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Aggregate Shock, Capital Market Opening, and Optimal Bailout

Se-Jik Kim · Ivailo Izvorski

KOREA INSTITUTE FOR
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Executive Summary

This paper explores the joint effect of aggregate productivity shocks and capital market liberalization on the optimal bailout (or liquidation) policy of banks towards defaulted borrowers. It suggests that in bad times both good and bad firms default on their obligations, it is harder for the bank to distinguish between the two and therefore it is less costly to bail out defaulted firms. Therefore, the optimal liquidation rate in a closed economy may be substantially lower in recessions than in booms. In an economy with open capital markets, however, the corporate rate of return has to be raised at least up to the world rate of interest by improving the composition of the corporate sector through higher liquidation in order to prevent an outflow of capital and the subsequent financial crisis. As a result, the optimal liquidation rate (bailout rate) during recessions may be much higher (lower) in an economy with liberalized capital markets than in a closed economy. The model in this paper explains why liquidation rates of defaulted firms have risen significantly and structural reform to facilitate more liquidation has been pursued after the financial crisis in those East Asian countries with more liberalized capital markets.

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I. Introduction

This paper explores the joint impact of aggregate productivity shocks and capital market liberalization on optimal bailout policies by banks towards defaulted borrowers. More specifically, it studies how the optimal bailout policy differs between recessions and booms, and how it is affected by capital market opening. This paper suggests that the optimal bailout policy in an economy with open capital markets could be completely different from that in one with closed capital markets.

The recent financial crisis in Asia reignited immense public and academic interest in optimal bailout policies during recessions or financial crises. In the crisis-hit countries, regulators and banks have

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been faced with the question whether more defaulted firms should be bailed out during the crisis, when not only "bad" firms but also many "good" firms are defaulting on their obligations and hence it is difficult to distinguish between the two. Should we, as a result, have a higher bailout ratio during recessions than during booms or the other way around? In East Asian countries of the pre-crisis period, it was often the case that the bailout of defaulting firms was more frequent during recessions.[1]

In the aftermath of the latest crisis, however, there has been an unprecedented surge in liquidation of the defaulting firms in the crisis-hit East Asian countries. For example, many of large conglomerates in Korea (called *Chaebols*) which used to be too big to fail for decades, have gone bankrupt.[2] In addition, the Asian countries under IMF rescue programs have begun to advance substantial structural reforms in the corporate sector.[3] The key structural reform measures included

1) For example, the Korean economy has undergone seven or eight slowdowns or recessions during 1971–1995, when capital markets were relatively closed. During this period, however, the monthly bankruptcy in Korea was very stable at around 0.2 percent of all the firms (including both the defaulted and the non-defaulted) rather than sharply rising in accordance with recessions. This suggests there was a "bankruptcy smoothing" through a rise in the ratio of the bailed-out among defaulted firms during recessions.

2) During 1997–1998, half of the top thirty conglomerates in Korea were put under court receivership, undergone workouts or otherwise went bankrupt. In addition, the monthly bankruptcy rate in Korea, which had been stable around 0.2 percent before, jumped to 2 percent at the peak of financial crisis in 1997.

3) The structural policy of facilitating more liquidation was pursued by the IMF, but also high in the priority list of domestic reformers in the crisis–

the set-up or reform of bankruptcy laws and practices to facilitate easier bankruptcy.[4] What accounted for this abrupt change of liquidation policy?

We suggest that an answer may be found in capital market opening. During the 1990s, the crisis-hit Asian countries had opened their capital markets to a substantial degree. For example, capital market liberalization has facilitated the increase in the share of nonresident equity holdings on the Korea Stock Exchange from under 5 percent of total market value in the early 1990s to 30 percent in 2000.[5] How is the opening of capital markets related to the change in liquidation rate?

To address these issues, the paper presents a twoperiod heterogenous agent model of default and bailout. The model partly builds on the recent incomplete contracting theory of debt (e.g., Bolton and Scharfstein (1990), Hart and Moore (1988), and Hart (1995).) In

hit Asian countries (see Goldstein (2000)). For detailed information on the IMF programs in those countries, see for example Berg (1999), and Chopra et al. (2001).

4) Some critics of the IMF program argue that the Asian crisis was basically a liquidity crisis so that structural reforms of promoting high liquidation induced unnecessary firm closures and undesirable intrusion into countries' political processes by the IMF (e.g, Feldstein (1998)). On the other hand, some argue that the crisis reflected underlying structural weaknesses, so that the ignorance of structural issues would invite repetition of crisis and therefore corporate and financial sector reforms have been warranted (e.g., Fischer (1998, 2001)).

5) In addition, total net private capital flows to Asian emerging markets more than quadrupled from \$21bn in 1992 to \$104bn in 1996, and bank lending also jumped from − \$4bn to \$38bn during the same period.

particular, the relation between the borrower and the lender is regarded as a contract, which specifies repayment amounts as well as the conditions under which control passes from the borrower to the lender.

The model includes several new features related to bailout, however. First, the model focuses on the issue of uncertainty of the quality of the firms to which a loan is extended and the effect of the bailout policy on the quality composition of the firms. There are two types of firms in the model higher productivity (good firms) and lower productivity (bad firms). The difference between the two classes is in the probability with which firms receive a positive productivity shock: on average, in every state of the economy, good firms receive a positive productivity shock with a higher probability than bad firms. The type of the firms is not observable by the lender, although the proportion of good firms in the first period sample is known. In particular, lenders cannot verify whether a particular firm is good or bad, even when they observe that some firms fail. This uncertainty makes the design of optimal bailout policy difficult. If lenders can distinguish good from bad firms, then the optimal policy after a negative economywide shock would be simple: bail out the good firms and let the bad firms go bankrupt. In reality, however, it is hard to distinguish the good from the bad firms and to judge whether a defaulted firm is good or bad. This type of uncertainty is more important in developing countries where the capacity of the banking system to assess profitability of firms is less sophisticated.

Second, this model focuses on the effect of an aggregate, economywide productivity shock on the difficulty lenders have in distinguishing between good and bad type among the defaulted firms. Once the aggregate productivity shock is observed, lenders cannot tell whether a particular firm is good or bad but can make an inference on the fraction of good and bad firms in the distressed and in the nondistressed sample. Based on this information, banks make their bailout decisions. Although it is impossible to tell whether a defaulted firm is good or bad, lenders may assess the probability that a defaulted firm is good or bad given the underlying probability distribution of good and bad firms. The difficulty of such probabilistic assessment depends on the state of the economy, or the stage of the business cycle in the model. In particular, the probabilistic distinction is more difficult in bad times because a large negative aggregate shock may lead not only bad firms but also many of good firms to default, which reflects some contagion effects and other systemic risks of recession.[6] By contrast, in good times it is plausible to assume that good firms do not usually default, and therefore most of the defaulted firms are likely to be bad.

