

ESSAYS ON BANKING CRISES AND DEPOSIT INSURANCE

A Dissertation

by

WEN-YAO WANG

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2008

Major Subject: Economics

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ABSTRACT

Essays on Banking Crises and Deposit Insurance. (August 2008)

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My research focuses on the reasons for banking crises and the corresponding policy rules that could help prevent such crises. This abstract briefly reviews the two essays in my dissertation. The first essay focuses on the optimal mechanism design of the deposit insurance system while the second essay studies the impact of international illiquidity on domestic banking crises.

The Recent Deposit Insurance Reform in the U.S. raised the coverage limit for certain types of deposits. In chapter II, I study the optimal coverage limit in a model of deposit insurance in the banking system. Because of the coverage limit, depositors have incentives to monitor the bank's risk-taking behavior, threatening banks with the withdrawal of deposits if necessary. The model includes risk-taking banks, heterogeneous depositors, and a benevolent insurance company providing deposit insurance. I find that partial coverage combined with risk-sensitive premia in the presence of capital requirements can improve social welfare and manage banks' risk-taking behavior. Moreover, when a partial coverage limit is in place, banks are better off by finding a balance between the higher premia and the depositors' monitoring and withdrawals.

Unlike chapter II, chapter III focuses on the role played by international illiquidity. I build a dynamic general equilibrium model (DGEM) of a small, open economy. The features I include in the model are nontrivial demands for fiat currencies, unanticipated sunspots, and financial/banking crises originated by sudden stops of

foreign capital inflows are. This chapter gives us a better understanding of the performance of alternative exchange rate regimes and associated monetary policies under a simple setup. I show the existence of multiple equilibria that may be ranked based on the presence of binding information constraints and on welfare. Moreover, I show that a strong connection of the scope for existence and for indeterminacy of equilibria with the underlying policy regime. I also find that the presence of binding multiple reserve requirements help in reducing the scope for financial fragility and panic equilibria.

To my *father, mother, sisters, and husband*

ACKNOWLEDGEMENTS

I would like to thank my committee chair, Dr. Gan, and my committee members, Dr. Jansen, Dr. Hernandez-Verme, and Dr. Bessler, for their guidance and support throughout the course of this research.

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CHAPTER I

INTRODUCTION

Obviously, current sub-prime mortgage turmoil in the U.S. has brought the banking and financial crises to the forefront of the public. Volumes of the literature have summarized elaborately the evolution of the development of the crises. First, crises may occur due to the mismanagement and the inappropriate manipulation of the public sectors. The ineffective defending of the exchange rate is one of the possibilities when we talk about currency crises in Latin American in 1960s and 70s. Crises could happen once the government cannot afford to defend the peg of the exchange rate. The fixed exchange rate regime will then collapse accompanying with the huge losses of the foreign reserves. Another possibility may provoke crises is associated with the imbalanced fiscal deficits and improper monetary expansion of the government. One example is the hyperinflation situation in Germany in 1920s. The wholesale price index in the year of 1923 is more than 700,000,000,000 if we use 1914 as a based year for indexing. Domestic currency is worthless because of the rapid growth in money supply and out of control inflation.

Then, the concerns of the public and the academia move to the self-fulfilling prophecy in a model of a banking crisis. In a traditional Arrow-Debreu setup, bank is a redundant sector. Diamond and Dybvig's (1983) paper provided a model of crises that emphasizes the role played by financial institutions and domestic banking system. Banks provide insurance and liquidity for depositors in the environment with uncertainty. Even though the deposit contracts will provide a superior allocation than the one in a pure exchange economy, expectation of depositors might generate an unanticipated crisis.

This dissertation follows the style and format of the Journal of Monetary Economics.

Depositors are born identically. However, depositors' withdrawal decisions depend on their own types which will be realized later and the expectation of what actions other depositors will take. Expectation of the people may vary; either because of the shock to the fundamental such as preferences, endowments, and technologies or will be affected by any event which may be totally unrelated to the fundamental of the economy. The latter is known as the shock of a sunspot¹. In chapter III of my dissertation, I will amplify the self-fulfilling prophecy; either the unnecessary panic among domestic depositors or the panic among foreign creditors might trigger crises. In the model, ex-ante identical domestic agents face the uncertainty of their types. The realization of depositors' type is private information. There is a standard problem in coordination that may lead to crises of a self-fulfilling type.

The evolution in the modern literature of crises does not stop here. Unlike the studying focuses on the huge government deficits and the self-fulfilling prophecy, the overexpansion of the private sector also provokes much discussion in the contemporary literature. Financial liberalization and deregulations accelerate international capital flows. Domestic banking system is the one which has direct access to deal with the great amount of free floating funds. In chapter III of my dissertation I call attention to the international illiquidity in a small open economy to reproduce several aspects of the East-Asian countries at the time of the crisis. The interaction between domestic banking system and foreign creditors is meant to provide a rigorous basis for the foundation to analyze the Asian crisis in 1997. In this chapter, I investigate the overexpansion of credit and the increasing risky behavior of domestic banking system. More importantly, I study the appropriate tight monetary policy in the form of reserve requirements to prevent bank run. A dynamic general equilibrium model with fiat currencies is introduced. This setup will allow us to extend the research easily to the comparison between different monetary policies and various exchange rate regimes. Private sector is a net debtor of the rest of the world, and there is an exogenous upper limit to foreign credit at each point in time. Depositors are born identically but face uncertainty. Crises come into the model in

¹ Please see *The New Palgrave Dictionary of Money & Finance* (1992, P.601) for more discussion and the definition of the sunspot equilibrium.

the form of sudden stops of foreign credit and/or the possible unreasonable panics among depositors. This research aims at giving a more accurate policy suggestion that prevents the crisis from the over-expansion of the banking sector. To set the stage for what I try to study, both domestic and foreign fiat currencies circulate in the economy. Domestic investment is subject to multiple reserve requirements that take the form of currency reserves. I find that the reserve requirements will prevent the panic and run equilibrium from happening.

Besides, the concerns about pervasive banking crises induce and lead many countries to provide deposit insurance. “After all, there is an element in the readjustment of our financial system more important than currency, more important than gold, and that is the confidence of the people themselves”, said by President Franklin in his first Fireside Chat. Indeed, adopting deposit insurance at the time of the crises will not only protect small depositors, restoring the confidence of the people and preventing the unnecessary panic and runs might be the most important task. The U.S., for example, has adopted deposit insurance at the time of the Great Depression in 1933. While D-D model proved that the deposit insurance may successfully prevent run equilibrium, an accompanying moral hazard concerns have never been forgotten since the very first stage when the U.S. adopted deposit insurance. The U.S. Savings & Loan (S&L) crisis in 1980s, which resulted in approximately 3.2 percent of the GDP in the year of the crisis, has pointed to the central problem, the moral hazard of deposit insurance. Releasing geographical barriers of the branches increased competition among banks. Abolishing the Regulation Q lowered the banks’ charter values even further to the point banks engage risky banking practices. Then, under the protection of the deposit insurance, banks shift losses, the negative consequence of risk, to the FDIC easily.² As a consequence, bank’s moral hazard problem will put on great risk on deposit insurance funds. The relatively low capital-to-asset ratios made the owners of the banks felt less inhibited from taking excessive risks with depositors’ funds. All of the reasons listed

² As the explanation made in Keeley (1990), if the bank is insolvent but with a valuable charter, once the bank is assumed and purchased by the FDIC, the owner of the bank cannot trade and sell the franchise anymore. Therefore, if the bank has a valuable charter as asset, the owner of the bank will limit and manage the risk of failure.

above would give banks an incentive to take excessive risks, which is what we called moral hazard. Moreover, deposit insurance worsens the moral hazard problem by reducing the motivation for depositors to monitor and supervise the banks' gambling behavior.

Banks' excessive risk-taking and gambling behavior under the environment with imperfect information is what we call moral hazard. If banks' investment decisions are very costly to observe, banks tend to take higher risks than the level the FDIC is desirable. Since banks respond to incentives, I discuss whether partially-covered deposit insurance can manage banks' excessive risk-taking behavior in chapter II in my dissertation. It is interesting to see whether deposit insurance system will be devastated by the moral hazard problem and eventually increase the risk for banks to default. The merit of the deposit insurance is to prevent bank run and the chaos in financial market; however, it may in turn induce excessive risk-taking and run. Depositors who under the safety net of deposit insurance tend to pay less attention about the banks' excessive risk taking. Weakened market discipline also aggravates the moral hazard problem in banking system. In this chapter of my dissertation, I attempt to investigate the optimal mechanism design of deposit insurance. In particular, I focus on how the policies instrument such as risk-sensitive premium and capital requirements can be used to manage banks excessive risk-taking problem in an environment in which banks have incentives to gamble while motivated depositors monitor. As will be discussed later in chapter II, a partially covered deposit insurance system will provide an incentive for depositors to monitor and further manage the banks' moral hazard problem. This is the main access to reinforce the market discipline.

The financial markets are contagious and sensitive to various reasons that might trigger crises and bank runs. To give a complete perspective of the evolution of the crises, we should not neglect the recent sub-prime mortgage crisis happened in the U.S. This turmoil of the sub-prime mortgage crisis rooted in the housing markets could be another generation model of the crises. The moral hazard problem of the financial institutions mixed with the self-fulfilling prophecy among depositors and creditors give us another possibility to think about. My research will be extended toward this direction.

Competition among financial institutions and mortgage companies encouraged the risky behavior of making loans to sub-prime mortgage borrowers. The subsequent slowdown of the housing price boom and the burst of the housing bubble narrowed the chance for borrowers to refinance their mortgages. Hence, default rates and the number of home foreclosures are skyrocketing. It could be the first symptom toward the crisis. Liquidity concerns and increased risk aversion among banks made things worse by driving up the interest rates on loans. The widespread credit crunch and the potential banking crises can be seen as a consequence of the self-fulfilling panic withdrawals.

It is hard to clarify and pinpoint the cause of the crisis because crises usually blend with the surroundings. However, studying a specific type of crises, such as Asian crises or the crises triggering by moral hazard, can help us concentrate on the issue of what appropriate policy is to prevent bank runs. The rest of the dissertation is organized as follows. In chapter II, I first investigate the partial deposit insurance and the moral hazard in banking. When we talk about deposit insurance, one issue has always received lots of attention is how to price. In this chapter, how to determine an optimal coverage limit plays a central role in the theoretical model. The welfare-maximized coverage gives a reason for depositors to monitor. Then, I move from a partial equilibrium model in a closed economy to a small open economy with dynamic general equilibrium model. Mainly focusing on the international illiquidity in chapter III, I discuss how financial fragility might be influenced by different exchange rate regimes and, more importantly, the corresponding monetary policies. Tight monetary policy comes in the model in a form of reserve requirements. I find that this policy could be an appropriate policy to prevent bank run. Finally, I make a brief conclusion of my research and list some possible vehicles for future extensions in chapter IV.

CHAPTER II

PARTIAL DEPOSIT INSURANCE AND MORAL HAZARD IN BANKING

Countries with deposit insurances differ significantly on how much protection their deposit insurance would provide. The Deposit Insurance Reform in the U.S. in 2005 raised the coverage limit for retirement accounts. This paper studies the optimal coverage limit in a model of deposit insurance with capital requirements and risk sensitive premia. The model includes risk-taking banks, heterogeneous depositors, and a benevolent insurance company providing deposit insurance. I find that partial coverage combined with risk-sensitive premia in the presence of capital requirements can improve social welfare. Because of the partial coverage limit, depositors have incentives to do part of the monitoring of the bank's risk-taking behavior, threatening banks with withdrawals of deposits if necessary. Moreover, banks are better off by finding a balance between the premia and withdrawals by depositors.

2.1 INTRODUCTION

Countries differ significantly on how much protection their deposit insurance would provide. Most developed countries have a smaller coverage limit as a percentage of per capita GDP than developing countries (Demirguc-Kunt and Kane, 2002). In the U.S., the most recent deposit insurance reform, the Federal Deposit Insurance Act of 2005, has increased the coverage limit for retirement accounts to \$250,000, and this coverage limit would also be indexed to inflation adjustment in the future.

Raising the coverage limit, on the one hand, increases consumer's protection; on the other hand, however, it may create disincentives for depositors to monitor the banks' risk-taking behavior. Greenspan (2002) provided a great annotation for this moral hazard problem:

The market discipline to control risks that insured depositors would otherwise have imposed on banks and thrifts has been weakened. Relieved of that discipline, banks and thrifts naturally feel less inhibited from taking on more risk than they would otherwise assume. This incentive to take excessive risks is the so-called moral hazard problem of deposit insurance, the inducement to take risk at the expense of the insurer.³

The empirical evidence supports Greenspan's statement. Using a panel of 71 countries, Demirguc-Kunt and Detragiache (2002) show that countries with higher coverage limits would have higher probabilities of banking crises.

Thus, raising the coverage limit, while benefiting consumers, seems to contradict the goal of reducing the moral hazard problem. This contradiction has been discussed since the beginning of the deposit insurance system. It is indeed the case that widespread deposit insurance can easily achieve the goal of protecting small depositors and of preventing them from panicking; however, generous coverage limit encourages the excessive risk-taking behavior by financial institutions. Thus, it is necessary to build up a model of an optimal coverage limit. My optimal coverage model emphasizes the active role by the depositors in helping reduce the bank's excess risk-taking behavior. Under the partially-covered deposit insurance, rich depositors can credibly threaten the bank by monitoring and early withdrawals. As a consequence, the owners of the bank tend to choose prudently the investment combinations.

The literature on deposit insurance has not yet offered a model of optimal coverage. The existing models on resolving the moral hazard emphasizes the roles of capital requirement and risk-sensitive premia, under the assumption of full deposit insurance (Hellmann, Murdock, Stiglitz, 2000; Cooper and Ross, 2002). This assumption of full insurance is not consistent with the empirical evidence. My model suggests that the coverage limit can be an effective policy tool to manage moral hazard.

³ The Testimony of Chairman Alan Greenspan, Paragraph 7.

Because of the partial coverage limit, the depositors have an incentive to do part of the monitoring of the banks' risk-taking behavior, threatening banks with early withdrawal of deposits if necessary. Banks could be better off by finding a balance between the higher premia and the depositor's monitor and withdrawals. In addition, the coverage limit derived from the welfare maximization problem in this model provides us with an alternative method to the option pricing method in obtaining the appropriate coverage limit and risk premium.

Coverage limit varies across countries. Demirguc and Kane (2002) show that coverage limits among different countries may vary from a generous guarantee to a very tight limit. Using the ratio of the coverage limit to GDP per capita as a standard criterion, they find that some of the poor countries provide very generous coverage than the high-income countries. For example, Central African Republic, Chad, and Peru set up the coverage limits that are far above the deposits saved by their citizens. On the other hand, developed countries or relatively high-income countries tend to provide less protection. Austria, Belgium, Germany, and the United Kingdom have a coverage limit which is equal to or even less than the GDP per capita. The U.S. is counted as having an adequate coverage with the coverage limit three times greater than the GDP per capita. In addition, the authors observe that countries recently established the deposit insurance or revised the insurance system set up different coverage limits. Therefore, in this paper I study the optimal coverage limit and its effect on moral hazard.

Hellmann, Murdock, and Stiglitz (2000) argue that both the capital requirement and the deposit interest rate control are necessary for resolving the moral hazard problem. Banks are not willing to hold capital to an unlimited amount since the cost of the internal capital is greater than the return from a safe asset. Due to a simple revealed preference, the only reason banks finance the investment through capital is because of capital requirements. This policy puts shareholders at risk and may successfully suppress banks' gambling behavior. Deposit interest rate controls have not been in effect since the regulation Q was removed in 1986 in the U.S. Without further regulations, banks compete with each other by offering higher interest rates. In order to compensate

missing profits, banks will engage in risky banking practices. Cooper and Ross (2002) find that capital requirements coupled with full deposit insurance will support the first-best allocation without bank runs and monitoring from depositors. Their paper extends the traditional Diamond and Dybvig model to discuss moral hazard problem. They find that complete deposit insurance alone will not support the first-best outcome and monitoring is unnecessary to achieve the best allocation. Under a fully-covered insurance system, banks may not have any incentive to maintain costly capital since depositors' unnecessary panics and runs described by Diamond and Dybvig (1983) will be prevented. Capital requirements in my study serve as a way to manage the moral hazard problem under the partial deposit insurance. Not only banking regulations, partially-covered insurance system also reawakens depositors' monitoring and self-protection through early withdrawals.

Empirically, many researchers have studied and elaborately illustrated the role of market discipline under deposit insurance. Barajas and Steiner (2000) show the ability of the Colombian deposit insurance system to limit moral hazard when considering market discipline. Demirguc-Kunt and Huizinga (2004) provide us with cross-country evidence that explicit deposit insurance lowers the market discipline on banks' risk-taking. While some of the literature shows that market discipline can be an effective way to restrain the bank's risk-taking behavior, Maechler and McDill (2003), on the other hand, find that depositors' discipline may be present, but the actual effect on reducing a bank's excessive risk-taking cannot be determined. Also, Bliss and Flannery (2000) find that market discipline may not be an effective tool, and banking regulations and supervisions need to be in place. While some publications have addressed the issue of market discipline on banks' risk-taking behavior, the empirical results of market discipline are ambiguous and remain unclear.

The main purpose of this paper is to provide a theoretical foundation for market discipline on maximizing social welfare. In this paper, I make an effort to examine how partial deposit insurance affects market discipline through depositors' optimal behavior in a circumstance under which a limited depository coverage limit, a risk-sensitive

premium and contingent capital requirements are introduced. One thing deserves the special emphasis when I compare this paper to the literature. The main reason causes crisis or bank run in the model is because of the unobservable gambling behavior in the banking system. The bank has a temptation to engage in risky assets and benefits from the higher expected return. Once the bank gamble loses, the bank might become insolvent and illiquidity. Therefore, there is a bank run in this paper. On the other hand, Diamond and Dybvig focus on the runs triggered by the private information among depositors. Depositors save to the bank at the beginning of the period and withdraw any time they want depending on their random realized types. If there is a shock, whether it is related or is totally unrelated with the fundamental of economy, panics among depositors might cause huge withdrawals. Deposit insurance can successfully prevent panicking among depositors but may worsen banks' excessive risk-taking behavior. Even though the reason triggers bank run may be different, under the partial deposit insurance, it is easy for us to discuss a panic situation among depositors. In order to do that, the sequential service constraint should be considered.

Focusing on the moral hazard problem addressed here, the main contribution of this paper is to tackle the joint determination of optimal coverage limit and optimal risk premium within a partial equilibrium model. In this model, the deposit insurance with limited coverage is essential to the effort of managing the moral hazard problem. Because of the partial coverage limit, the depositors have an incentive to do part of the monitoring of the banks' risk-taking behavior, threatening banks with early withdrawal of deposits if necessary. To introduce market discipline and moral hazard problem, three types of agents are introduced in the model. Banks display excessive risk-taking behavior. Depositors are ex-ante heterogeneous with different endowments, and a benevolent insurance company provides deposit insurance. I find that partial deposit insurance combined with risk sensitive premium in the presence of capital requirements can improve social welfare.

2.2 THE ENVIRONMENT

2.2.1 Depositors

Ex-ante heterogeneous depositors are introduced in this paper; depositors are born with different endowments. Depositors care about the consumption at the end of the day. For simplicity, I only consider two types of depositors in the economy. There is continuum of depositors with unit mass in the economy. With a fixed fraction q , a depositor was born with higher endowments D_1 , and belongs to the group of rich; otherwise, she/he has endowments D_2 , and belongs to the poor. D_1 is greater than D_2 . The exogenous fraction q is public information, which is known by the bank, depositors, and the Federal Deposit Insurance Corporation (FDIC).⁴ In reality, small depositors have a relatively large portion of total savers, so I assume that $q < 1-q$. Depositors will decide whether they would monitor the banks' behavior, and whether they will withdraw their deposits early. I also assume that depositors only have access to a storage technology. That is if they keep their endowments at the beginning of the period, what they will expect at the end of the day is the left over endowments they save in their secret vault without any interests earning. Therefore, a rational depositor will save her/his endowments to the bank if there is no risk of losing the deposits.

Even though introducing different types of depositors in the setting is similar to the traditional Diamond-Dybvig (DD) banking model, I need to emphasize that the role played by the depositors is totally different. In DD model, depositor's type is private information; she/he could either be impatient or be patient. The patient depositor's panic and withdrawal causes bank run. On the other hand, depositors in our model could either be the rich or be the poor. I do not discuss the private information problem among different types of depositors. The informational asymmetries come into the model in the

⁴ In order to focus on the hidden action of the bank's gambling behavior, we do not discuss the situation when there is private information. However, we can extend our model later when introducing the dynamic in the system. Once the type of a depositor is private information and the self-fulfilling prophecy is included, depositors' behavior becomes more unpredictable. Not only does the expected withdrawals from the rich depositors rely heavily on what they expect other people to do, the possibility of the free rider will also affect which equilibrium the society will achieve.

form of the unobserved gambling behavior in the bank. Monitoring and withdrawal from the rich depositors would be one of the possible solutions to prevent bank failure triggering by moral hazard.

2.2.2 Banks

There is a continuum of identical banks with unit mass in the economy. For simplicity, I consider the behavior of a representative bank. In this model, only the bank has access to investment technology. A representative bank forms its investment portfolio by choosing any combination between two assets: a prudent asset with certain return α , and a risky asset with a random realized return R , which belongs to a normal distribution $\sim N(\bar{R}, \sigma^2)$. \bar{R} is greater than α , and $\alpha > 1$.

While some literatures have considered the moral hazard addressed here, I extend the traditional banking model in a number of ways. The most important difference is introducing heterogeneous depositors. Different types of depositors might take different actions. Especially the rich depositors can give banks a credible threat by early withdrawal. Therefore, market participants' behavior will indirectly guide the bank to take the desirable action for which the whole society can be better off. Other than that, this model allows a more flexible investment technology; the bank can choose any gamble-prudent combinations to invest. The bank's moral hazard problem arises in this environment because of the hidden actions of its risk-taking behavior. Only the bank itself will know the amount invested in the risky assets. Since it is impossible or very costly for either depositors or the deposit insurer to observe the information, banks' excessive risk-taking behavior is the key in this model triggering bank run. In the literature, Hellmann, Murdock, and Stiglitz (2000) limited the portfolio in which the bank can choose in between either safety assets or the risky assets when discussing the moral hazard problem in banking. Even though Cooper and Ross (2002) modified the Diamond-Dybvig banking model by offering another riskier investment technology, the bank still faces the restricted choices of its investment portfolio.

2.2.3 The FDIC

The FDIC serves as the benevolent social planner, who cares about both the welfare of depositors and banks. If we assume that banks are in a perfectly competitive market, competition among banks leads to zero profit. We can expect a symmetric equilibrium in which all banks pay the same interest rate, r , for deposits, where $r > 1$. If that is the case, the welfare maximization problem for the FDIC simply becomes the one that maximizes only depositor's expected returns. Intuitively, the higher the deposit rates a bank is willing to offer, the more funds the bank might attract to finance its investment. Also, the higher the deposit rate a bank needs to pay, the more likely it is to engage in a risky investment portfolio⁵. I deviate from the perfect competition assumption among banks. The representative bank generates some normal profits from transferring the funds⁶. Therefore, the FDIC's problem maximizes the expected return of both depositors and the bank.

Under an explicit deposit insurance system, either one with full insurance or the one with a binding maximum coverage limit, the deposit insurer finances its projects and commits to its obligations by charging risk premia, P , among banks.

2.3 THE MODEL

I first consider the situation where there are no banks, the autarkic equilibrium. Since I assume that depositors have no access to the investment technology, the resources depositors are born with at the beginning of the period, $qD_1 + (1-q)D_2$, is the amount they can consume at the end of the day with depreciation rate β , where $0 < \beta < 1$. Under full information, Diamond and Dybvig (1983) provide the reason for banks to exist in our economy: the bank's deposit contract provides allocations superior to those of the pure exchange market. The bank not only provides liquidity, it also offers the insurance, which generates the return for depositors in each state of the world as closer as possible.

⁵ In a general equilibrium setting, interest rate is going to clear the market. However, in our model, we temporarily consider the partial equilibrium setting for simplicity, and will extend our model to the general equilibrium later.

⁶ See Boyd, Chang, and Smith (2002) for some discussions of the bank's normal profits.

In our model, the insurance is offered by the FDIC instead of the bank. The deposit contract becomes more complicated when private information and hidden actions occur in the model. If the bank's investment choices are hidden actions and cannot be observed by depositors and the deposit insurer, the bank's risk sharing facility might come with some cost, the moral hazard problem. In this section, I discuss three possible scenarios in the economy: without the deposit insurer in section 3.1, with the fully covered deposit insurance in section 3.2, and with the partial coverage insurance plan in section 3.3. Analyzing the coverage-determination process is important because the interaction among market participants relies heavily on the optimal coverage limit when we consider the moral hazard in banking. Therefore, I put more efforts to emphasize the benefits of the partial deposit insurance scheme, and investigate its effect to reduce the bank's moral hazard problem.

2.3.1 Without the FDIC

If there is no deposit insurer, the economy simply goes back to the situation in which the bank provides deposit contracts that transform the illiquid assets into liquid liabilities. The heterogeneous depositors decide how much they want to deposit, and whether they will monitor the bank's behavior. I assume that both the rich and the poor depositor face a fixed monitoring cost, d , which does not vary across different endowments. Since there is no deposit insurance in place, even the poor depositor, who was born with lower endowments D_2 , will engage in monitoring. If depositors engage in monitoring, they observe the true failing probability of the bank, P_F . On the other hand, if depositors are not willing to spend monitoring costs, d , they can only gather the information of the bank's failing probability, P_F^* , from the past information. Market discipline might come from the unprotected depositors in the economy. Without the FDIC, depositor's self-protection is necessary, and might arise either by asking for a higher deposit interest rate or by withdrawing early from the bank. No matter which action the depositors are going to take, monitoring is the first step towards an effective market discipline. With monitoring, depositors can observe the bank's failing probability in advance. The

opportunity cost of the depositor's monitoring is the potential interest she/he might earn from saving. I find an endogenous threshold for either the rich or the poor depositor to monitor. If

$$D_j > D^* = \frac{P_F \cdot d + (1 - P_F) \cdot rd}{(1 - r) \cdot P_F + r \cdot P_F^*}, \text{ where } j = 1, 2,$$

depositors are willing to monitor the bank's gambling behavior⁷. Given the bank's true failing probability, P_F , the estimated past failing probability, P_F^* , and depositor's monitoring cost, d , if the initial endowments the depositor was born with exceeds D^* , monitoring will be the best choice for the depositor to take.

2.3.2 The Fully-Covered Deposit Insurance System

The benefits of the deposit insurance, as significant as they are, have not come without cost. Some people are concerned that instead of protecting the small depositors, which have a relatively large portion of total savers, fully covered deposit insurance may increase the likelihood of a bank's failure. Could the fully covered deposit insurance policy be a source that triggers the bank's excessive risk-taking behavior, and further increase the bank's failure rate?

At the beginning of each period, depositors save inelastically in the bank, and the bank chooses the combination of the optimal gamble and prudent assets. Obviously, depositors have no incentives to monitor and withdraw early under the fully covered deposit insurance system.⁸ Every depositor gets the guaranteed principal plus interests no matter what happens to the bank. Even if the bank is insolvent and assumed by the FDIC, a depositor has nothing to lose under the safety net offered by the FDIC. How to finance the FDIC's deposit insurance plan is simply by charging the risk-sensitive premium from the financial institutions depending on the risk they take.

⁷ This can be seen as a special case when we discuss depositors' monitoring in section 3.3. Under the circumstance that no deposit insurance in place, we find a threshold for depositor to monitor by considering the optimal coverage limit is equal to zero.

⁸ Under the full covered deposit insurance system, depositors would monitor banks' behavior if they know the full insurance is not always feasible. In our paper, we rule out this possibility.

