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ABSTRACT

In this paper, we review three branches of theoretical literature on financial crises. The first one deals with banking crises originating from coordination failures among bank creditors. The second one deals with frictions in credit and interbank markets due to problems of moral hazard and adverse selection. The third one deals with currency crises. We discuss the evolutions of these branches of the literature and how they have been integrated recently to explain the turmoil in the world economy. We discuss the relation of the models to the empirical evidence and their ability to guide policies to avoid or mitigate future crises.

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1. Introduction

Financial and monetary systems are designed to improve the efficiency of real activity and resource allocation. A large empirical literature in financial economics provides evidence connecting financial development to economic growth and efficiency; see, for example, Levine (1997) and Rajan and Zingales (1998). In theory, financial institutions and markets enable the efficient transmission of resources from savers to the best investment opportunities. In addition, they also provide risk sharing possibilities, so that investors can take more risk and advance the economy. Finally, they enable aggregation of information that provides guidance for more efficient investment decisions. Relatedly, monetary arrangements, such as the European Monetary Union (EMU) and many others in the past, are created to facilitate free trade and financial transactions among countries, thereby improving real efficiency.

A financial crisis – marked by the failure of banks, and/or the sharp decrease in credit and trade, and/or the collapse of an exchange rate regime, etc. – generates extreme disruption of these normal functions of financial and monetary systems, thereby hurting the efficiency of the economy. Unfortunately, financial crises have happened frequently throughout history and, despite constant attempts to eliminate them, it seems unlikely that they will not repeat in the future. Clearly, the last few years have been characterized by great turmoil in the world's financial systems, which even today, more than five years after its onset, does not seem to have a clear solution. Between the meltdown of leading financial institutions in the US and Europe, the sharp decrease in lending and trading activities, and the ongoing challenge to the European Monetary Union, these events exhibit ingredients from several types of financial crises in recent history: banking crises, credit and market freezes, and currency crises.[3]

Over the years, many theories have been developed to explain financial crises and guide policymakers in trying to prevent and mitigate them. Three literatures have been developed, more or less in parallel, highlighting the analytical underpinnings of three types of crises: banking crises and panics, credit frictions and market freezes, and currency crises. At a later stage, mainly following the East Asian crisis in the late 1990s, these literatures have become more integrated, as the events in the real world proved that the different types of crises can occur together and amplify each other in different ways.

In this survey, we provide a review of the basic theories of financial crises of the three types described above and the way they interact with each other. Importantly, this is not meant to be a comprehensive survey of the financial-crises literature. The literature is too big to be meaningfully covered in full in one survey. Instead, we attempt to present the basic frameworks and describe some of the directions in which they influenced the literature and the way they relate to recent events. We also address some of the policy challenges and shed light on them using the analytical tools at hand. We hope that this survey will be helpful in highlighting the basic underlying forces that have been studied in the literature for over three decades in a simple and transparent way, and will be an easy and accessible source to the many economists who are now interested in exploring the topic of financial crises following the events of the last few years.

In Section 2, we review the literature on banking crises and panics. Banks are known to finance long-term assets with short-term deposits. The advantage of this

[3] Many authors provide detailed descriptions of the events of the last few years. For example, see Brunnermeier (2009) and Gorton (2010).

arrangement is that it enables banks to provide risk sharing to investors who might face early liquidity needs. However, this also exposes the bank to the risk of a bank run, whereby many creditors decide to withdraw their money early. The key problem is that of a coordination failure, which stands at the root of the fragility of banking systems: When more depositors withdraw their money from a bank, the bank is more likely to fail, and so other depositors have a stronger incentive to withdraw. In this section, we describe the theoretical underpinnings behind bank runs and the lessons to policy analysis.

Banking systems have been plagued with bank runs throughout history; see, e.g., Calomiris and Gorton (1991). Policy lessons adopted in the early 20th century led governments to insure banks, which substantially reduced the likelihood of such events. However, runs are still a prominent phenomenon behind financial crises. Many runs happened in East Asian and Latin American countries even in the last two decades. In the recent turmoil, a classic 'text-book' type of bank run was seen in the UK for Northern Rock Bank (see Shin (2009)), where investors were lining up in the street to withdraw money from their accounts. Beyond that, there were many other examples of runs in the financial system as a whole. The repo market, where investment banks get short-term financing, was subject to a run (Gorton and Metrick (2012)) when financing has all of a sudden dried up. This led to the failure of leading financial institutions, such as Bear Stearns and Lehman Brothers. This credit squeeze was to a large extent a coordination failure among providers of capital in this market, who refused to roll over credit, expecting a failure of the borrower due to the refusal of other lenders to roll over credit. This is similar to the models of bank runs due to coordination problems that we review. Runs also occurred on money-market funds and in the asset-backed-commercial-paper market (see for example, Schroth, Suarez, and Taylor (2012)), which were very prominent events in the recent crisis.

While Section 2 emphasizes fragility faced by financial institutions due to coordination failures by their creditors, in Section 3 we review models that analyze frictions in loans extended by financial institutions and other lenders. Broadly speaking, these are models of credit frictions and market freezes. This literature highlights two key problems that create frictions in the flow of credit from lenders to borrowers. When these frictions strengthen, a financial crisis ensues that can even lead to a complete freeze. One problem is that of moral hazard. If a borrower has the ability to divert resources at the expense of the creditor, then creditors will be reluctant to lend to borrowers. Hence, for credit to flow efficiently from the creditor to the borrower, it is crucial that the borrower maintains 'skin in the game', i.e., that he has enough at stake in the success of the project, and so does not have a strong incentive to divert resources. This creates a limit on credit, and it can be amplified when economic conditions worsen, leading to a crisis. Another problem is that of adverse selection. In the presence of asymmetric information between lenders and borrowers or between buyers and sellers, credit and trade flows might freeze. Again, this may lead to a crisis if asymmetric information is very extreme.

Such forces were clearly on display in recent years. The credit freeze following the financial meltdown of 2008, and the credit flow freeze in the interbank markets are both manifestations of the amplification of economic shocks due to the frictions in credit provision, brought by the principal-agent models that we review here. As economic conditions deteriorated, borrowers found themselves with less 'skin in the game', and so lenders refused to provide credit to them, since doing so would lead borrowers to divert cash, and take excessive risk. This, in turn, worsened the economic conditions of borrowers, amplifying the initial shock. Similarly, the sharp increase in asymmetric information, following the collapse of Lehman Brothers in 2008, contributed to a total market freeze, where investors were reluctant to trade in assets with each other, due to the heightened uncertainty about the value of assets they trade.

Overall, the models of Sections 2 and 3 highlight fragility on the different sides of the balance sheet of a financial institution. Clearly, both types of fragility have been at work in recent crises, as we mention above. Importantly, such fragilities can reinforce each other, as we point out in Section 3. That is, creditors of a financial institution are more likely to panic and run when problems of moral hazard and asymmetric information reduce the value of its assets or make it more uncertain.

An important aspect of financial crises is the involvement of the government and the potential collapse of arrangements it creates, such as an exchange rate regime. In Section 4, we review models of this kind, focusing on currency crises. Many currency crises, e.g., the early 1970s breakdown of the Bretton Woods global system, originate from the desire of governments to maintain a fixed exchange rate regime which is inconsistent with other policy goals such as free capital flows and flexible monetary policy. This might lead to the sudden collapse of the regime. Like in the bank-run literature, coordination failures play an important role here too. When the central bank tries to maintain a fixed exchange rate regime, it might decide to abandon it under pressure from speculators. Then, speculators again find themselves in a coordination problem, where they attack the regime if and only if they believe others will do so. In such coordination failures, the event of a currency crisis becomes a self-fulfilling belief. This is also similar to debt crises, where the government may decide to default under pressure from creditors. Then, creditors are facing a coordination problem, where they liquidate their bond holdings if and only if they expect that others will liquidate their claims. Consequently a debt crisis becomes a self-fulfilling expectation.