Third, this model focuses on how capital market opening affects the optimal bailout policy. The small open economy version of the model introduces international investors who take their capital abroad if the expected rate of return in the country is lower than the international interest rate. So the optimal bailout is affected by this possibility of capital outflows in the case of open economy. In bad times when the economy has experienced a negative economy-wide

6) Contagion effects have been addressed in both international and domestic context in the existing literature. There is already large literature of international crisis contagion that has grown rapidly especially after recent Mexico and East Asian currency crises (see e.g., Eichengreen et al (1996), Masson (1998) and Jeanne (2000)). There are also studies that focus on the contagion effects in the domestic context, for example, Goodhart and Huang (2000) which propose a model where the lender of last resort seeks to abate contagion effects as well as moral hazard problem.

productivity shock, it would happen that without liquidation, the expected rate of return of the domestic corporate sector for the next period would be lower than the international interest rate. So capital would flow out, which would lead to a financial crisis. We focus on the case where the sudden capital outflow will have huge adverse effects on the domestic economy, which may reflect the premature termination of projects as in Diamond and Dybvig (1983) or the shortage of working capital. Hence, from the standpoint of the domestic bank (or the domestic central bank), it is necessary to prevent capital from flowing out.[7)]

Several important conclusions follow from the model presented in this paper. First, it may be optimal to bail out only a fraction of all defaulted firms, depending on the size of the realized aggregate shock. Because banks cannot distinguish good from bad firms, the optimal bailout policy is always probabilistic. That is, there would be some good firms, which would be liquidated and some bad firms, which would be allowed to continue production. This result holds because it is the aggregate, economywide shock and not the idiosyncratic shock that ultimately drives the optimal bailout policy given lack of information on the quality of each individual firm.

Second, in a closed economy, the optimal bailout ratio is higher in a recession than in a boom. The intuition for this result is clear.

7) How costly capital outflow is to the domestic economy may be illustrated by examining the collapse of stock markets in crisis-hit Asian countries. The Thai stock price index, which was around 800 six months ahead of the crisis, plummeted to 360 six months after the crisis. The Korea stock price index also has halved between six months before and after the crisis (from around 760 to 330). Indonesia also suffered such a sharp fall in stock prices.

Bailouts have costs and benefits. Bailouts are costly because they allow bad firms to operate alongside good firms, which lowers capital productivity and the future aggregate output. On the other hand, bailouts could be beneficial because they prevent the liquidation of firms, which is costly given that the reallocation of capital from a defaulting firm to others may require some adjustment costs. The optimal bailout policy is determined when benefits and costs strike a balance. In good times when good firms do not usually go bankrupt, the defaulted firms are more likely to be bad. In bad times when many of good firms also default, it is harder to distinguish between good and bad firms among the defaulted, and therefore less costly to bail out defaulted firms. Hence it may be beneficial to bail out more defaulting firms in bad times.[8)]

Thirdly, in a recession, the optimal liquidation rate is higher for an economy with open capital markets than without it. This suggests that a higher liquidation or more rigorous structural reform effort is needed in the case of an open economy hit hard by a negative aggregate shock. This is in a sharp contrast with the case of a closed economy where when having an adverse shock, the liquidation rate could be very low. The reason is straightforward. As an adverse shock reduces the expected rate of return of the domestic corporate sector, the economy with open capital markets needs to guarantee the international interest rate. Otherwise, international investors would take capital out, which may lead to a financial crisis. Given the huge costs

8) This suggests that recessions are likely to reduce the amount of restructuring in a closed economy setting. Using data from the US manufacturing sector, Caballero and Hammour (2000) provide some evidence on the disruptive effect that recessions can have on the restructuring process.

of sudden capital outflow, the economy needs to protect itself from such massive capital outflow. For this purpose, expected rates of return to international investors have to be raised through improving the quality of firms. Hence more liquidation of the defaulted, which are more likely to be bad type, is required. This may explain why the liquidation ratio has risen in crisis-hit East Asian countries, which had opened their capital markets substantially before the crisis. Without capital market opening, they would have had higher bailout rate (lower liquidation rate). Once capital markets are opened, the only way to prevent capital flight would be to pursue structural reforms that facilitate more liquidation of defaulting firms.

The rest of the paper is organized as follows. Section Ⅱ sets up the basic model. Section Ⅲ describes the solution, which determines the optimal bailout policy in a closed economy, and examines the optimal solution in relation to the aggregate shock. Section Ⅳ discusses the optimal bailout in an open economy. Section Ⅴ concludes the paper.

II. Basic Model

The model economy has two periods, $t=1,2$. There is a continuum of domestic firms defined on the interval [0,1], and a single (domestic) bank. In the first period, each firm borrows an amount k from the bank, invest in physical capital, and produce homogenous output. Then during the first period, the realization of the aggregate shock θ is revealed, and the output of each firm becomes known to itself. At the end of the first period, firms must repay an amount of d to the bank. Those firms whose output cannot cover the payment are in default[9] and the bank has the option to liquidate them or bail them out. Thus, in the second period the bank must decide on the fraction of firms to bailout (or, alternatively, liquidate). This section describes the model in detail.

1. Aggregate productivity shock

The aggregate shock affecting the economy, denoted by θ_t, is uniformly distributed on the interval [θ^l , θ^u]. The shock would be directly related to the productivity shock affecting output. The lower bound of the aggregate shock is assumed to be associated with recessions and the upper bound with booms.

9) Sometimes the information on a firm's default remain a private information which the bank knows but the public does not. For example, if the bank rolls over or provides a new loan today to a firm that is certain to default tomorrow, the public may not exactly know the financial difficulty of the firm.

The aggregate shocks between the two periods (t=1,2) are positively correlated, reflecting a persistency of aggregate shocks. More specifically the relationship is given by:

$$\theta_2 = \theta_1 \tag{1}$$

This suggests that the revelation of the aggregate shock in the first period provides information on that of the second period.[10)]

2. Firms

Firms, whose measure is one, produce homogenous output using the production function:

$$y = A_t k_t^{\alpha}, \quad \alpha < 1 \tag{2}$$

where A_t is a productivity shock and k_t is physical capital.[11)] For simplicity, the depreciation rate of physical capital is zero in the first period, but one in the last period. There is an alternative storage technology with rate of return (r_s) assumed equal to zero.

There are two types of firms in the economy: good and bad firms. The difference between the two is that they receive different idiosyncratic shocks in each period. The idiosyncratic productivity shock that good firms get is defined as:

10) We may instead just assume that people believe there is such a correlation regardless of the actual relationship. Under this alternative assumption, the main results of the paper continue to hold.

11) We may instead assume $y = A_t k_t^{\alpha} n_t^{1-\alpha}$, where n_t is labor employed.

$$A_t = \begin{cases} A & \text{with probability } \pi_t \\ 0 & \text{with probability } 1 - \pi_t \end{cases} \tag{3}$$

While the idiosyncratic shock bad firms get is:

$$A_t = \begin{cases} A & \text{with probability } \delta_t,\ 0 \leq \delta_t < \pi_t \\ 0 & \text{with probability } 1 - \delta_t \end{cases} \tag{4}$$

That is, the probability of zero productivity shock of a bad firm is always higher than that of a good firm. Thus, the probability of failure for bad firms is not less than that of good firms. At the beginning of the first period, the fraction of good firms is common knowledge and is assumed to be equal to x. If a firm receives a zero productivity shock, it produces nothing and cannot repay d. So it would be declared in default by the bank.

