Financial Innovation for Rent Extraction

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Abstract

This paper makes the case that a significant number of recent financial innovations were designed to extract rents from public safety nets or bailouts and resulted in a large redistribution of resources to the financial sector. 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. This allows for more efficient 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.

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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, 2008).

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 for rent extraction destroys this role. (3) Financial innovation for rent extraction 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 finanical 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, and two states of nature. We assume that the endowment of bankers is risky, creating insurance opportunities. The financial net worth of bankers plays an important role in the economy because it determines the level of financial intermediation, capital investment and, in turn, output and wages in the economy. The paper first desribes the decentralized equilibrium if an insurance market to trade claims across the two states of nature exists. If such a market does not exist, households find it optimal to provide transfers (or "bailouts") when the financial net worth of bankers falls below a certain threshold, because the cost of the transfer is lower than the lost wages arising from a credit crunch. Bailouts are thus an optimal response of the household sector to the role of bankers as bottlenecks in the financial intermediation process. In our setting, bailouts are state-contingent transfers that substitute for market-provided insurance.

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 can extract a potentially large fraction of societal resources.

In a symmetric equilibrium, bankers extract all the resources from households in the state of nature in which the aggregate endowment is high and receive a bailout in the low state of nature. However, rent extraction can go further still since the described symmetric equilibrium leaves money on the table in the high state of nature. Under some circumstances, bankers find it optimal to choose a non-symmetric equilibrium in which they form two groups that bet against each other. In this type of equilibrium, inspired by the credit default swap transactions between Goldman Sachs and AIG, the banking sector as a whole can extract a bailout with probability one. One group of bankers is set to fail and the other group obtains the benefits from the bailout. In the limit, this strategy allows bankers to extract the entire aggregate wealth of the economy from households.

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 finanical 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., 2013). 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.[1] 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.

Finally, let us note that 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 in the resulting large losses. Other

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

factors included agency problems along every steps of the chain of financial intermediation, "animal spirits" who held distorted beliefs, and externalities in financial markets. However, regardless of the economic mechanism that led to large risk-taking, the financial sector earned significant bailout rents from the explicit and implict guarantees that covered the financial sector led to

Related Literature This paper is related to a long 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. We contribute to this literature by emphasizing rent extraction from public safety nets as a novel objective for financial innovation.

The paper is also related to the literature on the welfare effects of bailouts. The desirability of bailouts is typically viewed as a trade-off between their positive efficiency effects versus their negative incentive effects. The positive efficiency effects of bailouts may include ruling out multiple equilibria, e.g. in models of bank runs in the tradition of Diamond and Dybvig (1983), or relaxing binding financial constraints.[2] The adverse incentive effects (or the 'moral hazard') of bailouts have long been recognized (see e.g. Bagehot, 1873) and constitute a type of folk theorem: by limiting the potential losses of financial institutions, bailouts reduce precautionary incentives and therefore increase their risk-taking. 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). Keister (2010) and Farhi and Tirole (2012) 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. Furthermore, an important strand of the literature on bailouts emphasizes the time consistency problem that arises: ex-ante, policymakers would like to com-

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

mit to being tough to provider proper incentives for risk-taking, but ex-post they would like to provide bailouts because of their positive efficiency effects. For more detail see e.g. in Jeanne and Korinek (2013).

This paper makes two contributions to the literature on bailouts. First, we show that financial innovation massively deteriorates the trade-off between the 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. Secondly, we put central focus on the redistributive aspects of bailouts. In our model, bailouts constitute a redistribution from the household sector to the financial sector, but because bank capital is essential for the economy, the transfer increases household welfare by avoiding a credit crunch. In a way, the financial sector can extract large rents because of its essential position in the economy.

Our methodological innovation is based on a very 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 typically determined by corner solutions. In a general equilibrium model, these corner solutions are either set by financial regulation, by solvency concerns if actors can be sent into bankruptcy, or – if no other constraints are imposed – by the resource constraint of the economy, which represents the natural rent extraction limit.[3]

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, 2009). 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 (2013) contribute to this topic by analyzing a distinct mechanism for how deregulation redistributes resources towards the financial sector, even in the absence of bailouts: they show that large losses lead to a credit crunch that hurts everybody in the economy in the economy, but large profits accue solely to the financial sector since output is limited by potential output on the upside. Deregulation leads to greater volatility and therefore increases the welfare of the financial sector at the expense of the rest of society.

In the empirical literature, there are a number of papers that provide evidence that financial institutions derive substantial benefits from safety nets. Noss and Sowerbutts (2011) distinguish two approaches used in the literature,

[3]One interpretation of the risk-taking that led to the Icelandic crisis is that the financial system efficiently extracted all the pledgeable resources in the economy.

