly insurance against the low state of nature, i.e. they would be willing to pay to avoid creating such a market. This corresponds to  $\bar{f} < 0$  in the formulation above. The intuition is that bankers know that they will receive bailouts (public insurance) if the market does not exist. If the market is created, it becomes individually optimal for them to insure in it, i.e. they have to pay to obtain similar insurance to what they would have gotten for free.

Under point (ii), bankers have excessive incentives to create an insurance market if this allows them to extract rents. For some risks for which it is expensive to create insurance markets, it would be socially desirable to rely on public insurance. However, perversely, the expectation that there will be a bailout will make it desirable for bankers to create the market, engaging in financial innovation for rent extraction. One way of interpreting the result is that financial innovation is directed at creating an arbitrage opportunity. We can view bailouts as akin to a state-contingent security that bankers will receive and that comes at zero cost (for uncompensated bailouts with  $t'_H = 0 < p$ ) or that may come at an underpriced cost (for compensated bailouts with  $|t'_H| < p$ ). By introducing a new security that is collinear with the existing bailout but trades in the market at a different price, bankers can earn arbitrage profits: they sell risky claims at a price  $p$  in the market and pay only  $|t'_H| < p$ , allowing them to pocket the difference.

## 4 Policy Measures

There are several categories of policy measures that can be taken to reduce the scope for rent extraction in the described framework, such as (i) limits on bailouts, (ii) compensation for bailouts, (iii) different conditioning of bailouts, (iv) restrictions on risk-taking, and (v) limits on financial innovation. In the following, we cover the first two in detail.

### 4.1 Limiting Bailouts

The most direct policy measure to reduce the rent extraction emanating from bailouts is to reduce the size of bailouts. In our benchmark model, we laid out a set of assumptions that, in the limit, allowed bankers to extract the entire surplus of the economy in the good state of nature. Here we discuss how two restrictions on bailouts can reduce rent extraction to zero. We can split the bailouts discussed in Lemma 5 into two parts: the part of the bailout that makes up for bank losses  $x_{bs} < 0$  satisfies the creditors of banks; the part that brings the net worth of bankers up to  $w_{bs} = \hat{k}$  recapitalizes banks. Conceptually, both can be given in a manner that avoids rent extraction.

**Lemma 12** (Bailouts, Limited Liability). *The maximum bailout transfer  $\bar{t}_s^{LL}$  under limited liability satisfies*

$$\bar{t}_s^{LL} = \min \left\{ \hat{k}, x_{hs} + \min \{0, x_{bs}\} \right\}$$

*Proof.* We focus on the case  $x_{bs} < 0$  in which bankers owe a payment to households. As captured in Assumption 1, bankers cannot commit to make negative payments and will default if they have negative financial net worth in period 2.

If bankers with negative net worth  $x_{bs} < 0$  are forced to take advantage of limited liability before they receive a transfer from households, then the period 2 wealth levels of the two sets of agents are

$$\begin{aligned} w_{bs} &= \max \{0, x_{bs}\} + t_s \\ w_{hs} &= \min \{0, x_{bs}\} + x_{hs} - t_s \end{aligned} \tag{12}$$

The first term on the right-hand side of each budget constraint reflects that bankers can abrogate any debts  $x_{bs} < 0$  under limited liability, and households experience a corresponding loss. After this transaction, households are willing to inject funds into bankers as long as banker net worth is less than  $\hat{k}$  and households have sufficient

funds, i.e.  $t_s \leq \min \{0, x_{bs}\} + x_{hs}$ . The maximum transfer that bankers with limited liability can obtain from households is therefore  $\bar{t}_s^{LL} = \min \left\{ \hat{k}, x_{hs} + \min \{0, x_{bs}\} \right\}$ .  $\square$