The first assumption to be made concerns the fashion in which the probabilities of firm–specific idiosyncratic shocks, π_t and δ_t, depend on the common aggregate shock θ_t:

$$\pi_t = \pi(\theta_t) \tag{5}$$

and

$$\delta_t = \delta(\theta_t) \tag{6}$$

Assumption 1 *The probability of a positive shock increases with the aggregate productivity shock for good firms, and is non–decreasing for bad firms:*

$$\frac{d\pi_t}{d\theta_t} > 0 \tag{7}$$

$$\frac{d\delta_t}{d\theta_t} \geq 0 \tag{8}$$

Assumption 2 *The probability of a positive shock increases with the aggregate shock at a faster rate for good firms than bad firms:*

$$\frac{d(\pi_t - \delta_t)}{d\theta_t} > 0 \tag{9}$$

The above assumptions indicate that regardless of a boom or a recession, bad firms default with a higher probability, while in a recession $(\theta = \theta^l)$, relatively more of good firms compared to bad firms default. This reflects that in a recession a large negative aggregate shock may lead many firms, both good and bad, to default, and consequently even many of healthy firms suffer. This may be due to some contagion effects and other systemic risks of recession. In boom, however, good firms do not usually go bankrupt, and therefore most of the defaulted firms are likely to be bad. Given the law of large numbers, the rate of default in the economy as a whole depends on the aggregate and not on the idiosyncratic shocks.

Assumption 3 *For all* θ_1, $x\pi(\theta_1) + (1-x)\delta(\theta_1) > 0$.

This tells us that the expected rate of return of the firms in this economy is positive at the beginning of the first period, so that agents will invest given that there is any other alternative investment opportunity with a positive return.

To illustrate, assume that the support of θ is [0,1]. Then the following linear functions satisfy all of the above assumptions:

$$\begin{aligned} \delta_t &= 0, \quad \pi_t = \pi^l + (\pi^u - \pi^l)\theta_t, \\ \pi^u &= 1, \quad \pi^l \in (0,1) \end{aligned}$$

since

$$\frac{\partial \delta_t}{\partial \theta_t} = 0, \quad \frac{\partial \pi_t}{\partial \theta_t} = \pi^u - \pi^l > 0, \quad \frac{d(\pi_t - \delta_t)}{d\theta_t} = \frac{\partial \pi_t}{\partial \theta_t} > 0 \ and$$

$$x\pi^l + (1-x)\delta^l = x\pi^l > 0$$

3. The bank and the financial contract

To simplify the model, we assume there is a single lender, a domestic bank, that provides financing to all the firms in the economy and makes decisions on bailout of defaulting firms. The bank here can be viewed as the banking system of an economy as a whole or a composite of commercial banks and the central bank (or the government). The assumption fits well developing countries where a large number of the banks are state-owned or state-controlled and so they behave like a single entity controlled by the government.[12)]

At the beginning of the first period, all firms borrow an amount k from the bank. All firms receive the same amount of loan since the bank cannot distinguish the good from the bad firms. The financial contract requires a payment of d (> 0) at the end of the first period, and specifies that if the repayment is not made, the bank would declare the firm in default. In case of default, control rights pass to the bank which decides on the fraction λ of the firm it would liquidate or, alternatively, the fraction $1-\lambda$ of the firm that it would bailout (i.e., the bank would forgive repayment on d for a fraction $1-\lambda$ of the

12) Of course, we would instead explicitly introduce both a large number of commercial banks and a central bank, which does not alter the main results of the current model on optimal bailout.

defaulted firms). That is, λ represents the rate of bankruptcy among defaulted firms.

The liquidation value for capital in the amount k is equal to L. Let $L=lk$. Then the ratio between liquidation to original value of capital, l, is less than one: $l < 1$. This reflects the costs that incur in the process of reallocating capital from a liquidated firm to a surviving one.

Finally, the financial contract recognizes that the bank has access to a fixed technology (legal system, reputational punishment, etc.) that allows it to claim a fraction of the second period output by each firm.[13] That fraction is denoted by ϕ_S for the firms surviving in the first period, and ϕ_F for the firms failed in the first period but bailed out. For simplicity, we assume that $\phi_S=\phi_F=\phi$, given that allowing ϕ_S to differ from ϕ_F does not alter the main qualitative results of the paper.[14] That is, in the first period, the financial contract gives rise to

13) To focus on the quality composition issue, we assume away strategic default in the last period of this two-period model (t=1, 2). But we would explicitly introduce strategic default in the last period by introducing one more period (t=3) and assuming that the owner of the firm may have some private benefits by continuing the firm until the last period (t=3). Then the entrepreneur has an incentive to repay at least a fraction of the second period output at t=2 in the three period version of the model.

14) The assumption is reasonable in developing countries where the government (or the central bank) which owns or controls a major potion of the banks, makes ultimate bailout decision in a view to maximizing the value of the corporate sector or a certain fraction of it. Under the simplifying assumption, the bank may be viewed as providing debt at the beginning, and turning into an equity-holder in the second period. It is often the case that banks increase equity holdings of the borrower firms through debt-equity swap, equity participation and etc over time

cash flows equal to d if the firm repays, and L if the firm defaults and be liquidated (with a chance of λ); in the second period, the cash flow is equal to a fraction ϕ of the second period output.

Therefore, the financial contract can be written as (k, d, λ, L, ϕ). Notice that the financial contract explicitly allows for default, liquidation, bailout, as well as incomplete recovery in the second period.

in developing countries. We may explicitly introduce an alternative assumption that the bank provides finance to the firms in the form of both debt and equity from the beginning while the debt–equity ratio is allowed to change over time. The modification, however, would complicate the model without altering the qualitative results of the paper.

III. Bailout in a Closed Economy

In our model of a closed economy, domestic capital is inelastically supplied.[15] So the expected rate of return of capital in the closed economy does not affect the investment decision of domestic investors in both the first period and the second period.

1. Optimal Bailout Policy

This section analyses the optimal bailout policy after the aggregate shock in the first period, θ_1, has been revealed. As a result, the probabilities π_1 and δ_1 and the output of each firm are already known to the bank. In addition, given the serial correlation of productivity shocks, π_2 and δ_2 can be perfectly forecasted. In this case, the optimal bailout decision of the bank depends on the aggregates shock in the first period, or, alternatively, on the stage of the business cycle. To set notation, denote the number of defaulted firms in the first period by N_f. Then:

$$N_f \equiv 1 - x\pi_1 - (1-x)\delta_1 = x(1-\pi_1) + (1-x)(1-\delta_1) \qquad (10)$$

15) We may explicitly introduce the assumption that the agents seeks to maximize the utility that comes only from the second period consumption, $u(c_2)$, which does not change the key results. Then inelastically supplied domestic capital can be derived from the assumptions of no storage technology with positive rate of return and the utility depending on the second period consumption.