2.3.2.1 The Risk-Sensitive Premium and the Capital Requirements

When it comes to the solution for reducing bank's excessive risk-taking problem, two main streams have been discussed extensively in the literature: some of the literature focuses on the banking regulations such as capital requirements, co-insurance, and compulsory insurance while others look for the solution back to the market mechanism. In this section, I will discuss the effect of some contemporary banking regulations. When the bank's actions are not observable, the FDIC must design a compensation scheme for banks in a way that indirectly gives the bank incentives to take the correct actions. To solve the moral hazard problem, the FDIC offers the compensated contract to the bank with the risk-sensitive premium, P , and the corresponding capital requirements.

k is the percentage of the deposits held as capital requirements; kD is the shareholders' equity that can be used in a bank's investment activity. Capital is costly; it comes with a higher cost, ρ , than the return from prudent assets, α ⁹. Therefore, a rational bank will not be willing to hold more capital if the benefit of holding capital is less than the cost. At the beginning of the period, the FDIC charges the premium from all the banks and announces the regulation of capital requirements to the bank. Capital requirements serve as an indicator that shows how much the internal funds are used to finance the bank's investment portfolio. The higher the capital requirements, the more the potential losses the shareholders will suffer from the bank's failure.

The bank decides how much it will invest in gambling assets. Unlike the safe asset, the return of the gamble asset is a random variable, which is not realized by the time the bank forms its investment portfolio. Both bank's investment in the gamble assets and the realization of its return tell us whether the bank will survive, or if it might fail. The bank's survival probability with capital requirements and the risk-sensitive premium is:

$$\Pr(Ri + \alpha[(1+K-P)(D_1+D_2)-i] - (\rho K+r)(D_1+D_2) > 0) = \Pr(R > R_1),$$

⁹ The same assumption is made in Hellmann, Murdock, and Stiglitz (2002) when discussing the policy of capital requirements.

where $R_1 \equiv \alpha - (1/i)[\alpha(1+K-P) - (\rho K + r)](D_1 + D_2)$. If the realized return R is greater than the survival threshold R_1 , the bank survives; otherwise, the bank fails. The bank's expected return is

$$\int_{R_1}^{\infty} \{Ri + \alpha[(1+K-P)(D_1 + D_2) - i] - (\rho K + r)(D_1 + D_2)\} f(R) dR$$

Comparing this outcome with the experiment without capital requirements¹⁰, the gambling asset chosen by the bank will be smaller if both risk-sensitive premium and capital requirements are in place. Figure 2.1 shows the bank survival thresholds with and without capital requirements, where R_1 expresses the threshold with capital requirements while R_f shows the survival threshold without policy instruments. Under a full coverage insurance system, the bank's failing probability, P_F , also expresses the fraction of the banks that may fail in the economy. Therefore, I derive the premium, $\{P_F r[qD_1 + (1-q)D_2] - \gamma\} / [qD_1 + (1-q)D_2]$, from the FDIC's budget constraint, where γ is the left over franchise value if the bank is insolvent and assumed by the FDIC.

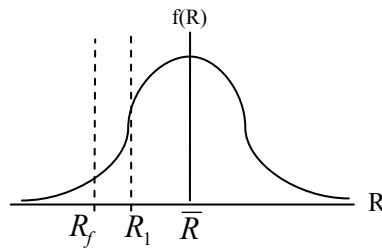


Figure 2.1 The Survival Threshold of the Risk-Taking Bank

The bank's optimal choice of gambling asset under risk-sensitive premium is

$$i_1 = \frac{[\alpha(1+K-P) - (\rho K + r)](qD_1 + (1-q)D_2)}{R_1 - \alpha} < i_f,$$

¹⁰ Appendix A shows the bank's behavior without capital requirements.

where $\rho > \alpha$ and i_f is the gamble asset chosen by the bank without policy instruments under the full coverage insurance system.

Under the fully covered deposit insurance, the capital requirement policy reduces the bank's incentives to gamble by narrowing the bank's survival probability. The reason is simple, the federal and state laws set different priorities for payment of receivership claims¹¹. The internal funds from the shareholders have the last priorities among all other claims from depositors and general creditors. The capital requirement policy reduces a bank's gamble incentives by putting shareholders at risk. The fear of loss will lead to a relatively prudential investment portfolio. This threat occurs when the bank chooses how much to gamble at the beginning of the period. It reduces the bank's failing probability, and simultaneously insures depositors.

2.3.3 The Partial Deposit Insurance System

People are rational and respond to incentives. In this section, instead of focusing on the banking regulation, I emphasize the role played by market discipline, referring to market power from depositors participating in the economy. Not only focusing on the deposit contract between offering by banks to depositors, in this section I discuss how the action of the FDIC will affect both banks and depositors. Deposit insurance works as part of the deposit contract when banking failure occurs. Given the optimal compensation from the FDIC, depositors may not take the action such as withdrawing early or asking for a higher interest rate to reduce banks excessive gambling behavior. Once the partial deposit insurance scheme rather than the fully-covered one is announced at the beginning of the period, both depositors and banks will adjust in response.

2.3.3.1 Depositors' Monitoring

Timing of the model is as follows. At the beginning of each period, the FDIC announces the maximum coverage limit and capital requirements to the public. Both banks and

¹¹ Summarized by the FDIC, under the national depositor preference law, a failed institution's assets are to be distributed in the order as follows. The administrative expenses of the receiver, the claims of all depositors, general creditor claims, subordinated creditor claims, and the last the claims of shareholders.

depositors observe this information immediately. Since depositors are heterogeneous, the higher the endowments, the more likely the depositors are not fully protected by the partial-covered system. At this point in time, depositors make their decisions of how much they want to deposit to the bank and whether they want to monitor or not. The willingness to monitor is highly related to the coverage limit set up by the FDIC. The higher the coverage, the more protection the depositors will get when the bank fails. Thus, it is less likely for depositors to monitor and withdraw due to the monitoring cost and the opportunity cost of withdrawal. This model builds on the theoretical analysis of a one-shot game, depositors take all possible actions of a bank into consideration, and then chooses her/his best strategy.

To distinguish the responses among different groups of depositors, I assume that $rD_1 > D_1 > \bar{C} > rD_2 > D_2$. Under the maximum coverage limit, \bar{C} , the rich depositor will decide whether she/he wants to monitor while the poor depositor will save inelastically to the bank. The rich depositor whose endowment exceeds the coverage limit does not have full deposit protection; therefore, the rich depositor is willing to engage in monitoring. On the other hand, even if the bank fails, a poor depositor is the one who has access to the fully guaranteed amount, and will pay less attention to bank's gamble.

Our objective in this paper is to encourage risk-oriented monitoring from depositors, which is market discipline. The purpose of depositors' monitoring is to get an access to know the bank's gambling behavior and purchase the right to withdraw early. Without monitoring, a bank's investment decision is hidden action; only the bank itself knows how much it invests in gambling assets and its level of risk. However, with monitoring, the depositor who spends the monitoring cost, d , will observe the bank's true failing probability. Furthermore, early withdrawal can be seen as one of the consequences of monitoring. In the worst situation, if the bank fails and is liquidated by the FDIC, the depositors who choose to monitor can withdraw early by the amount which exceeds the maximum coverage limit. Early withdrawal somewhat provides

depositors another safety net outside the deposit insurance. This self protection is not free; the cost of early withdrawal is the interest losses.

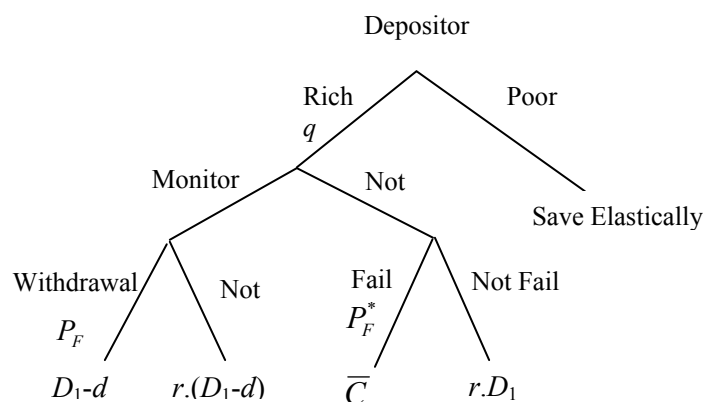


Figure 2.2 Depositors' Two-Step Decision

The discrete monitoring decision for the rich depositor in Figure 2.2 can be solved backward. Depositor's decision can be separated into two stages. In the first stage, whether the depositor is willing to monitor relies on depositor's expected earnings. Once the depositor decides to monitor, she/he spends a fixed monitoring cost, d , and will know the bank's failing probability, P_F . Then, depositor's decision moves to the next stage, whether she/he wants to withdraw earlier. With probability P_F , a depositor will withdraw early even if she/he loses the potential interest from savings. A depositor's expected return from monitoring is

$$P_F(D_1 - d) + (1 - P_F)r(D_1 - d).$$

If a depositor decides not to monitor the bank's behavior, she/he will observe a biased estimate of a bank's failing probability, P_F^* , from previous experience and information. Due to this decision, this depositor has no backup plan such as withdraw early can be chosen in the second stage. If the bank fails, the depositor receives, \bar{C} , the maximum

amount guaranteed by the FDIC. She/he loses any deposits exceeding \bar{C} . The expected return for a depositor without monitoring is

$$P_F^* \bar{C} + (1 - P_F^*) r D_1.$$

If a depositor's expected return from monitoring is greater than the one without monitoring, she/ he will monitor the bank's risk-taking behavior. If the initial endowment of the rich depositor is greater than D^* , where

$$D^* \equiv \frac{P_F^* \bar{C} + P_F d + (1 - P_F) r d}{(1 - r) P_F + r P_F^*},$$

She/he will monitor the bank to ensure her/his deposits; otherwise, she /he saves all without monitoring. Comparing to the threshold I derived early in section 3.1, the threshold for depositor to monitor is higher under the partially covered deposit insurance than the case when there is no insurance at all. The result is unsurprising. Without the protection offered by the FDIC, more depositors are willing to monitor the bank to make sure their own safety. Expected deposits of the heterogeneous depositors are

$$E(D) = q [\Pr(D_1 > D^*) (D_1 - d) + \Pr(D_1 < D^*) D_1] + (1 - q) D_2 \quad (2.1)$$

Since I assume that $r D_1 > D_1 > \bar{C} > r D_2 > D_2$, the first term in parentheses is the expected saving from the rich depositor, and the second term is the possible deposits from the poor. The expected withdrawal from the rich depositor is

$$E(W) = q \Pr(D_1 > D^*) P_F (D_1 - d - \bar{C}) \quad (2.2)$$

The depositor who spends the monitoring cost, d , will observe the bank's true failing probability, P_F . From equation (2.2), withdrawing the deposits in excess of the coverage limit, $D_1 - d - \bar{C}$, is the consequence of monitoring if this depositor observes something may go wrong in the bank. The higher the failing probability of the bank, the more likely the rich depositors will monitor the bank's investment decision.

$$\frac{\partial D^*}{\partial P_F} = \frac{(1 - r)(P_F^* (r d - \bar{C}) - r d)}{[(1 - r) P_F + r P_F^*]^2} < 0.$$

2.3.3.2 Banks' Gambling Behavior

As I assumed in the beginning of this paper, the bank forms its investment portfolio by choosing a combination of a safe asset with certain return α and a risky asset with random realized return R , where R belongs to $N(\bar{R}, \sigma^2)$. With the monitoring from depositors, a bank's response is different from the situation without the market discipline. At the beginning of the period, the FDIC announces the maximum coverage limit. If there is a binding coverage limit, banks will expect monitoring from certain group of depositors with fraction q . Therefore, when the bank makes its decision, it will take all possible actions from both depositors and the FDIC into consideration, and then choose how many risky assets it will gamble to maximize the expected return. The depositor's monitoring influences both the bank's survival probability and the available resources the bank can use to finance its investment portfolio. A bank's survival probability is

$$\Pr(Ri + \alpha \{(1+K-P)[E(D)-E(W)] - i\} - (\rho K + r)[E(D)-E(W)] > 0) = \Pr(R > R_2),$$

where $R_2 \equiv \alpha - (1/i)[\alpha(1+K-P) - (\rho K + r)]\{E(D)-E(W)\}$. If the random return from the gambling asset is less than the threshold value, R_2 , the bank fails; otherwise, the bank's expected return is

$$ER = \int_{R_2}^{\infty} \{R \cdot i + \alpha[(1+K-P)(E(D)-E(W)) - i] - (\rho K + r)[E(D)-E(W)]\} f(R) dR \quad (2.3)$$

The bank will maximize its expected return by choosing the optimal gambling assets, i_2 , and the corresponding failing probability, P_F . The optimal gambling asset is

$$i_2 = \frac{[\alpha(1+K-P) - (\rho K + r)](E(D)-E(W))}{R_2 - \alpha},$$

which is smaller than i_f , under the fully-covered deposit insurance.

2.3.3.3. The FDIC's Optimization Problem

The benevolent deposit insurer, FDIC, maximizes social welfare. The policy instruments the FDIC uses are the risk-sensitive premium, P , and the coverage limit, \bar{C} . At the beginning of each period, the risk-sensitive premium is charged and the maximum

coverage limit is announced.¹² Once the binding coverage limit is imposed, market discipline can be reinforced. Especially the action of the rich depositor will affect banks' gambling and risk-taking behavior. More than that, risk premium also will reduce the incentive for banks to gamble. The more risky assets the bank invests, this bank will generate a greater risk to lose the deposit insurance funds. Hence, the FDIC will charge a higher fee for insurance. The optimal risk premium is determined by the FDIC's budget constraint. When the bank is insolvent and fails, the FDIC reimburses the depositors to the point of the maximum coverage limit. For the use of funds for the FDIC, how much insurance funds need to be repaid depends on the depositor's monitoring and withdrawal decision. On the other side of the budget constraint, whether the bank is going to fail can be evaluated by how much risk the bank assumes. The risk-sensitive premium is determined by both the bank's and the depositor's decisions. Combining with capital requirements, the FDIC can restrain a bank's excessive risk-taking by counting on the action of the internal shareholders and the depositors who are not fully insured.

When the bank's actions are not observable, the FDIC must design a compensation scheme in a way that indirectly gives the bank the incentive to take the socially desirable actions. To solve the moral hazard problem, the FDIC offers the compensated contract with reasonable premium to a bank, and the adjusted premium relies heavily on a bank's risk. The FDIC's optimization problem is to maximize social welfare by choosing the optimal premium and coverage limit under its budget constraint. The FDIC's expected return is

$$\int_{R_2}^{\infty} \{ Ri + \alpha[(1 + K - P)(E(D) - E(W) - i) - (\rho K + r)[E(D) - E(W)]] f(R) dR \\ + q \{ P(D_1 > D^*) [P_F(D_1 - d) + (1 - P_F)r(D_1 - d)] + P(D_1 < D^*) (P_F^* \bar{C} + (1 - P_F^*)rD_1) \} \\ + (1 - q)rD_2 \} \quad (2.4)$$

The social welfare in equation (2.4) includes two major parts: the first element is the

¹² If the bank's type is private information which cannot be observed by the public, a simple revealed argument can be made in capital requirements. The lower the reported capital, the higher the risks a bank is going to take. Thus, the higher premium will be charged by the FDIC. Chan, Greenbaum, and Thakor (1992) provide a way to guide the bank to take the correct actions. The combination of the premium and capital requirements chosen by the bank can simply reveal the type of the bank.

bank's expected return from the combination of prudent-gamble investment portfolio, and the second element is depositor's expected return generated from both rich and poor depositors. The corresponding budget constraint is shown in the following equation (2.5).

$$\gamma + P[E(D) - E(W)] \geq P_F \left\{ q \left[\Pr(D_1 > D^*) \min(D_1 - d, \bar{C}) + \Pr(D_1 < D^*) \bar{C} \right] + (1 - q)rD_2 \right\} \quad (2.5)$$

The source of funds can be used to reimburse depositors is represented on the left hand side of the budget constraint. The FDIC's source of funds is the premium and the residual of the bank's liquidating franchise value, γ . The use of funds depends heavily on depositor actions, which are shown on the right hand side in equation (2.5). P_F is the bank's true failing probability, which can also be seen as the portion of the banks that are insolvent and assumed by the FDIC. While the poor depositor is fully insured, the safety net offered by the FDIC only partially covers the saving for the rich depositors.

2.4 SOLVING THE MODEL

In this section, I solve the multiparty problem using a numerical example. The behavior of the heterogeneous depositors in equation (2.1) and (2.2), the risk-taking bank in equation (2.3), and the benevolent FDIC in equations (2.4) and (2.5) can be solved simultaneously. In doing so, how important the market discipline is in the model can be shown. In order to solve the model numerically, I first set the values of the parameters in Table 2.1 as a benchmark, and then I describe the equilibrium results in section 2.4.2.

Table 2.1 Definition of the Variables and the Initial Values of the Parameters

Endogenous variable	
DEPOSITOR	Expected deposit ($E(D)$)
	Expected withdrawal ($E(W)$)
BANK	Gambling asset (i)
	Failing probability (P_F)
The FDIC	Coverage limit (\bar{C})
	Risk premium (P)
Exogenous variable	
DEPOSITOR	Endowment of rich (D_1): 125000
	Endowment of poor (D_2): 30000
	Rich percentage (q): 0.1
	Monitor cost (d): 100
BANK	Past failing probability (P_F^*): 0.05
	Return of gambling asset $\sim N(\mu = \bar{R} = 1.2, \sigma^2 = (0.15)^2)$
	Return of safe asset (α): 1.1
	Cost of internal capital (ρ): 1.12
	Gross interest rate for deposit (r): 1.04
	Capital requirement (K): 0.04

2.4.1 Parameters for the Numerical Example

Generally, the current scope and level of coverage limit of an individual account is up to \$100,000, which covers principal plus interests. In order to investigate the effect of market discipline, I assume that the endowments of the rich depositor are far above the maximum coverage limit while the total endowments of the poor are insured completely by the FDIC, where D_1 is \$125,000 and D_2 is \$30,000. Since I believe that small depositors are a relatively large portion of total savers, I assume that the percentage of the depositors who are not fully protected by the deposit insurer is 10%. The monitoring cost, d , equals to \$100.

In this model, capital is costly to the bank. As we can see in Table 2.1, the cost of the capital, ρ equals to 1.12, is greater than the rate of returns of a safe asset, where α equals to 1.1. If there is no capital requirement policy in the economy, a rational bank will not hold any capital. Beginning in 2007, the rate of risk-sensitive premium charged

by the FDIC to each institution is based on the capital ratio and the supervisory group assignment. For a well capitalized bank, the total risk-based capital ratio should be equal to or greater than 10%, and Tier1 risk-based capital ratio is equal to or greater than 6%, and the Tier 1 leverage capital ratio is equal to or greater than 5%. For an adequately capitalized bank, the capital ratio is located around 4% to 8%. In our model, the total risk-based capital ratio equals to kD/i , therefore I assume the percentage of the capital requirements is approximately 0.04 to 0.06.

Other benchmark parameters include return of the gamble assets, where $\bar{R} = 1.2$ and $\sigma = 0.15$; interest rate for deposits, $r = 1.04$; past failing probability, $P_F^* = 0.05$.

2.4.2 Equilibrium Results

The bank maximizes its expected returns by choosing optimal gambling asset and the failing probability while the depositor maximizes her/his expected returns by choosing optimal saving and withdrawal simultaneously. Given the risk premium and the coverage limit, the optimal gamble assets and expected withdrawals are determined by the best response functions derived from different participants in the market. Given the bank's investment portfolio, Figure 2.3. shows the depositor's expected returns in panel (a) and expresses the choice of withdrawals in panel (b). Those figures show a depositor's best response function given the bank's risk-taking behavior. Depositors' expected returns decline as the bank invests more in risky assets. Therefore, the best action for a rational depositor is to withdraw early in response. The more excessive risk-taking behavior the bank engages, the more likely the depositors are going to withdraw their funds. On the other hand, greater withdrawals from the depositors mean less available resources the bank will invest either in prudent assets or in risky assets.

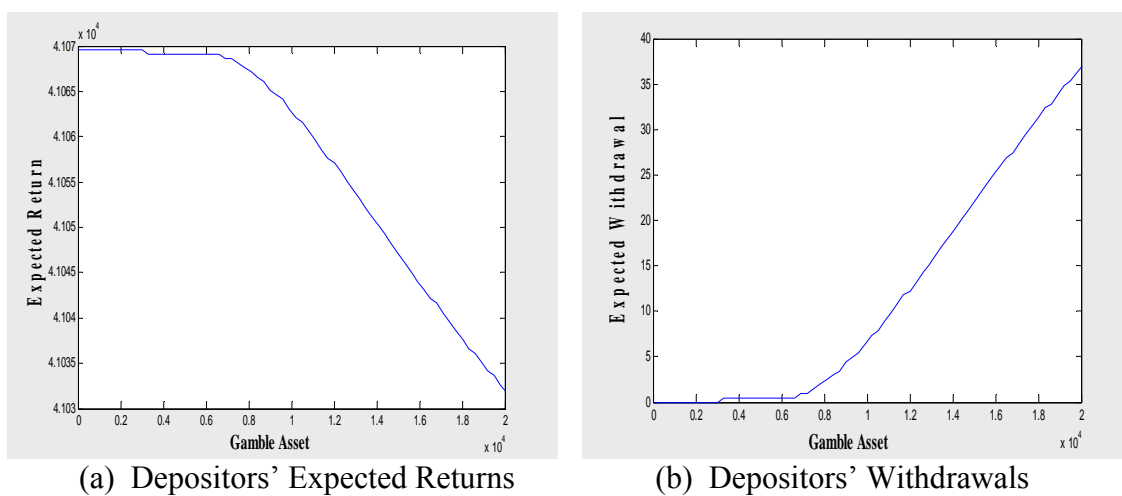


Figure 2.3 Depositors' Best Response Function

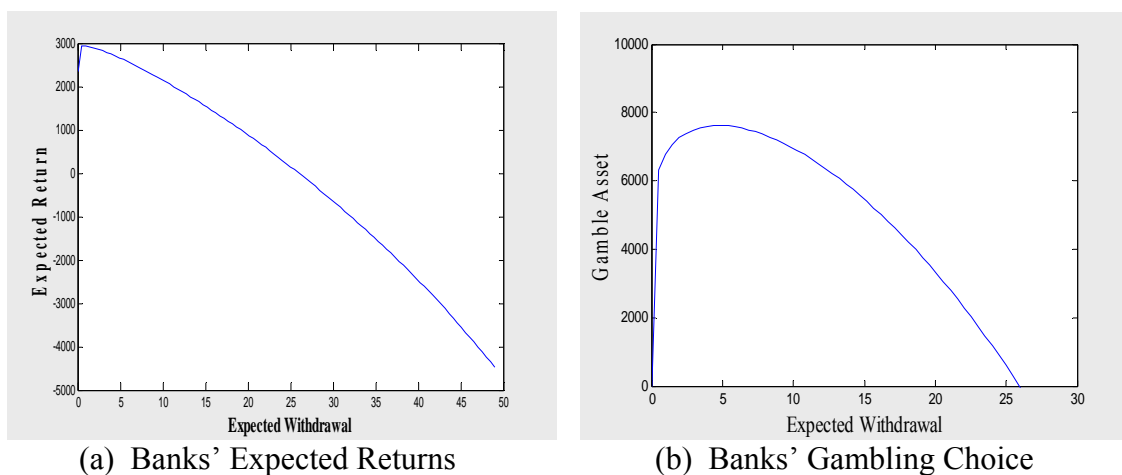


Figure 2.4. The Banks' Best Response Function

On the other hand Figure 2.4. shows the bank's expected returns in panel (a) and the gambling assets decrease as the depositor's expected withdrawals increase in panel (b). Given depositors' withdrawals, the bank's best response function can be shown in Figure 2.4.

The intersection of the depositors and the bank's best response functions determine the optimal choices of different market participants. This is shown in Figure

2.5. When varying the coverage limit, the optimal expected withdrawals from depositors decline gradually as the coverage limit rises. Eventually, if the deposit insurer provides a 100% guaranteed insurance to the public, when the coverage limit exceeds D_1 , depositors will not have any motivation to monitor and further withdraw. The market discipline can not work. This provides an explanation of why an improperly designed insurance plan will increase the risk of bank failure. The important job for the FDIC is to choose a proper premium and coverage that maximize social welfare.

There are two components of social welfare: the expected return for depositors and the expected return for the bank. Equilibria in the numerical example are determined in three steps. First, given the bank's investment portfolio, the depositor faces the decision whether she/he wants to monitor or not. If the answer is yes, the depositor has access to early withdrawals and, at the same time, she/he has to bear a monitoring cost. Second, given the information of depositors' monitoring and withdrawals, the bank will choose the combination of the risk-free and risky assets that maximize its expected returns.

Finally, given all the possible actions that could be taken by the market participants, the FDIC chooses the coverage limit and premium which maximizes social welfare. The bank's gamble decision and the depositor's choice of monitor and withdrawals can be derived simultaneously given the welfare-maximizing coverage limit. The equilibrium results are summarized in Table 2.2, and it enables us to compare each episode given the parameters in Table 2.1. In Table 2.2, the first column describes the endogenous variables in the multiparty-designed model. The second column shows the case where there is no bank; the third column displays the case without any deposit insurer; the fourth column discusses the case under fully covered insurance. The last column is the case I want to emphasize, the partial deposit insurance system.

Table 2.2 Welfare Comparison among the Sub-Cases

Case	I. Bank Without the FDIC	II. Bank With Full Coverage	III. Partial Deposit Insurance
THE FDIC			
Social Welfare	44102	43773	43973
Coverage Limit	.	.	90000
Risk Premium	.	0.0094	0.0019
BANK			
Expected Return	3130.2	2693.1	2936.4
Gamble Asset	7592.1	7580	6797.6
Failing Probability	0.003	0.009	0.0020
DEPOSITOR			
Expected Return	40971	41080	41036
Expected Deposit	39400	39500	39490
Expected Withdrawal	118.2	.	6.98

Case I: Bank without the FDIC and any effective banking regulation. If there is no deposit insurer, market discipline performed by depositors will be shown. There is no doubt that rich depositors will monitor the bank's risk-taking behavior. Poor depositors who were born with relatively less endowments D_2 , will monitor if the potential losses from a banking failure are greater than the cost of monitoring. In Table 2.2, the heterogeneous depositors who belong either to the rich or to the poor have incentives to monitor the bank's gambling behavior. Further, depositors may withdraw part of their saving early as a strategy of self protection when there is no insurance provided by the FDIC.