Intuitively, in the limited liability regime, bankers attempt to sell their entire endowment  $e_L$  in state  $L$  at the market price  $p_L^{RE}$ . Setting  $x_{bL} = 0$  allows them to extract the maximum possible bailout  $\hat{k}$  in that state of nature. The earnings from selling their endowment in the low state increase their wealth in the high state by  $p_L^{LL}e_L$ , and the bailout guarantees that their wealth in the low state is ultimately  $w_{bL} = \hat{k}$ . If  $p_L^{LL}e_L > e$ , then the market value of their earnings in the low state is greater than the endowment of households in the high state and households could not afford to buy all of it; therefore bankers sell as much as fits into the budget of households, resulting in  $w_{bH} = e + e_H$  and  $w_{hH} = 0$ .

The lemma underlines that the maximum transfers that bankers can extract when their financial net worth is negative is reduced by limited liability. However, during the 2008/09 financial crisis, there were numerous instances in which financial institutions were not subjected to limited liability. Formal examples include liabilities that were covered by FDIC guarantees.<sup>9</sup> Furthermore, a number of banks that market participants viewed as insolvent but ‘too-big-to-fail’ were propped up by bailouts and a host of implicit and explicit guarantees since policymakers feared that imposing losses on their creditors would lead to runs on the entire banking system.<sup>10</sup>

The resulting allocation is as follows:

**Lemma 13.** *If the limiting factor in the rent extraction regime is the maximum bailout  $\bar{t}_L^{LL} = \hat{k}$  under limited liability, then the period 2 wealth levels of the two agents satisfy*

$$W^{LL} = \begin{pmatrix} w_{hL} & w_{bL} \\ w_{hH} & w_{bH} \end{pmatrix} = \begin{pmatrix} e + e_L - \hat{k} & \hat{k} \\ e - p_L^{LL}e_L & e_H + p_L^{LL}e_L \end{pmatrix}$$

where  $p_L^{LL} = \frac{\pi}{1-\pi} \frac{V'_h(w_{hL})}{V'_h(w_{hH})}$  is the price of state  $L$  goods in the described allocation. The maximum bailout will indeed be the limiting factor as long as  $p_L^{LL}e_L < e$ . We call this allocation the ‘limited liability rent extraction allocation’  $\mathcal{R}^{LL}$ .

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<sup>9</sup>During the crisis, most advanced countries around the world increased the limits for deposit insurance. Many countries also extended guarantees to newly issued bonds. In the US, for example, the Temporary Liquidity Guarantee Program (TLGP) extended government guarantees to senior unsecured bonds issued by financial institutions.

<sup>10</sup>See e.g. Bloomberg, Feb. 20th, 2009, ”Citigroup, Bank of America Fall on Takeover Concerns.”

## 4.2 Compensating for Bailouts

An alternative strategy is for government to charge banks for the expected bailouts that they receive. An example are the FDIC insurance assessments that are meant to compensate the FDIC for any bailout risk. Such compensation can be viewed as an insurance premium. W.l.o.g., we consider an economy in which households provide an ex-post optimal bailout transfer  $t_L(x_L)$  to bankers in state  $L$  but assume that they have the ability to impose a compensating tax  $t_H \leq 0$  on bankers in state  $H$ . For a given transfer  $t_L = t(x_L)$ , we denote by  $\underline{t}_H(t_L) < 0$  the maximum compensation (i.e. the lowest negative number) that banks can transfer to households in state  $H$  without making bankers worse off than in the absence of any transfers. This  $\underline{t}_H$  satisfies

$$\pi V_b(x_{bL} + t_L) + (1 - \pi) V_b(x_{bH} + \underline{t}_H) = E[V_b(x_{bs})]$$

Any transfer  $t_H \in [\underline{t}_H, 0]$  ensures that the transfer/compensation scheme described by the vector  $(t_L, t_H)$  delivers a Pareto improvement. If  $t_L = 0$ , we observe that  $\underline{t}_H = 0$  as well.

