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An Overlapping Generations Model of Taxpayer Bailouts of Banks*

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Abstract

The paper constructs an overlapping generations model to evaluate how different bank rescue plans affect banks' risk-taking incentives. For a non-competitive banking industry, we find bailout with tax imposed on the old generation or equity bail-in to be efficient policies in the sense that they implement socially optimal risk-taking. In a competitive banking sector, no-bailout implements the socially-optimal risk-taking. Bailout policies financed by a tax imposed on the young generation always induce excessive risk-taking.

Keywords: Bank failures, taxpayer bailout of banks, equity bail-in, risk-taking by banks, financial fragility.

JEL Classification Number: G21, G28.

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1. Introduction

Recent economic history offers convincing evidence regarding the enormous magnitude of bank bailouts financed by taxpayer money in the United States. The savings and loan (S&L) crisis was the failure of over 1,043 S&L associations from 1986 to 1995, see Curry and Shibut (2000). The S&L crisis cost taxpayers $124 billion and the thrift industry cost additional $29 billion. During the financial crisis in 2008 the U.S. Congress authorized $700 billion to the Troubled Asset Relief Program (TARP) in order to stabilize the financial system.[1] Atkinson, Luttrell, and Rosenblum (2013) estimate an overall loss in the range of 40 to 90 percent of one year's output ($6 trillion to $14 trillion, the equivalent of $50,000 to $120,000 for every U.S. household). In addition, the cumulative bailout commitment (asset purchases plus lending by the Federal Reserve) during 2007–2009 was $7.77 trillion[2] and over $29 trillion according to Felkerson (2011).

Taxpayer bailout is not unique to the United States. Examples include the 1992 government of Sweden promise to guarantee all bank deposits of the nation's 114 banks and to establish separate units to handle non-performing loans, see Englund (2011). In the U.K., the average state support in 2009 for the top five U.K. banks exceeded £100 billion, with the average per bank being around £26 billion, see Oxera (2011). Further, on March 2013, the European Central Bank and the IMF arranged for a €10 billion bailout of Cyprus' banks, and not all depositors got their full deposit amount back from the failing banks. In December 2016, the government of Italy approved a taxpayer bailout of Italy's largest and oldest bank Monte dei Paschi di Siena. This was the third time that this bank was rescued using taxpayers' money.

Massive bailout programs have been implemented despite the fact that the economics profession has long understood how such bailout programs distort the incentives of banking institutions and associated investors.[3] Bailouts create severe moral hazard problems, leading to excessive risk-taking and thereby excessive financial fragility, see for example Acharya and Yorulmazer (2007),

[1]The U.S. Department of the Treasure has reported a more detailed account of the use of resources associated with TARP, see http://www.treasury.gov/initiatives/financial-stability/TARP-Programs/Pages/default.aspx .

[2]"Fed's Once-Secret Data Compiled by Bloomberg Released to Public," BloombergBusiness, December 23, 2011, http://www.bloomberg.com/news/articles/2011-12-23/fed-s-once-secret-data-compiled-by-bloomberg-released-to-public.

[3]Already in the 19th century Bagehot (1873) emphasized the favorable incentive effects associated with a consequent enforcement of bank closures. Hett and Schmidt (Forthcoming) provide empirical estimations of how bailout expectations develop during financial crises.

Diamond and Rajan (2012) or Farhi and Tirole (2012). However, ex ante commitments not to bail out banks face a structural time inconsistency problem. Once the economy faces a risk of a severe financial meltdown, governments tend to make use of the bailout instrument in order to avoid the exposure of important stakeholders categories, in particular bank owners and depositors, to financial shocks. Rosas (2006) has empirically estimated a model of bailouts with the goal of explaining the propensities of governments to engage in bailouts.

Recent studies revisit the investigation of the link between bailouts and bank risk-taking. Keister (2016) develops a theoretical model suggesting that a policy combining bailouts with prudential policy would outperform dogmatic policies applying either complete bailouts or no bailouts. According to Keister (2016), elements with bailout could be part of a desirable social insurance mechanism.[4] Keister and Mitkov (2016) study the interaction between the government's bailout policy and an individual bank's willingness to initiate actions that bail in its investors under circumstances where the bank and its investors can write complete, state-contingent contracts. Dell'Ariccia and Ratnovski (2013) introduce risk externalities between banks and demonstrate that bailouts may protect against contagion. They argue that systemic insurance effects created by bailout programs could reverse the relationship between bailouts and risk-taking. We do not consider this type of systemic risk effects within generations, but we rather emphasize the intergenerational effects created by different bailout programs. Bianchi (2016) analyzes some moral hazard and welfare issues associated with bailing out small (measure zero) perfectly-competitive firms in a small open economy, but these firms are not banks in the sense that they do not handle deposit accounts. Chari and Kehoe (2016) analyze the inefficiencies introduced by bailouts of firms and show that regulating leverage and taxing according to size may be needed.

In this study, we focus on government rescue plans of depositors and construct an overlapping generations model to evaluate how different rescue policies affect banks' risk-taking incentives. We show that bailout policies financed by a tax imposed on the young generation always induce excessive risk-taking under non-competitive as well as competitive banking sectors. Furthermore,

[4] In a more abstract setting, Kurlat (2010) has also emphasized that fragile financial structures, vulnerable to runs, may be a crucial element of socially optimal financial institutions under circumstances where liquidation is inefficient from an ex-post perspective.

this risk distortion is stronger under perfect competition than in the absence of competition. In the absence of competition between banks, we find a bailout policy financed by a tax on the old and equity bail-in to be efficient policies in the sense that they implement socially optimal risk-taking. Using a different setup, Kareken and Wallace (1978) obtain a similar result showing that bank liabilities are free of default risk provided that creditors know what portfolios banks hold and that bankruptcy is costly. In a competitive banking industry, the regime with a bailout financed by taxing the old generation as well as that with equity bail-in are not feasible because the old generation is left with no assets during periods with financial crisis. Under such circumstances, no bailout is optimal.

The use of an overlapping generations approach to analyze the effects of different rescue plans on banks' risk-taking behavior is important, because it facilitates distinguishing the effects of bailout programs financed by taxes imposed on existing generations from those financed by taxes imposed on future generations. The dynamic consideration is important in light of Qi (1994), who presents an overlapping generations version of the classical model by Diamond and Dybvig (1983). According to Qi (1994), the potential for intergenerational transfers improves the ability of banks to supply liquidity insurance, but banks may nevertheless be subjected to runs with excessive withdrawals or an insufficient amount of new deposits as the source of fulfilling their financial commitments. The overlapping generations framework has been applied before to model investment failures in the banking industry. Gersbach and Wenzelburger (2008) show that risk premia built into loan prices are insufficient to prevent banking crises. Gersbach and Wenzelburger (2011) analyze stability issues in the banking sector from a macroeconomic perspective. In addition, the OLG framework enables us to investigate is the effect of government rescue policies on savings. More importantly, the OLG model in this paper is ideal for evaluating a possible distortion whereby the choice of risk taken by one generation of bank owners affects the welfare of the next generation.