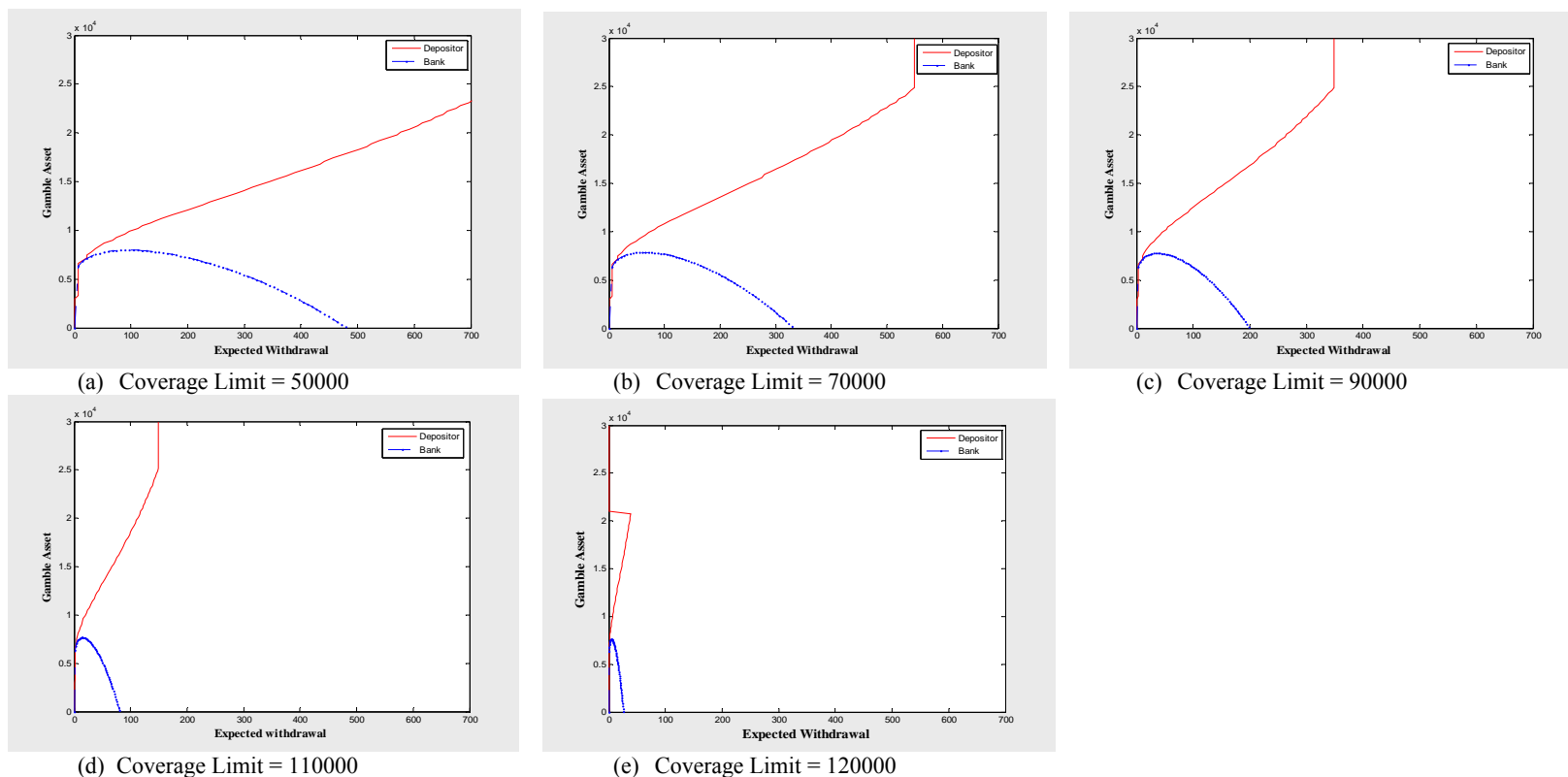


Figure 2.5 The Best Response Function of Both Depositors and Banks when Varying Coverage Limit¹³

¹³ The vertical axis is the gamble assets chosen by the bank. The horizontal axis is the expected withdrawal chosen by the depositors. The upward-sloping red line represents the best response function for depositor, and shows the diminishing expected withdrawal in Figure 2.5. Once the depositor is under fully protection, when coverage exceeds 125000, she/he has no incentives to monitor or withdraw early. On the other hand, the downward-sloping blue-dotted line describes the bank's best response function given depositor's behavior. The more the expected withdrawal, the less the bank is going to invest in gambling assets. As we can see in Figure 2.5, the bank's response function bows inward gradually when the coverage limit rises from 50,000 to 120,000. Under partial covered deposit insurance system, depositor's monitoring is expected when the bank makes its investment decision. In addition, the bank expects that the less effort depositor is going to make in monitoring when the coverage becomes more extensive and generous.

Case II: Bank with a fully-covered deposit insurance system. Under the full protection provided by the FDIC, there is no strong incentive for depositors to monitor or even withdraw. Depositors' decision depends upon the contingent plans they make at the beginning of the period. However, in each state of the world, either the bank wins the gamble or loses the gamble, there is no difference of the saving decision for any type of depositors. In the worst scenario, bank run, both the rich and the poor depositors will receive the full guaranteed amount from the deposit insurer. In the third column in Table 2.2, the heterogeneous depositor chooses to save inelastically and makes no early withdrawals. Comparing to the scenario without the FDIC, depositors under a fully covered insurance system are better off because of the complete safety net. Some literature has discussed that adopting improper deposit insurance will increase the bank failures. Under the fully covered deposit insurance, the strategy of depositors' early withdrawals might not credibly threaten the bank's excessive gambling behavior. As a consequence, the bank's failing probability will increase because of the relatively large risky assets chosen by the bank. One goal the government always wants to achieve is financial stability. Since crises are costly, without market discipline from the rich, one possible solution to reduce the bank's gambling behavior and failing probability is through banking regulations. Risk-sensitive premium serves as a good policy instrument that forces the bank to take the social desirable action. The more the bank engages in gambling, the higher the premium the FDIC will charge depending on the risk assessment system.

Case III: Partial deposit insurance with capital requirements and risk-sensitive premia. In this case, I consider the effect from both the FDIC and the depositors' discipline to manage bank's moral hazard problem. The last column in Table 2.2 shows the equilibrium with depositors' monitoring and early withdrawals. When the government sets up an unlimited coverage for insurance, there is no monitor in the economy, and early withdrawal is impossible to be a choice for depositors. However, under the partial coverage system, the depositors whose endowments exceed the maximum coverage limit might take different actions. Whether rich depositors monitor

or not relies on the expected returns from monitoring and withdrawals. More importantly, rich depositors' action has a close relationship with the optimal coverage limit. From Table 2.2, the optimal coverage in this numerical example is \$90,000. When the maximum coverage limit reaches certain high level, most of the savings from depositors are insured, the potential losses from the rich depositors will shrink to a very low level. Once the cost of the monitoring is above than the possible losses the depositors may bear, depositors will not monitor.

The benefit of the fully covered deposit insurance is the safety net provided by the FDIC to the small depositors. However, in order to finance this one-hundred-percent guarantee, the FDIC needs to charge an overall higher level of risk premia as we can observe in Table 2.2. I also consider the effectiveness to reduce the bank's risk-taking behavior among different insurance system. The decrease of the investment in gamble assets is significant when we move from the full coverage system to the partial coverage insurance. As a result, bank's failing probability is lower due to relatively prudential investment. I also observe social welfare improvement in the mechanism design of the partial deposit insurance system. When the partial coverage system is in place, the bank is better off by finding a balance exchanging the higher premium to depositor's monitor and withdrawals. Withdrawal early is the best choice for depositors under partial coverage system. Compared with the fully covered insurance plan in case II, the premium the bank needs to pay in the case III shrinks under the partial deposit insurance system; however, at the same time, the bank has to deal with the potential market discipline from the depositor's monitoring and early withdrawal.

For depositors, the fully covered insurance generates the maximum expected returns among all cases I investigate. Under a complete protection by the insurance plan, the depositors will not lose a penny since all deposits and interests are guaranteed by the FDIC. Therefore, the interest losses from monitoring and early withdrawal can be avoided. However, the inevitable drawback from the full coverage system is that it encourages the bank's risk-taking behavior. In order to make a credible threatening to the bank and protect their own deposits, depositors need to scarify some chances to earn

the full interest from saving inelastically to the bank. Partially covered deposit insurance gives the rich depositors strong motivations to monitor and withdraw if necessary. Also, comparing partially covered system to Case I, depositors are better off under the partial deposit insurance with market discipline than under the case in which every depositor monitors even for those individuals with relatively low endowments. If there is no deposit insurance in place, the cost of monitoring is much greater than under the partially covered system. One thing deserves a special emphasis is we can not really compare the situation without deposit insurance with the case under partially covered system. Since depositors are risk neutral instead of risk averse, without banking regulations and the deposit insurer, both depositors and bank are willing to engage in risky banking practice and gamble for higher returns. Also, the way I introduce heterogeneous depositors already rules out the possibility of the panic run equilibrium. Therefore, without the possibility of a negative consequence such as a bank run, social welfare I derived in case III cannot be compared fairly with the situation with partially-covered system.

It is worth pointing out that our model provides us an alternative way to derive the optimal risk premium. Depending on the Risk-Based Assessment System from the FDIC, a financial institution will be charged with the risk-sensitive premium from 5 to 43 cents per hundred dollars. In our model, the optimal risk premium under the full coverage system is 94 cents per hundred dollars. However, the risk-sensitive premium decreases if we consider the partial deposit insurance system. The potential premium locates in the range around 19 cents per hundred dollars depending on the risks the bank will take. The more the bank invests in the gamble assets, the greater the risk premium the bank pays. This result emphasizes the important insight that a successful partial coverage policy requires a corresponding policy for the risk premium. To be effective, the market discipline accompanying the risk premium policy can reduce the bank's moral hazard problem.

2.5 SHOCKS

In this section I discuss four sets of examples. The first three cases show how possible shocks among depositors—shifting the proportion of the rich, the monitoring cost, and the information of the past failing probability—affect people’s behavior and social welfare. Then, the last case illustrates the shock on banks—varying the random gambling return—affects people’s behavior and social welfare.

2.5.1 The Effects of Varying the Percentage of the Rich

In this section I consider the effect if increasing the proportion of the rich depositor, q . The welfare comparison is shown in Figure 2.6 panel (a) If the percentage of the rich depositors increases, the expected deposits save in the bank is increasing. Once the resource deposits to the bank increases, the proportion a bank invests in the risk asset may increase in response. However, there is a relatively larger portion of depositors will monitor the bank’s risk taking behavior.

Under the partial deposit insurance system, the higher the percentage of depositors who belong to the rich, the less likely the depositor will be insured completely if the bank fails. Thus, the expected withdrawal from the depositor might increase and market discipline will improve social welfare. How does this shock influence the FDIC’s decision? *Ceteris paribus*, as the rich percentage increases, as we find in 2.6 panel (c), instead of charging a high premium, effective market discipline may be a good way to reduce the bank’s risk-taking behavior. On the other hand, more available funds could finance the bank’s investment. Thus, the bank tends to gamble more and puts depositors at risks. As a result, as we can see from Figure 2.6 panel (b), the effect of varying the percentage of the rich depositor is unclear for the optimal coverage.

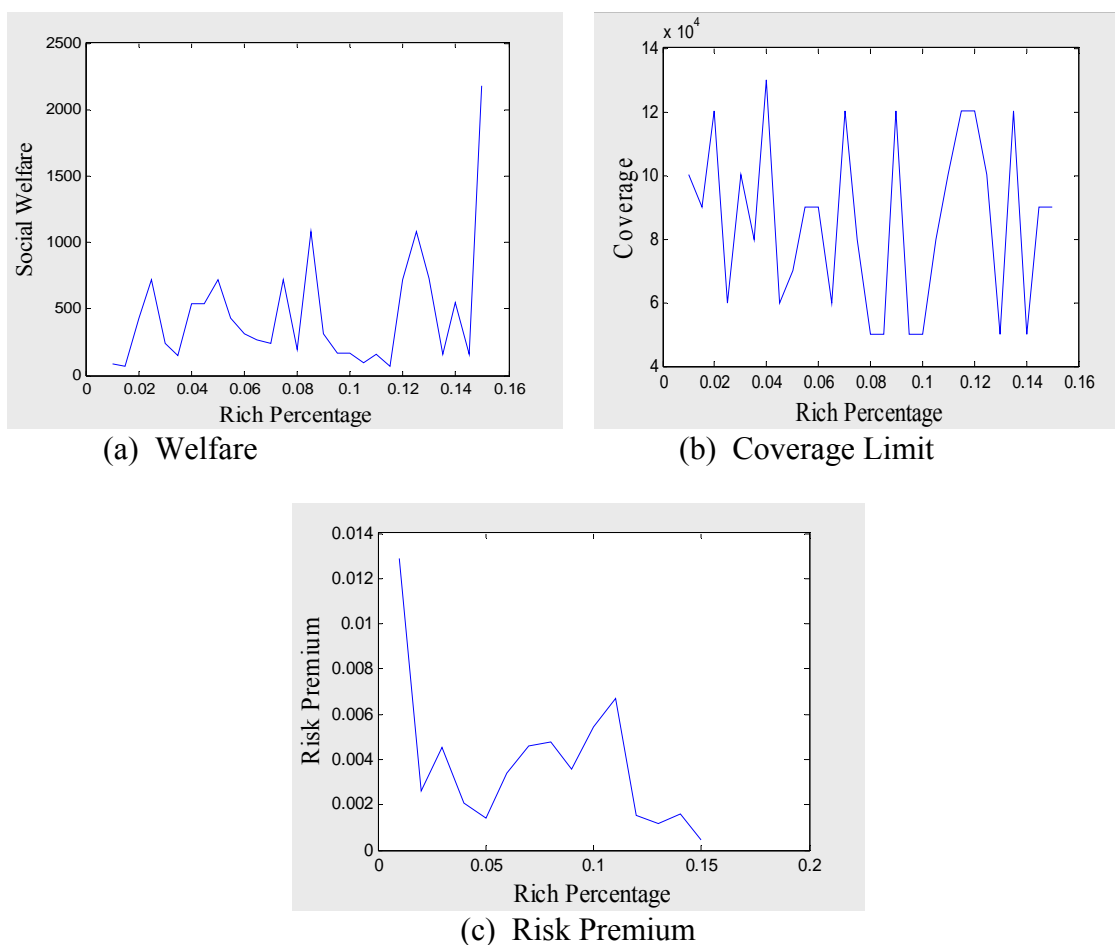


Figure 2.6 The Effect of Varying the Rich Percentage: q

2.5.2 The Effects of Varying the Monitoring Cost

Under the partial deposit insurance, depositors face trade-off. The benefit from monitoring is to have a chance to withdraw early and to avoid the potential losses. The opportunity cost of monitoring is the interest from saving. The higher the monitoring cost, the less the available funds depositors can save to the bank if monitoring. Since the funds saved to the bank generate interests, depositors will receive less interests earning. Thus, the higher the monitoring cost, the less likely for depositors to monitor. If that is the case, the bank may engage more in risky investment activities without market

discipline from depositors. Intuitively, as the monitoring cost increases, the advantage of the partial deposit insurance diminishes.

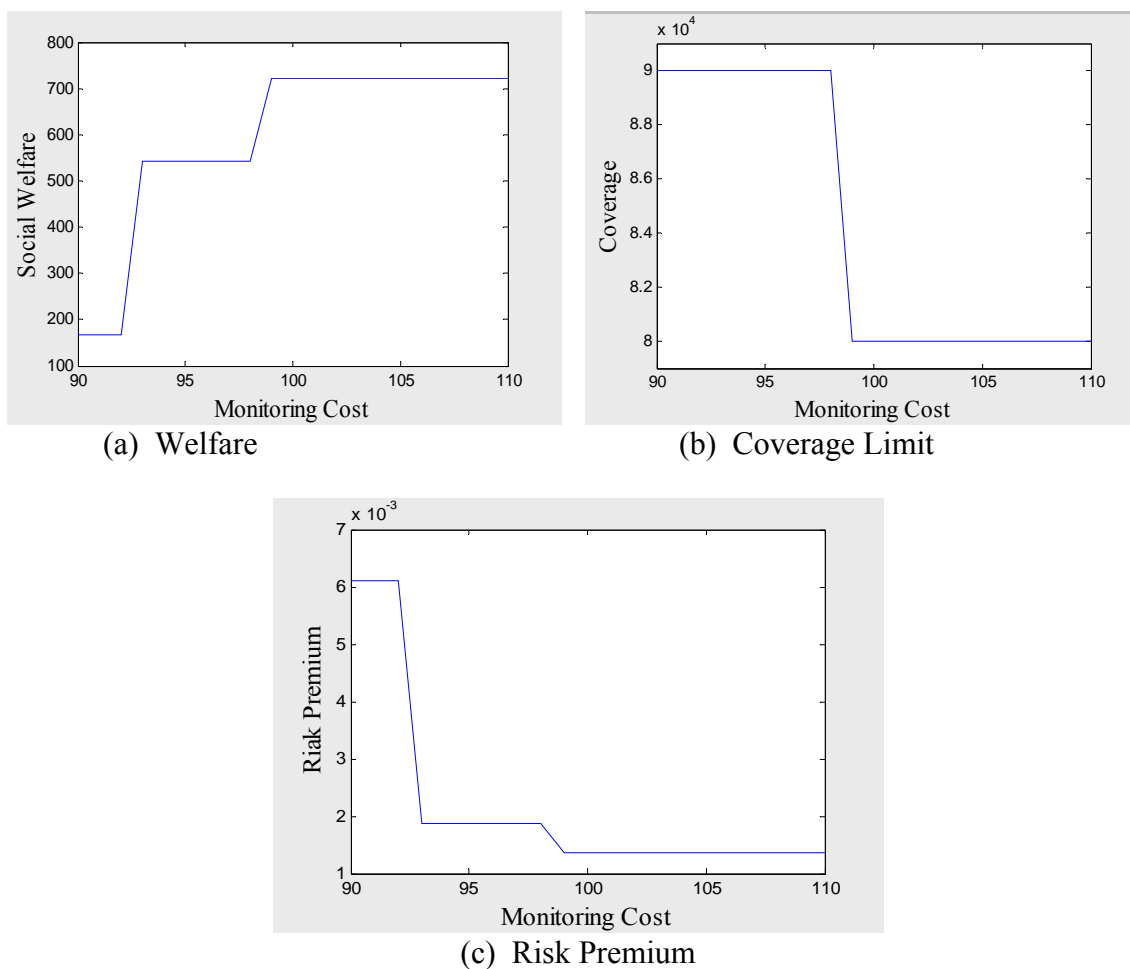


Figure 2.7 The Effect of Varying the Monitoring Cost: d

Figure 2.7 panel (a) shows the effect of varying the monitoring cost. Surprisingly, the welfare increases when we vary the monitoring cost. Since the higher the monitoring cost reduces the incentives for depositors to monitor, the bank has relatively abundant resources to finance its investment. That is why the bank's expected return may rise. If the bank's expected return dominates the total welfare, we can observe that rising

monitoring cost increase social welfare. In Figure 2.7 panel (b), optimal coverage limit drops while the monitoring cost increases. If the monitoring cost is too high, market discipline is weakened. Under this situation, how the FDIC motivates depositors and threatens the bank's excessive risk-taking behavior is to lower the coverage. Lower the coverage will stimulate depositors' monitor. As a consequence of the lower coverage, the less premia will need to finance the insurance if bank fails.

2.5.3. The Effects of Varying the Information of the Past Failing Probability

The information of the past failing probability, P_F^* , will influence a depositor's monitoring decision. If the depositor chooses to save the monitoring cost and does not monitor, she/he cannot accurately tell the bank's failing probability. The only way for a depositor to estimate the bank's gambling behavior and its failing probability is to use past information. The greater the past failing probability, the more likely the rich depositor believes that the bank will gamble this period; and more likely the depositor is to predict she/he will lose the amount uninsured by the partial deposit insurance. The more uncovered funds the rich depositor might lose the more effort the depositor is willing to put into monitoring. Therefore, the bank's risk-taking behavior will be suppressed by the higher past failing probability.

In Figure 2.8 panel (a), when the past failing probability becomes higher and higher, it will reduce depositors' incentive to save and the depositors' expected return. Also, the bank expects the likelihood of depositors' early withdraw is increasing when depositors observed a relatively higher bank's failure from the past information. Therefore, the bank will invest prudently and the expected return from the bank will be lower. If a relatively higher probability of bank's failure in the past is due to the unobservable risky banking practice, the FDIC tends to lower the optimal coverage limit even more to stimulate market discipline from depositors' monitoring.

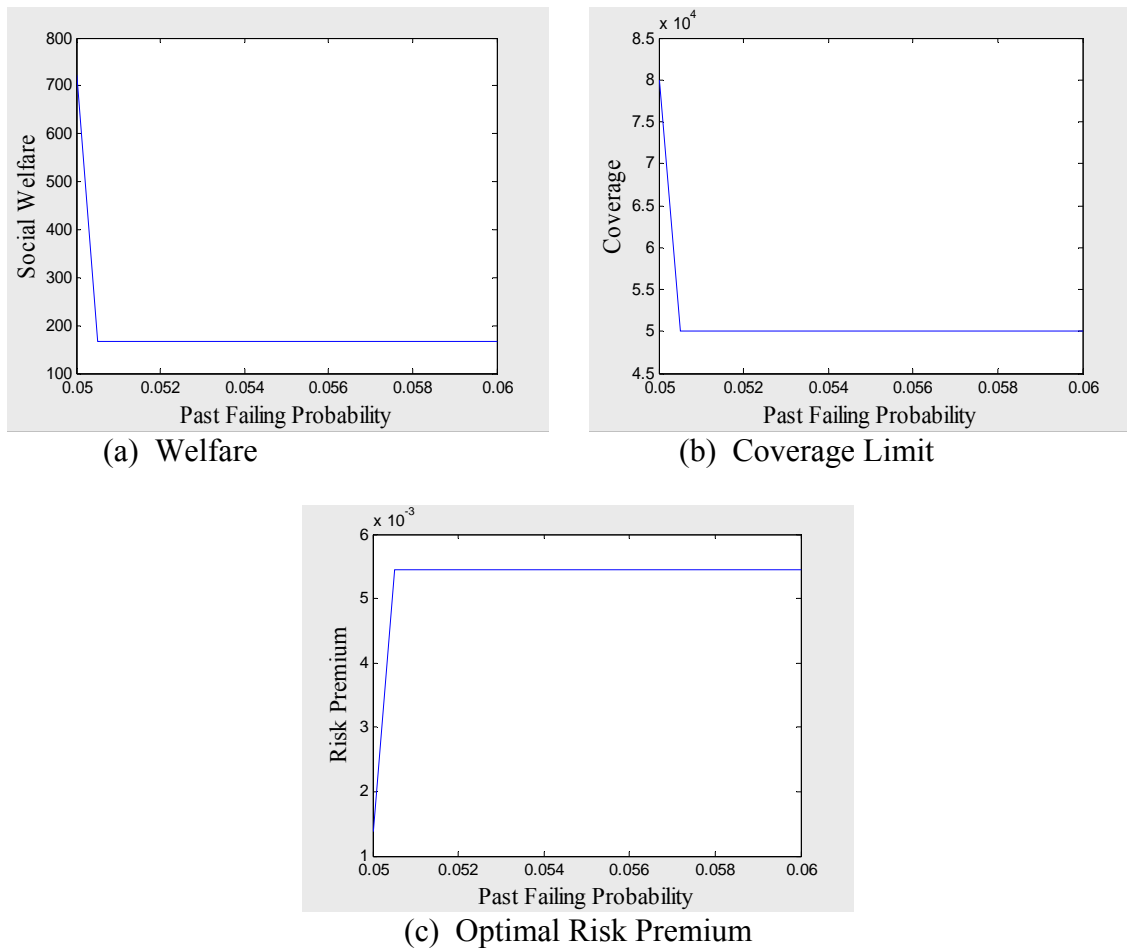


Figure 2.8 The Effect of Varying the Past Failing Probability: P_f^*

2.5.4 The Effects of Varying the Variance of the Gambling Return

Unlike the safe asset, I assume that the return of the gambling asset is a Normally distributed random variable with parameters (\bar{R}, σ^2) .

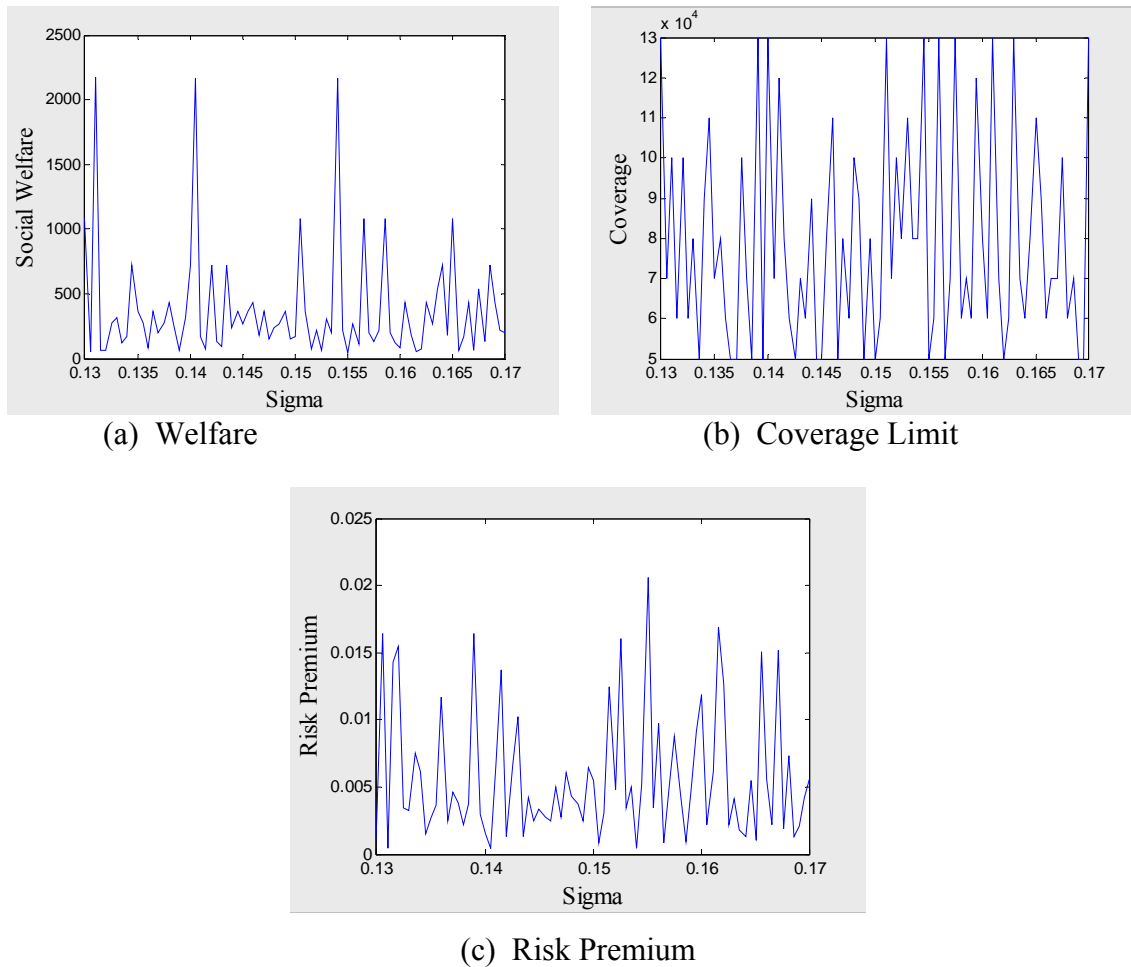


Figure 2.9 The Effect of Varying the Variance of the Random Gambling Return: σ

At the beginning of each period, the bank makes its investment decision by choosing the combination of the prudent and risky assets. Therefore, both the bank's survival probability and the optimal choice of the gambling asset are highly related to the variance of the random return. The greater the variance of this gambling asset, the higher the chance the bank is going to fail and has zero return. It becomes less likely for the bank to take the risk even if the expected return of the risky asset is higher than the prudent asset. Also, if the bank engages more in prudent assets, the lower the risk premium the FDIC will charge. However, in Figure 2.9 neither the coverage nor the risk premium reflect the effect of the higher variance of the gamble return.

2.6 CONCLUSIONS

It is not hard to understand why countries might want to adopt a deposit insurance scheme as a safety net after experiencing severe banking crises. In the previous literature, there are multiple roles attributed to deposit insurance: to restore the public's confidence in a time of crisis, to move away from continuing economic breakdown, and to protect mostly the small depositors.

The design of the “proper” deposit insurance scheme is still debatable. Even for the deposit insurance system in the US which has existed for more than a half century, the economic authorities still face a key challenge: how to deal with the bank's moral hazard problem. After reviewing the literature about banking regulations, Bhattacharya, Boot, and Thakor (1998) argue that market mechanisms such as cash-asset reserve requirements, risk-based capital requirement, risk-sensitive deposit insurance premium, and partial deposit insurance may all be effective in dealing with the moral hazard problem. Our model has incorporated capital requirements, risk-sensitive premium, and partial deposit insurance in a general equilibrium setting.

Both capital requirements and risk-sensitive premia are suggested in the literature as effective ways to help manage a bank's risk-taking behavior. We introduce the partial coverage of deposit insurance that can help in the effort to manage the moral hazard problem. Because of the partial coverage (as opposed to full coverage), depositors have an incentive to do part of the monitoring of the bank's risk-taking behavior, threatening banks with the withdrawal of deposits if necessary.

Our model is a partial equilibrium model, where banks display risk-taking behavior, depositors are ex-ante heterogeneous, and there is a benevolent insurance company providing deposit insurance. I find that a social welfare improvement can be achieved by this mechanism design. Moreover, when the partial coverage limit is in place, banks are better off, balancing the exchange of the higher deposit premia and the depositor's monitoring and potential withdrawals.

Analyzing this coverage-determination process has practical importance in two major areas. For the countries that have a well established deposit insurance system for a long period of time, the optimal coverage limit derived in our model provides the possibility to resolve the moral hazard in banking system, and further, prevent the risk-oriented bank run by reinforcing the market mechanism. More importantly, for the countries that have adopted the implicit deposit insurance or that are without any explicit depositor's protection in place, our model provides a theoretical basis supporting the introduction of a deposit insurance system. A properly-designed deposit insurance plan not only protects the small depositors but also reduces economic instability.