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 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 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.[4]

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., 2010), which allowed sponsoring banks to fund close to a trillion dollars of mortgage-backed securities via conduits

[4]See http://www.fdic.gov/bank/individual/failed/banklist.html for details.

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 (Brunnermeier, 2008).

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 "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.[5] In mid-2012, the ECB's exposure to such bonds was more than $400bn.

The rest of the paper is structured as follows: Section 2 introduces our benchmark model. The following section studies a number of different allocation systems and develops our main results on financial innovation for rent extraction when financial institutions can arbitrage between bailouts and existing insurance markets. 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 $i = h, b$. 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 $\pi < \frac{1}{2}$. One interpretation of state L is that it represents a "crisis" state.

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

$$U_i = E\left[c_{is}\right]$$

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 $c_i = (c_{iL}, c_{iH})'$.

[5] For example, a Barlays 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."

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 $1_M = 0$.

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, households may collectively decide to provide a bailout transfer $t_s = t_s(x_s)$ to bankers that satisfies $0 \leq t_s \leq x_{hs}$. Since the transfer decision is made collectively, this transfer 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 $t_s(x_s)$ in advance. We denote the resulting final period 1 wealth positions of the two agents by $w_{hs} = x_{hs} - t_s$ and $w_{bs} = x_{bs} + t_s$ and summarize them in a wealth matrix W.

At the end of period 1, the representative banker converts her wealth into productive capital using a linear technology $k(w) = w$. 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 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. The representative banker rents out her capital k competitively at the prevailing market interest rate. We assume that bankers jointly own a unit mass of one-period entities called firms, which are also indexed by $j \in [0, 1]$. Each firm 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. Since $\ell = 1$, firms pay out wages $\omega\ell = (1-\alpha)Ak^{\alpha}$ and gross interest $Rk = \alpha Ak^{\alpha}$ after production has taken place. (In equilibrium, firms make zero profits; therefore nothing would change if we assumed a different ownership structure.) Finally, both sets of agents consume.

Period 0	• bankers collectively choose whether to create insurance market at cost f • if market exists, agents determine state-contingent allocations x_s
Period 1	• nature picks a state $s \in \{1, 2\}$ • agents obtain endowments e_s • if market exists, trades are executed • result is interim wealth x_{is} • households collectively choose a transfer t_s • result is final period 1 wealth w_s • bankers convert wealth into capital $k_s = w_{bs}$
Period 2	• capital and labor are hired • production takes place • output is distributed and consumed

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) *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 in period 1, and that capital investment in period 2 of each state s is determined by the financial net worth of bankers, with a floor of zero,

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

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

We make assumption 1 for analytical simplicity, but, more broadly, our results continue to hold as long as some financial friction remains in place that keeps the marginal product of capital elevated when the financial net worth of bankers is low, for example because of a maximum leverage ratio. Alternative microfoundations for such frictions are given 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*. Each household consists of a continuum of members* $j \in [0,1]$ *that each supplies one unit of labor, which 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.[6] 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* $t_s(x_s)$ *in period* 1 *in a time-consistent manner.*

[6] 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.

This assumption prevents households from commit to a no-bailout-policy if bankers misbehave. 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, 2012.) In section **??** we show how varying degrees of commitment can be used to enjoy the positive efficiency effects of bailouts while averting the adverse incentive effects.

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* $E_s[e_{bs}] \geq [\alpha(1-\alpha)A]^{\frac{1}{1-\alpha}}$.

These are relatively weak assumptions. The first one 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. 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

Individual households take the prices p_s and ω as well as the transfer $t_s(x_s)$ as given. If $1_M = 1$, i.e. if the Walrasian market in period 1 exists, the optimization problem of a representative household is

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

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

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

Individual bankers take the prices p_s and R_s as given and internalize the transfer function $t_s(x_s)$ that is collectively determined by households. If a Walrasian market in period 1 exists, a representative bankers solves

$$
\begin{aligned}
U_b = \max_{x_{bs},w_{bs},k_s,c_{bs}} \ & E[c_{bs}] & (3) \\
\text{s.t.} \quad \Sigma_s p_s (x_{bs} + f - e_{bs}) &= 0 & (4) \\
w_{bs} &= x_{bs} + t_s(x_s) \\
k_s &= \max\{0, w_{bs}\} \\
c_{bs} &= R_s k_s
\end{aligned}
$$

In the period 0 budget constraint of bankers (4), we account for the fixed cost of operating the Walrasian market f. If no Walrasian market exists, we replace this constraint by the identity $x_{bs} = e_{bs} \forall s$. The next three constraints indicate that final period-1 wealth is determined by interim wealth x_{bs} 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

Households collectively take the behavior of individual agents as given. Given the interim wealth levels (x_{hs}, x_{bs}), they determine an optimal time-consistent transfer t_s in period 1 to maximize household welfare,

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

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. Households may find such a transfer advantageous since the wage $\omega = (1-\alpha) A (k_s)^\alpha$ is an increasing function of capital investment, i.e. $\partial\omega / \partial k_{bs} = F_{kl} > 0$.