Overall, the literature has emphasized two main explanations for bank failures: (a) Banks rely on high degree of leveraging, see Admati and Hellwig (2014) and McMillan (2014). (b) Banks take risks because they manage other people's money and rely on taxpayer money to bail them out, Kay

(2015). Our contribution to this literature is the characterization of how different types of rescue policies affect the risk-taking incentives of banks and the resulting financial stability or fragility. In particular, our adoption of the overlapping-generations framework makes it possible to highlight how the effects of bailout programs financed by taxes are linked to whether the taxes are imposed on existing generations or on future generations. This analysis is conducted for banking industries characterized by either perfect competition or no competition.

Since the 2008 financial crisis there have been attempts to introduce reforms of the financial sector in the United States, the European Union, and the United Kingdom, with emphasis on the protection of depositors and taxpayers from risky bank activities. For example, in the United States the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 (part of it has already been repealed) has the stated objective to "promote financial stability...and protect the American taxpayer by ending bailouts."[5] Our study can contribute to the design of this type of financial sector reforms as it generates knowledge regarding how the risk-enhancing effects of rescue programs depend on how precisely such programs are constructed.

Our study is organized as follows. Section 2 constructs an overlapping generations model of deposits, investment opportunities, and bailouts in the banking industry. Section 3 characterizes the steady state equilibrium path of deposits and bank profits when banks adopt a safe investment strategy. Section 4 describes different government bail-in and bailout policies, and defines social optimum. Section 5 characterizes the equilibrium risk-taking incentives of banks. Section 6 extends the model to a competitive banking industry where banks compete with respect to deposit interest rates. Section 7 presents concluding comments.

2. An overlapping generations model of bank ownership and profit

In each period $t = 0, 1, \ldots$, the economy consists of two representative agents, a young one and an old one, as well as one representative bank. The bank is owned by one of the agents. Let δ

[5] As for the European Union, Erkki Liikanen chaired the High Level Expert Group on Reforming the Structure on the Banking Sector (2012), see http://ec.europa.eu/internal_market/bank/docs/high-level_expert_group/report_en.pdf. John Vickers was the author of the final report and recommendations of the Independent Commission on Banking (2011) in the United Kingdom, see http://webarchive.nationalarchives.gov.uk/20131003105424/https:/hmt-sanctions.s3.amazonaws.com/ICB%20final%20report/ICB%2520Final%2520Report[1].pdf.

$(0 < \delta < 1)$ denote the time discount factor.

2.1 Banks

To simplify the initial exposition, the benchmark model assumes that the representative bank does not pay interest on deposits. Section 6 extends the model to an interest paying bank where the degree of competition influences the interest rate margin (return on bank investments less interest paid to depositors).

The representative bank has access to an investment technology which makes it possible to channel the acquired deposits into one of two projects: (1) A safe project, which yields per-dollar net return $\rho^S > 0$ in the subsequent period. (2) A risky project, which yields a net return $\rho^R > \rho^S$ with probability λ, and zero otherwise.[6] Therefore, with deposits d_t raised in period t, the bank's profit in period $t+1$ is given by

$$\pi_{t+1} = \begin{cases} \pi^S_{t+1} = d_t \rho^S & \text{(safe investment)} \\ \pi^R_{t+1} = \begin{cases} d_t \rho^R & \text{prob. } \lambda \\ 0 & \text{prob. } 1-\lambda \end{cases} & \text{(risky investment).} \end{cases} \tag{1}$$

Hence, expected one-period profit from risky investment is $\mathrm{E}_t \pi^R_{t+1} = \lambda d_t \rho^R$, where E_t denotes the period t expectation operator for events to occur in $t+1$. Note that this expected bank profit does not take into account the loss of the principal financed by the d_t deposits because these may be covered by some of the rescue plans that we analyze.

In each period τ, $\tau = 0, 1, 2, \ldots$, the value of the bank is defined as the discounted expected stream of bank profits *starting from* period $\tau + 1$. Formally,

$$b_\tau = \sum_{t=\tau}^{\infty} \delta^{t+1} \mathrm{E}_t \pi_{t+1}, \tag{2}$$

where $\mathrm{E}_t \pi_{t+1}$ (expected profit one period ahead) can be obtained from (1) contingent on the bank's investment choice at each period $t > \tau$. Note that b_τ is also the period τ price that the young of

[6] Repullo (2004) introduces two assets in an OLG framework: A prudent asset and a gambling asset. He imposes a stricter restriction on the return structure than what we do as he assumes that the return on the prudent asset exceeds the expected return on the gambling asset. Furthermore, the purpose of Repullo's study is to explore the implications of capital requirements, whereas we focus on the effects of different types of rescue policies.

generation τ pays to acquire the bank from the old of generation $\tau - 1$.[7]

In particular, (2) implies that the steady-state value of the bank when it invests the *same* amount d of deposits and chooses to consistently follow the *same* fixed investment strategy in each period (either the safe or the risky project) is given by

$$b_\tau = b^S = \frac{\delta \pi^S}{1-\delta} = \frac{\delta d \rho^S}{1-\delta} \quad \text{or} \quad b_\tau = b^R = \frac{\delta \mathrm{E} \pi^R}{1-\delta} = \frac{\delta d \lambda \rho^R}{1-\delta}, \tag{3}$$

where π^S and π^R are obtained from (1) using $d_\tau = d$ for all $t = 0, 1, 2, \ldots$.

The base of deposits is the source of returns (optional increase in consumption capacity) in this economy. The bank influences how the return option is realized through its choice of whether to implement the safe or risky investment project. We assume that the bank's repayment to the depositor cannot be made contingent on the project choice. Outsiders can only observe whether the bank repays the depositor or not. Thus, our model introduces a potential moral hazard problem according to which the bank may have incentives to gamble with the deposits. As has been extensively discussed in the literature, this moral hazard problem may be particularly severe if the government has committed itself to a bailout policy.

The bank's operation is founded on a tradeable charter valid for an infinite horizon. The bank can be viewed as an infinitely-lived investment technology with period-specific returns characterized by (1), and these investments have to be funded period-by-period with bank liabilities (deposits) as the exclusive instrument of financing. Within the framework of the OLG structure, a period-t failure of the bank's investment would imply that depositors (who made a deposit in $t-1$) lose their money unless they are rescued either by a taxpayer bailout plan or via a bail-in plan.

There are two mechanisms for the creation of links between generations in our model. Firstly, the adoption of bailout policies financed by imposing a tax on the young generation affects the resource constraint facing the young generation. Secondly, the value of the bank determines the price at which the bank is sold from one generation to the next. Through this price the risk-taking of one generation will affect the next generation as shown by (2) or (3). It should be emphasized

[7] This price is the value of bank equity which cannot serve as an input for the bank's production activities because the proceeds that the old generation receives from selling the bank to the young are consumed by the old. In other words, b_τ should be interpreted as the sale value of a document of ownership, entitled its holder to claim future bank profits.

that the horizon of each bank owner and each bank customer is restricted to two periods within the framework of the OLG structure, and this eliminates reputational considerations.

2.2 Deposits and investments

The young agent is endowed with ω units of a *real* resource that could be used for deposits and acquisition of bank ownership when young, and also as consumption at old age. More precisely, the endowment can be allocated in two ways: to acquire ownership (shares) of the bank from the old generation and to direct funds into a deposit account with the bank. Therefore, the resource constraint of the young agent in period t is given by

$$d_t + b_t + T_t^Y = \omega, \quad t = 0, 1, \ldots, \tag{4}$$

where d_t is total bank deposits made by the young agent in period t and b_t is the period t value (price) of the bank acquired from the old. The period t value of the bank is the present value of the discounted sum of the bank's future (expected) profits (starting from period $t+1$) which is given by (2) or (3). Finally, in the resource constraint (4), T_t^Y denotes the tax imposed on the young agent at t to support a bailout of a failing bank investment, if the bank is unable to recover the deposit made by the previous generation and if the government finances the bailout with a tax on the young agent at t. Clearly, $T_t^Y = 0$ if no such bailout tax is imposed on the young agent at t.