The aim of this paper has been to understand the trade-off between the protection among depositors and bank risk taking when it comes to the issue of the properly-designed deposit insurance system. There are some possible directions in which the paper could be extended. One way to foster market discipline and boost the monitoring and supervision from the side of depositors is to introduce co-insurance.¹⁴ Co-insurance would require that depositors share the pre-specified potential losses from the failure of an insured bank regardless of the size of their deposits. Required contractually at the beginning of the period, this coinsurance system seems to reinforce depositors' market discipline compulsorily. I should be able to discuss the questions such as how to determine the optimal share for depositors to bear, and what the impact of coinsurance is on the risk-enhancing moral hazard problem.

Our model is currently in real terms, but might be used to address real-world concerns regarding nominal coverage limits and inflation. In the U.S. the current coverage limit, \$100,000, was set in 1980. The American Banker Association has proposed to double the current limit. It may be interesting to find the optimal timing and frequency of adjustment of the coverage limits in the face of nominal adjustment costs and inflation. Furthermore, countries with high and volatile inflation rates may face particular difficulties in the timing and frequency of coverage limit adjustments. Issues of indexing and other solutions may provide avenues for future study.

¹⁴ According to Demirguc-Kunt and Huizinga (2004), relatively fewer countries such as Chile, Colombia, Poland and the United Kingdom have adopted co-insurance system.

CHAPTER III

FINANCIAL FRAGILITY AND EXCHANGE RATE REGIMES IN A SMALL OPEN ECONOMY

I build a dynamic general equilibrium model of a small, open economy that displays nontrivial demands for fiat currencies, unanticipated sunspots, and financial/banking crises originated by sudden stops of foreign capital inflows. The goal is evaluating the performance of alternative exchange rate regimes and associated monetary policies. I show the existence of multiple equilibria that may be ranked based on the presence of binding information constraints and on welfare. Moreover, I can show that there is a strong association between the scope for existence and for indeterminacy of equilibria and the underlying policy regime. I also find that the presence of binding multiple reserve requirements may help in reducing the scope for financial fragility and panic equilibria.

3.1 INTRODUCTION

The problems that lay at the heart of the Asian crises are no doubt the overexpansion of credit and the increase in risky behavior by banks in the domestic financial system. The abrupt reversal in the market conditions took the form of a sudden stop of foreign credit and the collapse of the confidence of the people, triggering a widespread financial crisis. This paper studies the interaction between monetary policies and alternative exchange rate regimes to ascertain the probability of a crisis, building from the characteristics of the Asian-crisis countries in 1997. There is no general agreement as to what the appropriate policies are for the countries that have experienced a severe financial crisis. To curb the pressure of the inflation and defend the domestic currency, a country should implement a tight monetary policy. In our paper, we introduce binding reserve

requirements as one form of tight monetary policy. Another example would be a closed economy in which a contraction of the money supply presses the interest rate upwards. This effect may aggravate the burdens of the financial institutions and banks, which might close due to insolvency. Besides, the fundamental weaknesses of the domestic banking sector in the countries of interest have called for the reform of the capitalization, such as increases of the capital requirements and the reserve requirements in financial institutions and in the banking system.

Intentionally, this paper does not aim to show how successful the monetary policy was either in defending the currencies in a time of a crisis or in managing the contagious spread among financial markets. Our goal is to concentrate on the role of monetary policy in the form of reserve requirements, in preventing the banking crises under a diverse setup of the exchange rate regimes.

To build a framework that allows us to analyze the issue just described, we use three building blocks to take us to our goal step by step. The first is to model the behavior of the participants in the domestic banking system. There is a strong agreement on the fact that the reason behind the Asian crises is located in the private sector: domestic banks in the countries of interest were overextended and had a negative debt position with the rest of the world. Unlike other previous crises originated from fiscal imbalances and/or government deficits, the Asian crises shed light on the increased risky behavior and the overexpansion of the banking system. This unique characteristic of the Asian crises provides us with a structural environment to study the connection among the banking system and several macroeconomic issues motivated by the crises. Hence, we propose to design our model economy as one of the individual East Asian country affected by the crisis in 1997.

The second block is to introduce different exchange rate regimes since the choices of monetary policy may vary under the associated exchange rate arrangement. It is a well-established fact that for economies open to international capital flows, the choice of exchange rate regime plays a central role in explaining the vulnerability and fragility of financial markets, as well as domestic price stability and long-run viability.

Therefore, our model studies the effect of the constant growth rate of domestic money supply and reserve requirements under the floating exchange rate regime while the domestic money supply is endogenously determined in the setup under fixed exchange arrangement.

The third block is to identify what the causes of the crises were. According to Kaminsky (2003), we are aware that currency crises may originate by a diversity of factors, and she finds six varieties:

...Four of those varieties are associated with domestic economic fragility, with vulnerabilities related to current account deterioration, fiscal imbalances, financial excesses, or foreign debt sustainability. But crises can also be provoked by just adverse world market conditions, such as the reversal of international capital flows. The so-called sudden-stop phenomenon identifies the fifth variety of crises. Finally, as emphasized by the second-generation models, crises also happen in economies with immaculate fundamentals. Thus, the last variety of crises is labeled self-fulfilling crises.¹⁵

In the model, we consider two possibilities when introducing crises. A crisis comes to our model either in the form of the sudden stop of foreign credit or in the form of panicking among domestic depositors. We put most of our effort to analyze the former because it is consistent with the real situation at the time of the Asian crises. However, we do not neglect the implicit reason aggravating the crises, the self-fulfilling panic and run.

The purpose of this study is to reinforce and fill in the missing association between the overexpansion of the financial system, banking crises, and exchange rate regimes/monetary policy. Thus, we focus our attention on the aforementioned linkage, which we believe is of the utmost importance for most open economies. Our general

¹⁵ Kaminsky (2003), p. 2.

intention is to evaluate the performance of alternative exchange rate arrangements and associated monetary policies. With this in mind, we build a Dynamic General Equilibrium Model -with micro-foundations- replicating a small, open economy with a nontrivial banking system. To fix ideas, we propose to design our model economy as an individual East Asian country affected by the crisis in 1997.

The previous literature has documented extensively the events of the East Asian crisis of 1997. A remarkable example is the paper by Goodhart and Delargy (1998), which compares the East Asian crises in 1997/98 with the financial crises of 1870-1914. According to the authors, these two sets of crises share some common characteristics. First, they have a common origin in the over-expansion of the private sector in Emerging Market Economies that are net debtors with the rest of the world. Second, the countries of interest displayed rapid growth, with booms in foreign capital inflows and in asset markets. Third, the overexpansion of the private investment activity and the fragility of the banking system were apparently connected. Fourth, there was evidence of financial contagion between these countries. However, the authors also establish that most differences between these two sets of crises arise from the underlying exchange rate regimes: fixed exchange rates earlier versus flexible exchange rates later.

There seems to be a general agreement on the fact that Indonesia, South Korea, and Thailand were the countries most affected by the East Asian 1997/98 crisis, followed by Malaysia, Laos and the Philippines. It stands to reason that, up to a significant extent, these countries share some common characteristics and that they display a similar structural environment to study the implementation of particular policies. Clear examples of such similarities lie in the structure and behavior of the financial sector. Before the currency crises in these countries, there was a boom in private borrowing. The sources of financing of this boom were mostly non-performing or low-performing loans due to the risky-lending behavior by banks. Lindgren et al (1999), and Kishi and Okuda (2001) establish also that there was an apparent lack of sound financial structure that only got worse with the ill-oriented process of financial and capital liberalization in most of these countries. In addition, the financial assets of

banks represented an extremely high fraction of the banks' total assets -as opposed to financing in capital markets, and borrowing from foreign banks represented a significant portion of the domestic banks' loans. Finally, most of these countries had intermediate pegs in place at the onset of the crisis. According to the standard chronology of the crisis, the floating of the baht in July 1997 in Thailand apparently triggered the crisis. A subsequent change in expectations led to the depreciation of most currencies in the region, bank runs, and rapid withdrawals of foreign capital. The consequence was a dramatic economic downturn, in particular in Indonesia, Korea and Thailand.

We must also mention that these countries displayed as well significant differences in the speed and magnitude of the economic recovery in the aftermath of the crises. As an example, we can mention that real fixed investment and the growth of real GDP had almost returned to their pre-crisis levels in South Korea in the first two years, but they continued to fall in Indonesia. We intend to provide with a plausible explanation of the observed diversity in the recovery processes in these countries by evaluating the variations in the effective exchange rate regime in place and its associated monetary policies.

It is a well-established fact that for economies open to international capital flows, the choice of exchange rate regime plays a central role in explaining the vulnerability and fragility of financial markets, as well as domestic price stability and long-run viability. In the past decade, economies open to international capital flows¹⁶ have been - and still are- in the process of moving away from intermediate pegs, some toward harder pegs (such as currency boards or arrangements with no separate legal tender), but more towards systems with greater exchange rate flexibility. However, the evidence does not appear to support a particular exchange rate regime and, thus, whether is better to fix or to float is still an open issue¹⁷. Finally, we also argue that when the nominal exchange rate is left to float and, of course, there is no intervention of the monetary authority in the

¹⁶ Mostly, economies classified as developed or emerging markets by the IMF. See Fischer (2001).

¹⁷ For example, see Bencivenga, Huybens and Smith (2002), Calvo and Reinhart (2002), and Hernandez-Verme (2004).

market for foreign exchange (dirty floating), alternative monetary targets may imply different *de facto* exchange rate regimes.

Tables 3.1.A and 3.1.B summarize the exchange rate arrangements in the Asian countries. At the time when the East Asian countries opened their economies to international capitals, most of them switched towards more flexible exchange rate arrangements. Thus, during most of the 1980s and the first part of the 1990s, Indonesia, Korea, Thailand and Malaysia had managed floating arrangements –an intermediate peg, while Philippines had free floating. However, there were some important differences after the 1997 twin crises: Philippines continued with free floating, Indonesia, Korea and Thailand moved from intermediate pegs to free floating as well, but Malaysia had a very hard peg in place.

The model in this paper shares the influence of Diamond and Dybvig (1983) and Chang-Velasco (2000a, 2000b, 2001). Henceforth, we will use D-D as short for Diamond and Dybvig, and C-V as short for Chang and Velasco. Among the most desirable properties displayed by financial institutions in the D-D framework, we must mention the banks' real role in allocating, defined by the design and implementation of deposit contracts that provide allocations superior to those of exchange markets. D-D also offers a theoretical understanding of why bank-run-equilibria can be costly even under deposit insurance. However, the original D-D framework modeled a closed economy. Then, we must take this framework further, and use it in the context of the study of a small, open economy such as a typical East-Asian crisis country.

Table 3.1.A Evolution of Exchange Rate Regimes in the East Asian Countries

Country	Period		Exchange Rate Regime Classification	
	From	To	Narrow Classification	Broad Classification
Hong Kong	Jul-72	Oct-74	Peg to U.S. dollar	Fixed
	Nov-74	Oct-83	Independently floating	Floating
	Oct-83	Dec-04	Peg to U.S. dollar	Fixed
Indonesia ^{a/}	Jan-83	Jul-98	Managed floating	Intermediate
	Aug-98	Jan-02	Independently floating	Floating
Japan	Jan-70	Dec-72	Bretton Woods basket peg	Fixed
	Jan-73	Dec-04	Independently floating	Floating
Korea, Rep. of	Aug-76	Dec-79	Peg to U.S. dollar	Fixed
	Jan-80	Nov-97	Managed floating	Intermediate
	Dec-97	Dec-04	Independently floating	Floating
Malaysia	Jan-70	Jun-72	Peg to pound sterling	Fixed
	Jul-72	Jun-73	Peg to U.S. dollar	Fixed
	Jul-73	Aug-75	Independently floating	Floating
	Sep-75	Mar-93	Limited flexibility w.r.t. a basket	Intermediate
	Apr-93	Aug-98	Managed floating	Intermediate
	Sep-98	Dec-04	Peg to U.S. dollar	Fixed
Philippines	Oct-81	Jun-82	Limited flexibility w.r.t. U.S. dollar	Intermediate
	Jul-82	Sep-84	Managed floating	Intermediate
	Oct-84	Dec-04	Independently floating	Floating
Singapore	Aug-73	Jun-87	Limited flexibility w.r.t. a basket	Intermediate
	Jul-87	Dec-04	Managed floating	Intermediate
Thailand ^{a/}	Jan-77	Feb-78	Peg to U.S. dollar	Fixed
	Mar-78	Jun-81	Limited flexibility w.r.t. a basket	Intermediate
	Jul-81	Mar-82	Managed floating	Intermediate
	Apr-82	Oct-84	Limited flexibility w.r.t. U.S. dollar	Intermediate
	Nov-84	Jun-97	Limited flexibility w.r.t. a basket	Intermediate
	Jul-97	Jun-98	Managed floating	Intermediate
	Jul-98	Jan-02	Independently floating	Floating

^{a/} The information from the Central Bank of Indonesia (floating) is different from that of the IMF (managed floating) after the year 2002. The same happens in Thailand. *Source: Frankel et al (2002).*

Table 3.1.B Exchange Rate Regimes in the East-Asian Countries
Before the Crisis and After the Crisis

Country	Before/During the crisis	After the crisis
Japan	Free floating	Free floating
Philippines	Free floating	Free floating
China	Managed floating	Managed floating
Indonesia	Managed floating	Floating
Korea	Managed floating	Floating
Singapore	Managed floating	Managed floating
Thailand	Managed floating	Managed floating → floating
Malaysia	Managed floating	Fixed
Hong Kong	Fixed	Fixed

Source: Frankel et al (2002).

About 20 years after D-D, Chang and Velasco had a series of illuminating discussions on extending some aspects of the D-D model to the study of the fragility of banking systems and exchange rate crises for a small, open economy. However, the C-V model ignored the central role played by the fiat nature of money in today's world: in the C-V framework, people hold a currency because they derive utility from it, which in itself attaches intrinsic value to what they intend to be fiat money. In our paper, we try to take fiat money seriously, and introduce non-trivial demands for alternative fiat currencies: domestic and foreign. Thus, we consider that one of the contributions of our paper is in the way we introduce fiat money. In particular, we consider a single type of domestic deposits, and banks must hold a fraction of these deposits as currency reserves. Then, fiat money enters our model by the regulation that governs the multiple reserve requirements in this economy. Moreover, banks must hold two types of unremunerated currency reserves: reserves denominated in domestic currency and reserves denominated

in foreign currency¹⁸. Therefore, there is meaningful nominal exchange rate in our model, and this nominal exchange rate will be determined according to the exchange rate regime and the monetary policy in place.

Table 3.2 Reserve Requirements on Local and Foreign Currency Deposits for Selected Countries, End December 1996

Country	Reserve requirement on LCD	Reserve requirement on FCD	Denomination of reserves held on FCD	Participation of FCD in total deposits
	(%) of LCD	(%) of FCD		(%)
Argentina	17.0	17.0	F	50.0
Bolivia	10.0	20.0	F	92.0
India	10.0	0.0	n.a.	n.a.
Japan	1.3	0.3	L	5.1
Malaysia	13.5	13.5	L	n.a.
Peru	9.0	45.0	F	74.7
Philippines	17.0	0.0	n.a.	48.4
Russia	10.0	5.0	L	36.5
Turkey	8.0	11.0	F	49.3
Vietnam	10.0	10.0	F	29.8

Legend: LCD = Local Currency Deposits; FCD = Foreign Currency Deposits. Source: Baliño et al (1999)

We must mention the recent discussion in the literature that highlights the important role of such reserve requirements as a policy tool that can be instrumental in monetary control as well as capital controls and/or capital flow stability¹⁹. Table 3.2 and Table 3.3 summarize the reserve requirements on foreign currency deposits and the relative regulations of the banking system in some of the East Asian countries and other selected countries. For example, during the early 1990s, both Malaysia and Thailand used increases in reserve requirements during periods of heavy capital inflows as a mechanism to control the infusion of foreign capitals in the domestic economy. Finally,

¹⁸ See Hernandez-Verme (2004) for the original discussion.

¹⁹ See for example Reinhart and Reinhart (1999) and Ariyoshi et al (2000).

our model also benefits from the use of a dynamic framework in an economy with an infinite horizon, as is the Overlapping Generations framework.

Self-fulfilling prophecies and strategic complementarities are very helpful concepts that may account for the presence of multiple equilibria in stationary allocations. The potential for the realization of self-fulfilling prophecies is ever present in alternative versions of the Overlapping Generations model with outside assets in general, and models with one or more fiat currencies in particular. The recent literature on open economy macroeconomics has used intensively self-fulfilling prophecies as a tool that may lead to very important underlying explanations for financial fragility, currency crises and/or speculative attacks.²⁰ In such contexts, the presence of informational and institutional frictions in economic models with micro-foundations can exacerbate situations that are already problematic, such as credit rationing, financial repression and endogenously arising volatility, complicating the standard analysis of separating and pooling equilibria. Our model, as a dynamic general equilibrium model with micro-foundations of a small, open economy where there is uncertainty and informational frictions, shares the potential for both insight and analytical complications. Then, the matter of the source and form of uncertainty is a very important one, together with the appropriate utilization of the information and action sets available to agents at all points in time. We borrow heavily from the non-monetary version of C-V (2001) which is very standard to study this type of problems.

However, we believe that we improve on the way in which we introduce and treat potential crises. In particular, one argument of the C-V framework was that when the probability of a crisis is public information, each agent in this economy must use this information when contemplating optimal plans of action at the beginning of every period, and, as result, the optimal behavior of agents is invariant with respect to whether the crisis was realized or not. Alternatively, we introduce the potential for uncertainty of the crisis by using a sunspot variable: a random variable unconnected to the fundamentals of the economy and that expresses the extrinsic uncertainty. We also

²⁰ Cole and Kehoe (1996) and Obstfeld (1996) are very interesting examples of these applications.

consider the potential for intrinsic uncertainty, in the form of sudden stops of foreign credit.

Table 3.3 Regulations on Reserve Requirements in Selected Asian Countries

Regulation/ Country	Liquidity requirements	Reserve requirements	Remuneration of the Required Reserves
China	Ratio of outstanding loans to deposits must not exceed 75%. Ratio of current assets to current liabilities must be at least 25%.		
India	Minimum liquidity is 25% of deposits of scheduled commercial banks. Cash-reserve ratio is 11%.	Upper limit on reserve requirement is 15%.	
Indonesia	None.	Statutory reserve in Rupiah should be 5% of 3 rd party fund in Rupiah; statutory reserve in foreign currency should be 3% of the 3 rd party fund in foreign exchange.	None
Malaysia	15% of eligible liabilities.	4% of eligible liabilities.	None
Philippines	Of 9% against peso deposits, and deposits that are substitute liabilities of universal and commercial banks.	Of 4% for deposits maintained with the BSP (up to 40% of the total reserve requirement); Of 9% for time and saving deposits, etc.	
Singapore	18%	3%	Depends on the maturity of the financial asset and market rates.
Thailand	Of 6% of total deposits of all types. Of 6% of total foreign short-term borrowing. Of 6% of total borrowing with return linked to variables.		None

Source: Kishi and Okuda (2001) <http://www.mof.go.jp/jouhou/kokkin/tyousa/tyou041g.pdf> and World Wide Web <http://microfinancegateway.org/>

In summary, we model a small, open economy that reproduces several aspects of the East-Asian countries at the time of the crisis. The private sector is a net debtor of the rest of the world, and there is an exogenous upper limit to foreign credit at each point in

time. *Ex-ante* identical domestic agents face an uncertainty whose realization is private information. There is a standard problem in coordination that may lead to crises of a self-fulfilling type. Our set up allows us to study the effects of sudden stops and bank runs, and how do they relate to each other. Domestic and foreign fiat currencies may circulate in the economy, and domestic investment is subject to multiple, unremunerated reserve requirements that take the form of currency reserves. Then, we model two such economies that are similar in every respect, except for their choice of exchange rate regimes. The first economy has floating exchange rates, and we intend to replicate the main characteristics share by Indonesia, Korea, Philippines and Thailand after the crisis. We evaluate the performance of two alternative monetary policies that will lead to different de facto exchange rate regimes: a constant rate of money growth versus a policy of inflation targeting. In the second economy, a fixed exchange rate regime is in place, and we intend to replicate the main characteristics of Malaysia after the crisis.

Our results show the existence of multiple equilibria that we may rank based on the presence of binding information constraints and on welfare. Moreover, we can show that there is a strong association between the scope for existence and for indeterminacy of equilibria and the underlying policy regime. We also find that the presence of binding multiple reserve requirements may help in reducing the scope for financial fragility and panic equilibria.

The remainder of the paper proceeds as follows. In Section 2, we present the first model economy, a small, open economy where a floating exchange rate regime is in place and no crises are possible in equilibrium. We then analyze not only the properties of stationary and dynamic equilibria but also consider the effects of two alternative monetary policies. Banks have access to foreign borrowing of different dates and maturities at fixed world interest rates, displaying a nontrivial maturity structure that may determine the existence and type of equilibria. In Section 3, we present the second model economy, a small, open economy where there is a very hard peg (a fixed exchange rate regime) but yet again, crises do not obtain. Next, in Section 4, we introduce the possibility of crises by introducing extrinsic and intrinsic uncertainties. We

formulate the re-optimization problem by banks after a sudden stop. We also emphasize the interaction between standard monetary policy and a policy of multiple reserve requirements, and we show how it will affect the equilibrium results in our model. Finally, in Section 5, we present the main conclusions of the analysis, and discuss its limitations and potential for future research.

3.2 A FLOATING EXCHANGE RATE REGIME: INDONESIA, KOREA, PHILIPPINES AND THAILAND AT THE TIME OF THE CRISIS

In this section, we build a model of a small, open economy that captures the main stylized characteristics shared by the Indonesian, Korean, Filipino and Thai economies at the time of the crisis. At this point, we do not allow for events that could lead to a crisis of any type. The model is in the spirit of Diamond and Dybvig (1983), and Chang and Velasco (2000a, 2000b and 2001). In this small, open economy, the private sector is a net debtor of the rest of the world, and there is an exogenous upper limit to foreign credit faced by domestic banks at each point in time. *Ex-ante* identical domestic agents face an uncertainty whose realization is private information, and there is a standard problem in coordination that may lead to crises of a self-fulfilling type. Domestic and foreign fiat currencies may circulate simultaneously in the economy, and investment is subject to multiple, unremunerated reserve requirements (that are binding, in general) that take the form of currency reserves. A flexible exchange rate regime is in place, and there are no legal domestic restrictions on either using foreign currency or on obtaining foreign credit. We consider two alternative monetary policies to accompany the floating exchange rates: a policy of a constant (and exogenous) rate of money growth and a policy of inflation targeting. Each one of these policies may imply a different *de facto* exchange rate regime.

In the remainder of this section, we describe the features of the model as well as the main results in an economy where no crises are possible.

3.2.1 The Environment

We consider a small, open and pure exchange economy consisting of an infinite sequence of two-period lived, overlapping generations. Time is discrete, and indexed by $t=0, 1, 2, 3, \dots$.

Each of the future generations consists of a continuum of agents with unit mass. We will use the terms young and old for agents in their first period of life and in their second period of life, respectively. Agents are ex ante identical, but they can become of one of the following types: impatient, with probability $\lambda \in (0,1)$, and patient, with probability $(1-\lambda)$. As we will see later on, impatient agents will derive utility from consuming at the end of their youth, while patient agents will derive utility only from consuming in their old age. At $t=0$, there is a generation of initial old. The initial old consist of a continuum of old individuals with unit mass. A fraction $(1-\lambda)$ of these initial old are of the impatient type.

We separate each period into two sub-periods: the morning and the afternoon. Interaction and trade will be different in each sub-period. In summary, young agents may do different things in the morning than in the afternoon, and the same applies to old agents. In this set up, as we will see later in the paper, banks will turn out to be coalitions of individual agents, they are competitive, and we can assume then they are identical. The latter facilitates the analysis by allowing the examination of only a representative bank.

3.2.1.1 Endowments and Preferences

Each period, there is a single tradable good. This good is homogeneous across countries, and agents all over the world cannot produce it. When young, agents receive w units of the single good, first thing in the morning. Old agents receive no endowments.

If an agent who is born at time t turns out to be of the impatient type, she will consume c_{1t} units of the single good at the end of period t , while she is still young, and she will derive the utility $u(c_{1t}) = \ln(c_{1t})$. However, if this agent turns out to be of the patient type instead, she will consume $c_{2,t+1}$ units of the good at the end of time $t+1$,

when old, and she will derive the utility $u(c_{2,t+1}) = \ln(c_{2,t+1})$. Accordingly, the expected utility of an individual agent born at time t would be

$$E[u(c_{1t}, c_{2,t+1})] = \lambda \ln c_{1t} + (1 - \lambda) \ln c_{2,t+1} \quad (3.1)$$

3.2.1.2 Storage Technology

All young agents and domestic banks have access to the following storage/investment technology: for one unit of good invested in the beginning of period t , the agent receives the return $R > 1$ goods at the end of $t+1$. However, she would receive only a return of $r < 1$ if she were to liquidate the investment early, at the end of period t . The only available technology for the short-term investment is this same storage technology. For instance, if an agent liquidates early, she would get the return $r < 1$ per good at the end of period t , and if she stores the proceeds again between the end of period t and the end of period $t+1$, then she will get the return $r \cdot r = r^2 < 1 < R$ per good at the end of period $t+1$. Thus, long-term storage technology dominates early liquidation in rate of return.

3.2.1.3 The Informational Structure

While all agents are *ex-ante* identical at the time of birth, they face uncertainty at the end of their first period of life. At this point of time, they will learn whether they are of the impatient type or of the patient type. A young agent will be of the impatient type at the end of her first period of life with probability $\lambda \in (0,1)$. Of course, the same young agent would be of the patient type with probability $(1 - \lambda)$. The parameter λ is public information, and realizations of types are i.i.d. across agents and over time. However, the type of an individual agent is private information: once an individual realizes her type, only that individual herself knows her true type, giving rise to a standard private information problem. The latter will have serious implications for the design of deposits contracts that banks can offer.

Given the structure of information in our model, only agents of the patient type can credibly pretend to be of the impatient type. To do so, and to avoid capture, an individual of the patient type who misrepresents her type would have to withdraw as

many goods from the bank as an individual of the impatient type would at the end of period t (c_{1t}). However, an individual of the patient type who behaves according to her true type would withdraw c_{2t+1} goods from the bank at the end of $t+1$. Then we could write a truth-telling condition as

$$c_{2t+1} \geq rc_{1t} \quad (3.2)$$

Equation (3.2) holds as an incentive-compatibility or self-selection condition that allows no motivation for patient agents to misrepresent their types and, that, therefore, forces agents to behave according to their true type.

3.2.1.4 Multiple Fiat Currencies

Two fiat and outside currencies may circulate in the small, open economy at any point in time. The monetary authority in the domestic country issues one of them. M_t is the outstanding nominal stock of domestic currency at the end of period t and p_t denotes the domestic price level. The domestic price level p_t represents the number of units of domestic currency that individuals need to exchange for one unit of the good at time t . In addition, foreign currency may circulate in the domestic economy. We use Q_t to denote the outstanding stock of foreign currency in the domestic country, at the end of period t . The price of the good in the rest of the world p_t^* represents the number of units of foreign currency that individuals need to exchange for one unit of the good at time t , and it is exogenous. We use e_t to denote the nominal exchange rate, measured as the number of units of domestic currency exchanged for one unit of foreign currency. Then,

$\frac{p_t}{p_{t+1}} > 0$ and $\frac{p_t^*}{p_{t+1}^*} > 0$ are the gross real rates of return on domestic and foreign

currency, respectively. For simplicity –and without loss of generality, we also assume that the foreign rate of inflation is exogenous and constant over time, meaning that the gross real return on foreign currency satisfies $\frac{p_t^*}{p_{t+1}^*} = \frac{1}{(1 + \sigma^*)}$, where $\sigma^* > -1$ is the exogenous net inflation rate in the rest of the world.

Finally, we assume there is free international capital mobility in this small, open economy, and that there are no legal restrictions to the use of foreign currency in the domestic country. Purchasing Power Parity also holds in equilibrium, so that $e_t p_t^* = p_t$ is satisfied.