The total cash flow from liquidation and repayment to the bank at t= 1 is:

$$\lambda L N_f + (1 - N_f)d \tag{11}$$

After making partial liquidations and receiving repayments, the bank has extra capital to lend to firms for their operations in the second period. In a closed economy where there are no alternative investment opportunities with positive return and the expected rate of return from investment is positive, the bank lends all of the capital to firms for production in the second period. Suppose that each firm that has not defaulted in the first period receives additional capital k_a per firm while each firm that has defaulted but bailed out does not receive any additional capital. The sum of the total additional disbursements must be equal to the amount obtained from liquidation and repayment in the first period:

$$(1 - N_f)k_a = \lambda L N_f + (1 - N_f)d \tag{12}$$

or,

$$k_a = \frac{\lambda L N_f + (1 - N_f)d}{(1 - N_f)} \tag{13}$$

The capital of firms that have not defaulted in the first period prior to the distribution of additional capital is:

$$k - d + Ak^{\alpha} \tag{14}$$

while after the distribution, capital per surviving firm that would be used for the second period production is

$$(k - d + Ak^{\alpha}) + k_a = k + Ak^{\alpha} + \frac{\lambda L N_f}{(1 - N_f)}. \tag{15}$$

At the beginning of the second period, the expected second period output of firms that have not defaulted is:

$$\begin{aligned} W &= A\left[(x\pi_1)\pi_2 + ((1-x)\delta_1)\delta_2\right](k + Ak^{\alpha} + \frac{\lambda L N_f}{(1 - N_f)})^{\alpha} \\ &= A\left[(x\pi_1)\pi_1 + ((1-x)\delta_1)\delta_1\right](k + Ak^{\alpha} + \frac{\lambda L N_f}{(1 - N_f)})^{\alpha} \\ &\equiv w(k + Ak^{\alpha} + \frac{\lambda L N_f}{(1 - N_f)})^{\alpha} \end{aligned} \tag{16}$$

The capital in the second period per defaulted firms that have been bailed out (or get forgiveness on *d*) is *k*, because their output in the first period is zero and they cannot receive any additional capital for the second period production. Hence the expected second period output of the firms that have defaulted and have been bailed out is:

$$\begin{aligned} Z &= (1-\lambda)A\left[(x(1-\pi_1))\pi_2 + ((1-x)(1-\delta_1))\delta_2\right]k^{\alpha} \\ &= (1-\lambda)A\left[(x(1-\pi_1))\pi_1 + ((1-x)(1-\delta_1))\delta_1\right]k^{\alpha} \\ &\equiv (1-\lambda)zk^{\alpha} \end{aligned} \tag{17}$$

The expected return to the bank at the end of the second period, denoted by V, is:

$$V = \phi w(k + Ak^{\alpha} + \frac{\lambda L N_f}{(1 - N_f)})^{\alpha} + \phi(1-\lambda)zk^{\alpha} \tag{18}$$

The bank, therefore, chooses λ to solve the following optimization problem:[16)]

$$\max_{\lambda} V(\lambda) = \phi w(k + Ak^{\alpha} + \frac{\lambda L N_f}{(1 - N_f)})^{\alpha} + \phi(1 - \lambda) z k^{\alpha} \tag{19}$$

Depending on the parameters, there can exist both corner solutions and interior solutions. Consider the case where there exist interior solutions. Then, the solution to the bank's maximization problem is given by the solution to the following first order condition:

$$\frac{\partial V}{\partial \lambda} = \phi[w\alpha(k + Ak^{\alpha} + \frac{\lambda L N_f}{(1 - N_f)})^{\alpha-1}\left[\frac{L N_f}{(1 - N_f)}\right] - zk^{\alpha}] = 0 \tag{20}$$

which gives:

$$\begin{aligned} zk^{\alpha} &= w\alpha(k + Ak^{\alpha} + \frac{\lambda L N_f}{(1 - N_f)})^{\alpha-1}\left[\frac{L N_f}{(1 - N_f)}\right] \\ \left(\frac{\alpha w}{zk^{\alpha}} \frac{lk N_f}{(1 - N_f)}\right)^{1/(1-\alpha)} &= (k + Ak^{\alpha} + \frac{\lambda L N_f}{(1 - N_f)}) \end{aligned} \tag{21}$$

So we have

$$\lambda^* = \left[\left(\alpha l \frac{\frac{w}{(1-N_f)}}{\frac{z}{N_f}}\right)^{1/(1-\alpha)} - 1 - Ak^{\alpha-1}\right] \frac{(1 - N_f)}{l N_f} \tag{22}$$

That is, the optimal λ^* is expressed as a function of the structural parameters α, l, and x and the aggregate shock θ_1. Define:

16) The single domestic bank here may be interpreted as both a commercial bank and the central bank. As commercial bank, it seeks to maximize the return from its lending (eq. (18)). As the central bank, it would maximize total output of the corporate sector (equal to the second period consumption here) which is the same as eq. (18) with $\phi = 1$. It is obvious that the solutions for the two optimization problems are the same.

$$M(\theta_1) \equiv \left[\left(\alpha l \frac{\frac{w}{(1-N_f)}}{\frac{z}{N_f}} \right)^{1/(1-\alpha)} - 1 - Ak^{\alpha-1} \right] \tag{23}$$

and express λ^* as :

$$\lambda^* = M(\theta_1)\frac{(1-N_f)}{lN_f} \tag{24}$$

Then if $M(\theta^l) < 0$, the optimal solution in a closed economy denoted by λ^{closed} is always $\lambda^{closed} = 0$, that is, zero liquidation (alternatively, full bailout). However, if $M(\theta^u) > 0$, there is a solution for which $\lambda^* > 0$

We make the following assumption on the relationship between θ_t and $M(\theta_t)$:

Assumption 4 $M(\theta^l) < 0$, $M(\theta^u) > 0$ *and* $\frac{\partial M(\theta_t)}{\partial \theta_t} > 0$.

To illustrate an example to satisfy the above assumption, assume that the support of θ_1 is [0,1], and $\alpha l(1 - x\pi^l)/(x(1-\pi^l)) < 1$. Then the following linear functions meet all of the above assumptions:

$$\begin{aligned} \delta_t &= 0, \;\; \pi_t = \pi^l + (\pi^u - \pi^l)\theta_t \\ \pi^u &= 1, \;\; \pi^l \in (0,1) \end{aligned}$$

since in this case $\frac{wN_f}{z(1-N_f)} = 1 + \frac{1-x}{x(1-\pi_1)}$ and hence

$$\begin{aligned} M(\theta_1 = \theta^l) &< 0 \\ M(\theta_1 = \theta^u) &\to \infty \end{aligned}$$

$$\frac{\partial M(\theta_1)}{\partial \theta_1} = \frac{\alpha l}{1-\alpha}\left(\alpha l \frac{\frac{w}{(1-N_f)}}{\frac{z}{N_f}}\right)^{\alpha/(1-\alpha)} \left(\frac{\partial}{\partial \theta_1}\left(\frac{wN_f}{z(1-N_f)}\right)\right)$$
$$= \frac{\alpha l}{1-\alpha}\left(\alpha l \frac{\frac{w}{(1-N_f)}}{\frac{z}{N_f}}\right)^{\alpha/(1-\alpha)} \frac{1-x}{x(1-\pi)^2}\left(\frac{\partial \pi_1}{\partial \theta_1}\right) > 0$$

Given the assumption, we can establish the following proposition:

Proposition 1 *Under Assumptions 1–4, given the first period aggregate productivity shock, there may exist a partial bailout solution to the bank's optimization problem (19):*

$$\lambda^{closed}(\theta_1) \in (0, 1) \tag{25}$$

That is, even though the bank cannot distinguish good firms from bad firms, it is optimal for it to engage in a partial probabilistic bailout —liquidate a fraction λ^* of the defaulted firms and bail out the rest. This suggests that there would be some good firms which would be liquidated and some bad firms which would be bailed out and allowed to continue production.