The young agent's allocation (4), together with Assumption 1, rule out account fees imposed by banks on one-period storage of d_t deposits.

ASSUMPTION 1. *Young depositors posses a technology for one-period storage of money at no cost. Furthermore, if depositors are indifferent between own storage of money and bank deposits, they will choose to deposit money with the bank.*

The first part of Assumption 1 is widely used in models of bank deposits as a way to avoid analyzing bank storage fees (see Diamond and Dybvig (1983) and Qi (1994), as examples). The second part is needed only if banks do not pay interest on deposits, as otherwise bank deposits dominate self-storage of money. Clearly, even an arbitrarily low (close to zero) interest would ensure that the second part of Assumption 1 is satisfied as long as depositors believe that their deposits are safe or because deposits are protected via rescue programs.

Initially, the bank is owned by the old agent. The old agent at $t+1$ collects the bank deposit d_t (if available), the bank profit π_{t+1} (if any), the proceeds from selling the bank to the young generation b_{t+1}, and consumes the entire amount at old age. Formally, the lifetime expected utility function of a young of generation $t = 0, 1, 2, \dots$ is

$$U^t = \begin{cases} \delta c^S_{t+1} & \text{if the bank channels deposits to safe projects} \\ \delta \mathrm{E}_t c^R_{t+1} & \text{if the bank channels deposits to risky projects.} \end{cases} \tag{5}$$

The specification of consumption depends on three things: the government rescue plan, the bank owners' choice of investment project, and the state of nature under risky investment. Therefore, the exact specification of consumption will be derived in Sections 3, 5, and 6 as part of the equilibrium derivation process.

2.3 Sequence of events and equilibrium

The sequence of events within each period t is as follows:

Stage 1: Realization of the return on the bank's period $t-1$ safe or risky investment (success or failure). Realized profit π_t is collected by the owner of the bank (the old agent) according to (1).

Stage 2: Potential rescue plan implementation (bail-in or bailout). Only deposits and interest (if promised) are rescued, whereas bank profit is not.

Stage 3: The bank is sold to the young agent for a price b_t (discounted sum of future profits).

Stage 4: The young agent uses the remaining resources to make a new bank deposit d_t.

Stage 5: New bank owners invest depositors' money in a safe or a risky project.

Note that the ordering of stage 3 and stage 4 is not arbitrary as it reflects the outcome that the return on bank deposit is lower than the expected return on buying bank equity. For that reason, bank deposits are used for storing the remaining endowment after the young agent acquires the bank and pays tax (if any).

It should be emphasized that we consider rescue policies whereby only deposits and interest (if promised) are recovered if the bank investment fails, but not bank profits. Furthermore, within each period we specify the sequence of events to be such that the transfer of ownership from the old to the new generation takes place only after the old generation collects the realized profits and after the implementation of a potential bank rescue program.

Stage 5 in each period's sequence of events introduces a potential element of surprise by the new bank owner. Whereas in Stage 3 and Stage 4 the young agent makes decisions by correctly anticipating the bank owner's investment decision on the equilibrium path, the derivation of an equilibrium will verify that the new owner would not benefit from deviating from the investment decision anticipated by the young agent in Stage 3 and Stage 4. We apply the Markov Perfect Equilibrium (MPE) developed in Maskin and Tirole (1987, 1988) as the equilibrium concept for this intergenerational game among bank owners of different generations.[8]

DEFINITION 1. *Let the action (investment decision) set of each new bank owner be* $A \stackrel{\text{def}}{=} \{S, R\}$ *(safe or risky investment), and let* $U^t(S)$ *and* $U^t(R)$ *be the corresponding values of (5). Then, for each generation* $t = 0, 1, 2, \ldots$, *a generation-invariant (time-invariant) dynamic best response function* BR *constitutes a MPE if* $a_t = BR(a_{t-1})$ *where* $a_t \in A$ *maximizes the utility (5) of generation* t *and* $a_{-1} \in A$ *is given.*

Definition 1 implies that each new generation of young bank owners observes the investment choice of the previous generation of bank owners (safe or risky) and chooses the investment choice to maximize utility, taking into account the how the subsequent generation of bank owners will respond and choose their investment. For example, the game begins in period $t = 0$ when generation 0 acquires the bank and decides how to invest given the investment choice made by generation $t = -1$ (before the game begins).

3. Deposits and profits under safe investments

Suppose all generations of young bank owners choose to invest in the safe investment portfolio when they buy and take ownership of the bank, so that $a_t = S$ for all $t = 0, 1, 2, \ldots$. Let d^S denote the steady state bank deposit made by a young agent (as a bank customer). Assumption 1 and

[8] In Maskin and Tirole (1987, 1988), there are only two players who alternate their moves (one player moves in odd periods and the other one in even periods). Here, we apply this game to many generations of new bank owners where each generation makes an investment decision in response to the investment decision made by the previous generation, and by correctly anticipating the best response of subsequent generations.

equation (4) imply that $d^s = \omega - b^S$ will be deposited in the bank each period, where b^S is derived in (3). Then, equation (4) (savings allocation of the young agent) together with equation (1) (the one-period bank profit), and (3) (the price for which the bank is sold from one generation to the next) form a system of three equations with three variables: d^S (deposit amount), π^S (per-period bank profit), and b^S (bank value). The solution of this system is a function of the rate of return on safe investment (ρ^S), the initial endowment of the young agent (ω), and the discount factor (δ), and is given by

$$d^S = \frac{\omega(1-\delta)}{1-\delta(1-\rho^S)}, \quad \pi^S = \frac{\omega(1-\delta)\rho^S}{1-\delta(1-\rho^S)}, \quad \text{and} \quad b^S = \frac{\delta\omega\rho^S}{1-\delta(1-\rho^S)}. \tag{6}$$

The following results demonstrate some important properties of the model.

Result 1. *(a) An increase in the time discount factor reduces total deposits and per-period bank profit, but increases the bank's value. Formally,* $\partial d^S/\partial\delta < 0$, $\partial\pi^S/\partial\delta < 0$, *and* $\partial b^S/\partial\delta > 0$.

(b) An increase in the rate of return on safe investments reduces total deposits, increases per-period bank profit, and the bank's value (and hence price).
Formally, $\partial d^S/\partial\rho^S < 0$, $\partial\pi^S/\partial\rho^S > 0$, *and* $\partial b^S/\partial\rho^S > 0$.

Result 1(a) can be explained as follows. An increase in δ increases the value of the bank, because the discounted sum of future profits are then weighted by a higher δ. Further, an increase in δ implies that the young generation must pay a higher price to acquire the bank from the old one. This, in turn, leaves less money available for deposits in the bank. But, lower deposits then translate into lower per-period profit for the bank, and lower increase in consumption capacity from one period to the next. A similar explanation applies to Result 1(b). A higher return on the bank's investments increases the per-period profits of the bank, thereby inducing a higher value of the bank and a higher price to acquire the bank. But, the resource constraint (4) implies that a higher acquisition price of the bank leads to lower deposits.