With respect to the general guidelines for domestic monetary policy, the monetary authority in the domestic country accomplishes all injections and/or withdrawals of domestic currency through lump-sum transfers. In particular, each young agent will receive the equivalent of τ_t goods *ex ante*, at the beginning of period t , regardless of type. We have two reasons behind our choice of this particular scheme of monetary transfers: first, we minimize the presence of an adverse selection problem, and second, we do not require the monetary authority to have additional information that could be of a private nature²¹.

At $t=0$, there is an initial-old generation that behaves as any old agent from the future generations would. In particular, a fraction $1 - \lambda$ of these initial old individuals would be of the patient type, and, thus, would like to consume in their old age. In standard models with overlapping generations, the initial conditions of the economy describe the initial stock of the different assets that exist in the economy, and they play a key role. Typically, the initial stocks of assets indicate the “endowments” of the members of the generation of initial old individuals. There are two initial conditions in this economy: the nominal supplies of domestic and foreign currency at $t=0$. Thus, we let $M_0 > 0$ and $Q_0 > 0$ denote the nominal supply of domestic and foreign currency in the small open economy, respectively, and they are in the hands of the initial old. The members of the initial-old generation of the patient type all have an equal share of the initial money supplies. Thus, each initial old would have the equivalent of

$$\frac{M_0}{(1 - \lambda)p_0} + \frac{e_0 Q_0}{(1 - \lambda)p_0} \text{ goods at the beginning of period } t = 0.$$

²¹ We must point out that, in this framework, the question of “who gets what and when” is not a trivial one, and different answers to it may have a crucial influence on the equilibrium results. The transfer scheme we propose may not be neutral, in the sense that it may affect the self-selection constraint. In Appendix B-1, we present alternative results for the case where the monetary authority gives transfers only to young agents who claim to be of the impatient type, after the realization of types.

3.2.2 Financial Intermediation

In this section, we explain the nature of banks, as well as the role they play in this small, open economy. We follow the standard Diamond-Dybvig set up, where individuals make deposits of all of their endowments in banks, and banks act purely as financial intermediaries. In this environment, a bank is simply a coalition of individual agents. Given the latter, we may treat all of these financial institutions as identical and then focus on the behavior of a representative bank.

In this environment, banks arise endogenously and they pool together the resources owned by individuals at the beginning of their lives. This allows banks to offer individuals partial insurance against uncertainty of their potential types, and provide them with allocations that are Pareto superior to autarky. In the context of a small, open economy, as mentioned by C-V (2000), domestic agents may also benefit from pooling their resources and acting together, if such economy does not display aggregate uncertainty. This is the case in our model.

A bank that is a coalition of individuals born at the beginning of period t , starts in business at the beginning of period t as well. Following the standard practice in the literature, a representative bank will behave so that it maximizes the expected utility of individual agents in our model economy, given by equation (1). This will be in their best interest as well, given that banks are coalitions that represent collections of individual agents.

3.2.2.1 Access to Foreign Credit Markets

In this economy, only banks may access the world credit markets. Domestic banks may trade with the rest of the world in several primary debt markets, and the debt instruments available may provide them with a variety of terms and/or dates of maturity. Henceforth, when we use the term “banks” without further qualification, we refer to banks that start in business at the beginning of time t .

Domestic banks have access to three different foreign-debt instruments, at different points in time. The first foreign-debt instrument is a short-term loan that starts at the beginning of period t and matures at the end of period t ; we use d_{0t} to denote the amount traded of this asset, and $r_0^* > 0$ to denote the associated gross real interest rate. We can also think of this first instrument as intra-period debt. The second asset is also a short-term foreign-debt instrument, but this loan starts at the end of period t and matures at the end of period $t+1$; we use d_{1t} to denote the amount that banks trade of this asset, and $r_1^* > 0$ is the corresponding gross real interest rate. The last foreign-asset available is a long-term loan that starts at the beginning of period t and matures at the end of time $t+1$; we use d_{2t} to denote the amount traded of this long-term asset by domestic banks, and $r_2^* > 0$ is its gross real interest rate. We follow the standard practice in the literature by assuming that $r_0^* > 0$, $r_1^* > 0$ and $r_2^* > 0$ are time-invariant and exogenous gross real interest rates that are determined in the corresponding foreign credit market.

We will henceforth restrict our attention to allocations where the domestic country is a net borrower from the rest of the world, as was the case in most East-Asian countries at the time of the crisis. Thus, banks always hold non-negative positions of all instruments of foreign debt, implying that $d_{0t} \geq 0$, $d_{1t} \geq 0$, and $d_{2t} \geq 0$. We will see later that the amounts borrowed from the rest of the world cannot all be zero at the same time.

In addition, a domestic bank starting operations at the beginning of period t will face exogenous foreign-borrowing constraints at times t and $t+1$. We can write these foreign-borrowing constraints as

$$d_{0t} + d_{2t} \leq f_0 \quad (3.3)$$

and

$$d_{1t} + d_{2t} \leq f_1 \quad (3.4)$$

Both f_0 and f_1 are measured in goods. Then, $f_0 > 0$ in equation (3.3) is the exogenous maximum amount that domestic banks starting operations at the beginning of t can

borrow from the rest of the world at time t : intra-period debt and long-term debt. Similarly, $f_1 > 0$ in equation (3.4) is the exogenous maximum total amount of debt maturing at the end of $t+1$ that a bank starting operations at the beginning of t can borrow from the rest of the world.

3.2.2.2 Fractional-Reserves Banking and Multiple Reserve Requirements

The structure of multiple reserve requirements in our model follows Hernandez-Verme (2004) in that all investment done by domestic banks is subject to the financial regulations of the domestic country²². Domestic banks must hold some of these reserves in the form of domestic currency, and hold another part of these reserves in the form of foreign currency. In particular, let $\phi_d \in (0,1)$ denote the fraction of deposits that the banks must hold in the form of domestic currency. When held from t to $t+1$, domestic currency reserves earn the gross real rate of return $\left(\frac{p_t}{p_{t+1}}\right)$. Similarly, $\phi_f \in (0,1)$ denotes the fraction of deposits that banks must hold in the form of foreign currency. Foreign currency reserves held between t and $t+1$ earn the gross real rate of return $\left(\frac{e_{t+1}p_t}{e_t p_{t+1}}\right)$.

Obviously, we will assume that $\phi_d + \phi_f < 1$. Finally, we must mention that we will focus on allocations where both reserves requirements are binding. This will transpire if $\left(\frac{p_t}{p_{t+1}}\right) < R$ and $\left(\frac{p_t^*}{p_{t+1}^*}\right) < R$ both hold.

3.2.2.3 The Timing of Transactions

In our model, there are no transactions among individual agents of any age or type, either domestically or with the rest of the world. All transactions take place through the banks. Thus, banks in this model are inherently financial intermediaries.

Figure 3.1 describes the sequence of events and choices by a representative member of a typical future generation, which is born at t and dies at the end of period

²² We further assume that all agents investing domestically must hold currency reserves.

$t+1$. These individuals live for four sub-periods: the morning of period t , the afternoon of period t , the morning of period $t+1$, and the afternoon of period $t+1$. We now proceed to describe the transactions that take place each sub-period.

The morning of period t : Young individuals are born first thing in the morning of period t . These young individuals have two sources of funds at this point: their endowment of w units of the single good, and the monetary transfer of τ_t goods from the monetary authority. These young individuals make deposits in banks. In particular, young agents deposit inelastically the total of whatever resources they have at this time. Hence, deposits in banks amount to $w + \tau_t$ goods per young agent.

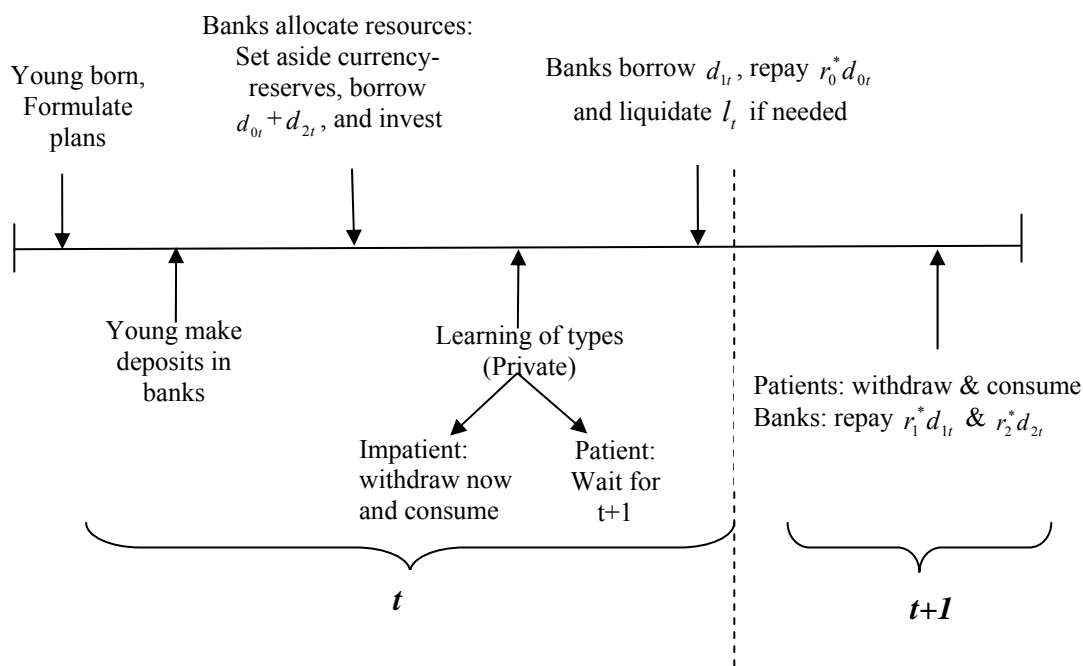


Figure 3.1 Sequence of Events

On the other side of the financial market, we have the banks. Of course, banks receive deposits from young individuals. The banks have also the ability to borrow funds from the rest of the world—which individual agents do not have. Then, banks have two

sources of funds in the morning of time t that they can dispose of. The first source is the amount deposited by individuals, but they must set aside first the required currency reserves. Then, the amount of deposits that banks can utilize in the morning of time t is $(1 - \phi_d - \phi_f)(w + \tau_t)$ goods. The second source of funds is total credit obtained from abroad at the beginning of t , in the form of intra-period and long-term debt, $d_{0t} + d_{2t}$. Banks combine these resources together in order to finance a long-term investment that uses the domestic storage technology. Let k_t denote investment in this long-term asset. Then, we can express the budget constraint the representative bank faces at the beginning of period t by using the following inequality:

$$k_t \leq d_{0t} + d_{2t} + (1 - \phi_f - \phi_d)(w + \tau_t) \quad (3.5)$$

The afternoon of period t : Individual agents learn their types early in the afternoon of time t . An impatient agent derives utility from consuming c_{1t} at that point in time, while a patient agent will derive utility only from consuming $c_{2,t+1}$ goods at the end of the next period. Then, banks need to pay the withdrawals by all agents claiming to be of the impatient type. Given that λ is public information, all the banks know that there are only λ individuals of the impatient type²³. If each agent claiming to be of the impatient type withdraws, then banks would only allow total withdrawals amounting to λc_{1t} goods. Banks must also repay $r_0^* d_{0t}$ of principal plus interest of intra-period foreign debt. The banks' have a potential source of new funds at this point: a new short-term foreign loan of d_{1t} goods. In case more funds are required, the banks could liquidate early part of the long-term storage/investment. Early liquidation is costly in the sense that it obtains the effective return $r < 1 < R$ instead. Then, we can write the budget constraint faced by a representative domestic bank at the end of period t as the inequality below,

$$\lambda c_{1t} + r_0^* d_{0t} \leq r l_t + d_{1t} \quad (3.6)$$

²³ The banks do not know the identities of the true impatient agents.

We must mention also that there is a sequential service constraint in place at the end of period t . This means that the bank's payment to any individual agent who is in the line for withdrawals depends only on that agent's position in the queue of depositors: the first to come is also the first served. In case the bank exhausts its resources before repaying all foreign loans that are due and all depositors left in the line for withdrawals, the bank closes, and any future payments contracted by the bank are lost.

The morning of period $t+1$: There are no "active" transactions in this sub-period. Both patient agents and banks wait for the durations of this sub-period. If all agents behave according to their true type, then all impatient agents have already consumed in the morning of time t .

The afternoon of period $t+1$: At the end of period $t+1$, agents of the patient type who behave according to their true type wish to withdraw funds from the bank in order to finance their old-age consumption of $c_{2,t+1}$ goods each. Repayments of the long-term foreign debt $(r_2^* d_{2t})$ and the new short-term foreign debt $(r_1^* d_{1t})$ are due as well. If the bank did not close at the end of period t , then it will use the return of the remaining long-term investment -given by $R(k_t - l_t)$ goods- together with the gross real return on its currency reserves to pay its obligations. The return on these currency reserves is $\phi_d(w + \tau_t)/(1 + \sigma)$ to reserves held in the form of domestic currency, and $\phi_f(w + \tau_t)/(1 + \sigma^*)$ to reserves held in the form of foreign currency. It will be helpful to notice at this point that one of the consequences of the regulations on reserve requirements concerning the financial sector in this economy is that banks have an additional source of funds at the end of $t+1$ -even if they yield each a dominated real rate of return. We think this contributes to reduce the likelihood of a panic of patient depositors who did not want to withdraw at the end of period t . Then, the budget constraint faced by a representative bank at the end of the afternoon of period $t+1$ can be written as the following inequality

$$(1 - \lambda)c_{2,t+1} + r_2^* d_{2t} + r_1^* d_{1t} \leq R(k_t - l_t) + \phi_d \left(\frac{p_t}{p_{t+1}} \right) (w + \tau_t) + \phi_f \left(\frac{1}{1 + \sigma^*} \right) (w + \tau_t) \quad (3.7)$$

3.2.2.4 Deposit Contracts

Given the uncertainty in the type of individual domestic agents and the fact that its actual realizations are private information, the representative bank must use some kind of self-selection mechanism to prevent agents from misrepresenting their type. The inequality in (2) embeds this truth-telling constraint.

Autarkic Equilibrium: in the absence of financial intermediation, individuals can only access the storage technology. An agent of the impatient type liquidates her investment through the storage technology, obtaining $r(w + \tau_t)$ goods at the end of period t . Then again, an agent of the patient type waits until the end of her second period of life, obtaining $R(w + \tau_t)$ goods.

Financial Intermediation: As we have mentioned before, a representative bank is a coalition of individuals. As such, the bank will offer a deposit contract consisting of the contingent pair $(c_{1t}, c_{2,t+1})$ to individuals. c_{1t} is the amount offered to agents who claim to be of the impatient type and withdraw at the end of period t , while $c_{2,t+1}$ is the amount that banks offer to individuals claiming to be of the patient type who wait until the end of period $t+1$. Banks choose the pair $(c_{1t}, c_{2,t+1})$ specified in the deposit contract to maximize the objective function (3.1), subject to the constraints (3.2)-(3.7). As in the standard D-D model, these deposit contracts may provide individuals with allocations that are Pareto superior to those of autarky. In particular, the bank offers partial insurance against the uncertainty of types in the deposit contract, so that $r(w + \tau_t) < c_{1t} < c_{2,t+1} < R$ holds.

3.2.3 A Floating Exchange Rate Regime with a Constant Rate of Money Growth

Under a policy that prioritizes a constant rate of growth of the supply of domestic currency, the monetary authority dictates the evolution of the nominal supply of domestic fiat currency. In this environment, such a policy takes the form of

$$M_{t+1} = (1 + \sigma)M_t, \forall t \geq 0 \quad (3.8)$$

where $\sigma > -1$ is the exogenous and constant rate of domestic money growth, chosen by the domestic monetary authority. Equation (3.8) is a standard first order nonlinear difference equation that governs the evolution of the exogenous nominal supply of domestic fiat currency. Accordingly, the government budget constraint under this policy is

$$\tau_t = \frac{M_t - M_{t-1}}{p_t} = \frac{M_t}{p_t} \left(\frac{\sigma}{1 + \sigma} \right) = z_t \left(\frac{\sigma}{1 + \sigma} \right) \quad (3.9)$$

Notice that $z_t \equiv M_t/p_t$ equation (3.9) represents the total as well as the per young agent²⁴ real holdings of domestic currency at t .

3.2.3.1 General Equilibrium

There are several conditions to satisfy in a general equilibrium. We can summarize the market clearing conditions under a policy of constant rate of domestic money growth by using equations (3.10)-(3.16) below. First, given that the single good is homogeneous across countries and there are no restrictions on international goods trade, the purchasing power parity condition must hold. Thus

$$p_t = e_t p_t^* \quad (3.10)$$

In addition, without any restrictions on international capital flows, there is no arbitrage between the gross real domestic interest rate and world-determined interest rates, after we control for the different length of the maturity periods. Then, we restrict our attention to allocations where the following “*perfect no arbitrage*” condition holds

$$R = r_2^* = r_0^* \cdot r_1^* \quad (3.11)$$

We focus throughout on situations where the reserve requirements bind. This transpires when

$$R > \frac{p_t}{p_{t+1}} = \frac{z_{t+1}}{z_t(1 + \sigma)} \quad (3.12)$$

and

²⁴ Recall that the modulus of the total population is 1.

$$R > \frac{p_t^*}{p_{t+1}^*} = \frac{1}{(1 + \sigma^*)} \quad (3.13)$$

Equation (3.14) below describes the clearing in the market for domestic real money balances exchanged for goods. In particular, the currency reserves that banks must hold in the form of domestic currency pin down the demand for domestic real money balances, yielding

$$\frac{M_t}{p_t} = z_t = \phi_d(w + \tau_t) \quad (3.14)$$

Next, equation (3.15) describes the equilibrium in the market for foreign currency in exchange for goods. We now define $q_t \equiv Q_t/p_t^* = eQ_t/p_t$ as the real holdings of foreign currency per young agents at t . It is also the case here that the currency reserves that banks must hold in the form of foreign currency determine the demand for foreign real money balances, and

$$\frac{e_t Q_t}{p_t} = q_t = \phi_f(w + \tau_t) = \frac{\phi_f \cdot z_t}{\phi_d} \quad (3.15)$$

We also find that all equilibria must satisfy

$$\frac{e_{t+1}}{e_t} = \left(\frac{p_{t+1}}{p_t} \right) \left(\frac{p_t^*}{p_{t+1}^*} \right) \quad (3.16)$$

Finally, we must also highlight again that, under this policy of floating exchange rates with a constant rate of domestic money growth, equation (3.9) describes the government budget constraint.

3.2.3.2 Steady-State Equilibria

In this section, we describe separating stationary equilibria where all agents behave according to their true type and there are no problems of liquidity. In such allocations, there is no early liquidation of the long-term investment by banks²⁵.

In this environment, a stationary allocation is such that the real balances of domestic currency per young agent, $z_{t+1} = z_t = z > 0$, are constant over time. As a result, the gross real return on domestic currency, $\frac{p_t}{p_{t+1}} = \frac{1}{1+\sigma}$, is constant over time as well.

Combining equations (3.9) and (3.14), and imposing stationarity conditions, we obtain that the real value of the monetary transfer in a stationary equilibrium is equal to

$$\tau = \frac{\sigma\phi_d w}{1 + \sigma(1 - \phi_d)} \quad (3.17)$$

Notice also that, from equation (3.15), it follows that $q_{t+1} = q_t = q > 0$ holds whenever $z_{t+1} = z_t = z > 0$ is satisfied, in a stationary equilibrium. In addition, from equation (3.16), we obtain that the growth of the nominal exchange rate must also be constant over time in a stationary allocation. Specifically, the growth of the nominal exchange rate depends on the domestic and foreign monetary policy parameters σ and σ^* , obtaining

$$\frac{e_{t+1}}{e_t} = \frac{1 + \sigma}{1 + \sigma^*} \quad (3.18)$$

Finally, the amounts borrowed from abroad are stationary for all types of foreign debt-instrument, and equal to $d_0 \geq 0$, $d_1 \geq 0$ and $d_2 \geq 0$, respectively. The foreign borrowing constraints in (3.3) and (3.4) bind.

²⁵ In these type of equilibria we also find that $[\partial L(\cdot)/\partial l_t] < 0$, where $L(\cdot)$ is the Lagrangean for the banks' problem, and l_t denotes early liquidation of the long-term investment. This condition implies that banks do not liquidate investment early, and thus $l_t = 0$ in equilibrium.

Thus, we can define a stationary equilibrium as the set of all the triplets $(z, q, \tau) \gg 0$ and $(d_0, d_1, d_2) > 0$ that are constant over time, where $e_{t+1}/e_t = (1 + \sigma^*)/(1 + \sigma) > 0$ is constant as well.

We proceed by first checking the conditions for existence of the stationary equilibria as well as their bifurcation properties. We next analyze whether these equilibria display uniqueness or local uniqueness, followed by an examination of the issue of determinacy.

Existence of Steady-state Equilibria: We summarize our results for this type of separating equilibria in Table 3.4. We classify our results into two categories, according to the maturity-structure of the foreign interest rates. Equilibria belonging to the first category (Case I) display a maturity-structure of interest rates such that the intra-period foreign debt is relatively cheaper than the inter-period short-term debt. Thus, $r_0^* < 1$ and $r_1^* > r_2^* = R$ obtains for all equilibria in Case I. Alternatively, equilibria belonging to the second category (Case II) display a different maturity-structure of interest rates, with inter-period short-term debt cheaper than intra-period debt. Then, $r_0^* > 1$ and $r_1^* < r_2^* = R$ obtains for all equilibria in Case II.

Table 3.4. Existence of Steady-State Equilibria with *Ex-ante* Transfers
 No early liquidation: $l_t = 0$. A Floating Exchange Rate Regime

		Case I	Case II
Type of Equilibria	Amount Borrowed	$r_0^* < 1$ and $r_1^* > r_2^* = R$	$r_0^* > 1$ and $r_1^* < r_2^* = R$
No intra-period foreign debt	$d_2 = f_0$ $d_0 = 0$ $d_1 = f_1 - f_0$	Equilibria exist only for values of σ sufficiently high .	Equilibria do not exist.
Interior solution	$d_2 > 0$ $d_0 = f_0 - d_2$ $d_1 = f_1 - d_2$	Equilibria exist when σ is neither too low nor too high .	Equilibria exist when σ is neither too low nor too high .
No long-term foreign debt	$d_2 = 0$ $d_0 = f_0$ $d_1 = f_1$	Equilibria exist for values of σ sufficiently high .	Equilibria exist for values of σ sufficiently low .

In addition, it is possible to observe three different types of equilibria within either Case I or Case II. We can describe each one of them as follows:

- a) *Equilibria with no intra-period debt* d_0 . These equilibria are stationary allocations characterized by $d_0 = 0$, $d_2 = f_0$ and $d_1 = f_1 - f_0$. We might interpret such an equilibrium as one where domestic banks would like to borrow arbitrarily large amounts of long-term foreign debt d_2 , but the upper bound to the foreign borrowing in (3.3) binds, and $d_2 = f_0$.
- b) *Equilibria with interior solutions for* d_0 , d_1 and d_2 . In such an equilibrium, there are nontrivial amounts of each type of loan from abroad, such that $0 < d_2 < f_0$, $d_0 = f_0 - d_2 > 0$, and $d_1 = f_1 - d_2 > 0$.

- c) *Equilibria with no long-term debt* d_2 . These equilibria are stationary allocations where $d_2 = 0$, $d_0 = f_0$ and $d_1 = f_1$. We might interpret one such equilibrium as a situation where domestic banks would like to borrow arbitrarily large amounts of intra-period foreign debt d_0 , but the upper bound to the foreign borrowing in (3.3) binds, and $d_0 = f_0$.

We must point out that the stationary equilibria display bifurcations in this economy. Bifurcations imply that there are differences with respect to the existence, number, type and properties of steady-state equilibria, and they occur mostly due to different ranges for the value of the parameter of domestic monetary policy σ .

The interaction between the maturity-structure of foreign interest rates and the domestic policy parameter σ explains the different equilibrium sets. The structure of the interest rates represents the relative cost of borrowing each of the different types of foreign-debt, while the rate of domestic money growth indicates the return of the currency reserves held by banks. For instance, a bank is more willing to borrow long-term from abroad when the domestic inflation rate is low instead of high. The same applies when the long-term foreign debt is relatively cheaper. In the remainder of this section, we describe qualitatively the results on existence as a function of the domestic rate of money growth²⁶.

Stationary equilibria with no intra-period foreign debt exist only in Case I, and only when the rate of domestic money growth is high enough. However, when intra-period debt and long-term debt are relatively expensive (Case II,) equilibria do not exist, regardless of the value of σ .

Alternatively, the existence of equilibria with interior values of all foreign-debt requires the domestic rate of domestic money growth not be either too low or too high, whatever the underlying maturity-structure of the interest rates. Finally, equilibria with no long-term debt do not exist for values of σ that are low enough in situations where

²⁶ For more details, see Appendix B-2. Notice too that the results on existence as a function of σ^* are qualitatively similar. This is mostly because the parameters σ and σ^* affect the banks' budget constraint given by (7) in the same fashion.

intra-period and long-term foreign debt are relatively cheaper (Case I). We observe the exact opposite results for situations where inter-period short-term foreign debt is relatively cheaper: equilibria do not exist for rates of domestic inflation that are too high.

Local Uniqueness and Determinacy of Steady-State Equilibria: The issue of multiple equilibria raises a new set of questions related to local uniqueness and determinacy of equilibria. In standard general equilibrium theory, the construction of the economic environment usually ensures that the economy is “regular”²⁷, i.e. the number of equilibria is finite, and, thus, the properties of local uniqueness and determinacy are satisfied. However, it is still possible to find economic environments that do not constitute “regular” economies, where there is typically a continuum of equilibria. Thus, in an economy that is “not regular”, the properties of local uniqueness and determinacy of equilibria are typically not satisfied.

In our set up, even for fixed domestic rates of money growth and foreign inflation rates, we typically find that many different stationary combinations of the foreign interest rates satisfy the equilibrium conditions. In fact, we obtain a continuum of stationary equilibria. Thus, in our model, the stationary equilibria do not display the property of local uniqueness, and, therefore, they are indeterminate.

To fix ideas and to illustrate the absence of local uniqueness, we take the type of equilibria with no intra-period debt under Case I. We display the solution in Figure 3.2. Notice that, because of perfect no arbitrage, $r_2^* = R$, which already reduces the dimension of the price vector. However, these stationary equilibria lie on the thick gray line in the three-dimensional space of the interest rates, and there is a continuum of them. Moreover, we can also construct an extra mapping from the foreign interest rates to the policy parameter σ , and find all the ranges of values of the domestic rate of money growth that are consistent with these equilibria existing. In our diagram, the boundaries of such ranges of values of σ are implicitly defined by the functions $A'(\sigma)$ and $B'(\sigma)$ ²⁸. Proposition 3.1 illustrates this fact.

²⁷ For more detail, see Mas-Colell et al (1995), p.591.

²⁸ See Appendix B-3 for definitions of the boundaries and more detail.

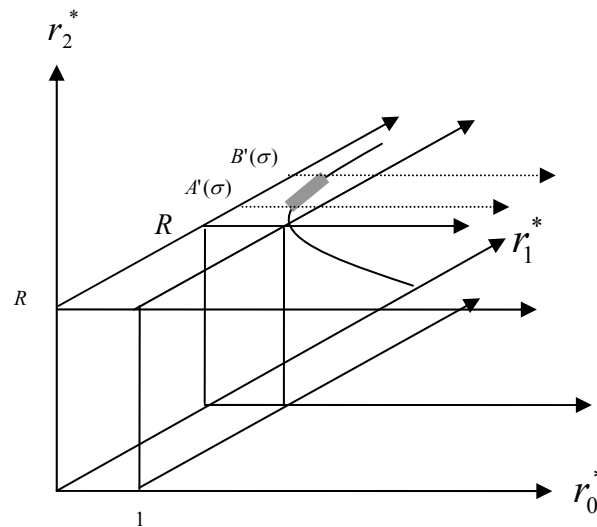


Figure 3.2 The Continuum of Equilibria

Proposition 3.1 *In the set of all separating stationary allocations where all agents behave according to their true type and there is no early liquidation of the long-term investment, there are bifurcation values of the monetary policy parameter σ that determine regions in the space of foreign interest rates. Some these regions are inconsistent with the existence of stationary equilibria. There are some other regions where steady-state equilibria exist. When equilibria exist, the equilibrium is not unique (not even locally), and we will typically observe a continuum of equilibria as combinations of the three foreign interest rates.*

We describe the details of the results on existence and number of equilibria for the different Cases and types in Appendix C. The proof is available upon request from the authors.