2. Impact of the Aggregate Shock

Further, we can examine how the aggregate shock or the stage of the business cycle affects the optimal bailout policy in a closed economy.

Consider first the case of a recession in the first period ($\theta_1 = \theta^l$). Then under Assumption 4, the expression $\lambda^* = M(\theta^l)(1 - N_f)/lN_f$ is negative, which means that the optimal solution is $\lambda^{closed}(\theta^l) = 0$, i.e., full bailout of all defaulted firms.

Consider now the case of a boom in the first period ($\theta_1 = \theta^u$). Under Assumption 4, the expression $\lambda^* = M(\theta^u)(1 - N_f)/lN_f$ is positive. Then a comparison between the boom and the recession scenarios suggests that in a closed economy under Assumptions 1–4, the optimal liquidation ratio in a recession is lower than in a boom:

$$\lambda^{closed}(\theta^l) < \lambda^{closed}(\theta^u) \tag{26}$$

To generalize the result, consider the more general case of a first period shock, $\theta_1 \in [\theta^l, \theta^u]$. To analyse the impact of the aggregate shock θ_1 on the bank's optimal liquidation ratio, define θ^* by the following equation:

$$M(\theta^*) = 0 \tag{27}$$

The existence of θ^* follows from Assumption 4. Then using that $\partial M(\theta_1)/\partial\theta_1 > 0$, for every $\theta_1 \in [\theta^l, \theta^*]$, we have $M(\theta_1) < 0$ and hence:

$$\lambda^{closed}(\theta_1) = 0 \tag{28}$$

For $\theta_1 \in (\theta^*, \theta^u]$, on the other hand, differentiating λ^* with respect to θ_1 gives:

$$\frac{\partial\lambda^*}{\partial\theta_1} = \frac{\partial M(\theta_1)}{\partial\theta_1}\left(\frac{1 - N_f}{lN_f}\right) + M(\theta_1)\frac{\partial\left(\frac{1-N_f}{lN_f}\right)}{\partial\theta_1} \tag{29}$$

Note that under Assumption 1:

$$\frac{\partial N_f}{\partial\theta_1} = x\frac{\partial(1-\pi)}{\partial\theta_1} + (1-x)\frac{\partial(1-\delta)}{\partial\theta_1} < 0 \tag{30}$$

and hence:

$$\frac{\partial\left(\frac{1-N_f}{lN_f}\right)}{\partial\theta_1} > 0 \tag{31}$$

Thus, $(\partial\lambda^*/\partial\theta_1)$ is positive. Therefore, the following proposition is established:

Proposition 2 *The bank's liquidation ratio is non-decreasing (or the bailout ratio is non-increasing) in the aggregate shock:*

$$\frac{d\lambda^{closed}}{d\theta_1} \geq 0 \tag{32}$$

and there exists θ^*, such that for any $\theta_1 \in (\theta^*, \theta^u)$, the liquidation rate is monotonically increasing in the aggregate shock ($\frac{d\lambda^{closed}}{d\theta_1} > 0$).

That is, the optimal policy in a closed economy is to liquidate more firms in "good" times (when the aggregate shock in the first period is higher) and to bail out more firms when times are "bad" (when the aggregate shock in the first period is lower). The reason for the result is clear. Recall that in good times, good firms do not usually default, and therefore the defaulted firms are more likely to be bad. In bad times, however, not only bad firms but many of the good firms may default. In bad times, it is then harder to distinguish between good and bad firms, and therefore less beneficial to liquidate (alternatively, less costly to bail out) defaulting firms. Hence, it may be optimal to bail out more firms as a percent of the total number of failed firms in bad times.

IV. Optimal Bailout in a Small Open Economy

We now examine how the optimal liquidation rate is affected by capital market opening. In particular, we focus on the case of recession, and show that the optimal bailout policy in time of a bad aggregate shock could substantially differ between the case of open economy and closed economy.

1. Open Economy and Capital Outflows

To study the small open economy case, we introduce international investors who can invest across countries and examine their optimal decision on capital outflow.

(1) *International Investors*

In addition to the (demestic) bank, there are risk–averse international investors in an economy with open capital market. A continuum of international investors, whose measure is one, can invest across countries, while the bank can invest only at home.

In the first period, the bank has its own capital amounting to k as in the case of closed economy. In addition, international investors lend $k^F(>0)$ to the domestic bank. The financial contract requires the bank's repayment of D to international investors at the end of the first period.[17] For simplicity, assume there is no default by the bank.[18]

17) We implicitly assume that $D \geq (1+r_1)k^F$ where r_1 is the international interest rate in the first period.

The bank lends $\bar{k}=k+k^F$ to the domestic firms, whose measure is one.[19] The financial contract between the bank and domestic firms is the same here as in the closed economy case. In particular, the bank which receives control rights on the defaulted firms decides on the liquidation rate, λ. Therefore this open economy is similar to the closed economy in the previous sections, while international investors supply additional capital in the first period. It also follows that $\bar{k}>k$, that is, an open economy has more initial capital due to additional lending provided by international investors.[20]

At the end of the first period, the bank receives $d(1-N_f)$ from

18) Given that the bank can be viewed as a composite of the central bank and commercial banks, this assumption implies that there is no national default.

19) In the current model, we do not explicitly introduce domestic investors, while the bank can be viewed to be owned by domestic investors. Of course, we would explicitly introduce domestic investors who can invest only at home. For example, we introduce domestic investors who invest k in the domestic bank in the form of equity and receive return at the end of the second period. The modification, however, does not alter the main results of the paper.

20) Assuming a positive k^F implies that the expected rate of return from investing in this country in the first period $(=\int_{\theta^l}^{\theta^u}[x\pi(\theta_1)+(1-x)\delta(\theta_1)]d\theta_1)$ is not less than the international interest rate $(=r_1)$. Positive foreign capital also implicitly implies that opening capital markets is beneficial to the receiving country as well. To explicitly incorporate the benefits of capital market opening, we may introduce, for example, domestic labor into the production function as $y_t=A\,k_t^{\alpha}\,n_t^{1-\alpha}$. Then the rise in k^F will raise the return to the domestic workers, which would raise the welfare of the economy.

the firms that had a positive productivity shock. It also gets λLN_f from liquidating λ fraction of defaulted firms, as in the closed economy case. But the bank repays D to international investors.

In the beginning of the second period, the bank lends $d(1 - N_f) + \lambda LN_f - D$ to the firms that have not defaulted in the first period. Hence each non–defaulted firm receives additional capital amounting to $d + \lambda LN_f \ / \ (1 - N_f) \ - \ D \ / \ (1 - N_f)$ from the bank, while each firm that has defaulted but bailed out does not receive any additional capital.

Information asymmetry exists between the bank and international investors. The bank knows which firms defaulted in the first period, based on which firms pay d to it. International investors cannot observe which are defaulting, but can observe which are liquidated.