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 all individual agents 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.

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

where $U_b = E\left[c_{bs}\right]$ 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 they can trade claims with households (see e.g. Allen and Gale, 1988, 1991). This gives 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, ω_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, 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 Model Solution

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

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

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.[7] 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 at 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.

3.2 Equilibrium without Insurance Market

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

[7] 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.

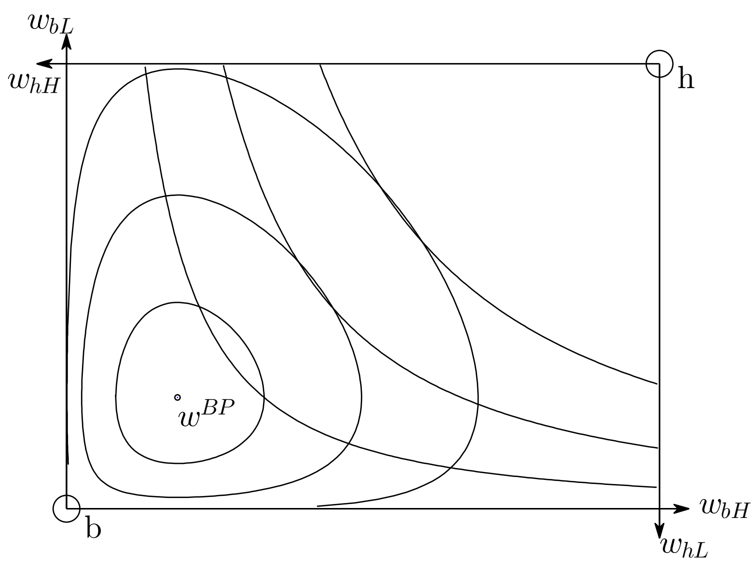

Figure 1: Indifference Curves in Modified Edgeworth Box

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

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

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

$$F_{kl}(\hat{k}, 1) = \alpha(1-\alpha)A\hat{k}^{\alpha-1} = 1 \tag{7}$$

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. ■

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 $\lim_{k\to 0} F_{k\ell}(k, 1) = \infty$. As long as $F_{k\ell} > 1$, 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

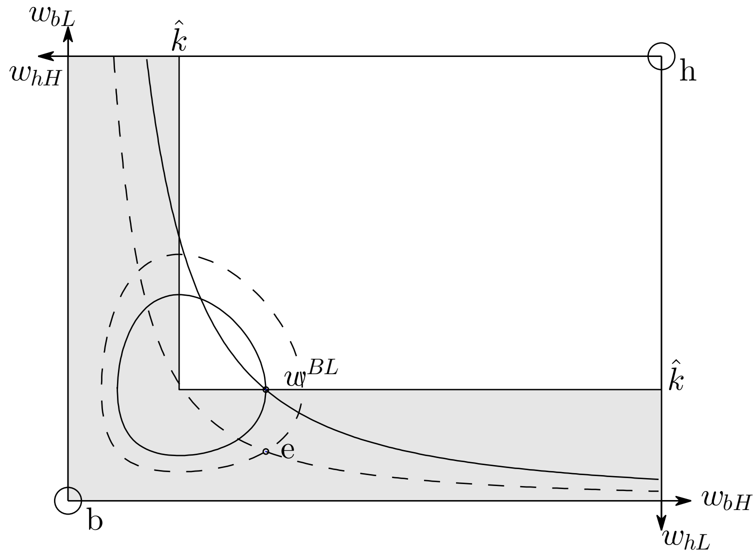

Figure 2: Bailout Equilibrium

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

$$p_L = \frac{\pi}{1-\pi} \tag{8}$$

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

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

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

$$\pi V_b^{'}\left(w_{bL}\right) \cdot \left[1 + t_b\left(x_L\right)\right] - (1-\pi)\, p_L V_b'\left(w_{bH}\right) \cdot \left[1 + t_b\left(x_H\right)\right] = 0 \tag{9}$$

where we use the short-hand notation $t_b(x_s) = \partial t(x_s)/\partial x_{bs}$.