3.2.3.3 Dynamic Equilibria

Combining equations (3.9) and (3.14) yields the following dynamic system

$$z_t = \phi_d w + \phi_d z_t \left(\frac{\sigma}{1 + \sigma} \right) \quad (3.19)$$

It is evident from equation (3.19) that this environment is stationary when both currency reserve requirements bind, given that the domestic money supply is exogenous under floating exchange rates. Therefore, we observe only trivial and immediate dynamics in the transition from the initial conditions to the stationary equilibria, but equilibria are not truly dynamic. Then, only steady-state equilibria exist in this environment when the reserve requirements bind.

3.2.4 Floating Exchange Rates with a Policy of Inflation Targeting

We now proceed to study a policy of inflation targeting under floating exchange rates. Under the policy of inflation targeting, the monetary authority sets once and for all the target net rate of domestic inflation to be the constant rate $i, \forall t \geq 0$. The domestic nominal supply M_t adjusts to meet this target. Notice that under a policy of a constant rate of domestic money growth, the monetary authority chooses the nominal money supply exogenously. However, under this policy of inflation targeting M_t adjusts endogenously to satisfy the monetary policy rule.

We define this policy such that domestic prices evolve according to the following nonlinear difference equation

$$\frac{p_t}{p_{t+1}} = \frac{1}{1+i}, \forall t \geq 0 \quad (3.20)$$

Our framework allows us to compare the existence and properties of equilibria under the two alternative monetary policies described in this paper, with floating exchange rates. In particular, given the stationarity of the environment when reserve requirements bind, the dynamic systems under these two monetary policies are identical in situations where the monetary authority sets a domestic rate of money growth (σ) similar to the inflation target (i) under the second policy, i.e. $\sigma = i$. Thus, there are no

dynamic equilibria under any of these two policies, and the properties inherent to the steady-state equilibria remain unchanged.

3.3 A FIXED EXCHANGE RATE REGIME: THE CASE OF MALAYSIA AT THE TIME OF THE CRISIS

In this section, we consider a small, open economy that operates under a fixed rather than a flexible exchange rate regime. As we did in section 3.2, we do not consider the cases where crises are possible. As in Hernandez-Verme (2004), we construct this fixed exchange rate regime such that a currency board emerges as a special case, and, to simplify matters and fix ideas, we restrict our attention to the study of equilibria under this particular very hard peg. The intention is to build a model of a small, open economy that captures the main stylized characteristics of the Malaysian economy at the time of the crisis²⁹. Of course, in all respects except for the exchange rate regime that is in place, the economy remains as described in the previous sections.

3.3.1 Monetary and Foreign Exchange Policy

In this section, we consider a fixed exchange rate regime, where the monetary authority chooses exogenously and once and for all the nominal exchange rate at the initial period $t=0$. Without loss of generality, we let $e > 0$ denote the time invariant and exogenous nominal exchange rate set by the monetary authority at $t=0$. Then, the policy parameter e does not change for all periods onward. Under this policy, the central bank must stand ready to buy or sell foreign currency at the fixed exchange rate, causing the domestic money supply to change as necessary to meet this target. The latter implies that the nominal supply of domestic currency is endogenous: by fixing the nominal exchange rate, the monetary authority gives up full control of M_t .

²⁹ It is possible to argue as well that the model in this section not only represents the Malaysian economy, but the Hong-Kong economy as well.

The monetary authority may also choose to hold reserves in the form of interest-bearing, foreign assets. The purpose of these reserve-holdings is to back the domestic money supply. For simplicity, we assume there is only one type of interest-bearing foreign asset that performs this function. Let B_t^* denote the stock of this foreign asset held by the monetary authority at the end of period t . By convention, we assume that this foreign asset is denominated in foreign currency, and $\tilde{r} > 0$ is the long-term, gross foreign real interest rate paid by this asset. Under this regime, the role of the foreign reserves is to back a fixed fraction $\theta \in (0,1]$ of the domestic money supply, according to what the Central Bank perceives as necessary. This policy is a variation of the one used in Hernandez-Verme (2004)³⁰: at time $t=0$, the Central Bank sets exogenously the value of the policy parameter θ from within the support set that $\theta \in (0,1]$ gives. This value set for θ is also time invariant. Then, the following equation governs the evolution of the reserves of foreign assets held by the monetary authority

$$B_t^* = \theta \left(\frac{M_t}{e} \right) \quad (3.21)$$

Notice that a currency board arrangement obtains as a particular case, when the monetary authority sets $\theta = 1$ in equation (3.21). However, in the remainder of this section we consider the more general case of $\theta \in (0,1]$

The new regime of monetary and foreign exchange policy thus defined imposes additional restrictions on the resources effectively available to the government. For instance, a change in the foreign-reserve position of the monetary authority affects the resources available to the government as well, and the government's budget must account for it. In addition, the nominal supply of domestic currency is endogenous in that it adjusts to keep the nominal exchange rate at the level set by the government, e . The government implements any of these changes through lump-sum transfers of τ_t

³⁰ Here, we assume for simplicity that there is no backing of domestic deposits. Therefore, the value of the parameter ξ in Hernandez-Verme (2004) is zero in our paper.

goods given *ex-ante* to all young individuals at time t . Then, the resulting government budget constraint for this economy is

$$\tau_t = \frac{M_t - M_{t-1}}{p_t} - \frac{B_t^* - \tilde{r} \left(\frac{p_t}{p_t^*} \right) B_{t-1}^*}{p_t^*} \quad (3.22)$$

The first term on the right hand side of equation (3.22) represents the real value of any changes in the nominal supply needed to sustain the fixed nominal exchange rate. The second term indicates the effects of any changes in the real foreign-reserve position of the government.

We can rewrite equations (3.21) and (3.22) in terms of real balances of domestic currency, $z_t \equiv M_t / p_t$. Then we obtain

$$\frac{B_t^*}{p_t^*} = \theta \cdot z_t \quad (3.23)$$

and

$$\tau_t = (1 - \theta) \cdot z_t + \left(\tilde{r} \cdot \theta - \frac{1}{1 + \sigma^*} \right) \cdot z_{t-1} \quad (3.24)$$

3.3.2 General Equilibrium

In a general equilibrium, several conditions must be satisfied. First, purchasing power parity and “perfect no arbitrage” in equations (3.10) and (3.11), respectively, still hold. In addition, as a consequence of this exchange rate regime, the domestic country with fixed exchange rates inherits the inflation rate in the rest of the world, and

$$\frac{p_t}{p_{t+1}} = \frac{p_t^*}{p_{t+1}^*} = \frac{1}{1 + \sigma^*} \quad (3.25)$$

However, notice that σ^* is not a parameter under the control of the monetary authority.

After using (3.25) together with (3.16), it is obvious that $(e_{t+1}/e_t) = 1$ obtains, reflecting the fact that the nominal exchange rate is constant over time. Then, we can also combine conditions (3.12), (3.13) and (3.25) and obtain

$$R > \frac{p_t}{p_{t+1}} = \frac{p_t^*}{p_{t+1}^*} = \frac{1}{1 + \sigma^*} \quad (3.26)$$

Condition (3.26) signifies that the long-term asset dominates both domestic currency and foreign currency in rate of return. Equations (3.14) and (3.15) still hold, but (3.23) and (3.24) replace equations (3.8) and (3.9). Obviously, the inequalities (3.5) and (3.6), representing the banks' budget constraints at the beginning and at the end of period t , still apply. However, condition (3.7) under the new policy now reads

$$(1 - \lambda)c_{2t+1} + r_2^*d_{2t} + r_1^*d_{1t} \leq R(k_t - l_t) + \frac{(\phi_d + \phi_f)}{1 + \sigma^*}(w + \tau_t) \quad (3.27)$$

3.3.3 Steady-State Equilibria

In this section, we describe the set of separating stationary equilibria where all agents behave according to their true type and there are no problems of liquidity, under a fixed exchange rate regime (i.e., e is fixed, and the condition $\theta \leq 1$ holds.) As before, there is no early liquidation of the long-term investment by banks.

In this environment, we also define a stationary allocation as a combination of the triplets $(z, q, \tau) \gg 0$ and $(d_0, d_1, d_2) > 0$ that is constant over time. Notice that the foreign-borrowing constraints defined in (3.3) and (3.4) still apply, and they are binding.

Combining equations (3.23), (3.24) and (3.14), and imposing conditions for stationarity, we obtain that the real value of the monetary transfer under a fixed exchange rate regime is

$$\tau = \frac{\phi_d w \{(1 + \sigma^*)[1 + \theta(\tilde{r} - 1)] - 1\}}{(1 + \sigma^*) - \phi_d \{(1 + \sigma^*)[1 + \theta(\tilde{r} - 1)] - 1\}} \quad (3.28)$$

It is straightforward to show that $(1 + \sigma^*)[1 + \theta(\tilde{r} - 1)] > 1$ holds, $\forall \sigma^* > -1$. Then, to fix ideas, we assume that $(1 + \sigma^*) - \phi_d \{(1 + \sigma^*)[1 + \theta(\tilde{r} - 1)] - 1\} > 0$ holds for the remainder of this section, which yields the condition $\tau > 0$ that holds.

In the remainder of this section, we evaluate the conditions for the existence of the stationary equilibria as well as their bifurcation properties. We next analyze whether

these equilibria display the local uniqueness property, followed by an examination of the issue of determinacy³¹.

Existence of Steady-State Equilibria: We summarize our results for this type of separating equilibria in Table 3.5. As in Section 3.2, we classify our results into either Case I or Case II, according to the maturity-structure of the foreign interest rates. In addition, following also the analysis in Section 3.2, it is possible to observe the following three different types of equilibria within either Case I or Case II:

- a) *Equilibria with no intra-period debt d_0 .* In such allocations, $d_0 = 0$, $d_2 = f_0$ and $d_1 = f_1 - f_0$ are obtained.
- b) *Equilibria with an interior solution.* In such equilibria, there are nontrivial amounts of each type of loan from abroad: $0 < d_2 < f_0$, $d_0 = f_0 - d_2 > 0$, and $d_1 = f_1 - d_2 > 0$ are satisfied.
- c) *Equilibria with no long-term debt d_2 .* In these equilibria $d_2 = 0$, $d_0 = f_0$ and $d_1 = f_1$ are obtained.

Under a fixed exchange rate regime like the one presented here, domestic and foreign inflation are always equal, even in non-stationary allocations. In situations where the rate of foreign inflation is high, banks have no incentive to borrow long-term funds from abroad because inflation would reduce the real value of the assets that the banks would use when such debt is due³². We observe an interaction between the maturity-structure of foreign interest rates and the inflation rate, now given by σ^* .

³¹ Table 3.11 and Table 3.12 in Appendix B-1 shows the equilibrium results when the transfers are given to the impatient agent.

³² Such combination of events could lead to a bank run and/or a panic among all agents, if there was uncertainty in this respect.

Table 3.5 Existence of Steady-State Equilibria with *Ex-ante* Transfers.
No early liquidation: $l_t = 0$. A Fixed Exchange Rate Regime

		Case I	Case II
Type of Equilibria	Amount Borrowed	$r_0^* < 1$ and $r_1^* > r_2^* = R$	$r_0^* > 1$ and $r_1^* < r_2^* = R$
No intra-period foreign debt	$d_2 = f_0$ $d_0 = 0$ $d_1 = f_1 - f_0$	Equilibria exist only for values of σ^* sufficiently high .	Equilibria do not exist.
Interior solution	$d_2 > 0$ $d_0 = f_0 - d_2$ $d_1 = f_1 - d_2$	Equilibria exist when σ^* is neither too low nor too high .	Equilibria exist when σ^* is neither too low nor too high .
No long-term foreign debt	$d_2 = 0$ $d_0 = f_0$ $d_1 = f_1$	Equilibria exist only for values of σ^* sufficiently high .	Equilibria exist only for values of σ^* sufficiently low .

Different combinations of foreign interest rates and foreign inflation produce a variety of situations that translate into different equilibrium sets. We can understand such an interaction because both the foreign interest rates and foreign inflation represent costs that banks must face. In particular, the structure of foreign interest rates represents the relative cost of borrowing each of the different types of foreign-debt, while foreign inflation reduces the real return of the currency reserves held by banks. For instance, the banks' willingness to borrow long-term from abroad increases (decreases) when the inflation rate is low (high) or when long-term foreign debt is relatively cheaper (expensive.) Notice that high rates of foreign inflation may exacerbate the effect of the foreign interest rates: values of σ^* that are excessively high would increase the likelihood of violating the budget constrain that banks face at the end of $t+1$. In the remainder of this section, we describe qualitatively the results on existence as a function

of the foreign inflation rate. Notice that the results on the existence of stationary equilibria under a fixed exchange rate are qualitatively very similar to that under floating exchange rates, leaving aside, of course, that domestic and foreign inflation are equal under the former.

Under a fixed exchange rate regime, stationary equilibria with no intra-period foreign debt exist only when such a debt is relative cheaper (Case I.) Moreover, one of the following three cases applies: i) equilibria do not exist; or ii) equilibria exist only when foreign inflation is neither too low nor too high; or iii) equilibria exist only for values of foreign inflation that are high enough. Alternatively, when intra-period debt and long-term debt are relatively expensive (Case II,) these equilibria do not exist, regardless of the value that σ^* takes. In addition, equilibria with interior values for all foreign-debt instruments require foreign inflation to be neither too low nor too high, regardless of the underlying maturity-structure of the interest rates.

With respect to equilibria where banks do not borrow long-term from abroad are qualitatively different according to the maturity-structure of foreign debt. When Case I obtains, we can observe one of the following three cases: i) equilibria do not exist; or ii) equilibria exist only for values of σ^* that are not too low or too high; or iii) equilibria exist only when the foreign inflation is high enough. Things are somehow different under Case II; one of the three following situations may obtain: i) equilibria do not exist; or ii) equilibria do not exist for values of foreign inflation that are too high or too low; or iii) equilibria exist only when the foreign inflation is high enough.

Uniqueness and Determinacy of Steady-State Equilibria: Under a fixed exchange rate regime, we still find many different combinations of foreign interest rates that satisfy the equilibrium conditions, even for fixed values of the foreign inflation rate. In fact, this economy is “not regular”, and there is a continuum of stationary equilibria as well under a fixed exchange rate regime. Thus, the stationary equilibria do not display the property of local uniqueness, and, therefore, they are indeterminate. Moreover, none of the stationary allocations is a “regular equilibrium.”

It is straightforward to show that we can extend the analysis in Appendix C to the case of fixed exchange rates. The proof is available upon request from the authors.

In Proposition 3.2, we compare the locally uniqueness and indeterminacy properties that obtain in equilibrium under the different exchange rate regimes.

Proposition 3.2: *The existence of the steady-state equilibria under both floating and fixed exchange rate regimes is strongly conditioned on the domestic policy parameter σ , for floating exchange rates, and foreign inflation σ^* for a fixed exchange rate regime. In general, we would observe that $\sigma \neq \sigma^*$. The latter implies that, a priori, the scope for existence and indeterminacy are also different under alternative exchange rate regimes. However, they are not strictly comparable without further information, making it difficult to rank the alternative regimes in this respect.*

3.3.4 Dynamic Equilibria

Under a fixed exchange rate regime, the dynamics originates from the government budget constraint, and the fact that both the money supply and foreign reserve holdings must adjust to keep the nominal exchange rate at its set level. Specifically, by combining (3.24) with (3.14), we obtain the following first order linear difference equation

$$\tau_t = \eta_1(\sigma^*) + \eta_2(\sigma^*) \cdot \tau_{t-1} \quad (3.29)$$

We have rearranged terms in equation (29) so that:

$$\eta_1(\sigma^*) \equiv \frac{\phi_d w \cdot \left(1 - \theta + \tilde{r}\theta - \frac{1}{1 + \sigma^*}\right)}{1 - \phi_d(1 - \theta)} \quad (3.30)$$

and

$$\eta_2(\sigma^*) \equiv \frac{\phi_d \left(\tilde{r}\theta - \frac{1}{1 + \sigma^*}\right)}{1 - \phi_d(1 - \theta)} \quad (3.31)$$

On the one hand, notice that $1 - \phi_d(1 - \theta) > 0$ always holds regardless of the foreign inflation rate. On the other hand, the inequality $\tilde{r}\theta < \frac{1}{1 + \sigma^*}$ may hold for values of σ^*

that are low enough.³³ The consequences in terms of the implied dynamic behavior of this economy under a fixed exchange rate regime are significant. Particularly, in situations where $\sigma^* > \sigma_c^*$ holds, the dynamic paths are monotonic, and the eigenvalue can be either inside or outside the unit circle. Alternatively, when $\sigma^* < \sigma_c^*$ obtains, the eigenvalue $\eta_2(\sigma^*) \Big|_{\sigma^* > \sigma_c^*} < 0$, and it lies inside the unit circle. Thus, the dynamics are non-monotonic, leading to potential endogenously arising volatility in the absence of shocks.

The dynamic system under fixed exchange rates is decoupled, meaning that z_t and q_t (the real money balances held by banks) inherit their dynamics from the monetary transfer. The same applies to the banks' operative budget constraints (3.5), (3.6) and (3.27).

3.4 POSSIBILITY OF A CRISIS AND THE VULNERABILITY OF BANKS

We now allow for the possibility of a crisis in our model of the financial system. Consider the environment described in sections 3.2 and 3.3, but now with two new different sources of uncertainty. The first type of uncertainty is extrinsic, in that it does affect the depositors' beliefs but without relating to the fundamentals of the economy. The second type of uncertainty is intrinsic because there is an unexpected change in one of the fundamentals of the economy. In particular, we use the intrinsic uncertainty to replicate a sudden stop: an unanticipated and exogenous reduction of the amount of new credit from the rest of the world. Each of these types is independent of the other in our framework. We now describe things in more detail.

Extrinsic Uncertainty: We introduce a shock to the depositors' beliefs. The literature frequently illustrates the properties of this type of shock by using the example of a “bad dream” of the young domestic depositors. This “bad dream” originates in events that

³³ That is, for values of foreign inflation such that $\sigma^* < \sigma_c^* \equiv \frac{1}{\tilde{r}\theta} - 1$ holds.

have to do with the depositors' system of beliefs, but are unrelated to the fundamentals of the economy (e.g. a sunspot.) We will see later in this section, that under a particular set of circumstances, this "bad dream" can have a strong effect on outcomes, and it may lead to panic-equilibria, where generalized bank-runs obtain from a self-fulfilling prophecy.

Intrinsic uncertainty: It takes the form of a sudden stop of foreign credit. In our environment, we interpret a sudden stop of foreign credit as a permanent but unexpected reduction of $f_t > 0$. The amount f_t was initially and exogenously set, at the beginning of period t . This constraint on foreign credit was binding but banks had not acted on it yet. The sudden stop hits the economy right before the end of period t , and the new amount available of foreign credit at the end of period t decreases significantly. We use f'_t to denote the new foreign credit available at the end of t , and $0 \leq f'_t < f_t$ obtains. The aforementioned reduction is public information, and it may reduce both liquidity and solvency in the financial sector³⁴. Thus, a sudden stop in this framework can trigger a domestic crisis that takes the form of generalized bank runs, bankruptcy and closure in the domestic financial system.

We must point out that, in the absence of either extrinsic or intrinsic uncertainty, domestic agents will withdraw from banks according to their true type, and domestic banks anticipate this perfectly. Then, there is no need to liquidate the long-term asset early. In addition, there is not illiquidity or lack solvency that banks or depositors cannot anticipate. At the beginning of period t , the domestic banks have chosen the amounts of consumption offered in each contingent state of the world: $c_{1t} > 0$ for impatient individuals and $c_{2,t+1} > 0$ for patient individuals. The banks had formulated a plan that involved also $d_{0t} \geq 0$, $d_{1t} \geq 0$, $d_{2t} \geq 0$, and $l_t = 0$, but banks made effective only their choices of d_{0t} , d_{2t} and k_t before the shock at the end of period t .

³⁴ We could also argue that unanticipated reduction in foreign credit may trigger a shock to the preferences of depositors. If such a shock induces a crisis of a self-fulfilling nature, this may only exacerbate the existing problems in this economy. In this paper, for simplicity, we abstract from this possibility.

However, when a shock to the depositors' beliefs or a sudden stop occurs, and it becomes publicly available information, the availability of future resources changes irreversibly. Then, it may be in the depositors' best interest to withdraw as much as they can immediately. The presence of a sequential service constraint may only exacerbate this problem. Thus, it may not be optimal for any agent –specially, agents of the patient type- to wait for the next period to withdraw from the banks, since they believe that banks could be facing bankruptcy and closure. In particular, both banks and depositors may need to re-optimize to account for the change in circumstances, leading to what we call a Sequential Checking Mechanism of both their liquidity and solvency. Figure 3.3 illustrates the main points of the Sequential Checking Mechanism. Thus, after a shock of one of the types discussed above hits the small, open economy, a re-evaluation of the changes in the liquidity of banks is of the first priority. The new plan is defined by the pair $(\tilde{d}_{1t}, \tilde{l}_t)$. Depending on the results obtained in this evaluation, circumstances may require an analysis of the solvency of the banking system as well. To fix ideas, we now proceed to describe the definitions of liquidity, solvency and incentive compatibility associated with our framework for a small, open economy.

Liquidity: Chang and Velasco (2000a, 2000b and 2001) were among the first in the literature to mention the need to evaluate the liquidity position of banks in the context of financial crises in the emerging markets. They propose to use an illiquidity condition that summarizes the current situation of banks after a shock hits the domestic economy at the end of period t , assuming that a bank cannot commit not to liquidate fully the long-term investment if needed.

On the one hand, the real value of the bank's short-term obligations due at the end of period t is $c_{1t} + r_0^* d_{0t}$ goods, if all the depositors withdraw their deposits. On the other hand, if the bank were to liquidate early the full amount of its long-term investment at the end of time t , it would obtain $\tilde{l}_t = rk_t$ goods³⁵. Therefore, the

³⁵ Recall than, in the absence of either extrinsic or intrinsic uncertainty, there was no early liquidation in equilibrium, and thus $l_t = 0$ obtained. When we allow for either one of these two types of uncertainty,

representative bank has an illiquid position when the real value of its short-term obligations at the end of period t exceeds the liquidation value of the long-term investment, or equivalently, when the following inequality holds:

$$c_{1t} + r_0^* d_{0t} > rk_t \quad (3.32)$$

Of course, when the inequality in (3.32) does not obtain, we say that the bank has a liquid position.

We must also mention, however, that an illiquid position is a necessary but not sufficient condition for a bank-run equilibrium or bankruptcy in our model. The short-term resources of the bank may be insufficient at the end of t , but the bank could still be solvent next period if it is temporarily bailed-out. Then again, we also need to evaluate whether the representative bank is solvent or not.

Solvency: Even in the case where we find that the representative bank is illiquid by using condition (3.28), it is still viable to save it if we can show that the bank is solvent, and its illiquid position is just a temporary problem. Alternatively, if the bank is insolvent and illiquid, it is probably not a good idea to bail it out at the end of period t . We can summarize this idea with the following saying: “why throw away good money after bad money?”

When discussing the issue of solvency, the resources involved include not only rk_t but also the real value of foreign debt newly chosen at t , $0 < \tilde{d}_{1t} \leq f'_1$. We say that the representative bank is solvent if this bank still has enough resources left after covering both the withdrawals of deposits and foreign intra-period debt, even if the bank were to liquidate early the total of its long-term investment. Equivalently, the following inequality describes the conditions for the insolvency of a representative bank at the end of period t :

and a shock is realized, individuals may re-optimize, and the new choice of early liquidation would be $\tilde{l}_t \geq l_t$.

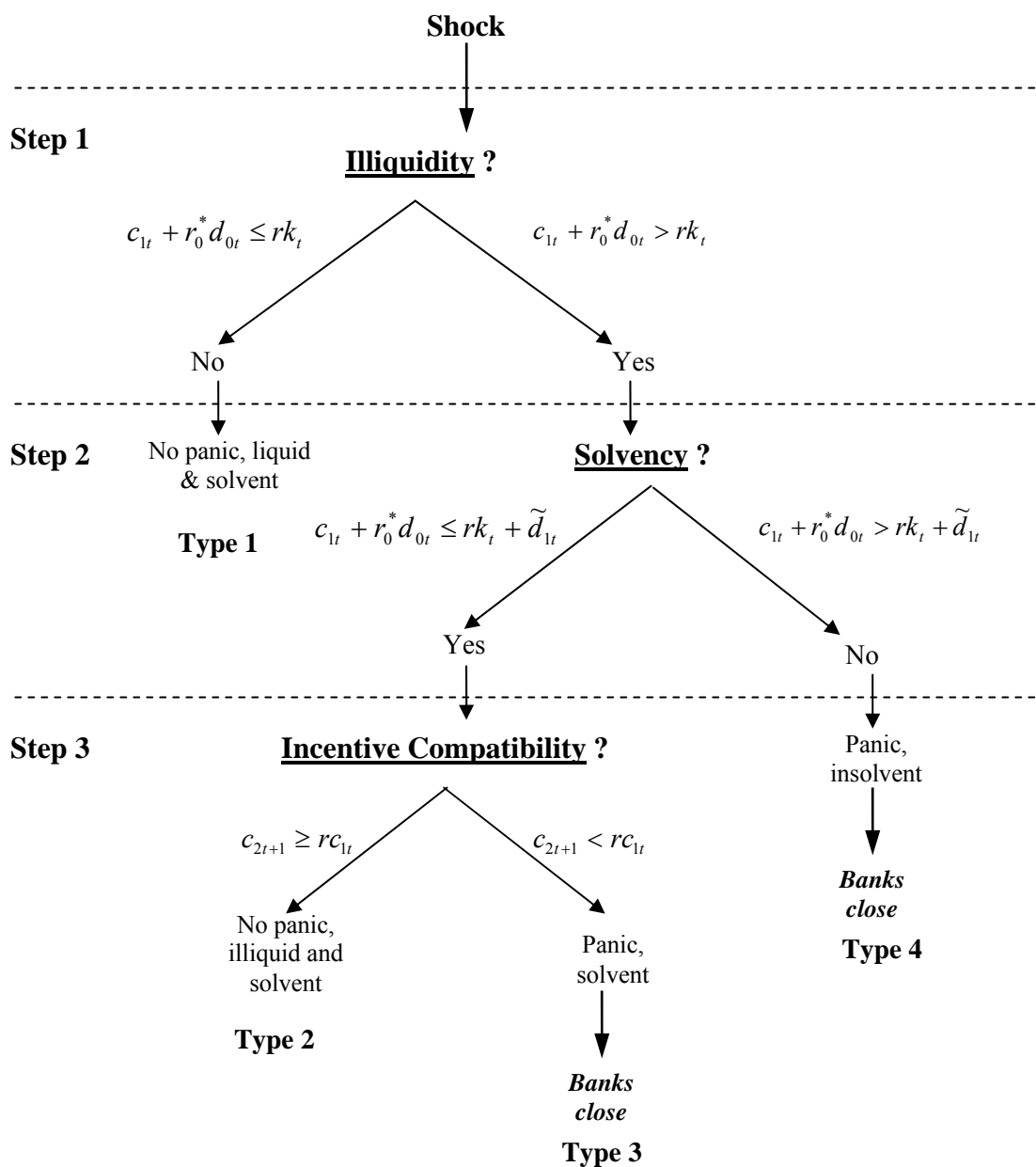


Figure 3.3 The Sequential Checking Mechanism

$$c_{1t} + r_0^* d_{0t} > rk_t + \tilde{d}_{1t} \quad (3.33)$$

The inequality in (3.33) means that if the real value of the new short-term foreign debt \tilde{d}_{1t} (i.e., the bail out) is enough to alleviate the temporary problem of liquidity, then it would be in the best interest of the foreign creditors to help this bank out instead of forcing it to close.