Such models are highly relevant to the current situation in the European Monetary Union. In the basis of the theory of currency crises is the famous international-finance trilemma, according to which a country can choose only two of three policy goals: free international capital flows (benefitting international risk sharing), monetary autonomy (the ability to employ monetary policy tools to stabilize inflation and output fluctuations), and the stability of the exchange rate (bringing about a reduction in transaction costs associated with trade and investment). Countries in the Euro zone now realize that in their attempt to achieve the first and third goal, they have given up on the second goal, and so have limited ability to absorb the shocks in economic activity and maintain their national debts, triggered by the global financial crisis. Coordination problems among investors and currency speculators aggravate this situation, and may have an important effect on whether individual countries in Europe are forced to default and/or leave the monetary union.

While the traditional literature on currency crises focused on the government alone, in Section 4.3 we review the 'third-generation' models of currency crises, which essentially connect models of banking crises and credit frictions (reviewed in Sections 2 and 3, respectively) with traditional models of currency crises (reviewed in Subsections 4.1 and 4.2). Such models were motivated by the East Asian Crises of the late 1990s, where financial institutions and exchange rate regimes collapsed together, demonstrating the linkages between governments and financial institutions that can expose the system to further fragility. This is again relevant for the current situation in Europe, as banks and governments are intertwined, and the fragility of the system depends to a large extent on the connections between them.

2. Banking Crises and Panics

Depository institutions are inherently unstable because they have a mismatch in the maturity structure between their assets and liabilities. In particular, they finance long-term investments with short-term deposits. This exposes banks to a risk of bank runs: when many depositors demand their money in the short term, banks will have to liquidate long-term investments at a loss, leading to their failure. This can lead to a self-fulfilling belief, whereby the mere belief that a bank run will occur causes a bank run, as depositors are better off withdrawing their money if they expect others to do so.

Diamond and Dybvig (1983)[4] provide a framework for coherent analysis of this phenomenon. In their model, agents may suffer idiosyncratic short-term liquidity needs. If they operate in autarky, consuming the returns on their own endowments, they would not be able to enjoy the fruits of long-term investments. By offering demand-deposit contracts, banks enable short-term consumers to enjoy those fruits. Banks rely on the fact that only a forecastable fraction of agents will need to consume early, and thus offer a contract that transfers consumption from the long-term consumers to the short-term consumers. This contract improves welfare as long as agents demand early withdrawal only if they genuinely need to consume in the short term. Banks thereby enable risk sharing among agents who ex ante do not know whether they will have early liquidity

[4] Another important paper on the topic from that period is Bryant (1980).

needs or not. The contract may also lead to a catastrophic bank run, where all depositors demand early withdrawal and the bank collapses. This turns out to be an equilibrium since under the belief that the bank is going to collapse, the rational behavior is indeed to run on the bank.

2.1 Diamond-Dybvig Economy

We now provide a formal description of an economy based on Diamond and Dybvig (1983). The version here follows Goldstein and Pauzner (2005). This will enable us to talk about equilibrium selection and policy implications.

There are three periods (0,1,2), one good, and a continuum [0,1] of agents. Each agent is born in period 0 with an endowment of one unit. Consumption occurs only in period 1 or 2 (c_1 and c_2 denote an agent's consumption levels). Each agent can be of two types: With probability λ the agent is impatient and with probability 1-λ she is patient. Agents' types are i.i.d.; we assume no aggregate uncertainty. Agents learn their types (which are their private information) at the beginning of period 1. Impatient agents can consume only in period 1. They obtain utility of $u(c_1)$. Patient agents can consume at either period; their utility is $u(c_1 + c_2)$. Function u is twice continuously differentiable, increasing, and for any $c \geq 1$ has a relative risk-aversion coefficient, $-cu''(c)/u'(c)$, greater than 1. Without loss of generality, we assume that $u(0)=0$.[5]

Agents have access to a productive technology that yields a higher expected return in the long run. For each unit of input in period 0, the technology generates one unit of output if liquidated in period 1. If liquidated in period 2, the technology yields R units of

[5] Note that any von Neumann-Morgenstern utility function, which is well defined at 0 (i.e., $u(0) \neq -\infty$), can be transformed into an equivalent utility function that satisfies $u(0)=0$.

output with probability $p(\theta)$, or 0 units with probability 1-$p(\theta)$. Here, θ is the state of the economy. It is drawn from a uniform distribution on [0,1], and is unknown to agents before period 2. We assume that $p(\theta)$ is strictly increasing in θ. It also satisfies

$$E_\theta[\, p(\theta)]u(R) > u(1)\,,$$

so that for patient agents the expected long-run return is superior to the short-run return.

2.2 Risk Sharing via Maturity Transformation

In autarky, impatient agents consume one unit in period 1, whereas patient agents consume R units in period 2 with probability $p(\theta)$. Because of the high coefficient of risk aversion, a transfer of consumption from patient agents to impatient ones could be beneficial, ex-ante, to all agents, although it would necessitate the early liquidation of long-term investments. A social planner who can verify agents' types, once realized, would set the period-1 consumption level c_1 of the impatient agents so as to maximize an agent's ex-ante expected welfare,

$$\lambda u(c_1) + (1-\lambda)u\left(\frac{1-\lambda c_1}{1-\lambda}R\right)E_\theta[p(\theta)].$$

Here, λc_1 units of investment are liquidated in period 1 to satisfy the consumption needs of impatient agents. As a result, in period 2, each one of the patient agents consumes an amount of $\frac{1-\lambda c_1}{1-\lambda}R$ with probability $p(\theta)$.

The first-best period-1 consumption c_1^{FB} is set to maximize this ex-ante expected welfare. The first-order condition equates the benefit and cost from the early liquidation of the marginal unit of investment. It can be shown that $c_1^{FB} > 1$, i.e., the consumption available in period 1 to impatient consumers exceeds the endowment (i.e., what they could consume in autarky). Hence, at the first best allocation, there is risk sharing, which is achieved via maturity transformation: a transfer of wealth from patient agents to impatient ones.

2.3 Banks and Multiple Equilibria

Without a social planner, risk sharing can be achieved via a banking sector. Assume that the economy has a banking sector with free entry, and that all banks have equal access to the investment technology. Since banks make no profits due to perfect competition, they offer the same contract as the one that would be offered by a single bank that maximizes the welfare of agents. Suppose the bank sets the payoff to early withdrawal r_1 at the first-best level of consumption, c_1^{FB}. If only impatient agents demand early withdrawal, the expected utility of patient agents is $E_\theta[p(\theta)]\cdot u(\frac{1-\lambda r_1}{1-\lambda}R)$. As long as this is more than the utility from withdrawing early $u(r_1)$, there is an equilibrium in which, indeed, only impatient agents demand early withdrawal. In this equilibrium, the first-best allocation is obtained.

However, as Diamond and Dybvig point out, the demand-deposit contract makes the bank vulnerable to runs. There is a second equilibrium in which *all* agents demand early withdrawal. When they do so, period-1 payment is now r_1 with probability $1/r_1$, and period-2 payment is 0; so that it is indeed optimal for agents to demand early withdrawal. This equilibrium is evidently inferior to the autarkic regime. The reason for multiplicity of equilibria is the strategic complementarities among agents: It is optimal for them to run if they think that others are going to run.

Table 1 describes the payments expected by agents when they withdraw at Period 1 vs. Period 2 as a function of the proportion n of agents between 0 and 1 who decide to withdraw at Period 1. Looking at the table, it is easy to see that under the above assumptions, there is an equilibrium with no run (*n=0*) and an equilibrium with a run (*n=1*).