We 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 $t_b(x_s) = 0$ for $x_{bs} > \hat{k}$ but $t_b(x_s) = 1$ 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 implement whichever equilibrium yields higher utility.

Lemma 2 (Insurance Allocation) *The wealth allocation of the two sets of agents in the insurance allocation is given by the matrix*

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

Their 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 $t_b(x_s)$ in the first-order condition (9) drop out. The behavior of bankers is then driven by the standard insurance condition ■

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

Proof. 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 all 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

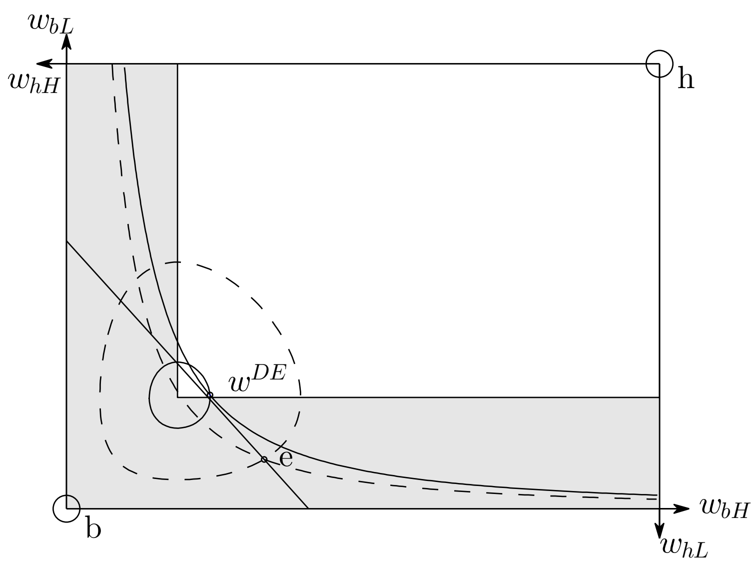

Figure 3: Decentralized Equilibrium

function is concave in capital so $F\left(\bar{k},1\right) > E\left[F\left(e_{bs}-f,1\right)\right]$ and the average wage earnings and capital income are increased. ■

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.

Lemma 3 (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 $[t_b(x_L)+1]=0$ vanishes in equation (9) and the remaining expression is negative for any $x_{bL}<\hat{k}$, implying that the optimum is given by a 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 because the transfer obtained by bankers has to satisfy $t_s \leq x_{hs}$, since households cannot transfer more resources than they own (lemma 1). This constraint is never binding in equilibrium because the resource constraint implies that $x_{bL}+x_{hL}>\hat{k}$ holds by assumption 4. (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, $1-\pi>\pi$. ■

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 have a very strong motive to buy such insurance.) Also, they know that their claims on bankers will always be honored because of bailouts. Furthermore, if state L materializes in period 1, households are collectively willing to provide a 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 substantial profits. If the probability of the low state is small, the described allocation is therefore consistent with observing large profits in the financial sector most of the time, even though no bailout transfers are received.

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

Proposition 1 (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*

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

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 π 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 stem directly 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 π 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 $k_H > k_L$. ■

3.3.2 Non-Symmetric Equilibrium

In this section we investigate non-symmetric equilibria in which bankers form two groups to bet against each other so as to extract bailouts in both states of nature.[8]

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_σ 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 1, we describe the optimal transfer policy of households as $t\left(x_{b(s)s}, x_{hs}\right)$ as in equation (6). The budget constraint of households now implies that the transfer is limited by $t_{s\sigma} \leq x_{hs}/n_\sigma$.

If bankers choose the insurance allocation, then all their allocations are identical and correspond to Walrasin equilibrium described above, yielding a level of utility U_b^{Ins} for bankers. Otherwise we describe the allocation chosen by bankers as follows:

Lemma 4 (Non-Symmetric Rent Extraction Allocation) *In the non-symmetric rent extraction regime, bankers split into two groups $\sigma \in \{L, H\}$ of mass n_σ with $n_L + n_H = 1$ that each go for broke in state $s = \sigma$. They achieve wealth allocations given by the matrix*

$$W^{RE2} = \begin{pmatrix} w_{hL} & w_{b(L)L} & w_{b(H)L} \\ w_{hH} & w_{b(L)H} & w_{b(H)H} \end{pmatrix} = \begin{pmatrix} 0 & \hat{k} & \frac{e+e_H-f-\hat{k}n_L}{n_H} \\ 0 & \frac{e+e_L-f-\hat{k}n_H}{n_L} & \hat{k} \end{pmatrix}$$

Furthermore we find $n_L > n_H$. Households, on the other hand, obtain a wealth allocation $w_h = (0, 0)$.