**Definition 14** (Compensated Bailout Transfers). Given a wealth allocation  $X$  in period 1, a compensated bailout transfer allocation consists of a vector of transfers  $t = (t_L, t_H)'$  and a wealth matrix  $W = X + t \cdot (1, -1)$  such that the transfer  $t_L$  solves the optimization problem of households described in lemma 5 and the transfer  $t_H$  satisfies  $t_H \in [\underline{t}_H, 0]$ .

One notable element in the set of possible compensatory transfers is  $\tilde{t}_H = -\frac{V'_b(w_{bL} + t_L)}{V'_b(w_{bH} - t_H)} t_L$ . This  $\tilde{t}_H$  is the premium that bankers would be willing to pay in the market in order to obtain the insurance transfer  $t_L$  in state  $L$  – in that case, the described compensation scheme simply replicates the insurance allocation of Lemma 6 that would prevail if an insurance market existed.

### 4.2.1 Market Equilibrium Under Compensated Bailout Transfers

Let us now focus on how bankers will trade in the insurance market if they have to pay to compensate households for bailout transfers. Specifically, assume that bankers receive a transfer  $t_L(x_{bL}; x_{hL})$  and pay an offsetting tax/premium in state  $H$  that is determined by a differentiable function  $t_H(t_L(x_{bL}; \cdot))$  satisfying  $t_H(0) = 0$  and  $t'_H(t_L) < 0$ . This changes the optimality problem of a banker to

$$\pi V'_b(w_{bL}) \cdot [1 + t'_L(x_{bL}; \cdot)] - (1 - \pi) V'_b(w_{bH}) \cdot [p_L - t'_H(t_L) t'_L(x_{bL}; \cdot)] = 0$$

As in our analysis above, we note that the the transfer function  $t_L(x_{bL}; x_{hL})$  – and by implication the function  $t_H(t_L)$  – has a kink at  $x_{bL} = \hat{k}$  and at  $t_L = \bar{t}_L$ , implying that the objective function of bankers is potentially non-concave. We follow our analysis above and separate the wealth space of bankers into two regions with  $t_L = 0$  and  $t_L > 0$ , solving for the local maximum in each of the two regions.

Under the rent extraction regime, bankers would increase risk-taking (i.e. decrease  $x_{bL}$ ) until the limit  $t_L = \bar{t}_L$  is hit. This strategy would be profitable as long as  $p_L > |t'_H(t_L)|$ , i.e. the market value of shifting payoffs into the high state is greater than the increase in the premium that bankers have to pay. If bankers have limited liability, then the net market value of the bailout they can extract is  $p_L \hat{k} + t_H(\hat{k})$ . Any premium  $t_H < 0$  therefore makes banker less inclined to choose the rent extraction allocation. However, if bankers have unlimited liability, then the premium increases the size of the speculative position that they have to take to extract the maximum rent possible – instead of  $p_L$  they earn only  $[p_L - t'_H(t_L)]$  on each unit of payoff sold against the low state. However, as long as  $p_L > |t'_H(t_L)|$  and bankers have unlimited liability, they can still sell claims against the low state until they have extract the entire endowment of households in the good state, replicating the rent extraction equilibrium of Lemma 7. We summarize this in the following proposition:

**Proposition 15** (Compensated Transfers and Equilibrium). *If the transfer rule in the economy is set such that  $p_L > |t'_H(t_L)|$ , then banker have less incentive to engage in rent extraction under limited liability. However, under unlimited liability, the same allocations as in the rent extraction allocation in lemma 7 is replicated. If  $|t'_H(t_L)| \geq p_L$ , then bankers will choose the insurance regime.*

*Proof.* See discussion above. □

One way of viewing the case of unlimited liability is that underpriced transfers  $p_L > |t'_H(t_L)|$  provide bankers with an arbitrage opportunity: an underpriced premium in state  $H$  allows them to collect a rent  $[p_L + t'_H(t_L)]$  at no cost. By sufficiently increasing the promised payoff in state  $L$ , they can still extract all of the economy's resources in state  $H$  and replicate the allocation  $W^{UL}$  as in lemma 7.