[Insert Table 1 Here]

While the multiplicity of equilibria seems to capture the fragility of banks and the element of surprise in financial crises in general, it poses two major difficulties for researchers and policymakers. First, the model provides no prediction as to when a bank run is more likely to occur. This stands in sharp contrast to the vast empirical research that finds evidence that financial crises are linked to various variables that capture the strength of fundamentals of the banking system (see for example, Gorton (1988) and Demirguc-Kunt and Detragiache (1998); for a recent review, see Goldstein (2012)). Second, policy analysis becomes quite difficult with multiple equilibria. If a policy measure is intended to reduce the likelihood of bank runs but also has other costs, then assessing the desirability of this policy measure becomes impossible if the likelihood of bank runs cannot be pinned down (with and without the policy measure in place).

2.4 Heterogeneous Signals and Unique Equilibrium

The global-games literature offers a solution to the problem of multiplicity of equilibria. The literature was pioneered by Carlsson and van Damme (1993), and then applied to financial crises in the context of currency attacks by Morris and Shin (1998). In this literature, assuming that agents observe noisy signals of the fundamentals of the economy leads to a unique equilibrium, where the fundamentals uniquely determine whether a crisis will occur or not. Goldstein and Pauzner (2005) build on this literature in the context of bank runs and derive a unique equilibrium.

Technically, the proof of uniqueness in Goldstein and Pauzner (2005) is quite different from that employed in the rest of the global-games literature due to the nature of payoffs in the bank run model, which violates a central assumption in the global-games framework. Specifically, in traditional global-games models, an agent's incentive to take a certain action monotonically increases in the proportion of other agents taking this action.[6] As one can see in Table 1, this does not hold in the bank run model, since in the region where the bank is bankrupt, the net benefit from running decreases when more people run. Goldstein and Pauzner (2005) overcome this problem and show uniqueness nevertheless under some conditions. For the purpose of our review, we will not get into these complexities here, but rather just briefly describe the intuition behind the traditional global-games framework and how it generates a unique equilibrium. The intuition in the bank-run context is closely related to the traditional intuition.

If the realization of the fundamental θ is common knowledge to agents before they make their choice whether to run or not, the model of Goldstein and Pauzner (2005) generates three regions of the fundamentals, which are depicted in Figure 1. Below a threshold $\underline{\theta}$, there is a unique equilibrium where all depositors – patient and impatient – run on the bank and demand early withdrawal. Here, the fundamentals are so low that the bank is insolvent and will fail no matter what other depositors do, and hence each depositor undoubtedly finds it profitable to withdraw. Above a threshold $\bar{\theta}$, there is a

[6] This property is referred to as "Global Strategic Complementarities".

unique equilibrium where patient depositors do not withdraw.[7] Here, the fundamentals are so high that the bank can survive and pay its liabilities even if all depositors demand early withdrawal. Hence, they choose not to withdraw. Between $\underline{\theta}$ and $\bar{\theta}$, there are multiple equilibria. Either everyone runs and the bank fails, or only impatient agents withdraw and the bank remains solvent. There are strategic complementarities, since depositors benefit from the run if and only if other depositors run, and hence there are two possible equilibria.

[Insert Figure 1 Here]

However, introducing noise in speculators' information about the fundamental θ, such that every depositor gets a signal composed of the true fundamental θ plus i.i.d. noise, changes the predictions of the model dramatically (even if the noise is very small). The new predictions are depicted in Figure 2. Now, the intermediate region between $\underline{\theta}$ and $\bar{\theta}$ is split into two sub-regions: below θ^*, a bank run occurs and the bank fails, while above it, there is no run and the bank remains solvent.[8]

[Insert Figure 2 Here]

This result can be best understood by applying the logic of a backward induction.[9] Due to the noise in patient depositors' information about θ, their decisions about whether to withdraw no longer depend only on the information conveyed by the signal about the realization of the fundamental. It also depends on what the signal conveys about other

[7] This upper dominance region is obtained with an additional assumption introduced by Goldstein and Pauzner (2005).

[8] This sharp outcome is obtained when the noise in the signal approaches zero. For larger noise, the transition from run to no-run will not be so abrupt, but rather there will be a range of partial run. This does not matter for the qualitative message of the theory.

[9] Strictly speaking, this intuition holds for the traditional global-games framework where global strategic complementarities hold. The intuition in the bank-run model of Goldstein and Pauzner (2005) is more involved.

depositors' signals. Hence, between $\underline{\theta}$ and $\bar{\theta}$, depositors can no longer perfectly coordinate on any of the outcomes (whether to run or not to run), as their actions now depend on what they think the other depositors will do based on the signal they receive. Hence, a depositor observing a signal slightly below $\bar{\theta}$ knows that many other depositors may have observed signals above $\bar{\theta}$ and therefore choose not to run. Taking this into account, this depositor also chooses not to run. Then, we know that depositors who receive signals just below $\bar{\theta}$ do not run on the bank. Applying the same logic, depositors who receive even lower signals also choose not to run. This logic can be repeated again and again, establishing a boundary well below $\bar{\theta}$, above which depositors do not run on the bank. The same logic can then be repeated from the other direction, establishing a boundary well above $\underline{\theta}$, below which depositors do run on the bank. The mathematical proof shows that the two boundaries coincide at a unique θ^*, such that all depositors run below θ^*, and do not run above θ^*.

As Figure 2 shows, in the range between $\underline{\theta}$ and $\bar{\theta}$, the level of the fundamental now perfectly predicts whether or not a crisis occurs. In particular, a crisis surely occurs below θ^*. We refer to crises in this range as "panic-based" because a crisis in this range is not necessitated by the fundamentals; it occurs only because agents think it will occur, and in that sense it is self-fulfilling. However, the occurrence of a self-fulfilling crisis here is uniquely pinned down by the fundamentals. So, in this sense, the "panic-based" approach and the "fundamental-based" approach are not inconsistent with each other. The occurrence of a crisis is pinned down by fundamentals, but crises are self-fulfilling as they would not have occurred if agents did not expect them to occur. The key is that the fundamentals uniquely determine agents' expectations about whether a crisis will occur, and in doing this, they indirectly determine whether a crisis occurs. Agents' self-fulfilling beliefs amplify the effect of fundamentals on the economy. Similarly, between θ^* and $\bar{\theta}$, even though the fundamental could support a crisis, it does not occur, as agents' expectations are coordinated on the no-crisis outcome.

Hence, the global-games approach produces empirical predictions that are consistent with the empirical literature mentioned above, where the occurrence of a crisis is linked to fundamental variables characterizing the state of the bank or the banking system. However, it still maintains the flavor of panic or self-fulfilling beliefs that emerges from the Diamond-Dybvig model, as crises are still driven by agents' expectations and not by fundamentals alone. This combination is an appealing feature of the global-games solution.

An important question is how to provide empirical validation for the existence of panic and self-fulfilling beliefs in real-world crises.[10] In the past, authors interpreted the evidence of the link between fundamentals and crises to go against theories of panic and self-fulfilling beliefs, but given the results of the global-games literature described here, this conclusion is clearly flawed. Two recent papers attempt to identify the role of panic and strategic complementarities more directly. Chen, Goldstein, and Jiang (2010) identify the effect of strategic complementarities in outflows from mutual funds by showing that the sensitivity of outflows to bad performance is stronger in funds that exhibit stronger strategic complementarities. Hertzberg, Liberti, and Paravisini (2011) use a natural experiment from Argentina and show that the release of public information makes banks react to information they already had, essentially because they expect other banks to react

[10] An alternative line of models describes banking crises as a result of bad fundamentals only. See, for example, Jacklin and Bhattacharya (1988), Chari and Jagannathan (1988) and Allen and Gale (1998).

to it. The use of such methodologies in more traditional crises datasets can prove useful for our understanding of the role that strategic complementarities and panic may have in such crises.[11]

Another appealing feature of the global-games solution is that the equilibrium in the global-games model captures the notion of strategic risk. Depositors who observe signals near the threshold where the bank fails, who ultimately determine the likelihood of a run, are not sure about how many people are going to run and whether the bank will fail. This strategic risk is of course very realistic; albeit it is missing from the multiple-equilibria framework, where in equilibrium agents know for sure how many people run and whether the bank will survive.