Given the information structure, the bank's liquidation rate may provide some information on defaulted firms to international investors. In particular, the higher liquidation of the defaulted the bank makes, the more information international investors acquire. In case of zero liquidation (full bailout), international investors cannot acquire any information on which have defaulted. With full liquidation, however, they can make perfect information on which have defaulted. In case of partial liquidation, they can get partial information on defaulted firms (recall that the information is useful to distinguish between good and bad firms).

In the second period, international investors may reinvest all of D to this country or take X (among D) abroad, using the information derived from the bank's liquidation rate. In case of reinvesting in the country $(D - X > 0)$, they lend to the firms of their own choice, not through the domestic bank. This assumption reflects the expansion in information set of the international investors after the bank makes decision on liquidation. The financial contract in the second period specifies that international investors receive η for a unit of lending from each firm that has a positive productivity shock, but nothing from the firm that has an adverse productivity shock in the second period. In this way, international investors here are assumed to be debt-holders, which reflects the fact that private debt flows to developing countries have been far greater than portfolio equity flows. In 1995, for example, the former reached $53.3 billion while the latter remained at $22.2 billion.[21)]

(2) *Expected Rate of Return*

International investors' decision on capital outflow depends on the expected rate of return they will receive from reinvesting in the country. The expected rate of return is determined as follows.

Let F denote total capital reinvested in the economy by international investors in the second period, that is,

$$F = D - X \tag{33}$$

21) The dominance of international debt over portfolio equity and FDI flows would reflect information asymmetry between local and foreign investors, under which foreign investors would prefer lending rather than equity investment. In addition, they would prefer short-term lending (as one-period loan in our model) rather than long-term lending, because the former would allow them to better respond to new information. Razin, Sadka and Yuen(1998) present a model where information asymmetry exists between domestic and foreign residents, and analyze the optimal taxes that differ across debt, equity and direct investment finance.

International investors would lend only to the firms that were not liquidated. The measure of the non–liquidated firms is

$$(1 - N_f) + (1 - \lambda)N_f = 1 - \lambda N_f \tag{34}$$

Given that international investors only know which firms are liquidated, they would not be able to perfectly distinguish between the defaulted and the non–defaulted unless in the case of full liquidation. To pool the risk, risk–averse international investors lend the same amount of capital to all the non–liquidated firms. Given a continuum of the firms, such equal distribution of lending across non–liquidated firms allows international investors to fully diversify the risk.

The amount of capital that they lend to each non–liquidated firm is:

$$\frac{F}{1 - \lambda N_f} \tag{35}$$

Given that international investors receive η for a unit of lending from each firm that has a positive productivity shock, the expected return to international investors, denoted by Π, is

$$\begin{aligned}\Pi &= \eta[(x\pi_1)\pi_1 + ((1-x)\delta_1)\delta_1]\left(\frac{F}{1-\lambda N_f}\right)\\ &+ \eta[(x(1-\pi_1))(1-\lambda)\pi_1 + ((1-x)(1-\delta_1))(1-\lambda)\delta_1]\left(\frac{F}{1-\lambda N_f}\right)\\ &= \frac{\eta}{A}[w + z(1-\lambda)]\left(\frac{F}{1-\lambda N_f}\right)\end{aligned} \tag{36}$$

The expected rate of return per unit of lending made by international investors, denoted by R_2, is then given by

$$R_2 = \frac{d\Pi}{dF} = \frac{\eta}{A}\left[\frac{w + z(1-\lambda)}{1-\lambda N_f}\right] \tag{37}$$

Therefore the expected rate of return to international investors depends on the liquidation rate (λ), and aggregate shock (θ):

$$R_2 = R_2(\lambda, \theta). \tag{38}$$

For simplicity, we make the following assumption.

Assumption 5 $wN_f - z(1-N_f) > 0$ *for all* $\theta_1 \in [0,1]$.

An example which satisfies the assumption is where the support of θ_1 is [0,1],

$$\begin{aligned} \delta_t &= 0, \quad \pi_t = \pi^l + (\pi^u - \pi^l)\theta_t \\ \pi^u &= 1, \quad and \quad \pi^l \in (0,1) \end{aligned}$$

since in this case $wN_f - z(1-N_f) = (1-x)x\pi^2 > 0$.

Under Assumption 5, it holds

$$\frac{\partial R_2}{\partial \lambda} = \frac{\eta}{A}\left[\frac{wN_f - z(1-N_f)}{(1-\lambda N_f)^2}\right] > 0 \tag{39}$$

which suggests that more liquidation of defaulting firms by the bank induces higher expected rate of return to international investors. This intuitively appeals because higher liquidation improves the quality composition of the firms to which international investors lend in the second period.

(3) *Optimal Capital Outflows during Recessions*

International investors' decision on capital outflows $X(\geq 0)$ (alternatively their investment in this country in the second period, $F = D - X$) is made after the bank has made its bailout decision (λ). Their optimal decision on capital outflows depends on whether the exogenous world rate of interest in the second period, denoted by r_2, is greater than the rate of return from reinvesting in the country, R_2, which in turn depends on the bank's decision on λ.[22]

Consider the case where the small open economy had a bad (country-specific) aggregate shock in the first period ($\theta_1 = \theta^l$). The bad economy-wide shock is likely to reduce the expected rate of return from reinvesting in the economy. Suppose that given the bad shock in the first period, the expected rate of return and the world rate of interest in the second period are given as

$$R_2(0,\theta^l) < r_2 < R_2(1,\theta^l) \tag{40}$$

That is, when there is a recession, the world rate of interest in the second period is greater than the rate of return from reinvesting in the economy in case of the bank's zero liquidation. But the former is lower than the latter in case of full liquidation.[23]

22) Our model focuses on the case where capital market opening, once implemented, cannot be reversed regardless of world interest rates. Bartolini and Drazen (1997) examine the case where a rise in world interest rates induces some of the countries that have liberalized their capital market in time of low world interest rates, to impose controls to trap capital onshore.

23) We here focus on the case of adverse country-specific shock (not adverse

Given eq. (39) and (40), there exists $\lambda^x \in (0,1)$ such that

$$R_2(\lambda^x, \theta^l) = r_2 \tag{41}$$

that is, there exists a liquidation rate which equalizes the rate of return from reinvestment with the world interest rate.[24]

Given the bank's decision on λ, international investors' optimal capital outflow is determined as follows. First, consider the case where the bank sets the liquidation rate of defaulting firms as: $\lambda \geq \lambda^x$. Then $R_2(\lambda, \theta^l) \geq r_2$. In this case, we have $X = 0$ (alternatively $F = D$). That is, international investors will not move capital out of the country (therefore fully reinvest in the country).[25]

Second, consider the case where the bank sets the liquidation rate as $\lambda < \lambda^x$. In this case, the rate of return for reinvestment in the

global shock), where with full bailout the home country's rate of return would fall far below the world rate of interest. This case matches well the 1997–98 Asian financial crisis when the crisis-hit countries suffered severe recessions while the US economy enjoyed a rapid economic growth (with the rate of growth above 4 percent). Razin and Rose (1994) analyzes how whether a shock is country-specific or global affects the correlation between the degree of capital mobility and the volatility of investment and output.

24) We can explicitly calculate λ^x from $R_2(\lambda^x, \theta^l) = \frac{\eta}{A}\left[\frac{w + z(1-\lambda^x)}{1-\lambda^x N_f}\right] = r_2$.