Incentive Compatibility: The last step is to check whether the Incentive Compatibility constraint in (3.2) is satisfied or not. Banks can be illiquid and solvent, but it is still possible that the allocation is not incentive compatible, leading to panics and closure.

We now illustrate the clear logic behind these three conditions with an example. If a bank does not have enough resources to deal with all the withdrawals today, we say that this bank has an illiquid position. However, if the solvency condition holds, individuals may still believe that the bank is worth saving by an adequate inflow of new short-term foreign debt. In order to reach a final decision, they must also check that the Incentive Compatibility constraint holds.

We now classify all the possible outcomes into four types. These types may arise within either Case I or Case II.

- a) Equilibrium of Type 1: Banks have a liquid position. Under these circumstances, banks are liquid and solvent, and there are no panics. We will call a situation like this a *separating non-panic equilibrium where banks hold liquid positions*.
- b) Equilibrium of Type 2: Banks have an illiquid position, but they are solvent and the Incentive Compatibility constraint is satisfied. Under this set of circumstances, the bank is illiquid but no panics occur. We will consider such an outcome a *separating non-panic equilibrium where banks hold illiquid positions*.
- c) Equilibrium of Type 3: Banks have an illiquid position, they are solvent, but the Incentive Compatibility constraint is not satisfied. Then, banks are illiquid and solvent but there are panics in equilibrium, and all banks must

close. We will call this outcome a *pooling equilibrium with panics but solvent banks*.

- d) Equilibrium of Type 4: Banks have an illiquid position and they are insolvent. Panics occur in equilibrium, and all banks must close. This situation is a *pooling equilibrium with panics, illiquid and insolvent banks*.

It is straightforward to show³⁶ that we may rank these different types of equilibria according to the social welfare that obtains in each case. We establish that: i) equilibria of Type 1 Pareto dominate equilibria of Type 2, Type 3 and Type 4; ii) equilibria of Type 2 are Pareto superior to equilibria of Type 3; and iii) equilibria of Type 3 dominate equilibria of Type 4.

In the next two sections, we describe briefly the relationship between financial fragility, a bad dream of depositors or a sudden stop of foreign credit. The Table 3.6 below may be helpful for keeping track of all the different types and their implications.

Table 3.6 Different Types of Equilibria

Separating Equilibria→No Panic	Pooling Equilibria→Panic
Type 1, liquid banks	Type 3, illiquid and solvent, not Incentive Compatible
Type 2, illiquid but solvent banks, Incentive Compatible	Type 4, illiquid and insolvent banks

3.4.1 A Bad Dream by Domestic Depositors

In this section, we describe briefly the potential effects on the economy by an unanticipated shock that is totally unrelated to the fundamentals of the economy. Suppose that a young individual has a bad dream. When she wakes up before the end of period t , she has the very strong belief that banks will close soon (before period t ends.)

³⁶ This proof is available upon request from the authors.

Given the strategic interdependence and coordination problems that are present in this environment, individuals realize that their personal welfare depends not only on their actions but they depend as well on the actions of other individuals in the economy. In particular, we observe complementarity in the strategic interaction between the individual depositors. Therefore, if an individual agent cannot observe the actions or types of others, she may panic if she believes that everyone in the economy has had the same bad dream. In other words, if she believes that everybody else is going to run, she runs as well. As a result, all domestic depositors would try to run to the banks to withdraw their resources immediately with the purpose of getting there before any other individual in the economy does, and we would have a self-fulfilling bank run in our hands.

To be able to replicate these results, we introduce a sunspot variable that reflects extrinsic uncertainty as perceived by the domestic depositors. A bad dream is just one example of the form that such a sunspot variable may take. The previous literature has documented extensively the effects that this particular type of uncertainty could have when it obtains together with strategic complementarity in the interactions of the individuals. Thus, we will not dig further in this respect. However, we must mention that, in our framework, the realization of the sunspot variable typically takes place at the end of period t , after the individuals learn their types. What happens next is not trivial, but it just follows the sequential checking mechanism that we described in Figure 3. The previous literature has described extensively the general works of this mechanism. We apply it with some minor variations: to check liquidity, then solvency and finally incentive compatibility.

3.4.2 A Sudden Stop of Foreign Credit

The second question that interests us is what features of this model allow for the existence of the intrinsic uncertainty that takes the specific form of a sudden stop of foreign credit. To mimic a sudden stop, we consider an unanticipated but permanent reduction of total foreign credit f_1 at the end of period t . Such permanent shock is public

information. As before, we assume that the domestic country is a net borrower from the rest of the world, and that it faces a binding borrowing constraint in each period. Recall that $f_1' < f_1$ denotes the new and lower amount of foreign credit available to domestic banks at the end of period t . The new credit constraint exacerbates any problem of credit rationing that may have existed previously, and it may severely cripple the domestic financial sector. Notice also that, after t , all the future generations will face the same new credit constraint.

3.4.2.1 The Re-Optimization Problem

At the beginning of the period t , banks choose their plan of action based upon the information set $\{f_0, f_1\}$. Banks formulate their plans by maximizing the *ex-ante* expected utility of a representative individual, subject to the relevant constraints. At the end of time t , banks learn the realization of $0 \leq f_1' < f_1$. This realization constitutes an irreversible reduction in the future resources available to banks that merits a revision of plans. Under f_1' , it may be possible that some decision rules that were optimal before are not optimal anymore. However, at this point in time, only two choice variables remain elastic: d_{1t} and l_t , since d_{0t}, d_{2t}, k_t and the reserve-holdings were chosen and made effective at the beginning of t (and, are thus inelastic.) Banks may choose to deviate from their original plans. They would do so by finding a new combination $(\tilde{d}_{1t}, \tilde{l}_t)$ that is optimal under the new circumstances.

After the sudden stop hits the domestic financial sector, this news is public. The sequence of events that follows are: after the shock, everybody realizes that the amount of new borrowing from abroad is less than it was when they formulated their original plans. Fortunately, people can still try to behave optimally by sequentially checking the situation of the banks. Thus, the need to re-optimize and re-formulate their plans triggers a new sequential checking to try to determine the best course of action under the new circumstances, and equilibria obtain accordingly.

The new borrowing constraint faced by banks at the end of period t implies that

$$\tilde{d}_{1t} \leq f_1' - d_{2t} \quad (3.34)$$

The sequential checking mechanism now requires re-evaluating (3.32), (3.33) and (3.2) by taking into account (3.34) as well. Banks now try to maximize the expected utility in (3.1) subject to the new budget constraint in (3.34), and the relevant budget constraints according to the exchange rate regime.

3.4.2.2 Equilibrium Results - Overview

In the remainder of this section, we describe the results for existence of each of the four different types of equilibria. We must emphasize that the existence and type of equilibrium will also depend on the particular “draw” of f_1' . In particular, when f_1' is still large enough, we find that there is a potential for avoiding self-fulfilling crises due to potential high expectations and low doubts by domestic depositors. When this obtains, the economy will gravitate more towards equilibria of Type 2 than Type 4. People do not worry about a bankruptcy even if the bank is illiquid.

However, under other circumstances, the financial system can be extremely fragile and volatile: either banks are liquid and solvent (equilibria of Type 1,) or they are illiquid and insolvent, leading to financial panic and closure.

3.4.2.3 Equilibria of Type 2 versus Equilibria of Type 4

A Type-2-equilibrium is such that banks are illiquid, solvent and the outcomes are incentive compatible. For a Type-3-equilibrium to obtain, the outcome must violate incentive compatibility instead. Equilibria of Type 4 are the worst possible outcome that can obtain, in terms of welfare: banks are illiquid and insolvent (and the issue of incentive compatibility does not matter much.) Tables 3.7 and 3.8 illustrate our results for Case I and Case II, respectively, under Floating Exchange Rates³⁷. We can partition the space of all possible equilibria into five sub-sets, depending on the value of the pair $(\tilde{d}_{1t}, \tilde{l}_t)$ that obtains. We define each one of the sub-sets as follows:

³⁷ We can also extend these results to cases where a fixed exchange rate is in place. We do not do so here due to space constraints. The interested reader can obtain these results upon request from the authors.

- a) Sub-set 1: allocations such that $(\tilde{d}_t, \tilde{l}_t) = (f'_1, k_t)$ obtains
- b) Sub-set 2: $(\tilde{d}_t, \tilde{l}_t) = (f'_1, \tilde{l}_t > 0)$ in equilibrium
- c) Sub-set 3: $(\tilde{d}_t, \tilde{l}_t) = (f'_1, 0)$ obtains in equilibrium
- d) Sub-set 4: $(\tilde{d}_t > 0, k_t)$ is satisfied in equilibrium
- e) Sub-set 5: equilibrium allocations where $(\tilde{d}_t > 0, 0)$ holds.

We must mention at this point that, under very special circumstances, it is possible to find some sub-sets in the space of all potential equilibrium allocations that are always incentive compatible. In a situation like the one just described, equilibria of Type 2 may become equilibria of Type 4 if they violate the solvency condition, but equilibria of Type 3 never obtain. Alternatively, in situations where it is not possible to guarantee incentive compatibility, we must find the appropriate sub-set where liquidity, solvency and self-selection intersect in the space of foreign interest rates and monetary policy parameters.

Case I. $(r_0^* < 1, r_1^* > r_2^* = R)$ *under Floating Exchange Rates*: Table 3.7 presents our results when Case I obtains. Notice that all allocations are incentive compatible and, thus, we can rule out the existence of equilibria of Type 3. Alternatively, we can find that the conditions for the existence of equilibria of Type 2 or of Type 4 are possible to satisfy in all sub-sets. Thus, we can observe equilibria where the financial system is very fragile, leading to panics and generalized bankruptcy.

Table 3.7 Sufficient Conditions for the Existence of Equilibria of Type 2 and Type 4 under Floating Exchange Rates.

Case I: $r_0^* < 1$, $r_1^* > r_2^* = R$, with $0 < \phi_d < 1$ and $0 < \phi_f < 1$

Re-Optimized Amounts	Bound 1 – from Illiquidity (A)	Bound 2 – from Solvency (B)	Incentive Compatibility (C)	Equilibrium of Type 2 exists if	Equilibrium of Type 4 exists if
1. $\tilde{d}_t = f_1'$ $\tilde{l}_t = k_t$	$(1-\lambda) \cdot (r_0^* \cdot f_0 - r \cdot k_t)$	$r_0^* \cdot f_0 - r \cdot k_t$	Guaranteed	$A < f_1' \leq B$	$A < B < f_1'$
2. $\tilde{d}_t = f_1'$ ³⁸ $\tilde{l}_t > 0$	$\frac{r \cdot (1 - \phi_d - \phi_f) - \left(\frac{r}{R}\right) \cdot H}{\left[1 - \left(\frac{r}{R}\right) \cdot r_1^*\right]} \cdot (w + \tau_t)$	$\frac{r \cdot (1 - \phi_d - \phi_f) - \left(\frac{r}{R}\right) \cdot H}{\left[-\left(\frac{r}{R}\right) \cdot r_1^*\right]} \cdot (w + \tau_t)$	Guaranteed	$B < f_1' \leq A$	$f_1' < B \leq A$
3. $\tilde{d}_t = f_1'$ $\tilde{l}_t = 0$	$(1-\lambda) \cdot r_0^* \cdot f_0 + \lambda \cdot r \cdot k_t$	$r_0^* \cdot f_0 + \left(\frac{\lambda}{1-\lambda}\right) \cdot r \cdot k_t$	Guaranteed	$A < f_1' \leq B$	$A < B < f_1'$

³⁸In this case, $l_t = (r_0^* \cdot f_0 - f_1') \cdot \left[\left(\frac{\lambda}{R}\right) \cdot r_1^* + \frac{(1-\lambda)}{r}\right] + \left(\frac{\lambda}{R}\right) \cdot H \cdot (w + \tau_t)$, where $H \equiv R(1 - \phi_d - \phi_f) + \phi_d \left(\frac{p_t}{p_{t+1}}\right) + \phi_f \left(\frac{p_t^*}{p_{t+1}^*}\right)$. Notice also that $\left[r \cdot (1 - \phi_d - \phi_f) - \left(\frac{r}{R}\right) \cdot H\right] < 0$ obtains in this case, requiring the condition $\left[1 - \left(\frac{r}{R}\right) \cdot r_1^*\right] < 0$ to hold, to ensure that $f_1' > 0$ is satisfied. Moreover, the condition $0 < f_1' < f_1$ must be satisfied for a country that is a net borrower with the rest of the world.

Table 3.7(Continued)

Re-Optimized Amounts	Bound 1 – from Illiquidity (A)	Bound 2 – from Solvency (B)	Incentive Compatibility (C)	Equilibrium of Type 2 exists if	Equilibrium of Type 4 exists if
4. $\tilde{d}_{it} > 0$ ³⁹ $\tilde{l}_t = k_t$	$\frac{\lambda \cdot r_1^* \cdot (1 - r_1^*) \cdot [(1 - \lambda) \cdot C \cdot f_0 - D \cdot (w + \tau_t)]}{(1 - \lambda) \cdot r_1^* (1 - r_0^*) \cdot r_0^* + \lambda \cdot [1 - (1 - \lambda) \cdot r_0^*] \cdot [(1 - \lambda) \cdot r_0^* - r_1^*]}$	$-\frac{r_1^* \cdot [F \cdot f_0 + \lambda \cdot J \cdot (w + \tau_t)]}{[(1 - \lambda) \cdot \lambda \cdot r_0^* + (1 - \lambda) \cdot r_0^* \cdot r_1^*]} > 0$	Guaranteed	$A < B \Rightarrow A < f_1' \leq B$	$A < B \Rightarrow f_1' > B$
5. $\tilde{d}_{it} > 0$ ⁴⁰ $\tilde{l}_t = 0$	$\frac{\left\{ r + \left[\left(\frac{1 - \lambda}{\lambda} \right) + \frac{(1 - \lambda) \cdot r_0^* - 1}{\lambda \cdot (1 - r_0^*)} \right] r_0^* \right\} \cdot f_0}{\left(\frac{r_*}{\lambda} \right) \cdot \left[\frac{(1 - \lambda) \cdot r_0^* - 1}{1 - r_0^*} + (1 - \lambda) \right]}$ $+ \frac{\left\{ r \cdot (1 - \phi_d - \phi_f) + \left[\frac{(1 - \lambda) \cdot r_0^* - 1}{r_1^* \cdot (1 - r_0^*)} \right] \right\} \cdot (w + \tau_t)}{\left(\frac{r_*}{\lambda} \right) \cdot \left[\frac{(1 - \lambda) \cdot r_0^* - 1}{1 - r_0^*} + (1 - \lambda) \right]}$	$\forall f_1' > 0,$ $f_0 \geq \left(\frac{1}{r} \right) \left[\left(\frac{1 - \lambda}{r_0^*} \right) \cdot H - r \cdot (1 - \phi_d - \phi_f) \right] \cdot (w + \tau_t) > 0$	Guaranteed	$f_1' > A \& f_0 \geq B$	$f_1' > A \& f_0 < B$

³⁹In this subset, $d_{it} = \left(\frac{\lambda}{r_1^*} \right) \cdot \left[\left(\frac{\phi_d}{1 + \sigma} \right) + \left(\frac{\phi_f}{1 + \sigma^*} \right) \right] - (1 - \lambda) \cdot r \cdot (1 - \phi_d - \phi_f) \cdot (w + \tau_t) - r_0^* \cdot f_1' - (1 - \lambda) \cdot (r - r_0^*) \cdot f_0$ holds in equilibrium. We also use the following definitions to simplify the notation further:

$$C \equiv \left[\frac{1 - (1 - \lambda) \cdot r_0^*}{1 - r_0^*} \right] \cdot \left(\frac{r}{\lambda} + \frac{r_0^*}{r_1^*} \right) - \left(\frac{r - r_0^*}{\lambda} \right), \quad D \equiv \left(\frac{1 - \lambda}{\lambda} \right) \cdot \left[1 + \frac{1 - (1 - \lambda) \cdot r_0^*}{(1 - r_0^*)} \right] \cdot r \cdot (1 - \phi_d - \phi_f) + \left[\frac{1 - (1 - \lambda) \cdot r_0^*}{r_1^* \cdot (1 - r_0^*)} \right] \cdot \left[\left(\frac{\phi_d}{1 + \sigma} \right) + \left(\frac{\phi_f}{1 + \sigma^*} \right) \right], \quad F \equiv \left[r - r_0^* - (1 - \lambda) \cdot r - \frac{\lambda \cdot (1 - \lambda) \cdot r_0^*}{r_1^*} \right] \quad \text{and}$$

$J \equiv r \cdot (1 - \phi_d - \phi_f) + \left(\frac{1}{r_1^*} \right) \cdot \left[\left(\frac{\phi_d}{1 + \sigma} \right) - \left(\frac{\phi_f}{1 + \sigma^*} \right) \right] > 0$. Notice also that, with respect to the condition that must be satisfied to guarantee solvency, only the case where

$$-\frac{r_1^* \cdot [F \cdot f_0 + \lambda \cdot J \cdot (w + \tau_t)]}{[(1 - \lambda) \cdot \lambda \cdot r_0^* + (1 - \lambda) \cdot r_0^* \cdot r_1^*]} > 0$$

yields a set of relevant economic allocations. Therefore, we focus on allocations where this is true.

⁴⁰In this subset, $d_{it} = \frac{R \cdot (f_0 - f_1') + \lambda \cdot H \cdot (w + \tau_t)}{r_1^* = R}$ obtains.

Table 3.8 Sufficient Conditions for the Existence of Equilibria of Type 2 and Type 4 under Floating Exchange Rates.

Case II: $r_0^* > 1$, $r_1^* < r_2^* = R$, with $0 < \phi_d < 1$ and $0 < \phi_f < 1$

Re-Optimized Amounts	Bound 1 – from Illiquidity (A)	Bound 2 – from Solvency (B)	Incentive Compatibility (C)	Equilibrium of Type 2 exists if	Equilibrium of Type 4 exists if
1. $\tilde{d}_t = f_1'$ $\tilde{l}_t = k_t$	Same as in Case I	Same as in Case I.	Guaranteed	Same as in Case I	Same as in Case I
2. $\tilde{d}_t = f_1'$ ⁴¹ $\tilde{l}_t > 0$	$\frac{[r(1 - \phi_d - \phi_f) - (\frac{r}{R})H](w + \tau_t)}{[1 - (\frac{r}{R})r_1^*]}$	Same as Case I.	Guaranteed	$f_1' > A$	Equilibria do not exist
3. $\tilde{d}_t = f_1'$ ⁴² $\tilde{l}_t = 0$	Same as in Case I	Same as Case I.	Only when $\sigma \in (\tilde{\sigma}, \tilde{\sigma}')$	$A < f_1' \leq B$ and $\sigma \in (\tilde{\sigma}, \tilde{\sigma}')$	$A < B < f_1'$
4. $\tilde{d}_t > 0$ $\tilde{l}_t = k_t$	It does not obtain	It does not obtain	It does not obtain	It does not obtain	It does not obtain
5. $\tilde{d}_t > 0$ ⁴³ $\tilde{l}_t = 0$	Same as in Case I	Same as in Case I	Binds when $r_1^* = r$. $\forall r_1^* \neq r \Rightarrow \forall \sigma \geq \hat{\sigma}$	$f_1' > A$ & $f_0 \geq B$, and either $r_1^* = r$ or $\forall r_1^* \neq r \Rightarrow \forall \sigma \geq \hat{\sigma}$	$f_1' > A$ & $f_0 < B$

⁴¹ In Case II, the denominator is positive. However, the value of f_1' associated to the illiquidity condition is negative. Thus, since the domestic country is always a net debtor with the rest of the world, the restriction $f_1' \geq 0$ never binds.

⁴² The values $\tilde{\sigma}$ and $\tilde{\sigma}'$ that support this equilibrium are the solution to the quadratic equation given by $a \cdot \sigma^2 + b \cdot \sigma + c = 0$. In this equation, $a \equiv \left[\left(\frac{1 - \phi_d}{\lambda} \right) N - Q \right]$,

$b \equiv \left[\left(\frac{2 - \phi_d}{\lambda} \right) N - \phi_d^2 w - Q \right]$, $c \equiv \frac{N}{\lambda}$, $N \equiv [(1 - \lambda)r + \lambda r_1^*](f_1' - r_0^* f_0) > 0$ and, $Q \equiv \phi_d w [R(1 - \phi_d - \phi_f) + \frac{\phi_f}{1 + \sigma^*}] > 0$. We also assume that $b^2 - 4ac > 0$, so that $\tilde{\sigma}$ and

$\tilde{\sigma}'$ are two real and distinct roots.

⁴³In this case,

$$\hat{\sigma} = \frac{- \left(R(1 - \phi_d - \phi_f) + \frac{\phi_f}{1 + \sigma^*} + \phi_d \right)}{R(1 - \phi_d - \phi_f) + \frac{\phi_f}{1 + \sigma^*}} < -1$$

. In particular, when $\sigma = \hat{\sigma}$, the Incentive Compatibility conditions holds with equality, and it binds.

Case II. ($r_0^* > 1, r_1^* < r_2^* = R$) *under Floating Exchange Rates:* Table 3.8 presents our results when Case II obtains. In this case, not all allocations are incentive compatible and, thus, we could observe some circumstances where equilibria of Type 3 do exist. In particular, in sub-sets 3 and 5, incentive compatibility can be violated for particular values of the monetary policy σ , and we could find that equilibria of Type 3 obtain. However, this is not possible in sub-sets 1 and 2. Moreover, notice that the sub-set 4 does not obtain under this particular configuration of foreign interest rates, and these equilibria cease to exist.

With respect to monetary policy, if the parameter σ is located outside of a particular range (for example, in sub-set 3 or if σ is extremely small in Sub-set 5,) the incentive compatibility condition is violated. Our method of examining equilibrium outcomes attempts to emphasize the potentially important role of monetary policy in an environment like the one presented in this paper. Specially, monetary policy is instrumental in determining whether the financial system has a potential for fragility, or in precluding some equilibrium outcomes that could be highly desirable from a welfare standpoint. For example, under circumstances where the monetary authority targets inflation rates that are sufficiently low, the drawback could be that the economy is more likely be in a situation where financial panics are present in equilibrium after the sudden stop of foreign credit.

Table 3.9 Sufficient Conditions for the Existence of Equilibria of Type 2 under Floating Exchange Rates
Case II. $r_0^* > 1$, $r_1^* < r_2^* = R$, with $\phi_d = \phi_f = 0$ (No Reserve Requirements)

Sub-Set	Re-Optimized Amounts	Incentive Compatibility	Equilibria of <i>Type 2</i>	Equilibria of <i>Type 4</i>
1.	$\tilde{d}_{1t} = f_1', \tilde{l}_t = k_t$	Not applicable	Cease to exist	Old Type 2 become of Type 4
2.	$\tilde{d}_{1t} = f_1', \tilde{l}_t > 0$	Not applicable	Cease to exist	Old Type 2 become of Type 4
3. ⁴⁴	$\tilde{d}_{1t} = f_1', \tilde{l}_t = 0$	Not applicable	Cease to exist	Old Type 2 become of Type 4
4.	$\tilde{d}_{1t} > 0, \tilde{l}_t = k_t$	It does not obtain	It does not obtain	It does not obtain
5.	$\tilde{d}_{1t} > 0, \tilde{l}_t = 0$	Binds when $r_1^* = r$. $\forall r_1^* \neq r \Rightarrow \forall \sigma \geq -1$	They do exist	They do exist

⁴⁴ In this sub-set, the Incentive Compatibility constraint is satisfied only when $\sigma = -1$. However, this violates the restrictions that we imposed on the parameter space, in order to obtain meaningful economic allocations. In particular, $\sigma > -1$ and $\sigma^* > -1$ applies.

Table 3.10 Sufficient Conditions for the Existence of Equilibria of Type 1 and Type 4 under Floating Exchange Rates⁴⁵

Case I. $r_0^* < 1$, $r_1^* > r_2^* = R$

Sub Set	Re-Optimized Amounts	Condition for Liquidity \Rightarrow Condition For Solvency (A)	Incentive Compatibility	Equilibrium of <i>Type 1</i> exists if	Equilibrium of <i>Type 4</i> exists if	Equilibrium of <i>Type 2 or Type 3</i> exist if
1.	$\tilde{d}_{1t} = 0$, $\tilde{l}_t = k_t$	$f_0 - (1 - \lambda) \cdot \left(\frac{r}{*}\right) \cdot k_t$	Guaranteed	$f'_1 \leq A$	$f'_1 > A$	They do not obtain.
2.	$\tilde{d}_{1t} = 0$, $\tilde{l}_t > 0$	$\frac{\left[\left(\frac{r}{R}\right) \cdot H - r \cdot (1 - \phi_d - \phi_f)\right] \cdot (w + \tau_t)}{\left(\frac{1 - \lambda}{\lambda}\right)(1 - r_0^*) + \left(\frac{r}{R}\right) \cdot r_1^*}$	Guaranteed	$f'_1 \geq A$	$f'_1 > A$	They do not obtain.

⁴⁵The sub-sets present in this table are non trivial, and we observe that $d_{1t} = 0$, $d_{2t} = f'_1$ and $d_{0t} = f_0 - f'_1$. Since the domestic country is a net borrower to the rest of the world, the conditions $d_{it} \geq 0$ and $f_0 - f'_1 \geq 0$ must hold. Also, equilibria do not exist under some particular circumstances, and we do not present these sub-sets in this table. For example of the case where $d_{1t} = 0$ and $l_t = 0$. The condition $c_{1t} < 0$ obtains, which violates the basic economic criteria, and equilibria therefore do not exist.

3.4.2.4 Equilibria of Type 1 versus Equilibria of Type 4

In Table 3.10, we present the sufficient conditions for the existence of equilibria of Type 1, with liquid and solvent banks. When Case I obtains, we find two non-trivial sub-sets of possible equilibria, both with $\tilde{d}_{1t} = 0$. In such circumstances, a liquid position implies a position that is solvent as well. Then, either equilibria are of Type 1 (with liquid and solvent banks, and very high social welfare), or they are of Type 4 (with illiquid and insolvent banks, panics and with the lowest social welfare.) There are not intermediate situations, though, and we cannot obtain equilibria of Type 2 or of Type 3. This implies a very fragile and highly volatile environment in the financial system that could very easily lead to panics and generalized bankruptcy.

3.4.2.5 Interaction of the Monetary Policy and Reserve Requirements

Our model provides a suitable framework for analyzing the interaction among various types of monetary policies: controlling the domestic rate of money growth, inflation targeting, fixed versus floating exchange rate regimes and regulations of multiple reserve requirements. Is it possible to place the banking system into a more vulnerable situation by removing the reserve requirements?

We perform the following exercise for situations where Case II obtains: does the scope for existence and determinacy change when the reserve requirements are not in place? We present these results in Table 3.9. In particular, notice that equilibria of Type 2 cease to exist in sub-sets 1, 2 and 3 when $\phi_d = \phi_f = 0$, thus increasing the scope for observing equilibria with financial panics.

3.5 CONCLUSIONS

In this paper, we investigate whether a particular monetary policy can help prevent financial crises that originate in illiquid positions by banks. We then compare the advantages and disadvantages of alternative *de facto* exchange rate regimes in achieving

economy stability. Finally, we evaluate the impact that a policy of multiple reserve requirements can have on the scope for existence of equilibria that are not vulnerable to crises.

In order to call attention to the questions that we are interested in, we build a dynamic general equilibrium model of a small, open economy that displays nontrivial demands for fiat currencies, unexpected sunspots, and financial/banking crises originated by sudden stops of foreign capital inflows. We motivate the effective demands for domestic and foreign fiat money with a policy of holding reserves of different national currencies. These reserves prevent banks from financing domestic investment, but they may also provide banks with access to liquid resources in their time of need. Under some particular circumstances, reserve requirements may reduce the likelihood of observing equilibria with illiquid and insolvent banks.

In situations where no crises are present, we observe that the monetary rule in place determines up to an important extent the existence and properties of equilibria. Typically, there is a continuum of stationary equilibria, and local uniqueness and determinacy are lacking. On the other hand, a fixed exchange rate regime seems to increase the potential for endogenously arising volatility in the economy in general, and in the financial system, in particular.

Next, we examine the case of a sudden stop in a small, open economy that is a net borrower from the rest of the world. Not surprisingly, we find that the magnitude of the reduction in foreign credit determines the existence of equilibria. However, more importantly, we find that it may also affect the scope for fragility and volatility of the banking system. Finally, we show the existence of multiple equilibria that we may rank based on the presence of binding information constraints and on social welfare.