Another advantage of pinning down a unique equilibrium is that it enables the researcher to compute the probability of a run and relate it to the terms of the banking contract.[12] Do demand deposit contracts improve welfare even when their destabilizing consequences are taken into account? How will they be designed in light of their effect on fragility? Goldstein and Pauzner (2005) show that banks become more vulnerable to bank runs when they offer a higher level of risk sharing. That is, the threshold θ^*, below which a run happens, is an increasing function of the short-term payment offered to depositors r_1.[13] However, even when this destabilizing effect is taken into account, banks still increase welfare by offering demand deposit contracts, provided that the range of fundamentals where liquidation is efficient is not too large. Characterizing the short-term

[11] See Goldstein (2012) for a review of the empirical literature and a discussion of strategies to identify strategic complementarities.
[12] Cooper and Ross (1998) study the relation between the banking contract and the probability of bank runs in a model where the probability of bank runs is exogenous.
[13] Note that the lower threshold $\underline{\theta}$ below which running is a dominant strategy is also an increasing function of r_1.

payment in the banking contract chosen by banks taking into account the probability of a run, they show that this payment does not exploit all possible gains from risk sharing, since doing so would result in too many bank runs. Still, in equilibrium, panic-based runs occur, resulting from coordination failures among bank depositors. This leaves room for government policy to improve overall welfare.[14]

2.5 A Basis for Micro Policy Analysis

One of the basic policy remedies to reduce the loss from panic based runs is the introduction of deposit insurance by the government. This idea goes back to Diamond and Dybvig (1983), where the government promises to collect taxes and provide liquidity (bailout money) to the bank in case the bank faces financial distress (i.e., when the number of agents demanding early withdrawal n exceeds the number of impatient agents λ).

In the context of the model described above, with deposit insurance, patient agents know that if they wait they will receive the promised return independently of the number of agents who run. Hence, panic based runs are prevented: patient agents withdraw their deposits only when this is their dominant action, i.e., when θ is below $\underline{\theta}(r_1)$ (rather than below the higher threshold $\theta^*(r_1)$). Actually, only with aggregate uncertainty, where λ is stochastic, an actual bailout occurs. With only idiosyncratic uncertainty, federal deposit insurance deters bank runs with no need to exercise the liquidity enhancing power. Extending the context of the above model, Keister (2012) highlights another benefit of

[14] Note that the Goldstein-Pauzner model only focuses on demand deposit contracts to ask whether they improve welfare and how much risk sharing they should provide. Outside the global-games framework, there are papers that study a wider variety of contracts, e.g., Green and Lin (2003), Peck and Shell (2003), and Ennis and Keister (2009). Models by Calomiris and Kahn (1991) and Diamond and Rajan (2001) provide justification for the demand deposit contract based on the need to monitor bank managers.

deposit insurance: it helps providing a better allocation of resources by equating the marginal utility that agents derive from private consumption and public-good consumption. That is, when bank runs occur, private consumption decreases, generating a gap between the marginal utility of private consumption and that of public-good consumption, so with bailouts, the government can reduce the public good and increase private consumption to correct the distortion.

However, deposit insurance also has a drawback, like any insurance it creates moral hazard: when the bank designs the optimal contract, it does not internalize the cost of the taxes that might be required to pay the insurance. Thus, the bank has an incentive to over-exploit the deposit insurance by setting r_1 higher than the socially optimal level. This drawback of deposit insurance is consistent with the critique made by Calomiris (1990) that "today's financial intermediaries can maintain higher leverage and attract depositors more easily by offering higher rates of return with virtually no risk of default". In the context of the model, this is costly as it increases the lower threshold $\underline{\theta}(r_1)$, below which crises occur without a coordination failure.

The framework developed above enables one to compare the benefits and costs of deposit insurance, and provide policy recommendations regarding the optimal design of this insurance. As mentioned above, the unique equilibrium coming out of the global-games framework enables the researcher to pin down the likelihood of a crisis, and analyze the effect of deposit insurance on it, and so provide recommendations as to the optimal amount and design of the insurance. Given the tradeoff described here, it is clear that some limits on insurance will be desirable. In a recent paper, Allen, Carletti, Goldstein, and Leonello (2012) use the global-games framework to conduct such analysis of optimal deposit insurance policy. Keister (2012) conducts analysis of optimal deposit insurance policy without employing the global-games methodology by checking the effect that the policy has on the range of fundamentals where a run may occur.

Overall, deposit insurance had a profound impact on the banking industry in many countries by reducing significantly the likelihood of runs and crises. However, its implications for moral hazard have to be considered carefully, and so there is room for more research on the optimal deposit insurance policy, as described in this subsection. In addition, as we discuss in the introduction, while deposit insurance was enacted for banks and was effective in reducing the likelihood of traditional bank runs, there are many sectors of the financial system – money market funds, repo markets, etc. – that are uninsured and in which massive runs have occurred in recent years. Hence, there is room to consider optimal insurance policies for these sectors in light of the tradeoffs described here.

2.6 Contagion and Systemic Risk

A main reason for concern with banking crises is that they spread across banks leading many to fail at the same time, and hence creating systemic risk. There is a large literature on contagion of banking crises, highlighting the different sources for spillovers and coordination among banks. Allen and Gale (2000b) and Lagunoff and Schreft (2001) show how contagion arises due to bank inter-linkages. Banks facing idiosyncratic liquidity needs insure each other and so provide efficient risk sharing. However, this creates links across banks, leading to spillover of shocks and contagion of crises. Dasgupta (2004) extends their model, using the global-games framework described above, analyzing the optimal insurance contracts among banks taking into account their undesirable implications for contagion. In Goldstein and Pauzner (2004), contagion is generated due to a common pool of investors investing in different banks. The failure of one bank leads investors to lose wealth and become more risk averse, and so they are more likely to run on the other bank. Kyle and Xiong (2001) and Kodres and Pritsker (2002) analyze related models, where contagion across assets is generated by the portfolio rebalancing made by investors who hold the different assets.

Some authors analyze contagion as a result of transmission of information. In these models, a crisis in one market/bank reveals some information about the fundamentals in the other and thus may induce a crisis in the other market/bank as well. Examples include King and Wadhwani (1990) and Chen (1999). Calvo and Mendoza (2000) suggest that the high cost of gathering information on each and every market may induce rational contagion. Recently, Oh (2012) analyzes a model of contagion where investors learn about other investors' types and points out that this can be a source of contagion.

Another source of systemic risk is the 'too big to fail' problem. Banks who become too big pose a big threat on the economy in case they fail, and so governments will be willing to provide a bail out to prevent this from happening. This, in turn, generates disincentives such that the bank will take on excessive risk knowing that the consequences will be borne by the taxpayer. Similarly, the government might be particularly concerned about the possibility of several banks failing together due to the particularly adverse implications this might have on the economy. Hence, the government will bail out banks only when many of them are about to fail. As pointed out by Acharya and Yorulmazer (2007) and Farhi and Tirole (2012), this might provide incentives to banks to choose correlated risks ex ante, which leads to correlated failures and destabilizes the system as a whole.

3. Credit Frictions and Market Freezes

In the above models of financial-institution failures, the returns on assets and loans held by the bank were assumed to be exogenous, and the focus was on the behavior of depositors or creditors of the banks. However, problems in the financial sector often arise from the other side of the balance sheet. The quality of loans provided by the banks is determined in equilibrium, and frictions exist that make banks cut on lending to protect themselves from bad outcomes.