4. Rescue policies and social optimum

In each period $t = 0, 1, \ldots$, the young representative agent buys the bank from the old agent and, as the new owner, decides whether to invest the newly deposited money (made by the young as a bank customer) in safe or risky projects. The main purpose of the study is to investigate the effects of government rescue policies on the risk-taking incentives of a new generation of bank owners.

4.1 Bank rescue policy options

We analyze government rescue policies targeting deposits (and interest, if promised), but not covering potential period-specific losses of bank profit. The bailout policies could be formulated in the form of implicit or explicit commitments from the government to guarantee deposits (up to the promised coverage) no matter whether the deposit insurance funds are sufficient or not in a formal sense. The important issue is that such bailout commitments are considered to be credible in the eyes of depositors and bank owners.

Consider an event where a bank owner chooses a risky investment strategy, which fails in the subsequent period. The analysis below will be conducted under three different government rescue plans. Two rescue plans shift the burden associated with bailouts to the taxpayer.[9] This can be implemented in two ways: Either the tax-funded bailout is financed by the same generation as the bailed-out depositors (the old generation) or by the next generation (the young generation).

Bailout with a tax on the old (O): The government levies a tax T_t^O on the old agent at t when the bank's investment fails, before the old agent sells the bank to the young one.

Bailout with a tax on the young (Y): The government levies a tax T_t^Y on the young agent at t before the young generation buys the bank from the old one and before the young generation deposits the remaining endowment in the bank as a bank customer.

Note that the agent plays a dual role in our model.[10] First, at young age the agent allocates resources to deposits, which are then collected back at old age. The amount and nature of deposits collected would depend on the outcome of the bank's investments, and on the type of rescue plan applied. Second, the old agent is also the owner of the bank. The old agent collects the period-

[9]Contemporary reforms of the banking industry in the United States and Europe have been planned with a priority for designing measures which would reduce the risk exposure facing the taxpayer. The extent to which these reforms will succeed to protect the taxpayer is subject to much debate.

[10]Also Merton and Thakor (2015) explore the implications related to the dual roles for individuals. They analyze individuals as both customers and investors of financial institutions as these individuals both buy financial services/products and supply risky financing. The intertwining of customers and investors has significant implications for government bailout policies because such policies typically end up as suboptimal protection of risk-taking investors and not only customers.

specific bank profit, and subsequently sells the bank to the young agent. The returns from these operations are used by the old agent to support consumption that enters the utility function (5).

The third rescue plan does not resort to taxpayer money.

Bail-in (I): The owner of the bank distributes shares of the bank to the depositor before the bank is sold to the young agent.

A bail-in rescue plan protects depositors if the bank maintains sufficient equity, whereas equity holders absorb the losses and are the residual claimants. Except for Section 6 that analyzes a perfectly-competitive banking sector, the model is designed in such a way that the value of the bank's future investment opportunities is sufficiently high so that depositors can always be paid back with bank equity.[11]

4.2 Welfare criterion

In order to evaluate the bank's risk-taking with respect to government rescue plans we introduce the following welfare criterion.

DEFINITION 2. *Safe investment is socially optimal if it yields a higher expected gross return than risky investment. Formally, the investment strategy S is socially optimal if*

$$1 + \rho^S \geq \lambda(1 + \rho^R), \quad or \quad \rho^R \leq \rho^{R*} \stackrel{\text{def}}{=} \frac{1 + \rho^S - \lambda}{\lambda}.$$

The parameter ρ^{R*} defines the threshold for the potential return on the risky investment, below which the safe investment is socially optimal. In other words, the threshold ρ^{R*} defines the minimum risky return above which the risky investment outperforms the safe investment from a social welfare perspective.

[11] In this model, equity value is not directly affected when the bank's investment fails because equity value equals the sum of profits beginning a period after the bank's investment fails. Using a different setup, Kareken and Wallace (1978) also find that the use of emergency loans does not affect the value of the bank. In reality, however, a bank failure may reduce equity value. Policies such as the requirement that banks hold contingent convertible capital (CoCo bonds) are established precisely to strengthen equity during crises by automatically converting these debt instruments into equity. Interestingly, Berg and Kaserer (2015) characterize the conditions under which CoCo bonds have destabilizing effects by providing bank owners with stronger incentives to take excessive risks.

5. Equilibrium strategic investment decisions

This section solves for the Markov Perfect Equilibrium (Definition 1) by analyzing the investment decision made by each generation t new bank owner whether to invest in the safe or the risky project. In particular, we explore the effects of different rescue plans on bank profit and consumption by the old agents.

Because the time discount factor δ does not vary with t, the period t discounted utility of generation t given by (5) implies that maximizing U^t is equivalent to maximizing c_{t+1}. Therefore, under safe investments, using (6), the old agent's consumption is given by

$$c^S_{t+1} = d^S + \pi^S + b^S = \frac{\omega(1+\rho^S-\delta)}{1-\delta(1-\rho^S)}. \tag{7}$$

The old-age consumption (7) corresponds to a stationary equilibrium in which all generations of bank owners invest in safe assets. In this case, the consumption of the old agent in $t+1$ has three sources: the deposits, the one-period profit from owning the bank, and the proceeds from selling the bank to the young agent.

Applying the equilibrium concept characterized in Definition 1, if the new bank owner in period t deviates and selects the risky investment, the period $t+1$ consumption of generation t becomes

$$c^R_{t+1} = \begin{cases} d_t + \pi^R + b_{t+1} & \text{if investment is successful in } t+1 \text{ so that rescue is not needed,} \\ d_t + b_{t+1} - T^O_{t+1} & \text{if investment fails and bailout is financed by taxing the old } (O), \\ d_t + (b_{t+1} - d_t) & \text{if investment fails and depositors are bailed in with owners' equity } (I), \\ d_t + b_{t+1} & \text{if investment fails and bailout is financed by taxing the young } (Y). \end{cases} \tag{8}$$

Note that unlike the consumption level (7) where d^S and b^S are already computed in (6), under risky investment the period t deposit d_t and the period $t+1$ value of the bank b_{t+1} in (8) are left as variables at this stage as they are both determined in the specific equilibrium that corresponds to the specific rescue plan.

The first case in (8) captures an event where the bank's investment does not fail, meaning that the old agent derives the income from the same three sources as in (7), although the profit is higher because the bank invested in the risky project which, when successful, yields a higher return $\rho^R > \rho^S$.

The second case corresponds to a failed bank investment under circumstances where the depositor is bailed out. The old agent then collects the bank deposit d_t, pays a tax to bail out the deposits d_t, and sells the bank for a price b_{t+1}. In this case, d_t and T^O_{t+1} cancel out because the old agent is bailed out with the old agent's tax bill (hence, $c^R_{t+1} = b_{t+1}$).

As with rescue plan (O), the third case in (8) plan (I) places the burden on the old generation, but deposits are now bailed in via owners' equity. Thus, the shares are now distributed to old depositors and are therefore subtracted from the period $t + 1$ bank value. Because d_t cancels out, the old-age consumption level is the same as in plan (O) and equals to $c^R_{t+1} = b_{t+1}$.