25) Here we implicitly assume that there is no cost paid by international investors when they take capital out of the country. Of course, we may instead assume a positive cost of taking capital out as τF, where $\tau > 0$. Then international investors' decision on capital outflow depends on whether the rate of return from reinvesting in this country (R_2) is greater than $(r_2 - \tau)$ or not.

economy is lower than the international rate of interest: $R_2(\lambda, \theta^l) < r_2$ Therefore international investors will take all of their capital out of the country, that is, $X = D$ (alternatively $F = 0$).

The above discussion suggests that international investors' optimal capital outflow (X^*) is a function of the bank's liquidation rate, λ:

$$X^* = \begin{cases} D & \text{if } \lambda < \lambda^x \\ 0 & \text{if } \lambda \geq \lambda^x \end{cases} \tag{42}$$

2. Optimal Bailout in an Open Economy

Now we examine the behavior of the domestic bank, another key agent, which takes international investors' optimal decision on capital outflow into consideration, and explore how the bank's optimal bailout decision is determined in an open economy in time of recession.

(1) *Cost due to Capital Outflows*

An abrupt capital outflow by international investors may incur huge costs to the domestic economy. This cost may reflect the premature completion of production as in Diamond and Dybvig (1983) or the shortage of working capital. For simplicity assume that the cost due to abrupt capital outflow for the economy is borne by the domestic bank.

To introduce the cost in a simplest way, assume that the cost due to capital outflow, denoted by C, is assumed to be proportional to capital outflow, X:[26)]

26) The cost function may be formulated in different ways. For example, the cost may be formulated to be proportional to total output of the

$$C = \beta X = \beta(D - F) \tag{43}$$

where β is a cost coefficient. The cost function tells us that a larger capital outflow incurs heavier costs to the domestic economy (or the bank).

Recall that the bank receives ϕ fraction of the output of the firms at the end of the second period in an open economy, as in a closed economy. But the amount of capital employed by the firms in the open economy case differs from that in the closed economy case. For a surviving (or non-defaulted) firm, the amount of capital employed for production in the second period is:[27]

$$k_2 = (\bar{k} + A\bar{k}^{\alpha}) - \frac{D}{1 - N_f} + \frac{F}{1 - \lambda N_f} + \lambda \frac{N_f}{(1 - N_f)} l\bar{k}. \tag{44}$$

For a firm that failed but was bailed out, the amount of capital is given by:

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economy in the second period rather than to capital outflow. Or the cost coefficient β may be formulated to take on $\beta^h(>0)$ or $\beta^l(=0)$ depending on whether capital outflow (or the share of capital outflow among total capital of the economy) exceeds some threshold level or not. These variant models, however, do not alter the main qualitative results of the paper.

27) To derive (44), note that for a non-defaulted firm, k_2 is given by: $k_2 = (\bar{k} + A\bar{k}^{\alpha}) - d + k_a$. In addition, each non-defaulted firm receives additional capital amounting to $d + \frac{\lambda L N_f}{1-N_f} - \frac{D}{1-N_f}$ from the bank. It also receives $\frac{F}{1-\lambda N_f}$ from international investors, which leads to: $k_a = d + \frac{\lambda L N_f}{1-N_f} - \frac{D}{1-N_f} + \frac{F}{1-\lambda N_f}$.

$$k_2 = \bar{k} + \frac{F}{1-\lambda N_f}. \tag{45}$$

Therefore, the expected value of the return to the bank in case of open economy, denoted by V^{open}, is

$$\begin{aligned} V^{open} &= \phi w \left[\bar{k} + A\bar{k}^{\alpha} - \frac{D}{1-N_f} + \frac{F}{1-\lambda N_f} + \lambda \frac{N_f}{(1-N_f)} l\bar{k} \right]^{\alpha} \\ &+ \phi(1-\lambda) z \left[\bar{k} + \frac{F}{1-\lambda N_f} \right]^{\alpha} - \beta X \end{aligned} \tag{46}$$

which suggests that capital outflow lowers V^{open} by βX.

We make the following assumption on the size of the cost due to capital flight.

Assumption 6 *The cost coefficient due to capital outflows (β) satisfies*

$$\beta > \frac{\phi z \bar{k}^{\alpha}}{D} \tag{47}$$

This assumption suggests that the damaging effect of capital outflows on the domestic economy exceeds a certain level.

(2) *Optimal Bailout during Recession*

Now we examine how the bank's optimal bailout decision is determined in an open economy in time of recession. Suppose that the economy had a bad shock in the first period ($\theta_1 = \theta^l$).

The bank seeks to maximize the return at the second period by choosing λ as in the case of a closed economy. In an open economy, however, the bank takes into account international investors' optimal decision on capital outflow in response to λ (or (42)) and the resulting costs.[28] Given that international investors' optimal capital outflow (X^*) depends on λ, V^{open} is expressed as a function of the liquidation rate: $V^{open} = V^{open}(\lambda)$. So given θ^l, the bank solves the following maximization problem:[29]

$$\begin{aligned}\max_{\lambda\in[0,1]} V^{open}(\lambda) &= \phi w\left[\bar{k} + A\bar{k}^\alpha - \frac{D}{1-N_f} + \frac{D-X^*}{1-\lambda N_f} + \lambda\frac{N_f}{(1-N_f)}l\bar{k}\right]^\alpha \\ &\quad +\phi(1-\lambda)z\left[\bar{k} + \frac{D-X^*}{1-\lambda N_f}\right]^\alpha - \beta X^* \\ \text{s.t. eq. (42)} & \qquad\qquad (48)\end{aligned}$$

To solve the optimization problem, first note that for a range of $\lambda\in[0,\lambda^x)$ we have $X^* = D$ and $\frac{\partial X^*}{\partial\lambda} = 0$ (as clear from (42)). So the derivative of V^{open} with respect to λ for $\lambda\in[0,\lambda^x)$, is given by

28) We may instead assume that the bank (or the central bank) maximizes net national income (which is $Y - C - \Pi$ where Y is total domestic output). It can be shown, however, that this variation of the model does not alter the main qualitative results of our paper.

29) We may explicitly introduce labor as another input in the production function, and assume that the bank would seek to maximize net income of the economy including labor income by the choice of λ. In this case, capital outflow would lower labor income in addition to the cost due to sudden outflows. Hence, in the variant model, the bank (or the central bank) would have stronger incentive to prevent capital outflow, while the main qualitative results of the paper continue to hold.

$$\frac{\partial V^{open}}{\partial \lambda} =$$

$$\phi w \alpha \left[\bar{k} + A\bar{k}^{\alpha} - \frac{D}{1-N_f} + \lambda \frac{N_f}{(1-N_f)} l\bar{k}\right]^{\alpha-1} \left[\frac{N_f}{(1-N_f)} l\bar{k}\right] - \phi z \bar{k}^{\alpha} \tag{49}$$

Putting $\frac{\partial V^{open}}{\partial \lambda} = 0$ yields the solution (denoted by λ^0) as:

$$\lambda^o = \left[\left(\alpha l \frac{\frac{w}{(1-N_f)}}{\frac{z}{N_f}}\right)^{1/(1-\alpha)} - 1 - A\bar{k}^{\alpha-1} + \frac{D}{(1-N_f)\bar{k}}\right] \frac{(1-N_f)}{lN_f} \tag{50}$$