Stiglitz and Weiss (1981) provide a basic rationale for the presence of such credit rationing, which is a common phenomenon in financial crises. While basic economic theory suggests that in equilibrium prices adjust so that supply equals demand and no rationing arises, they show that this will not occur in the credit market due to the endogeneity of the quality of the loan. There are two key frictions. The first one is moral hazard: If borrowers are charged a very high cost for credit, they lose the incentive to increase the value of their projects, and so are less likely to be able to pay back. The second one is adverse selection: If interest rates are high, only borrowers with bad projects will attempt to get loans, and again the bank is unlikely to receive the money back.

For these reasons, banks will ration credit, hampering the effectiveness of the financial system in providing capital to those who need it, and in extreme cases leading to a financial crisis, where credit drops dramatically. As mentioned in the introduction, credit rationing and credit freeze have been a very important part of the recent financial crisis, as lending to firms and households decreased sharply and so did lending among banks in the interbank market. In this section, we review basic theories of this kind.

3.1 Moral Hazard

When an entrepreneur borrows money to finance a project, he can take actions that reduce the value of the project and increase his own private benefits. Hence, a lender needs to make sure that the entrepreneur has a large enough incentive to preserve (or improve) the quality of the project, which will enable him to repay the loan. A direct implication is that the entrepreneur has to have a large enough stake in the investment or he has to be able to secure the loan with collateral. These considerations limit the amount of credit available to firms. They can lead to amplification of shocks to fundamentals and ultimately to financial crises.

Holmstrom and Tirole (1997) provide a canonical representation of this mechanism. In their model, there is a continuum of entrepreneurs, with access to the same investment technology and different amounts of capital A. The distribution of assets across entrepreneurs is described by the cumulative distribution function $G(A)$. The investment required is I, so an entrepreneur needs to raise I-A from outside investors. The gross return on the investment is either 0 or R>0, and the probability of getting R instead of 0 depends on the type of project that the entrepreneur chooses. The possible projects are described in Table 2.

[Insert Table 2 Here]

If the entrepreneur chooses a good project, the probability of a high return is p_H. On the other hand, if he chooses a bad project, the probability of a high return is only p_L. Of course, the assumption is that $p_H > p_L$. However, the entrepreneur may choose a bad project because a bad project provides him a non-pecuniary private benefit. The private benefit is either *b* or *B*, where *B*>*b*, so if unconstrained, the entrepreneur will always choose a bad project with private benefit of *B* over a bad project with private benefit of *b*.

The rate of return demanded by outside investors is denoted by γ, which can either be fixed or coming from an upward sloping supply function $S(\gamma)$. The assumption is that only the good project is viable:

$$p_H R - \gamma I > 0 > p_L R - \gamma I + B.$$

That is, investing in the bad project generates a negative total surplus. Hence, for outside investors to put money in the firm, it is essential to make sure that the entrepreneur undertakes the good project. The incentive of the entrepreneur to choose the good project will depend on how much "skin in the game" he has. That is, the entrepreneur will need to keep enough ownership of the project, so that he has a monetary incentive to make the "right" decision. A key implication is that it would be easier to provide external financing to entrepreneurs with large assets *A*, since they are more likely to internalize the monetary benefit and choose the good project rather than enjoying the non-pecuniary private benefits of the bad project.

To see this, let us derive the solution of this basic model. Consider a contract where the entrepreneur invests his funds *A* together with an amount *I-A* raised from an outside investor. Clearly, no one will receive any payment if the project fails and yields *0*. The key is to determine how the entrepreneur and the outside investor split the return of the project in case it succeeds, yielding *R*. In general, one can denote the payment to the entrepreneur as R_f and the payment to the outside investor as R_u, such that $R_f + R_u = R$.

A necessary condition for outside investors to be willing to provide financing to the entrepreneur is that the entrepreneur has an incentive to choose the good project. Otherwise, the total net present value is negative, and so the outside investor cannot break even. Hence, it is crucial that the entrepreneur benefits more from taking the good project than from taking the bad project. This implies:

$$p_H R_f \geq p_L R_f + B.$$

Denoting $\Delta p = p_H - p_L$, we get the incentive compatibility constraint:

$$R_f \geq B/\Delta p.$$

This implies that the maximum amount that can be promised to the outside investors – the pledgeable expected income – is:

$$p_H(R - B/\Delta p).$$

Hence, to satisfy the participation constraint of the outside investors, i.e., to make sure that they get a high enough expected income to at least break even, we need:

$$\gamma(I - A) \leq p_H(R - B/\Delta p).$$

This puts an endogenous financing constraint on the entrepreneur, which depends on how much internal capital *A* he has. Defining the threshold $\overline{A}(\gamma)$ as:

$$\overline{A}(\gamma) = I - p_H(R - B/\Delta p)/\gamma,$$

we get that only entrepreneurs with capital at or above $\overline{A}(\gamma)$ can raise external capital and invest in their projects. This is the classic credit rationing result going back to Stiglitz and Weiss (1981). The entrepreneur cannot get unlimited amounts of capital, since he needs to maintain high enough stake in the project so that outside investors are willing to participate.

Holmstrom and Tirole go on to introduce financial intermediaries, who have the ability to monitor entrepreneurs.[15] The monitoring technology available to financial intermediaries is assumed to prevent the entrepreneur from taking a bad project with high non-pecuniary private benefit *B*, thereby reducing the opportunity cost that the entrepreneur incurs when taking the good project from *B* to *b*. Monitoring yields a private cost of *c* to the financial intermediary. Financial intermediaries themselves need to have an incentive to pay the monitoring cost and make sure entrepreneurs are prevented from enjoying high private benefits *B*. Hence, they need to put in their own capital, and the amount of intermediary capital K_m available in the economy is going to be a key parameter in determining how much lending will occur.

An intermediary can help relax the financing constraint of the entrepreneur by monitoring him and reducing his incentive to take the bad project. Hence, even entrepreneurs with a level of capital lower than the threshold $\overline{A}(\gamma)$ will be able to get financing assisted by the intermediaries. Denoting the return required by the intermediaries as β, where β is determined in equilibrium and is decreasing in the amount of capital K_m that is available in the financial-intermediary sector, the threshold $\underline{A}(\gamma, \beta)$ of entrepreneur's capital *A* above which the entrepreneur can raise capital via financial intermediaries and invest is:

$$\underline{A}(\gamma, \beta) = I - I_m(\beta) - p_H(R - (b + c)/\Delta p)/\gamma.$$

[15] Strictly speaking, the financial intermediaries here are not necessarily intermediating between the outside investors and the entrepreneurs, but rather could be providing a different type of financing that can relax financial constraints via monitoring.

Here, $I_m(\beta)$ is the amount of capital provided by the financial intermediary, which is decreasing in the return β demanded by financial intermediaries. Hence, the entrepreneur only needs to raise $I - I_m(\beta)$ directly from outside investors. At the same time, the entrepreneur can only promise them an expected payment of $p_H(R - (b + c)/\Delta p)$, so that the entrepreneur and the financial intermediary maintain incentives to pick the good project and monitor, respectively. This implies that only entrepreneurs with more internal capital than $\underline{A}(\gamma, \beta)$ defined above will be able to raise capital via the financial intermediary sector.

Figure 3 depicts the equilibrium outcomes with regard to which entrepreneurs will be financed and invest, depending on how much capital they have. We can see that entrepreneurs with little capital – i.e., below $\underline{A}(\gamma, \beta)$ – cannot get financed and do not invest in their projects. Entrepreneurs with an intermediate level of capital – i.e., between $\underline{A}(\gamma, \beta)$ and $\overline{A}(\gamma)$ – can get financed only through financial intermediaries who assist them with their monitoring technology. Entrepreneurs with a high level of capital – i.e., above $\overline{A}(\gamma)$ – can get financed directly by the outside investors without the monitoring of the financial intermediaries. Of course, a key condition for this figure to hold is that $\underline{A}(\gamma, \beta)$ is smaller than $\overline{A}(\gamma)$. This will happen when *c* and β are not too large. In such a case, the financial intermediary sector is efficient and hence can provide financing to entrepreneurs, who are otherwise rationed in the credit market. If this condition does not hold, then the financial intermediary sector does not exist, and entrepreneurs simply get financing if and only if their level of internal capital is above $\overline{A}(\gamma)$.