The last case (Y) corresponds to a bailout, where the old depositor gets the money back, but does not bear the burden because the bailout tax is imposed on the young generation. As we show below, in this case, the value of the bank diminishes (b_{t+1} is smaller than in other cases), because the young generation will have less funds available for deposit and consequently bank profit declines in a subsequent period.

Note that the sale of the bank to the young generation always generates some revenue for the old generation. This is because b_{t+1} is affected by the expected stream of profits beginning in $t+2$. However, bank owners lose the period $t + 1$ profit if their bank investment fails in that period. Also, in the role as a depositor, the old agent collects back the deposits because either the bank's investment is successful or the depositor is bailed out or bailed in when the investment fails.

The following assumption eliminates some less relevant cases for our analysis of risk-taking.

ASSUMPTION 2. *Generation $t = -1$ bank owners, who are old at $t = 0$ when the game begins, made a safe investment decision. Formally, $a_{-1} = S$.*

Assumption 2 could be relaxed by assuming instead that the bank does not fail in period $t = 0$ when the game begins, even if generation $t = -1$ had chosen a risky investment. What matters here is to allow the young generation at $t = 0$ a "fresh" start without having to bear the consequences of a bank failure caused by the initial generation of bank owners with an exogenouslygiven investment decision. In fact, this assumption is not used in Subsection 5.1 that analyzes cases where the burden of rescuing a failed bank is on the old generation. However, Assumption 2 eliminates some tedious cases in Subsection 5.2 that analyzes bank rescue plans with the tax burden imposed on the young generation.

5.1 Bailout by taxing the old (O) or equity bail-in (I)

Consider the second (O) and third (I) cases in (8). Both cases capture consequences for the old generation of a failed bank investment. The old agent at $t = 1$ bears the entire burden of rescuing d_0 worth of deposits, a consequence of the risky investment decision made by period $t = 0$ bank owners, either via a bailout tax that equals to the rescued deposit d_0, or via an equity bail-in. In both cases, (8) shows that the consumption of the old agent becomes $c_1^R = b_1$ if the investment fails, because the tax on the old agent is $T_1^O = d_0$. In order to characterize the risk-taking incentives in these two cases it is therefore sufficient to characterize the incentives to maintain safe investments for one of these configurations.

With no loss of generality the analysis of the two rescue plans focuses on the decision made by generation $t = 0$ of bank owners. To solve for a MPE, we first characterize the conditions under which the best response to a safe investment decision made by the previous generation is also a safe investment, so that $BR(S) = S$. Subsequently, we characterize the conditions that rule out $BR(R) = R$ in a MPE.

Under Assumption 2, if the new generation 0 bank owner deviates from safe investments, the second (O) and third (I) cases in (8) imply that the expected consumption when old in $t = 1$ is

$$\mathrm{E}_0 c_1^{R,O} = \mathrm{E}_0 c_1^{R,I} = \underbrace{\lambda(d^S + \pi_1^R + b^S)}_{\text{investment success}} + \underbrace{(1-\lambda)b^S}_{\text{failure}} = \frac{\omega\left\{\lambda(1+\rho^R) - \delta\left[\lambda(1+\rho^R) - \rho^S\right]\right\}}{1-\delta(1-\rho^S)}, \quad (9)$$

where the expected bank profit is $\mathrm{E}_0 \pi_1^R = \lambda d^S \rho^R$, and d^S and b^S were substituted from (6). The expected next-period consumption (9) is the sum of the first and second cases in (8) weighted by the success and failure probabilities λ and $1 - \lambda$, respectively.

It is worth emphasizing two issues regarding the consumption level (9), because these issues underlie the methodology used in this paper to verify MPE. First, as explained on page 950 in

Maskin and Tirole (1987), to prove that a best response function is a MPE it is sufficient to rule out a utility-enhancing deviation in only one period (one generation). Second, specifically for this model, note that despite the deviation to a risky investment, the young at $t = 0$ acquire the bank for a price b^S (rather than b^R) and, consequently, deposit the remaining $d^S = \omega - b^S$ (rather than d^R) in the bank. This is because the young generation does not anticipate the one time "surprise" deviation from a safe investment. Formally, the investment decision by bank owners appears as the last stage of each periods' sequence of events that is listed in Subsection 2.3, meaning that the investment decision is made after the bank is sold to the young generation and after the deposits have been made.

Comparing consumption (7) with (9) reveals that a new bank owner in period 0 will not benefit from deviating from safe investments under the following condition:

$$\mathrm{E}_0 c_1^{R,O} = \mathrm{E}_0 c_1^{R,I} \leq c_1^S \quad \text{if and only if} \quad \rho^R \leq \rho^{R,O} = \rho^{R,I} \stackrel{\text{def}}{=} \frac{1 + \rho^S - \lambda}{\lambda}. \tag{10}$$

From (10) we can conclude that the risk-taking incentives are invariant across the rescue plans with bailout by taxing the old generation, and with equity bail-in. Furthermore, and importantly, the risk-taking incentives associated with rescue plans (O) and (I) support socially optimum risk-taking as the threshold in (10) coincides with that in Definition 2.

To conclude the analysis of rescue plans (O) and (I), Appendix A proves that the condition given by (10) rules out $BR(R) = R$ in a MPE. Therefore, (10) is also a sufficient condition for safe investments to constitute a MPE.

5.2 Bailout by taxing the young agent (Y)

Suppose that in period 0 the new owner deviates and chooses to invest the amount d^S of new deposits in the risky project. We now focus on the following type of bailout policy: If the bank's investment fails in period 1, the deposits are returned to the old agent via a tax $T_1^Y = d^S$ imposed on the next generation of young agents in period 1. A bailout tax imposed on the young agent would reduce the resources available for deposits by the young agent, as described in (4). Consequently, a smaller deposit volume would reduce the period $t = 2$ profit earned by the bank, and hence its sale value in $t = 1$, which we denote by $b^{R,Y}$.

Therefore, in view of (4), in an event that the bank's investment fails in $t = 1$ as a result of a risky investment made in $t = 0$, the (reduced) amount of deposit made by the young in $t = 1$ and the resulting lowered value of the bank are simultaneously determined from

$$d_1^{R,Y} = \omega - b_1^{R,Y} - T_1^{R,Y} = \omega - b_1^{R,Y} - d^S \quad \text{and} \quad b_1^{R,Y} = \delta\left(d_1^{R,Y}\rho^S + b^S\right), \tag{11}$$

where the superscript (R, Y) denotes risky investment under government bailout financed by a tax on the young agent, and b^S is determined in (6).

The first expression in (11) shows that the total deposit made in $t = 1$ after the bank's investment fails in $t = 1$ can be expressed by subtracting the bank's purchase price and the tax (to bailout the old agent's deposit) from the young agent's endowment. The last expression in (11) shows that the sale price of the bank in $t = 1$ is the sum of the period $t + 2$ safe return on the deposit volume $d_1^{R,Y}$ and the period $t = 2$ value of the bank given that generation t ($t = 1, 2, \ldots$) bank owners invest in safe projects (where both terms are discounted one period). Solving the system determined by the two equations in (11) yields

$$\begin{aligned} d_1^{R,Y} &= \frac{\omega - d^S - \delta b^S}{1 + \delta\rho^S} = \frac{\delta\omega(1-\delta)\rho^S}{(1+\delta\rho^S)\left[1 - \delta(1-\rho^S)\right]} \quad \text{and} \\ b_1^{R,Y} &= \frac{\delta\left[b^S + (\omega - d^S)\rho^S\right]}{1 + \delta\rho^S} = \frac{\delta^2\omega(1+\rho^S)\rho^S}{(1+\delta\rho^S)\left[1-\delta(1-\rho^S)\right]}, \end{aligned} \tag{12}$$

where d^S and b^S were substituted from (6).