[8] We thank AIG and Goldman Sachs for their creative financial contracting, which served as an inspiration for this subsection.

Proof. Following the logic of lemma 3, 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. ■

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

Proposition 2 (Mixed Strategy Equilibrium, Uncompensated Transfers)

1. *Bankers under unlimited liability choose the non-symmetric strategy rent extraction regime over the insurance regime if and only if* $U_b^{MRE} > U_b^{DE}$, *or*
$$\pi V_b u\left(\hat{k}\right) + (1-\pi) V_b \left(e + e_L - \hat{k}\frac{n_H}{n_L}\right) > U_b^{DE}$$
2. *This condition is more likely to be satisfied the higher* $\hat{k}$ *and* π *and the lower* e_L
3. *If bankers choose the 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. ■

3.4 Financial Innovation for Rent Extraction

In this section we endogenize the market structure 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 state $s = H$.

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

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

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.

When we introduce bailouts that are not compensated by offsetting transfers, the incentives to create a market between the two states of nature may change. In particular, bankers may create a market specifically in order to take on risk that will lead to bailouts:

Proposition 3 (Financial Innovation and Rent Extraction) *If the parameters of the economy are such that bankers find it optimal to follow the rent extraction strategy, they are willing to pay a higher fixed cost f to create a market to trade state-contingent claims than they would if rent extraction was not possible.*

One way of interpreting this 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 exisiting 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. If there are multiple states of nature, bankers will create those financial markets that allow them to extract the maximum bailout rents possible.

Example: Perverse Incentives of Bailouts on Market Creation For some parameter values it is not socially desirable to create a market for a given fixed cost f. However, if $e_L < \hat{k}$ it is socially desirable to provide a bailout in state L. And 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.

Example: Suppressing Insurance Markets In some situations, bankers would prefer to suppress markets that allow them to buy 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 our 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 the insurance that they would have gotten for free.

4 Policy Measures

This section discusses five categories of policy measures that can be taken to reduce the scope for rent extraction in the described framework. The categories that we cover are limits on bailouts, compensation for bailouts, different conditioning of bailouts, restrictions on risk-taking, and limits on financial innovation.

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 1 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 5 (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 $\bar{t}_s^{LL} = \min\left\{\hat{k}, x_{hs} + \min\{0, x_{bs}\}\right\}$. ■

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. 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.[9] 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.[10]

Lemma 6 *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*

[9] During the crisis, most advanced countries around the world increased the limits for deposit insurance. Many countries also extended guaranteeds 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.

[10] See e.g. Bloomberg, Feb. 20th, 2009, "Citigroup, Bank of America Fall on Takeover Concerns."

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'* $\mathcal{R}^{LL}$.

4.2 Compensating for Bailouts

Next we extend the framework of bailout transfers to allow for compensating transfers to households. These transfers can be viewed as insurance premia. 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 that allows households to receive a larger share of the surplus created by the transfer. 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 1 (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 1 and the transfer* $t_H \in [\underline{t}_H, 0)$.

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.

4.2.1 Market Equilibrium Under Compensated Transfers

Let us next return our focus to compensated transfer rules under which a transfer in state L is accompanied by a compensatory tax in state H as we described above in section 4.2. Specifically, we 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 $t_H(t_L(x_{bL}; \cdot))$ satisfiying $t_H(0) = 0$ 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 $p_L\hat{k} + t_H\left(\hat{k}\right)$. Any premium $t_H < 0$ therefore makes banker less inclined to choose the rent extraction allocation. If bankers have unlimited liability, then the premium increases how

Proposition 4 (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 3 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 3.

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 $p_L^{\mathcal{R}}$ in the rent-extration regime, not the one $p_L^{\mathcal{M}}$ 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.

4.3 Conditioning the Provision of Bailouts

Another way of limiting rent extraction is to change incentives by changing the manner in which bailouts are provided.

4.4 Imposing Limits on Risk-taking

4.5 Limiting Financial Innovation

5 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

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

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 5 (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 σ in which they receive bailouts and concentrate their endowment in the other state of nature. This reduces the aggregate wealth of the economy.

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 has analyzed the dual role of bailouts is substituting for missing markets and in distorting incentives. 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, the possibility of bailout transfers in states that are linearly dependent with existing financial markets allows bankers to engage in rent extraction: they 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 can extract bailout rents from the rest of society 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.

Future questions:

- fiscal limits
- rent extraction from agency problems
- central counterparties (CCPs): see FT article from Dec. 4th, 2012.

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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 conditions XX, YY and ZZ.) 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

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

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

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

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

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

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 equilibirum, and also the price vector.

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