The proposition therefore provides clear guidelines for how the compensation for expected transfers is to be set in order to avoid rent extraction.

**Remark 1** The marginal cost of regulation  $t'_H(t_L)$  needs to be set according to the price  $p_L^{RE}$  in the rent-extraction regime, not the one  $p_L^{Ins}$  in the insurance regime. If the rent extraction equilibrium is to be ruled out, this implies that the price has to be higher than the observed market price – what looks like the fair-market compensation for the transfer  $t_L$  is not sufficient to rule out the rent extraction equilibrium.

**Remark 2** Even small mispricing allows for massive rent extraction as long as  $[p_L + t'_H(t_L)] > 0$ , since bankers can scale up their strategy of rent extraction until they reach the natural limits of rent extraction – the resource constraint.

## 5 Extensions

### 5.1 Production Economy

We now endogenize output in the economy by assuming that bankers can pick their endowment from a concave production possibility frontier that is described by the function  $F(e_{b1}, e_{b2}) = 0$ . This allows bankers to determine the riskiness of the economy. For example, if they pick an endowment bundle that is constant across different states of nature such that  $F(\bar{e}, \bar{e}) = 0$  then there is no aggregate risk in the economy.

In the decentralized equilibrium of this economy under the insurance regime, it is easy to see that bankers will choose an endowment bundle such that their indifference curves are tangents to the production opportunity locus.

$$\frac{V'_b(e_{b1})}{V'_b(e_{b2})} = \frac{F_1(e_{b1}, e_{b2})}{F_2(e_{b1}, e_{b2})}$$

This allocates endowments across the two states of nature such that they choose their optimal trade-off between risk and return. Similarly, if bankers can trade with households in a Walrasian market, they will choose an endowment bundle such that

$$p^L = \frac{F_1(e_{b1}, e_{b2})}{F_2(e_{b1}, e_{b2})}$$

and risks are shared across all agents in the economy according to bankers' optimal trade-off between risk and return.

On the other hand, if bankers act according to the rent extraction regime, they will distort the real allocation of resources so as to maximize their payoffs after any bailouts they receive:

**Proposition 16** (Rent Extraction with Production). *1. In a symmetric rent extraction equilibrium, bankers choose an endowment  $e_L = 0$  to maximize  $e_H$ .*

*2. In a non-symmetric rent extraction equilibrium, bankers choose  $e_\sigma = 0$  in the state  $\sigma$  in which they receive bailouts and concentrate their endowment in the other state of nature.*

*In both cases, the strategy of bankers reduces the aggregate wealth of the economy by misallocating factors.*

We can interpret the allocation of resources chosen by bankers as maximizing the riskiness of the real economy: if they expect to obtain a bailout in state of nature  $s$ , then it is privately optimal for them not to allocate any resources to that state, but it makes the aggregate economy more risky. Measured at the relative prices at which households are willing to trade state-contingent claims, bankers engage in massively negative net present value production.

One example for such behavior may be to provide loans to risky real estate projects at the height of the housing boom: if home prices continue to increase (state  $H$ ), then such loans yield large positive payoffs; if home prices decline (state  $L$ ), lenders will obtain a bailout. Rent extraction therefore leads to large distortions in the real allocation of resources.

## 6 Conclusion

This paper analyzes the dual role of bailouts in substituting for missing markets and in distorting incentives. Our main observation is that financial innovation massively deteriorates the trade-off between the two – if bankers can create securities that are linearly dependent with bailout payments, they can effectively engage in arbitrage between the two and extract large rents from society.