If the new generation $t = 0$ bank owner deviates from safe investments, the first and fourth rows in (8) imply that the expected consumption of the old in $t = 1$ is

$$\begin{aligned} \mathrm{E}_0 c_1^{R,Y} &= \underbrace{\lambda(d^S + \pi_1^R + b^S)}_{\text{investment success}} + \underbrace{(1-\lambda)(d^S + b^{R,Y})}_{\text{investment failure}} \\ &= \frac{\omega\left\{\delta^2\rho^S\left[\rho^S - \lambda(1+\rho^R)\right] + \delta\left\{\lambda\left[\rho^R(\rho^S - 1) + \rho^S\right] + \rho^S - 1\right\} + \lambda\rho^R + 1\right\}}{(1+\delta\rho^S)\left[1-\delta(1-\rho^S)\right]}, \end{aligned} \tag{13}$$

where the bank profit is $\pi_1^R = d^S\rho^R$ with probability λ, d^S and b^S are given by (6), and $b^{R,Y}$ in (12). Comparing the expected consumption under (13) to the expected consumption under the same deviation under the (O) and (I) given by (9) reveals that if the bank fails, agents in generation $t = 0$ do get their deposit d^S back under rescue plan (Y), because it is financed by a tax levied on generation $t = 1$ young agents. This is not the case in (9) under rescue plans (O) and (I) that place the rescue burden on the same generation that is rescued.

Comparing the consumption profile (7) with (13) determines the period $t = 0$ incentive constraint under which the new bank owner does not deviate from safe investments. Formally,

$$\mathrm{E}_0 c_1^{R,Y} \leq c_1^S \quad \text{if and only if} \quad \rho^R \leq \rho^{R,Y} \stackrel{\text{def}}{=} \frac{\left[1 + \delta(1 + \rho^S - \lambda)\right] \rho^S}{\lambda(1 + \delta\rho^S)}. \tag{14}$$

It is important to note that (14) provides only a necessary condition for safe investments to be an equilibrium strategy, as it shows that the best response to safe investment by the previous bank owner is also to investment safely, so that $BR(S) = S$. But, the above derivation does not rule out the possibility that $BR(R) = R$ in a MPE (that we ruled out in Appendix A for the rescue plans (O) and (I)). However, as the next subsection shows, (14) provides a required *upper bound* on ρ^R (as a function of ρ^S) to guarantee that bank does not have incentives to deviate from safe investments. As this upper bound is *lower* than the associated incentive constraint under rescue plans (O) and (I), given by (10), we can draw all the desired conclusions about the risk incentives of bank owners under the different rescue plans even without having to formally rule out the possibility that $BR(R) = R$.[12]

5.3 Risk-taking incentives: The effects of rescue plans

Based on a comparison of the threshold values associated with the return on risky investment ρ^R given by (10) and (14), we now characterize how the different rescue plans affect the incentives of each generation of new bank owners to the maintain the safe investment strategy. In this respect, we can formulate the following conclusion.

Result 2. *A bailout tax imposed on the young generation is the least effective policy instrument to deter excessive risk-taking on behalf of the bank. A bailout tax imposed on the old generation and equity bail-in*

[12]The derivations are more tedious under rescue plan (Y) than the derivations we made for rescue plans (O) and (I) in Appendix A, because they require separate derivations for the cases when the bank fails and when it does not fail in period $t = 1$. The reason for this is that under rescue plan (Y), the young generation must bail out the deposit of the old generation, and consequently end up depositing a lower amount in the bank, if the bank fails in $t = 1$.

implement the socially optimal risk-taking. Formally,

$$\rho^{R,Y} < \rho^{R,O} = \rho^{R,I} = \rho^{R*}.$$

Figure 1 illustrates Result 2.[13]

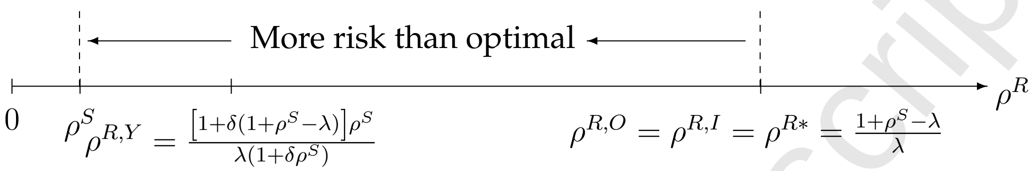

Figure 1: Rescue plans and bank owners' incentives to maintain safe investments.

From Result 2 we can conclude that a bailout tax imposed on the old generation would internalize the externalities associated with risk-taking. In contrast, shifting the burden to future generations magnifies the distortion associated with risk-taking. The growing unprecedented deficit in the United States may resemble such a tax policy.

In general, with rational consumers, Ricardian equivalence refers to the property that the effects of taxation are the same independently of whether the tax is imposed on the young or the old generation. Defined that way, Ricardian equivalence does not hold in our model. This means that it matters whether taxation to support bailout programs is imposed on the young or the old generation. The reason for why the Ricardian equivalence fails is precisely the feature that different types of bailout policies induce different magnitudes of banks' risk-taking incentives. More precisely, a bailout tax imposed on the young generation will induce young bank owners to take higher risks knowing that bailouts will be financed by the next generation.

6. Competitive banking industry with interest-paying banks

Suppose now that banks pay interest i on one-period deposits. That is, the bank promises customers who make a deposit of d_t dollars in period t, that the account will be credited with interest $d_t\, i$ in period $t+1$. In general, the interest rate level would depend on the market structure of the

[13]For a specific numerical illustration of Figure 1, suppose $\rho^S = 0.06$, $\lambda = 0.95$, and $\delta = 0.95$. Then, $\rho^S < \rho^{R,Y} = 6627/100,415 \approx 0.066 < \rho^{R,O} = \rho^{R,I} = \rho^{R*} = 11/95 \approx 0.11$. Note that in this parameter range, risky investments yield positive expected profits if $\rho^R > (1-\lambda)/\lambda = 1/19 \approx 0.053$.

banking industry. A high interest rate reflects a high degree of competition among banks, whereas no interest reflects the absence of competition (for example, a monopoly bank or cartel behavior in the banking industry).

Suppose that the interest i on a one-period deposit is in the range $0 \leq i \leq \rho^S$. Then, the bank's profit function (1) is now modified to

$$\mathrm{E}_t \pi_{t+1} = \begin{cases} \pi^S_{t+1} = d_t(\rho^S - i) & \text{(safe investment)} \\ \mathrm{E}_t \pi^R_{t+1} = \lambda d_t(\rho^R - i) & \text{(risky investment)}, \end{cases} \tag{15}$$

where the interest paid to depositors is subtracted from the rate of return on the bank's investment (provided the bank's investment does not fail).