[Insert Figure 3 Here]

Overall, the model demonstrates the frictions in the financial system. Entrepreneurs with profitable investment opportunities might not be able to finance them if they do not have enough capital already. This is because of a moral hazard problem, according to which they might not make the right choices with their projects unless their own wealth is at stake. As a result, investors and financial intermediaries will not finance the projects unless the entrepreneurs have their own capital at stake. While such frictions always exist, they might be exacerbated leading to severe credit rationing, which can be referred to as a “crisis”.

For example, in this model, a negative aggregate shock in the economy, shifting the distribution of capital $G(A)$ to the left, i.e., such that entrepreneurs have less capital on average, will be amplified, as entrepreneurs having less wealth will face stricter financial constraints and will be less likely to raise external financing. Hence, there is an accelerator effect, whereby shocks to the economy are amplified: An initial loss of capital causes further losses due to the tightening of financial constraints, making entrepreneurs unable to make profitable investments.

Another form of accelerator effect in this model operates via the financial intermediary sector, as a decrease in the capital K_m of the financial intermediary sector will also have an adverse effect on the real economy. This is because it leads to an increase in the equilibrium return β demanded by financial intermediaries, and to an increase in the threshold $\underline{A}(\gamma, \beta)$, above which middle-size entrepreneurs can get financed and invest. Hence, a decrease in financial intermediary capital will lead to contraction in real investment, specifically of middle-sized firms.

Holmstrom and Tirole (1998) study a related setup and develop the implications for government policy. Recall that entrepreneurs need to keep sufficient ownership in the firms that they run (R_f needs to be sufficiently high), so that they take the good project rather than the bad project. This limits their ability to offer sufficient return to outside investors (R_u is limited), and so in case of an adverse liquidity shock, they are limited in how much capital they can raise to keep running their projects and prevent welfare-reducing bankruptcy. This creates an incentive for holding liquid securities ex ante, so that they can use them when they are hit by adverse shocks and are financially constrained. Holmstrom and Tirole (1998) show that, in case of aggregate uncertainty, the government can improve overall welfare by issuing government debt and supplementing the supply of liquid securities in the economy.

The model of Holmstrom and Tirole (1997) and the related literature focus on the quality of loans provided by banks and other lenders, as they are determined endogenously in equilibrium. These papers ignore the financing pressure faced by banks, as they may be subject to panics and runs by their creditors, as in the previous section. Clearly, in the real world, these two types of frictions co-exist and amplify each other. When the quality of loans extended by banks deteriorates due to moral hazard considerations, bank depositors might panic and run, which will amplify the problem. Diamond and Rajan (2001) and others study models where the two sides of banks' balance sheets are considered endogenously, albeit they do not pin down when panic will arise. Interestingly, having a fragile liability structure may be a good thing, as it induces the bank managers to monitor loans more forcefully.

Finally, while the models described here focus on credit rationing and credit freeze due to incentive problems, a key question is why at certain times there are credit booms and excessive lending. Clearly, this was a key factor leading to the 2007 turmoil, as banks extended excessive credit for home purchases, fuelling a bubble in the real estate sector, which was the seed for the crisis. Allen and Gale (2000a) present a model where the possibility of risk shifting leads borrowers to borrow excessively, inflating the prices of the projects they invest in. When a bad shock occurs, the bubble bursts, and credit dries up. Lorenzoni (2008) studies a model of inefficient credit booms, where borrowers and lenders do not internalize the negative externalities that credit imposes on others. These externalities emerge due to fire sales that happen upon a bad shock that forces many borrowers to liquidate their assets at once. The presence of these externalities calls for government intervention to tame credit booms. Models by Bebchuk and Goldstein (2011) and Benmelech and Bergman (2012) study externalities in a credit freeze, and discuss optimal government policies to get the economy out of the freeze.

3.2 Implications for Macroeconomic Models

Financial accelerators in the spirit of Holmstrom and Tirole (1997) have been discussed in macroeconomic setups, showing how shocks to asset values can be amplified and become persistent in equilibrium.[16] Bernanke and Gertler (1989) provide one of the first financial-accelerator models in macroeconomics, emphasizing that financial frictions amplify adverse shocks and that they are persistent. That is, a temporary shock depresses not only current but also future economic activity. The mechanism goes through the agency problem between borrowers and lenders as

[16] For a survey of this literature, see: Brunnermeier, Eisenbach, and Sannikov (2012).

described above. A negative shock to the net worth of a borrower strengthens the agency problem between the borrower and potential lenders, which reduces lending and investment in equilibrium, hence amplifying the initial shock.

Kiyotaki and Moore (1997) identify an important dynamic feedback mechanism that strengthens the above forces. The reduction in investment in the future following a negative shock today lowers future economic activity and will reduce future asset prices. But since this decline is anticipated, it is immediately reflected in a fall in current asset prices. As a result, current net worth of potential borrowers is reduced today, lowering the collateral value they can provide, and hence limiting their debt capacity even further. Then, investment today is reduced more, and so demand for assets falls today even more, and price declines further, eroding productive agents' net worth in turn and so on. This feedback loop can amplify shocks significantly.

A large body of recent work builds on the models of Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) to analyze the effect of financial frictions due to credit constraints in macroeconomic settings. One important point in the data is the asymmetry between recessions and booms. Kocherlakota (2000) builds a model where credit cycles of the kind described by Kiyotaki and Moore (1997) are asymmetric: sharp downturns are followed by slow recoveries. Eisfeldt and Rampini (2006) develop a model where credit constraints are more binding in recessions, and so they match the empirical regularity that capital reallocation is lower in downturns than in booms. An important direction of research in macroeconomics is to take such models to the data and evaluate whether they can quantitatively match the evolution of key variables across business cycles. This is also important for policy analysis, as one can check the quantitative implications of various policy measures. Iacoviello (2005) adds nominal mortgage debt using real estate as collateral to evaluate the quantitative relevance of the Kiyotaki-Moore mechanism. Other authors have adopted similar framework to an international setting, for example Caballero and Krishnamurhty (2001) and Mendoza (2010), who study the dry-up of international capital inflows. We discuss this line of research more in the next section.

While in Kiyotaki and Moore (1997) credit is limited by the expected price of the collateral in the next period, other models emphasize the role of volatility. In Brunnermeier and Pedersen (2009), for example, borrowing capacity is limited due to the volatility of future prices. In Brunnermeier and Sannikov (2010), even productive entrepreneurs are concerned about hitting their solvency constraint in the future and consequently do not fully exploit their debt capacity. As volatility rises they cut back on borrowing by selling assets. This depresses prices further, leading to rich volatility dynamics.

A key feature missing from the macroeconomic models with frictions described above is the role of financial intermediaries. Clearly, the recent crisis has shown that financial intermediary capital has a crucial role in the economy, and losses incurred by financial intermediaries can have strong spillover effects to the rest of the economy. Recently, Gertler and Kiyotaki (2011) and Rampini and Viswanathan (2011) add a financial intermediary sector, as in Holmstrom and Tirole (1997), and analyze the dynamic interactions between this sector and the rest of the economy. Introducing this sector into macroeconomic models enables elaborate discussions on various policies conducted by governments during the recent crisis in attempt to stimulate the economy via the financial intermediation sector. Such policies are discussed by Gertler and Kiyotaki (2011).

A different angle on the role of credit frictions in the macro economy is provided by Eggertsson and Krugman (2012). They study a model with heterogeneous agents, where patient agents lend and impatient agents borrow subject to a collateral constraint. If, for some reason, the collateral requirement becomes tighter, impatient agents will have to go into a process of deleveraging, reducing the aggregate demand. This excess saving leads to a reduction in the natural interest rate that might become negative, and the nominal (policy) interest rate hits the zero bound, putting the economy into a liquidity trap. Then, traditional monetary policy becomes impossible, but fiscal policy regains some potency.