Similarly to $M(\theta_1)$ in a closed economy case (eq. (23)), we define:

$$M^o(\theta_1) \equiv \left[\left(\alpha l \frac{\frac{w}{(1-N_f)}}{\frac{z}{N_f}}\right)^{1/(1-\alpha)} - 1 - A\bar{k}^{\alpha-1} + \frac{D}{(1-N_f)\bar{k}}\right] \tag{51}$$

and express λ^0 as:

$$\lambda^0 = M^0(\theta_1) \frac{(1-N_f)}{lN_f} \tag{52}$$

By comparing between (23) and (51), we have[30)]

$$M^o(\theta_1) = M(\theta_1) + \frac{D}{(1-N_f)\bar{k}} + [Ak^{\alpha-1} - A(k+k^F)^{\alpha-1}]. \tag{53}$$

30) In a closed economy, it holds that $\bar{k} = k$, $F = 0$ and $D = 0$. Therefore, V^{open} is reduced to V. In addition, $M^0(\theta_1)$ becomes $M(\theta_1)$.

Since $\frac{D}{(1-N_f)k}+[Ak^{\alpha-1}-A(k+k^F)^{\alpha-1}]>0$, it follows that

$$M^o(\theta_1)>M(\theta_1) \tag{54}$$

which tells us that $M^o(\theta_1)$ is greater than $M(\theta_1)$.

Given $\theta_1=\theta^l$ and Assumption 4, there are two cases depending on the sign of $M^o(\theta^l)$. First, there is a case where

$$M(\theta^l)<0 \;\; and \;\; M^o(\theta^l)>0. \tag{55}$$

Given Assumption 4 (or $M(\theta^l)<0$), the optimal solution in a closed economy is always given as: $\lambda^{closed}=0$, that is, zero liquidation (alternatively, full bailout) as shown in the previous section. Given that $M^o(\theta^l)>0$, however, the liquidation rate for an open economy which maximizes V^{open} for a range of $\lambda\in[0,\lambda^x)$ is positive, that is, $\lambda^o>0$. Since the liquidation rate that maximizes V^{open} for $\lambda\in[0,1]$ should not be lower than λ^o, we have

$$\lambda^{open}\geq\lambda^o>0 \tag{56}$$

which suggests that in this case the bank's optimal liquidation rate in an open economy is positive, and therefore greater than in a closed economy.

Second, consider the case

$$M(\theta^l)<0 \;\; and \;\; M^o(\theta^l)<0. \tag{57}$$

Given $M^o(\theta^l)<0$, the derivative of V^{open} for $\lambda\in[0,\lambda^x)$ is given by

$\frac{\partial V^{open}}{\partial \lambda} < 0$, which gives

$$V^{open}(0) > V^{open}(\lambda) \quad \textit{for all } \lambda \in (0, \lambda^x) \tag{58}$$

which suggests that among $\lambda \in [0, \lambda^x)$, $\lambda = 0$ maximizes V^{open} as in a closed economy.

In this case, however, capital outflow incurs substantial costs. Given Assumption 6, it can be shown that

$$V^{open}(0) < V^{open}(1) \tag{59}$$

This suggests that the cost due to capital outflow is so large that the value of the return to the bank in case of full bailout ($\lambda=0$) leading to an abrupt capital outflow is lower than in case of full liquidation ($\lambda=1$).

Further, let λ^u denote the liquidation rate which maximizes V^{open} for a range of $\lambda \in [\lambda^x, 1]$ (that is, $\lambda^u = argmax_{\lambda \in [\lambda^x, 1]} V^{open}$). Then it holds

$$V^{open}(\lambda^u) \geq V^{open}(1) \tag{60}$$

From (58), (59) and (60), we then have

$$V^{open}(\lambda^u) > V^{open}(\lambda) \textit{ for all } \lambda \in [0, \lambda^x] \tag{61}$$

which gives the optimal liquidation rate in an open economy, denoted by λ^{open}, as:

$$\lambda^{open} = \lambda^u \geq \lambda^x \tag{62}$$

This suggests that the optimal liquidation rate in an open economy exceeds that in a closed economy at least by λ^x. As far as λ^x is far above zero, the optimal liquidation rate can be far greater in an open economy than a closed economy.

Therefore, the following proposition is established:

Proposition *Under Assumptions 1–5, it holds that*

$$\lambda^{open}(\theta^l) - \lambda^{closed}(\theta^l) > 0. \tag{63}$$

With an addition of Assumption 6, it holds

$$\lambda^{open}(\theta^l) - \lambda^{closed}(\theta^l) \geq \lambda^x (> 0) \tag{64}$$

The proposition implies that in recessions, the optimal liquidation rate is higher in an open economy than a closed economy. Particularly in case of huge costs due to capital outflow, there can be a sharp increase in the bank's optimal liquidation rate when moving from a closed economy case to an open economy case.[31] The intuition behind the proposition is clear. Given the persistence of productivity shocks, a bad productivity shock today could lower the productivity of the firms at least in the near future. If the bank bails out all the defaulting firms in an open economy (as in the closed economy case), many of bad firms would be operating alongside good firms in the second

31) In this section, we focus on the case of recessions ($\vartheta_1 = \theta^l$). As (54) suggests, however, it holds that for any $\theta \in [\theta^l, \theta^u]$, the optimal liquidation for an open economy is not lower than that of a closed economy.

period. As a result, the quality composition of the firms in the domestic corporate sector would not be good enough, and the rate of return to international investors' reinvestment would not be high enough to meet the world rate of interest. Consequently they would take capital out of the country. Given that the cost due to capital outflow is huge, the domestic bank would try hard to prevent capital from massively flowing out. To protect capital outflow, the bank should raise the rate of return to international investors high enough to meet the international rate of interest. For this, a structural reform facilitating a sharp increase in liquidation rate is warranted.

The need for higher liquidation in an open economy is in contrast to the optimal liquidation in a closed economy. In a closed economy, an adverse aggregate productivity shock is more likely to induce a low liquidation rate. It is because a bad aggregate shock, which affects negatively many good firms as well, makes it difficult for the bank to distinguish between good and bad firms. By contrast, in an open economy, low liquidation would be very costly to the extent that it induces substantial capital outflows. Therefore, structural reforms through a high liquidation would be necessary during recessions or economic crises.

V. Conclusion

This paper analysed the impact of an economy-wide productivity shock on the optimal bailout policy of the bank towards defaulted borrowers both in a closed and an open economy context. Closed economies are immune to risks related to capital outflows. As a result, the cost of bailing out defaulted firms in recessions is lower than in booms and the bailout ratio is higher in the former case. Liberalized capital markets put extra pressure on the domestic bank when it makes its optimal bailout decisions – failure to restructure a large enough number of firms (by not bailing them out) risks a capital outflow and the subsequent financial crisis. In a small open economy, the return on capital has to be above the world rate of interest in order for international investors to invest (stay) in the country. As a result, the optimal bailout rate may be lower in an economy with liberalized capital markets than that in a closed economy. This explains why the liquidation of defaulted firms have increased sharply after the Asian financial crisis in those East Asian countries with more liberalized capital markets

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