The next step in the agenda is to incorporate explicitly nontrivial capital accumulation. We can then examine in more detail meaningful potential differences in the length and magnitude of recovery under different exchange rate arrangements.

CHAPTER IV

CONCLUSIONS

Crises are costly. Approximate \$200 billion in debt on the bill of taxpayers is the price of the Savings & Loan crisis in the US around 1980. Literature studying the S&L crisis in the U.S. in 1980s pointed to the same central problem, the moral hazard in deposit insurance. Although financial liberalization and released regulations might encourage banks to engage in risky banking practices, the protection of the deposit insurance worsens banks excessive risk taking behavior. Therefore, the sequential reform acts of deposit insurance has been undertaking throughout the years. The starting point of the study in chapter II of my dissertation is the reform of the deposit insurance policy in 2005. I am particularly interested in one issue --- the coverage limit for certain retirement accounts will be increased from \$100,000 to \$250,000. Raising the coverage limit, on the one hand, increases consumer's protection; on the other hand, however, it may create disincentives for depositors to monitor the banks' risk taking behavior. Another interesting phenomenon I observed is the difference of coverage limit and how to price the deposit insurance among different countries. Raising coverage limit in the U.S. and the evidences of the different coverage limit across countries emphasize an important issue to think about, the optimal coverage limit. This paper is useful for studying several fundamental questions motivated by deposit insurance. How does the FDIC price the deposit insurance in an environment in which the moral hazard problem arise naturally? Does the optimal coverage limit working together with the proper risk premium successfully combat banks excessive risk taking? Does the market discipline work better to manage the moral hazard problem than prudent banking regulations such as capital requirements and the risk premium? If so, what should the government do to ensure the market discipline?

While some research have discussed parts of the moral hazard problem addressed here, the main contribution of this paper is to tackle the joint determination of optimal

coverage limit and optimal risk premium within a partial equilibrium model with heterogeneous depositors, depositor's monitoring, and bank's moral hazard problem. In the model, the deposit insurance with limited coverage is essential to the effort of managing the moral hazard problem. Because of the partial coverage, opposed to the full coverage, the depositors have an incentive to do part of the monitoring of the bank's risk-taking behavior. Depositors might threaten the banks with early withdrawal of deposits if necessary. The model includes three types of players; Banks display risk-taking behavior, depositors are ex-ante heterogeneous, and the benevolent insurance company provides deposit insurance. I find that partial deposit insurance combined with risk sensitive premium in the presence of capital requirements can improve social welfare. Moreover, when the partial coverage limit is in place, banks could be better off by finding a balance between the higher premia and the depositor's monitor and withdrawals. The coverage limit derived from the welfare maximization problem in this model provides us with an alternative to the option pricing method in obtaining the appropriate coverage limit and risk premium.

Beside the S&L crisis happened in the U.S., the occurrence of currency crises all over the world -Mexico in 1994, Asia in 1997, Russia in 1998, Brazil in 1998, Turkey in 1999 and Argentina in 2001, has caught the attention of the public and of the profession. A currency crisis is an abrupt and significant reduction in the value of a currency. When this occurs, the domestic fiat currency loses its ability to perform its basic functions as a medium of exchange, unit of account and store of value. Therefore, the central issue I address in my dissertation moves from the optimal mechanism design of deposit insurance in chapter II to the international illiquidity in a small open economy in chapter III. The overexpansion of the private sector, especially the domestic banking system, has been concluded as one of the most important element in the Asian crises in 1997. The potential association between the fragility of the financial system, currency crises, and exchange rate regimes/monetary policy has received relatively little attention in the previous literature. Thus, in chapter III I put the effort especially on the aforementioned linkage, which is of the utmost importance for most open economies. My general

intention is to identify more precisely why these Asian countries were suffered the contagious crises and how each country's specific feature, the performance of alternative exchange rate arrangements and associated monetary policies, influenced the fragility of the economy in the aftermath of the crises. With this in mind, I build a Dynamic General Equilibrium Model -with micro-foundations- replicating a small, open economy with a nontrivial banking system.

To fix ideas, I model a small, open economy that reproduces several aspects of the East-Asian countries at the time of the crisis. The private sector is a net debtor of the rest of the world, and there is an exogenous upper limit to foreign credit at each point in time. *Ex-ante* identical domestic agents face an uncertainty whose realization is private information. There is a standard problem in coordination that may lead to crises of a self-fulfilling type. This set up allows us to study the effects of sudden stops and bank runs, and how do they relate to each other. Domestic and foreign fiat currencies may circulate in the economy, and domestic investment is subject to multiple, unremunerated reserve requirements that take the form of currency reserves. Then, I model two economies that are similar in every respect, except for their choice of exchange rate regimes. The first economy has floating exchange rates, and I intend to replicate the main characteristics share by Indonesia, Korea, Philippines and Thailand after the crisis. I evaluate the performance of two alternative monetary policies that will lead to different de facto exchange rate regimes: a constant rate of money growth versus a policy of inflation targeting. In the second economy, a fixed exchange rate regime is in place, and I intend to replicate the main characteristics of Malaysia after the crisis.

The results show the existence of multiple equilibria that can be ranked base on the presence of binding information constraints and on welfare. I also can show that there is a strong association between the scope for existence and for indeterminacy of equilibria and the underlying policy regime. What kind of equilibrium the society will achieve at the end of the day depends not only on the bank's financial situation but also relies heavily on depositors' behavior. Whether the bank is illiquid at the end of the first period and/or insolvent at the beginning of the second period can help us narrow the

possible equilibria. However, the panic equilibrium will occur depends on one crucial condition, the incentive compatibility condition. If the patient agent panic and behavior just like impatient depositors and withdraw immediately, the run equilibrium will happen. In addition, in this paper, policies do matter. I find that the presence of binding multiple reserve requirements may help in reducing the scope for financial fragility and panic equilibria.

These two essays, chapters II and III in my dissertation, could be extended in many possible directions. Other than the detailed discussions at the end of each chapter, one issue deserves special emphasis. The financial markets are contagious and sensitive to various reasons that might trigger crises and bank runs. The current sub-prime mortgage crisis, for example, is mixing with many ingredients at the same time. How to model this crisis and further provide some helpful policy suggestion is the next topic I want to study. While to identify a starting point of a crisis might be straightforward, it is difficult to clarify or even model the widespread effects on financial markets. The first sign of the crises is related to the moral hazard problem from the excessive risk-taking behavior. Rooted in the housing market, competition among financial institutions and mortgage companies undoubtedly encouraged the risky behavior of making loans to the sub-prime mortgage borrowers. The subsequent slowdown of the housing price boom and the burst of the housing bubble narrowed the chance for borrowers to refinance their mortgages. Hence, default rates and the number of home foreclosures skyrocketed. The condition of the economy started to turn from bad to worse due to the liquidity concerns and increased risk aversion among banks. The higher interest rates on loans could serve as an accurate indicator. In addition, the widespread credit crunch and the fear of the banking crises might drive up the self-fulfilling panic withdrawals. The contagious effects among different markets might further generate externality which will affect agents' decisions.⁴⁶

⁴⁶ Kaminsky and Reinhart's (1999) finding is consistent with the current situation in the U.S.; an underway banking crisis may predict a future currency crisis. The high interest rates work to defend either the exchange rate or the fear of the inflation will aggravate the unstable markets. The current US mortgage crisis is just an example of how serious and contagious a crisis could be.

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APPENDIX A

TECHNICAL APPENDIX FOR CHAPTER II

1. Premium with Capital Requirements

Under the full covered deposit insurance, the survival probability of a bank can be derived directly from this bank's portfolio without considering any possible move of depositors. If the bank's return from the combination of the gamble-prudent investment is greater than the cost the bank needs to repay, the bank survives⁴⁷. Bank's survival probability is

$$\Pr(Ri + \alpha [(1-P)(D_1 + D_2) - i] - r(D_1 + D_2) > 0) = \Pr(R > R_f),$$

where $R_f \equiv \alpha - (1/i)[\alpha(1-P) - r](D_1 + D_2)$. To put it another way, if the random realized return R is greater than the survival threshold R_f , the bank survives; otherwise, the bank fails.

Under this environment, each bank faces the same flat rate premium, which is charged at the beginning of the period, no matter how much risk the bank takes. Bank's expected return is

$$\int_{R_f}^{\infty} \{Ri + \alpha[(1-P)(D_1 + D_2) - i] - r(D_1 + D_2)\} f(R) dR$$

, and the optimal gambling asset is

$$i_f = \frac{[\alpha(1-P) - r] \cdot [qD_1 + (1-q)D_2]}{R_f - \alpha}$$

⁴⁷ For simplicity, we do not consider the Diamond-Dybvig type's self-fulfilling bank run; instead, the bank may be closed only because it is insolvent when gambling failed.

APPENDIX B

TECHNICAL APPENDIX FOR CHAPTER III

1. Comparing Alternative Transfers-Schemes

In this section, we consider the case where the government gives transfers to young agents claiming to be of the impatient type after individuals learn their types. Notice that it is not possible to verify types directly, since they are private information.

1.1 The Model

In the situation where the government gives the transfers to young agents claiming to be of the impatient type after agents learn their types, we can write the conditions for a general equilibrium as

$$k_t \leq d_{0t} + d_{2t} + (1 - \phi_f - \phi_d)w \quad (\text{B.1.1})$$

$$\lambda c_{1t} + r_0^* d_{0t} \leq r_l l_t + d_{1t} + \lambda \tau_t \quad (\text{B.1.2})$$

$$(1 - \lambda)c_{2t+1} + r_2^* d_{2t} + r_1^* d_{1t} \leq R(k_t - l_t) + \phi_d \left(\frac{p_t}{p_{t+1}} \right) w + \phi_f \left(\frac{1}{1 + \sigma^*} \right) w \quad (\text{B.1.3})$$

$$R > \frac{p_t}{p_{t+1}} \rightarrow \frac{M_t}{p_t} = \phi_d w \quad (\text{B.1.4})$$

$$R > \frac{p_t^*}{p_{t+1}^*} = \frac{e_{t+1}}{e_t} \cdot \frac{p_t}{p_{t+1}} \rightarrow \frac{e_t Q_t}{p_t} = \phi_f w \quad (\text{B.1.5})$$

$$GBC : \lambda \tau_t = \frac{M_t - M_{t-1}}{p_t} \quad (\text{B.1.6})$$

1.2 Existence of Steady-State Equilibria under Floating Exchange Rates

When the monetary authority gives the transfers to young agents claiming to be of the impatient type, we observe the following:

$$z_{t+1} = z_t = \phi_d w \quad (\text{B.1.7})$$

$$\lambda \tau_t = \frac{M_t}{p_t} \left(\frac{\sigma}{1+\sigma} \right) = Z_t \left(\frac{\sigma}{1+\sigma} \right) = \phi_d w \left(\frac{\sigma}{1+\sigma} \right) \quad (\text{B.1.8})$$

and

$$\frac{p_t}{p_{t+1}} = \left(\frac{M_t}{\phi_d w} \right) \left(\frac{\phi_d w}{M_{t+1}} \right) = \frac{1}{1+\sigma} \quad (\text{B.1.9})$$

We present these results in Table B.1 below.

Table B.1 Existence of Steady- State Equilibria with Transfers to Young Impatient Agents, $l_t = 0$. A Floating Exchange Rate Regime

		Case I	Case II
Type of Equilibria	Amount Borrowed	$r_0^* < 1$ and $r_1^* > r_2^* = R$	$r_0^* > 1$ and $r_1^* < r_2^* = R$
No intra-period foreign debt	$d_2 = f_0$ $d_0 = 0$ $d_1 = f_1 - f_0$	We can observe one of two cases: 1. Equilibria do not exist, or 2. Equilibria exist only for values of σ sufficiently low .	We can observe one of two cases: 1. Equilibria exist for all relevant parameter values, or 2. Equilibria exist only for values of σ sufficiently high .
Interior solution	$d_2 > 0$ $d_0 = f_0 - d_2$ $d_1 = f_1 - d_2$	Equilibria exist only when σ is neither too low nor too high	Equilibria exist only when σ is neither too low nor too high
No long-term foreign debt	$d_2 = 0$ $d_0 = f_0$ $d_1 = f_1$	We can observe one of three cases: 1. Equilibria do not exist, or 2. Equilibria exist only for values of σ that are neither too low nor too high, or 3. Equilibria exist only for values of σ sufficiently low .	We can observe one of three cases: 1. Equilibria do not exist, or 2. Equilibria exist only for values of σ that are neither too low nor too high, or 3. Equilibria exist only for values of σ sufficiently high .

1.3 Existence of Steady-State Equilibria under Fixed Exchange Rates

Table B.2 on the next page, presents the results for situations where the monetary authority gives transfers to young agents claiming to be of the impatient type.

Table B.2 Existence of Steady-State Equilibria with Transfers to Young Impatient Agents. A Fixed Exchange Rate Regime

		Case I	Case II
Type of Equilibria	Amount Borrowed	$r_0^* < 1$ and $r_1^* > r_2^* = R$	$r_0^* > 1$ and $r_1^* < r_2^* = R$
No intra-period foreign debt	$d_2 = f_0$ $d_0 = 0$ $d_1 = f_1 - f_0$	We can observe one of three cases: 1. Equilibria do not exist, or, 2. Equilibria exist for values of σ^* that are neither too low nor too high, or, 3. Equilibria exist only for values of σ^* sufficiently low.	We can observe one of three cases: 1. Equilibria do not exist, or, 2. Equilibria exist for values of σ^* that are neither too low nor too high, or, 3. Equilibria exist only for values of σ^* sufficiently high.
Interior solution	$d_2 > 0$ $d_0 = f_0 - d_2$ $d_1 = f_1 - d_2$	Equilibria exist for values of σ^* that are neither too low nor too high.	Equilibria exist for values of σ^* that are neither too low nor too high.
No long-term foreign debt	$d_2 = 0$ $d_0 = f_0$ $d_1 = f_1$	We can observe one of three cases: 1. Equilibria do not exist, or, 2. Equilibria exist for values of σ^* that are neither too low nor too high, or, 3. Equilibria exist only for values of σ^* sufficiently low.	We can observe one of three cases: 1. Equilibria do not exist, or, 2. Equilibria exist for values of σ^* that are neither too low nor too high, or, 3. Equilibria exist only for values of σ^* sufficiently high.

2. Bifurcations under a Floating Exchange Rate Regime

A. Case I. $r_0^* < 1$ and $r_1^* > r_2^* = R$

In this section we illustrate the presence of bifurcation values for the monetary policy parameter σ , under floating exchange rates. It is straightforward to replicate and extend such analysis for the case of fixed exchange rates. To fix ideas, we focus on the case where equilibria do not have long-term foreign debt and Case I obtains (i.e. $r_0^* < 1$ and $r_1^* > r_2^* = R$).

To get matters started, it will be helpful to define the following functions:

$$H(\sigma) \equiv R(1 - \phi_d - \phi_f) + \frac{\phi_d}{1 + \sigma} + \frac{\phi_f}{1 + \sigma^*} \quad (\text{B.2.1})$$

$$A(\sigma) \equiv \frac{Rf_0 + \lambda H(\sigma) \cdot (w + \tau_t)}{f_1} \quad (\text{B.2.2})$$

$$B(\sigma) \equiv \left(\frac{1 - \lambda}{f_1} \right) \left\{ \frac{[Rf_0 + H(\sigma) \cdot (w + \tau_t)]}{1 - \lambda} - \frac{r \cdot f_1}{\lambda} \right\} + \left(\frac{1 - \lambda}{f_1} \right) \sqrt{\frac{r \cdot f_1}{\lambda} - \frac{[Rf_0 + H(\sigma) \cdot (w + \tau_t)]^2}{1 - \lambda} + 4 \frac{r \cdot R \cdot f_0 \cdot f_1}{\lambda(1 - \lambda)}} \quad (\text{B.2.3})$$

$$C(\sigma) \equiv \left(\frac{1 - \lambda}{2f_1 r} \right) \left\{ \frac{r \cdot [Rf_0 + H(\sigma) \cdot (w + \tau_t)]}{1 - \lambda} - \frac{R \cdot f_1}{\lambda} \right\} + \left(\frac{1 - \lambda}{2f_1 r} \right) \sqrt{\frac{R \cdot f_1}{\lambda} - \frac{r \cdot [Rf_0 + H(\sigma) \cdot (w + \tau_t)]^2}{1 - \lambda} + 4 \frac{r \cdot R^2 \cdot f_0 \cdot f_1}{\lambda(1 - \lambda)}} \quad (\text{B.2.4})$$

Notice that the limits of these functions as σ approaches 0 from the right or infinity from the left are well defined and bounded.

The existence and properties of equilibria may vary when the value of the monetary policy parameter σ changes. In particular, the properties of the main factors defined in equations (B.2.1)-(B.2.4) will change as σ changes, and so will the existence and/or properties of the stationary equilibria. Of course, we restrict our attention to allocations where $\sigma > -1$ holds.

a) Case I with $C(\sigma) < A(\sigma) < B(\sigma)$

There are three possible situations: curve $C(\sigma)$ and $A(\sigma)$ intersect twice, they intersect once or they do not intersect at all. Also, from the first order condition of the constrained maximization problem⁴⁸, we know that an equilibrium exists when $C(\sigma) < r_1^* < A(\sigma)$ and $R < C(\sigma)$. In this case, the existence of equilibria requires values of σ that are high enough. We illustrate these results below, in Figure B.1 panel (a) to (e).

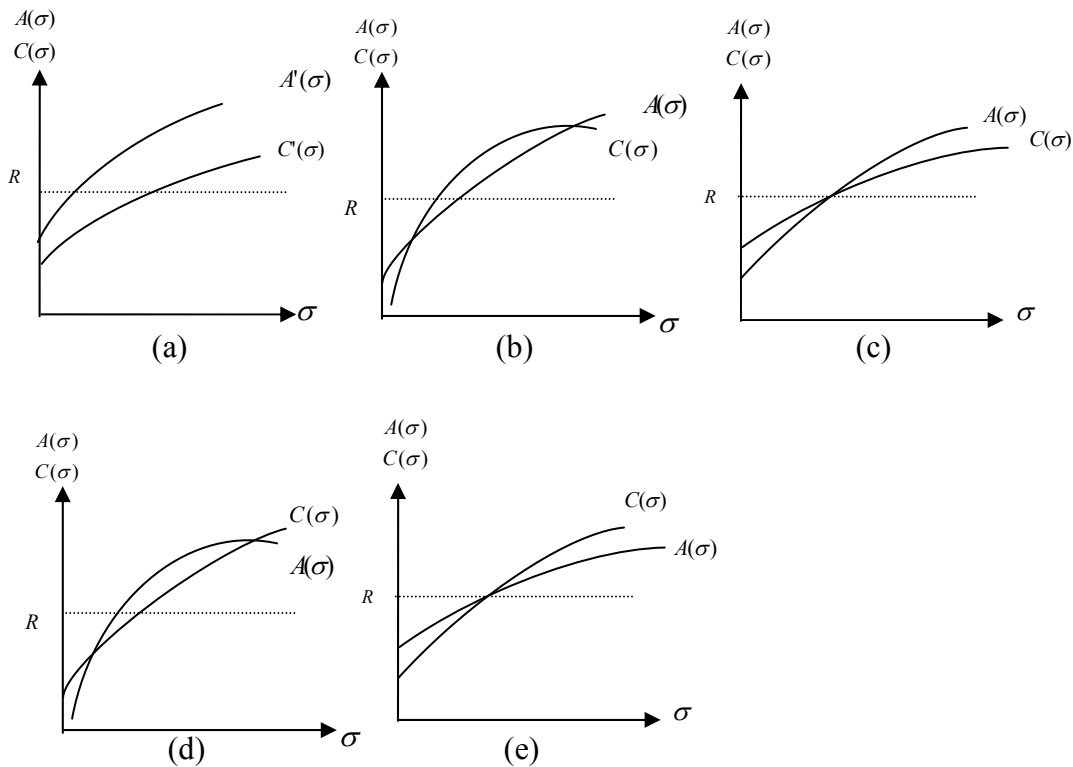


Figure B.1 Bifurcation Values for the Parameter σ .

Case I and $C(\sigma) < A(\sigma) < B(\sigma)$

⁴⁸ We can summarize the extra restrictions that the First Order Conditions impose on r_1^* as follows: equilibria do exist only when the conditions $r_1^* > A(\sigma)$, $r_1^* \leq B(\sigma)$, and $r_1^* > C(\sigma)$ are satisfied.

b) Case I with $C(\sigma) < B(\sigma) < A(\sigma)$

The following conditions obtain in equilibria with no long-term foreign debt:

$$-\infty < \lim_{\sigma \rightarrow 0^+} \frac{\partial B}{\partial \sigma} < 0 \quad (\text{B.2.5})$$

$$-\infty < \lim_{\sigma \rightarrow 0^+} \frac{\partial C}{\partial \sigma} < 0 \quad (\text{B.2.6})$$

$$\lim_{\sigma \rightarrow \infty^-} \frac{\partial B}{\partial \sigma} = 0 \quad (\text{B.2.7})$$

and

$$\lim_{\sigma \rightarrow \infty^-} \frac{\partial C}{\partial \sigma} = 0 \quad (\text{B.2.8})$$

However, we cannot determine, *a priori*, which of these limits has a larger magnitude, as σ approaches zero or infinity. In Figure B.2 panel (a), we illustrate the fact that when the condition $B(\sigma) > C(\sigma), \forall \sigma > -1$ obtains, equilibria exist only for values of σ that are high enough. In Figure B.2 panel (b), instead, we observe that equilibria do not exist when $C(\sigma) > B(\sigma), \forall \sigma > -1$ holds, since it violates the extra constraint derived from the First Order Conditions.

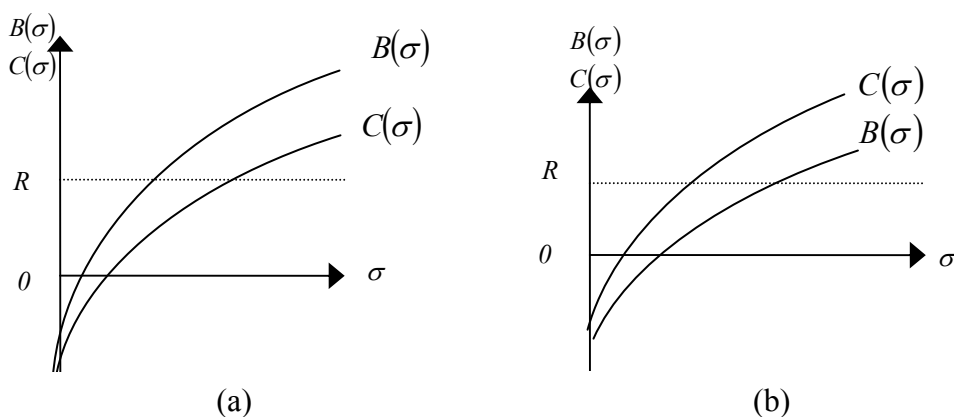


Figure B.2 Bifurcation Values for the Parameter σ . Case I and $C(\sigma) < B(\sigma) < A(\sigma)$

3. Multiplicity and Indeterminacy of Stationary Equilibria

--Floating Exchange Rates

We use the case of equilibria with no intra-period debt to illustrate the uniqueness and determinacy properties of equilibria, together with the role played by the policy parameter σ . It is straightforward to extend the analysis to other types of equilibria or to the case of fixed exchange rates. Typically, we observe a continuum of stationary equilibria that, of course, are not locally unique or determinate.

A. Case I. $r_0^* < 1$ and $r_1^* > r_2^* = R$.

The thick gray lines in Figure B.3 display the combinations of foreign interest rates that are consistent with the existence of equilibria. The condition $C'(\sigma) < A'(\sigma) < B'(\sigma)$ obtains in Figure B.3 panel (a), while $A'(\sigma) < C'(\sigma) < B'(\sigma)$ holds in Figure B.3 panel (b). In each case, there is a continuum of equilibria. Thus, equilibria are not locally unique or determinate.

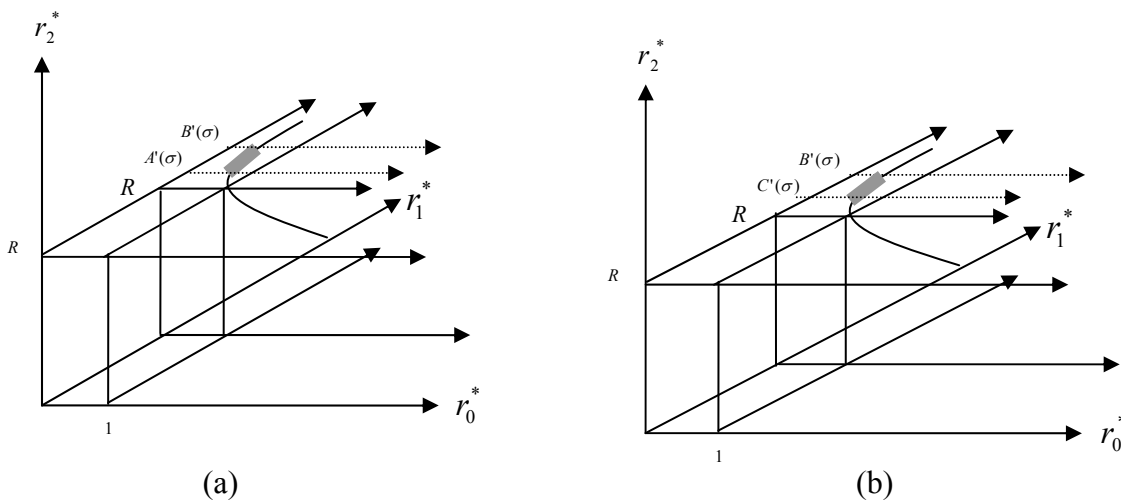


Figure B.3 Multiplicity and Indeterminacy of Stationary Equilibria.

Case I. $r_0^* < 1$ and $r_1^* > r_2^* = R$

B. Case II. $r_0^* > 1$ and $r_1^* < r_2^* = R$

The gray curves in Figure B.4 constitute the combinations of interest rates for which all equilibrium conditions hold. The condition $C'(\sigma) < A'(\sigma) < B'(\sigma)$ holds for the case illustrated in Figure B.4 panel (a), but $A'(\sigma) < C'(\sigma) < B'(\sigma)$ is satisfied in panel (b).

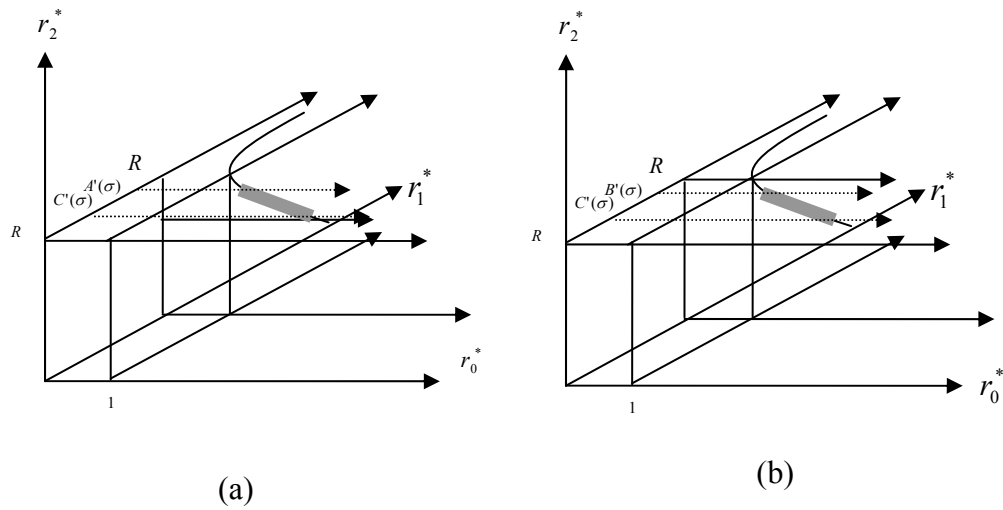


Figure B.4 Multiplicity and Indeterminacy of Stationary Equilibria.

Case II. $r_0^* > 1$ and $r_1^* < r_2^* = R$

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