The distortive effects of transfers can be kept in check if limited liability is strictly enforced and if bailouts are compensated for by appropriate taxation or regulation. However, if such regulation is insufficient, bankers can sell claims that pay out in states in which they receive bailout transfers since they do not need to worry about the downside of their investments in such states, and allocate their upside across the remaining states of nature. As a result, they extract bailout rents and shift the average allocation of resources in their favor. A byproduct of such behavior is to increase the volatility of consumption across states of nature. Rent extraction is likelier the greater the wealth of the household sector that bankers can extract, the lower the probability of the state of nature into which losses are shifted, and the lower the net worth of bankers.

In the described setting, the distribution of resources between the financial sector and the real economy depends on the level of financial innovation and financial regulation. Financial innovation redistributes towards the financial sector by increasing the share of resources extractable through bailouts, while financial regulation stems against this mechanism. The state of financial regulation therefore has first-order redistributive implications for the economy. The resulting cat-and-mouse game between regulators and the financial sector is an important question for future research.

Furthermore, we assume that fiscal revenue can be raised up to the limit given



by the endowment of the household sector. However, large bailout payments impose great strains on the ability of governments to raise revenue, as countries such as Iceland, Ireland, or Spain have experienced in recent years. Fiscal capacity is therefore an important constraint on bailout rent extraction. Furthermore, raising large amounts of fiscal revenue introduces tax distortions into the behavior of the private sector.

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## A Mathematical Appendix

### A.1 Monopolistic Bankers

This appendix shows that all the allocations of the economy remain unchanged if bankers act monopolistically in the period 2 market for loans. Throughout our analysis, the optimality conditions of bankers depend on the relative marginal valuations of payoffs  $V'_b(w_{bH})/V'_b(w_{bL})$  across different states of nature. See for example optimality condition (9). Let us investigate how these relative marginal valuations change under monopoly power.

If bankers act monopolistically in the period 2 market for loans, then they internalize that additional supply of capital will lower the interest rate that they receive and perceive the monopolistic value of bank capital (denoted by superscript  $m$ ) as

$$V_b^m(w_{bs}) = \max_{k_s} \alpha A(k_s)^\alpha \quad \text{s.t.} \quad k_s \leq w_{bs}$$

Bankers supply all their wealth  $w_{bs}$  since the marginal revenue from additional lending is always positive. The marginal monopolistic value of bank capital is

$$V_b^{mon'}(w_{bs}) = \alpha^2 A(k_s)^{\alpha-1}$$

We observe that  $V_b^{mon'}(w_{bs}) = \alpha V_b'(w_{bs}) \forall w_{bs}$ , i.e. the monopolistic marginal value of bank capital is a constant fraction  $\alpha$  of the value perceived by competitive agents. If bankers exert monopoly power, the relative marginal valuations of payoffs  $V_b'(w_{bH})/V_b'(w_{bL}) = V_b^{mon'}(w_{bH})/V_b^{mon'}(w_{bL})$  are unchanged since the constant  $\alpha$  cancels out. The resulting optimal allocations are all unchanged.

## B Parameterization Used for Figures

This appendix describes the parameterization of the model that we use to generate the Figures in the text. The production technology in the economy is assumed to be Cobb-Douglas

$$f(k) = Ak^\alpha$$

with  $A = 3$  and  $\alpha = 0.5$ . Both bankers and workers have log utility  $u(c) = \log(c)$ . The probability that the economy is in the low state is  $\pi = 0.6$ . The endowment matrix of the economy is

$$E = (e_h, e_b) = \begin{pmatrix} 2 & 1 \\ 2 & 1/4 \end{pmatrix}$$

Figure 1 depicts three sets of indifference curves for each agent. One set passes through the endowment point. The other two correspond to the cases that bankers have a fraction 0.45 and 0.6 of the economy's total endowment respectively.

Figure 2 depicts the indifference curves of both agents passing through the endowment point and the decentralized equilibrium, and also the price vector.

Figure 3 depicts the indifference curves of both agents passing through the endowment point and the equilibrium with transfers.