3.3 Asymmetric Information

While the previous subsections emphasized moral hazard as a source of failure in financial systems, another key factor behind the breakdown of financial markets, including credit markets, is adverse selection. As we mentioned before, Stiglitz and Weiss (1981) point to adverse selection as a potential reason for credit frictions: When lenders do not know the quality of their borrowers, increasing the interest rate will only attract bad borrowers to them, and so the interest rate cannot increase freely to clear the market, and we might get an equilibrium with credit rationing.

The analysis of market breakdown due to asymmetric information and adverse selection goes back to Akerlof (1970). He analyzes a market where sellers have private information about the quality of the assets that they are trying to sell. As a result, buyers are reluctant to buy the assets from them because they realize that the sale represents negative information about the asset. In extreme situations, when the only motivation to trade is based on information, this leads to a complete market breakdown: no transactions will happen in equilibrium. If there are other gains to trade between sellers and buyers, trade may still occur. But, the increase in the magnitude of asymmetric information, due to an increase in the share of informed agents or in the degree of underlying uncertainty, might reduce trade.

This analysis can be easily applied to credit markets or interbank markets. Indeed, many commentators have attributed the freeze in these markets during the recent crisis to a sharp increase in the degree of asymmetric information about the credit quality of borrowers and the value of assets in the financial system. This is because the toxic assets held by banks were hard to evaluate and the exposure of different institutions to them was unknown. So, a financial crisis here represents an outcome where the market ceases to perform its fundamental role of enabling the realization of gains from exchange due to the increase in asymmetric information that makes agents reluctant to perform such an exchange. Several government programs were designed to alleviate the problem by removing toxic assets from the financial system and restore flows of trade and credit as a result. Recent papers by Tirole (2012) and Philippon and Skreta (2012) perform theoretical analysis of such policy intervention in light of the problem of asymmetric information.

An interesting feature of models of asymmetric information and adverse selection is that they generate externalities that might lead to amplification and extreme equilibrium outcomes. In models by Pagano (1989) and Dow (2004), uninformed traders have stronger incentive to participate in the market if they know that there are more uninformed traders there, since then they are exposed to a lesser adverse selection problem. As a result, there is a coordination problem that can lead to sharp changes in market depth, resembling what we see in a financial crisis. Recently, Morris and Shin (2012) show that the amplification becomes even more severe when traders have different information about the extent of the adverse selection problem, i.e., about how many informed traders are present. This leads to a contagious process, by which very small changes can lead to a market freeze.

4. *Currency Crises*

Historically, financial crises have often been marked with large disturbances in currency markets, which have spilled over to the financial sectors and the real economies of affected countries in various ways. In the events of the recent years, the deepening of the crisis in Europe is strongly associated with the attempt to maintain the common currency area, which also has implications for the financial sectors and real economies of countries in the Euro zone. In this section, we review the development of the theoretical literature on currency crises, and its connection to the literatures on banking panics and crises and credit frictions, which were reviewed in the previous sections.

Currency crises originate from the attempt of governments to maintain certain financial and monetary arrangements, most notably a fixed-exchange rate regime. Their goal is to stabilize the economy. At times, these arrangements become unstable, which leads to a speculative attack on a fixed exchange rate regime and from there to a financial crisis.

The best way to understand the origins of currency crises is to think about the basic trilemma in international finance. A trilemma, as Mankiw (2010) recently wrote in the context of the 2010 Euro crisis, is a situation in which someone faces a choice among three options, each of which comes with some inevitable problems. In international finance, it stems from the fact that, in most nations, economic policy makers would like to achieve the following goals. First, make the country's economy open to international capital flows, because by doing so they let investors diversify their portfolios overseas and achieve risk sharing. They also benefit from the expertise brought to the country by foreign investors. Second, use monetary policy as a tool to help stabilize inflation, output, and the financial sector in the economy. This is achieved as the central bank can increase the money supply and reduce interest rates when the economy is depressed, and reduce money growth and raise interest rates when it is overheated. Moreover, it can serve as a lender of last resort in case of financial panic. Third, maintain stability in the exchange rate. This is because a volatile exchange rate, at times driven by speculation, can be a source of broader financial volatility, and makes it harder for households and businesses to trade in the world economy and for investors to plan for the future.

The problem, however, is that a country can only achieve two of these three policy goals. In order to maintain a fixed exchange rate and capital mobility, the central bank loses its ability to control its policy instruments: the interest rate, or equivalently the monetary base. Because, under free capital mobility, the interest rate becomes anchored to the world interest rate, by the interest rate parity, and the monetary base is automatically adjusted to the pre-determined money demand. This is the case of individual members of the European Monetary Union. In order to keep control over the interest rate or equivalently the money supply, the central bank has to let the exchange rate float freely, as in the case of the US. If the central bank wishes to maintain both exchange rate stability and control over the monetary policy, the only way to do it is by imposing capital controls, as in the case of China.

Currency crises occur when the country is trying to maintain a fixed exchange rate regime with capital mobility, but faces conflicting policy needs, such as fiscal imbalances or fragile financial sector, that need to be resolved by independent monetary policy. This leads to a shift in the regime from the first solution of the trilemma described above to the second one. The sudden depreciation in the exchange rate is often referred to as a currency crisis. It often has implications for the financial system as a whole and for the real economy, where agents were used to rely on a fixed exchange rate regime, and often have to adjust to the change abruptly and unexpectedly. We elaborate more on this in Subsection 4.3.

The theoretical currency-crises literature is broadly classified into three generations of models, which we now turn to describe in more detail.

4.1 First-Generation Model of Currency Crises

This branch of models, the so-called 'first generation models of currency attacks' was motivated by a series of events where fixed exchange rate regimes collapsed following speculative attacks, for example, the early 1970s breakdown of the Bretton Woods global system.

The first paper here is the one by Krugman (1979).[17] He describes a government that tries to maintain a fixed exchange rate regime, but is subject to a constant loss of reserves, due to the need to monetize persistent government budget deficits. These two features of the policy are inconsistent with each other, and lead to an eventual attack on the reserves of the central bank, that culminate in a collapse of the fixed exchange rate regime. Flood and Garber (1984) extended and clarified the basic mechanism, suggested by Krugman (1979), generating the formulation that was widely used since then.

Let us provide a simple description of this model. The model is based on the central bank's balance sheet. The asset-side of the central bank's balance sheet at time *t* is composed of domestic assets $B_{H,t}$, and the domestic-currency value of foreign assets $S_t B_{F,t}$, where S_t denotes the exchange rate, i.e., the value of foreign currency in terms of domestic currency. The total assets have to equal the total liabilities of the central bank, which are, by definition, the monetary base, denoted as M_t.

In the model, due to fiscal imbalances, the domestic assets grow in a fixed and exogenous rate:

$$\frac{B_{H,t} - B_{H,t-1}}{B_{H,t-1}} = \mu.$$

Because of perfect capital mobility, the domestic interest rate is determined through the interest rate parity, as follows:

$$1 + i_t = (1 + i_t^*) \frac{S_{t+1}}{S_t},$$

where i_t denotes the domestic interest rate at time *t* and i_t^* denotes the foreign interest rate at time *t*. Finally, the supply of money, i.e., the monetary base, has to be equal to the

[17] The model by Krugman (1979) builds on an earlier paper by Salant and Henderson (1977) about a speculative attack on gold reserves.

demand for money, which is denoted as $L(i_t)$, a decreasing function of the domestic interest rate.