The analysis in this section modifies the analysis of previous sections (which relied on non-interest bearing deposit accounts) by assuming that competition among banks drives up the interest rate paid on one-period deposits. Formally,

ASSUMPTION 3. *The banking industry is perfectly competitive. The representative bank pays interest equal to $i = \rho^S$ in a steady-state equilibrium in which all generations of bank owners adhere to safe investments.*

Assumption 3 and (15) imply that the bank makes normal ($\pi^S_{t+1} = 0$) profit in a steady-state equilibrium in which all generations of bank owners adhere to safe investments. This implies that a one-period deviation from a safe investment would increase the expected bank profit to $\mathrm{E}_t \pi^R_{t+1} = \lambda d_t(\rho^R - \rho^S) > 0$, which is proportional to the difference between the uncertain return on a risky investment and the deposit rate the bank promises to pay.

Consider now the investment decision made by new young bank owners in order to maximize their utility (5). Unlike Section 5, the bank now promises to pay interest $i = \rho^S$ on one-period deposits. In this case, bank owners can secure their $t + 1$ consumption under the safe investment strategy so that

$$c^S_{t+1} = d_t(1 + i) = \omega(1 + \rho^S). \tag{16}$$

In (16), period t total deposit satisfies $d_t = \omega$ because the young generation does not spend resources on buying bank equity as the banks make no profit with competitive interest rates.

If a new bank owner deviates and chooses a risky investment in period t, the period $t+1$ old-age consumption (8) is now modified to

$$c^R_{t+1} = \begin{cases} \omega(1+\rho^S) + \overbrace{\omega(\rho^R - \rho^S)}^{\pi^R_{t+1}} & \text{if investment is successful in } t+1, \\ 0 & \text{if investment fails, no rescue plan } (N), \\ \omega(1+0) & \text{if investment fails, bailout financed by taxing the young } (Y). \end{cases} \tag{17}$$

Note that a bailout tax imposed on the young generation (Y) cannot recover the interest promised to depositors, because the young agent does not possess sufficient resources. Therefore, only the principal ω could be returned to depositors. Also, the rescue plans (O) and (I) are omitted from (17), because they are totally ineffective when the old agent loses all the assets during a bank failure. In this sense, rescue plans (O) and (I) are in practice equivalent to no bailout (N). No bailout was not analyzed in Section 5 because, with non-competitive banking, old agents always had some equity which depositors could claim if no rescue plan is implemented, as reflected in the consumption (8). In contrast, the old agent's consumption (17) is financed solely by deposits plus interest and, possibly, the one-period profit from the interest spread $\omega(\rho^R - \rho^S)$ if the bank's risk-taking attempt is successful.

Under a no-bailout policy (N), the combination of (16) with the first and second rows in (17) implies that risky investment is not beneficial for the young bank owner in period t if and only if

$$\mathrm{E}_t c^{R,N}_{t+1} = \lambda\omega(1+\rho^R) + (1-\lambda)0 \le c^S_{t+1} \quad \text{or} \quad \rho^R \le \rho^{R,N} \stackrel{\text{def}}{=} \frac{1+\rho^S-\lambda}{\lambda}. \tag{18}$$

The threshold in (18) coincides with the socially optimal risk-taking threshold (Definition 2), meaning that in this configuration there are no excessive incentives for risk-taking.

Next, the bottom row in (17) shows that a bailout financed by a tax imposed on the young generation guarantees that the old agent is able to consume the deposit principal but not the promised interest. If the bank's investment does not fail, the top row shows that the one-period profit associated with risky investment will be added to the old-age consumption. Therefore, under a (partial) bailout policy (Y) financed by a tax imposed on the young agent, the risky investment is unprofitable for a young bank owner in period t if and only if

$$\mathrm{E}_t c_{t+1}^{R,Y} = \lambda\omega(1+\rho^R) + (1-\lambda)\omega(1+0) \leq c_{t+1}^S, \quad \text{or} \quad \rho^R \leq \rho^{R,Y} \overset{\text{def}}{=} \frac{\rho^S}{\lambda}. \tag{19}$$

In view of the discussion after equation (14), it is important to note that (19) also provides only a necessary condition for safe investments to be an equilibrium strategy, as it shows that the best response to safe investment by the previous bank owner is also to investment safely, so that $BR(S) = S$. The above analysis yields the following result.

Result 3. *The incentives for risk-taking under a no-bailout policy (N) supports the socially optimal level of risk-taking. Further, a bailout policy financed by a tax imposed on the young generation (Y) induces excessive risk-taking. Formally,*

$$\rho^S < \frac{\rho^{R,Y}}{\lambda} < \rho^{R,N} = \rho^{R*}.$$

Figure 2 illustrates Result 3.[14]

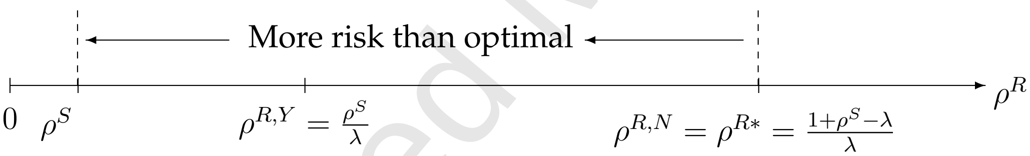

Figure 2: Bailout and no-bailout rescue plans and incentives to maintain safe investments when the bank pays the competitive deposit rate.

Result 3 captures the idea that a tax bailout can induce the bank to exploit the risk-taking option if this bailout facilitates shifting the tax burden to the next generation. This feature also holds true when banks do not pay interest.

From Result 3 we can conclude that the Ricardian equivalence fails to hold true also with a banking industry operating under perfect competition. Interestingly, a comparison between Result 2 and Result 3 reveals that a bailout tax imposed on the young generation yields a higher option value associated with risk-taking in a banking industry operating under perfect competition than in the absence of competition. This option value is higher with more intense deposit market competition, implying that intensified competition induces more severe moral hazard problems.

[14] For a specific numerical illustration of Figure 2, suppose $\rho^S = 0.06$ and $\lambda = 0.95$. Then, $\rho^S < \rho^{R,Y} = 6/95 \approx 0.063 < \rho^{R,N} = \rho^{R*} = 11/95 \approx 0.11$. Note that in this parameter range, risky investments yield positive expected profits if $\rho^R > (1-\lambda)/\lambda = 1/19 \approx 0.053$.

This means that the combination of perfect competition and a bailout tax imposed on the young generation induces a stronger risk-taking distortion than the same policy introduced into a banking industry without competition. This can be verified formally by comparing the thresholds associated with a bailout tax imposed on the young generation in Result 2 and Result 3.

7. Conclusion

We design an OLG model to evaluate the effects of different types of government rescue plans of depositors on banks' risk-taking incentives. The paper shows that the way bailouts are funded have a significant impact on the risk incentives of bank owners. We establish analytically that bailout policies financed by a tax imposed on the young generation induce excessive risk-taking independently of whether the banking industry is characterized by perfect competition or no competition. Further, we find that this risk distortion is stronger with perfect competition. In the absence of competition between banks, we find a bailout policy financed by a tax on the old generation and an equity bail-in to be efficient policies in the sense that they implement socially optimal risk-taking. Under such circumstances, it is possible to design bailout plans that avoid the moral hazard problem. In a competitive banking industry, the regime with a bailout financed by taxing the old generation as well as that with equity bail-in are not feasible because the old generation is left with no assets during periods with financial crisis. Under such circumstances, no bailout is optimal.

Overall, our analysis highlights as a robust finding that bailout policies financed by a tax imposed on the young generation induce excessive risk-taking. In this respect our study can be seen as a particular argument against shifting the financial burden to future generations as far as bailout policies are concerned.

By design, the OLG environment imposes a liquidity constraint as the young generation must invest resources to acquire ownership of the production technology (banks). This acquisition diverts resources from real investments, see Shy and Stenbacka (2017). It can be shown that a bailout tax imposed on the young further magnifies this distortion because it diverts a larger amount of resources away from deposits which are used for investment purposes.

It should be emphasized that our analysis is not conducted with the objective of characterizing the socially optimal bailout policy in general.[15] Instead, our study has a more applied orientation insofar as we evaluate the effects of four different, empirically relevant types of bailout policies on banks' risk-taking incentives. Of course, our study could be executed with a higher ambition in this respect.

The paper does not provide an explanation based on political economy considerations as a basis for the bailout policies analyzed. In part, this seems reasonable in light of the feature that the depositors within each generation are homogeneous. However, the model makes distinctions between bailout taxes imposed on the young and the old generation and therefore highlights the conflict of interest among generations. This conflict of interest could serve as a basis for attempting to make the type of bailout policy endogenous. In this respect the nature of population growth (or decline) could be decisively important as determinant of the emerging type of bailout policy. Such an approach could yield complementary insights to those of Mitkov (2016). His paper focuses on a population with heterogeneous investors (depositors) and characterizes rescue programs determined by distributional concerns, thereby characterizing endogenously determined limitations on the coverage of deposit insurance.[16]

As pointed out by a referee, our analysis has abstracted from attempting to explain the reason why governments rush to bail out banks. In particular, our model does not incorporate bank runs. But, clearly, old consumers could experience a loss of utility if their consumption falls below a certain threshold in line with, for example, Chen and Hasan (2006). In the framework of our model, unsuccessful risky investments could cause old-agent consumption to fall below such a threshold.

For reasons of tractability, we have restricted the banks' asset portfolios to a risky or a safe portfolio. One possible extension of the model could be to allow banks to diversity their portfolios

[15] Green (2010) and Bernardo, Talley, and Welch (2014) discuss the design of corporate bailout policies from a more general perspective, and Cole (2013) presents empirical evidence regarding the effects of the TARP-program on bank lending volumes.

[16] Another, very different, but nevertheless very interesting political economy feature associated with bailouts is empirically documented by Altavilla, Pagano, and Simonelli (2016). They establish that in stressed Euro-area countries, recent domestic bailed-out banks with public ownership have increased their holdings of domestic public debt significantly more than other banks.

by selecting the degree of riskiness from a continuum of available risk levels. Furthermore, in line with the dominant tradition in the banking literature, we have focused on a banking industry characterized by bundling of deposits with risk. In an earlier study, Shy and Stenbacka (2007), we have explored the implications of introducing a policy instrument for controlling the fraction of perfectly-liquid accounts.

It should be pointed out that our analysis tends to underestimate the magnitude of the distortions created by the bailout system because the model relies on the, rather naive, assumption that banks need to collect deposits in order to invest. However, as recently shown in McLeay, Radia, and Thomas (2014), the basis for bank money creation need not be restricted to deposits. In this case, the taxpayer may be liable for bailing out failing banks' risky investments financed by money that was created by banks.

Our study could also be extended to analyze the repeated moral hazard problem faced by bank owners. In general, the overlapping generations approach does not easily lend itself to a study of the effects of bailout policies on the persistence of moral hazard,[17] because the horizon of each bank owner is limited to two periods. Another extension may involve introducing a lifetime utility function that results in positive consumption in both periods. One effect would be that increased consumption in the first period would further lower the amount of deposits, and hence act as if the endowment (and hence investments) are reduced. However, if the two-period utility function introduces strong substitution effects between the two periods, deposits and hence investment may increase or decrease.

Appendix A Sufficient condition for safe investment under rescue plans (O) and (I)

This appendix characterizes the conditions needed to rule out $BR(R) = R$ in a MPE when the government implements rescue plans (O) and (I). For the sake of this particular analysis, suppose that $BR(R) = R$ were consistent with a MPE. Then, if generation $t = 0$ deviates from $a_0 = S$ to $a_0 = R$, generation $t = 1$ (and subsequent generations) of new bank owners will also choose

[17]Diamond (1989) has demonstrated that moral hazard does not persist in credit market with repeated interaction as considerations related to reputation would ultimately eliminate the incentives for excessive risk-taking.

$a_1 = R$. On the $BR(R) = R$ equilibrium path, the deposit level d^R and the value of the bank b^R in each consecutive period are jointly determined from the young agent's resource constraint (4) and the present value of the bank under risky investment (3). Solving the two equations yields,

$$d^R = \frac{\omega(1-\delta)}{1-\delta(1-\lambda\rho^R)} \quad \text{and} \quad b^R = \frac{\delta\lambda\omega\rho^R}{1-\delta(1-\lambda\rho^R)}, \tag{A.1}$$

which is analogous to the safe investment equilibrium (6) modified for a risky investment equilibrium under rescue plans (O) and (I). Note that (A.1) holds true regardless of whether the bank fails or does not fail in $t = 1$, because the rescue burden does not affect the young agents who can therefore use their entire endowment ω to purchase the bank for b^R and deposit the remaining $d^R = \omega - b^R$ in the bank. Therefore, the expected period $t = 2$ consumption of generation $t = 1$ (and all subsequent generations) is

$$\mathrm{E}_1 c_2^{R,O} = \mathrm{E}_1 c_2^{R,I} = \underbrace{\lambda(d^R + \pi^R + b^R)}_{\text{investment success}} + \underbrace{(1-\lambda)b^R}_{\text{failure}} = \frac{\lambda\omega(1+\rho^R-\delta)}{1-\delta(1-\lambda\rho^R)}, \tag{A.2}$$

where the expected bank profit is $\mathrm{E}_1\pi^R = \lambda d^R \rho^R$, and d^R and b^R were substituted from (A.1).

The last step needed to rule out $BR(R) = R$ in a MPE is to compute expected consumption of generation $t = 1$ associated with a deviation from a risky to a safe investment decision (given that generation $t = 0$ chose a risky investment). In this case,

$$\mathrm{E}_1 c_2^{S,O} = \mathrm{E}_1 c_2^{S,I} = d^R + \pi_2^S + b^R = \frac{\omega\left[1+\rho^S-\delta(1+\rho^S-\lambda\rho^R)\right]}{1-\delta(1-\lambda\rho^R)}, \tag{A.3}$$

where now the bank profit is $\pi_2^S = \lambda d^R \rho^S$, and d^R and b^R were substituted from (A.1). Note that, according to the sequence of events listed in Subsection 2.3, the deviation to S occurs only after the bank is sold to the young for a price b^R, and d^R deposits are made during which the young agent expects to be on the risky equilibrium path (before the new owners unexpectedly deviate to S).

Comparing (A.2) with (A.3) reveals that $\mathrm{E}_1 c_2^{S,O} = \mathrm{E}_1 c_2^{S,I} \geq \mathrm{E}_1 c_2^{R,O} = \mathrm{E}_1 c_2^{R,I}$ under the condition derived in (10). Therefore, under this condition $BR(R) = R$ is not a MPE strategy.

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