The inconsistency between a fixed exchange rate regime, $S_t = S_{t+1} = \bar{S}$, with capital mobility and the fiscal imbalances comes due to the fact that the domestic assets of the central bank keep growing, but the total assets cannot change since the monetary base is pinned down by the demand for money, $L(i_t^*)$, which is determined by the foreign interest rate. Hence, the obligation of the central bank to keep financing the fiscal needs puts downward pressure on the domestic interest rate, which, in turn, puts upward pressure on the exchange rate. In order to prevent depreciation, the central bank has to intervene by reducing the inventory of foreign reserves. Overall, $\bar{S}B_{F,t}$ decreases by the same amount as $B_{H,t}$ increases, so the monetary base remains the same.

The problem is that this process cannot continue forever, since the reserves of foreign currency have a lower bound. Eventually, the central bank will have to abandon the current solution of the trilemma – fixed exchange rate regime and perfect capital mobility – to another solution – flexible exchange rate with flexible monetary policy (i.e., flexible monetary base or equivalently flexible domestic interest rate) and perfect capital mobility.

The question is what the critical level of domestic assets $B_{H,T} = B^*_{H,T}$ is and what the corresponding period of time T is, at which the fixed-exchange rate regime collapses. As pointed out by Flood and Garber (1984), this happens when the shadow exchange rate – defined as the flexible exchange rate under the assumption that the central bank's foreign reserves reached their lower bound while the central bank keeps increasing the domestic assets to accommodate the fiscal needs – is equal to the pegged exchange rate.

At this point, there will be a speculative attack on the currency, depleting the central bank's foreign reserves and forcing an immediate devaluation of the domestic currency.

This is depicted in Figure 4. The upper panel depicts the shadow exchange rate schedule and the pegged rate schedule as functions of domestic assets. Their intersection determines the level of domestic asset where the regimes switch occurs. The switch will not occur at a lower level of domestic assets because at that point there is no incentive to launch the speculative attack (it will yield a trading loss to the speculators). The switch will not occur at a higher level either because there is gain to be made at the intersection point, leading all speculators to attack at that point. The lower panel describes the path of foreign assets, which are quickly depleted at the point of the attack.

[Insert Figure 4 Here]

4.2 Second-Generation Models of Currency Crises

Following the collapse of the European Exchange Rate Mechanism (ERM) in the early 1990s, the so-called first-generation model of currency attacks did not seem suitable anymore to explain the ongoing crisis phenomenon. The events in Europe at that time featured governments actively making decisions between fighting the declining economic activity level and remaining in the exchange rate management system. Hence, there was a need for a model where the government's choice is endogenized, rather than the first-generation models where the exchange rate regime is essentially on 'automatic pilot'. This led to the development of the so-called 'second generation model of currency attacks,' pioneered by Obstfeld (1994, 1996).

Hence, in this line of models, the government/central bank is setting the policy endogenously, trying to maximize a well-specified objective function, without being able to fully commit to a given policy. An outcome of these models is that there are usually self-fulfilling multiple equilibria, where the expectation of a collapse of the fixed exchange rate regime leads the government to abandon the regime. This feature seemed attractive to many commentators as they thought it captured well the fact that crises where unexpected in many cases. This is related to the Diamond and Dybvig (1983) model of bank runs described in Section 2, creating a link between these two literatures.

Obstfeld (1996) discusses various mechanisms that can create the multiplicity of equilibria in a currency-crisis model. Let us describe one mechanism, which is inspired by Barro and Gordon (1983). Suppose that the government minimizes a loss function of the following type:

$$(y - y^*)^2 + \beta\varepsilon^2 + cI_{\varepsilon \neq 0}.$$

Here, y is the level of output, y^* is the target level of output, and ε is the rate of depreciation, which in the model is equal to the inflation rate. Hence, the government wants to minimize some combination of the rate of inflation and the distance from the target level of output. In addition, the third term is an index function, which says that there is a fixed cost in case the government deviates from the existing exchange rate. The interpretation is that the government is in a regime of zero depreciation (a fixed exchange rate regime), and deviating from it is costly.

Overall, when deciding on the rate of depreciation, the government has to weigh the costs against the benefit of depreciation. The costs are coming from the second and third terms above: There is a cost in operating the economy under inflation and there is a cost in deviating from the promise of a fixed exchange rate regime. The benefit in depreciation is that it enables reduction in the deviations from the target level of output. More precisely, creating inflation (which is equivalent to depreciation here) above the expected level serves to boost output.

This effect of inflation on output is coming from the Philips Curve. It is demonstrated in the following expression, specifying how output is determined:

$$y = \bar{y} + \alpha(\varepsilon - \varepsilon^e) - u.$$

Here, $\bar{y}$ is the natural output ($\bar{y} < y^*$, i.e., the government sets an ambitious output target level to overcome distortions in the economy), u is a random shock, and ε^e is the expected level of depreciation/inflation that is set endogenously in the model by wage setters based on rational expectations. The idea is that an unexpected inflationary shock ($\varepsilon > \varepsilon^e$) boosts output by reducing real wages and increasing production.

Importantly, the government cannot commit to a fixed exchange rate. Otherwise, it would achieve minimum loss by committing to $\varepsilon = 0$. However, due to lack of commitment, a sizable shock u will lead the government to depreciate and achieve the increase in output bearing the loss of credibility. Going back to the trilemma discussed above, a fixed exchange rate regime prevents the government from using monetary policy to boost output, and a large enough shock will cause the government to deviate from the fixed exchange rate regime.

It can be shown that the above model generates multiplicity of equilibria. If wage setters coordinate on a high level of expected depreciation/inflation, then the government will validate this expectation with its policy by depreciating more often. If they coordinate on a low level of expected depreciation, then the government will have a weaker incentive to deviate from the fixed exchange rate regime. Hence, the expectation of depreciation becomes self-fulfilling.

Similarly, closer to the spirit of the Krugman (1979) model, one can describe mechanisms where speculators can force the government to abandon an existing fixed-exchange rate regime by attacking its reserves and making the maintenance of the regime too costly. If many speculators attack, the government will lose significant amount of reserves and will be more likely to abandon the regime. A self-fulfilling speculative attack is profitable only if many speculators join it. Consequently, there is one equilibrium with a speculative attack and a collapse of the regime, and there is another equilibrium where these things do not happen.[18]

This issue is also strongly related to sovereign debt crises and in particular those currently experienced in Europe. Speculators can attack government bonds demanding higher rates due to expected sovereign-debt default, creating an incentive for the central bank to abandon a currency regime and reduce the value of the debt or alternatively to default. This justifies the initial high rates. In the sovereign-debt literature, authors have studied self-fulfilling debt crises of this kind. For example, Cole and Kehoe (2000) analyze the debt maturity structure under financial crises brought on by a loss of confidence in a government, which can arise within a dynamic, stochastic general equilibrium model.

As we discussed in Section 2, having a model of multiple equilibria creates an obstacle for policy analysis. Morris and Shin (1998) were the first to tackle the problem of multiplicity in the second-generation models of speculative attacks. They first express

[18] Note that self-fulfilling speculative attacks can arise naturally from a first-generation model as demonstrated by Obstfeld (1986). Hence, this is not the distinguishing feature of the second-generation models. Rather, the optimizing government is the distinguishing feature of the second-generation models.

this model in an explicit game theoretic market framework, where speculators are players having to make a decision whether to attack the currency or not. Then, using the global-games methodology, pioneered by Carlsson and van Damme (1993), they are able to derive a unique equilibrium, where the fundamentals of the economy uniquely determine whether a crisis occurs or not. This is important since it enables one to ask questions as to the effect of policy tools on the probability of a currency attack. The global-games methodology, relying on heterogeneous information across speculators, also brought to the forefront the issue of information in currency-attack episodes, leading to analysis of the effect that transparency, signaling, and learning can have on such episodes (e.g., Angeletos, Hellwig, and Pavan (2006) and Goldstein, Ozdenoren, and Yuan (2011)).[19]

4.3 Third-Generation Models of Currency Crises

In the late 1990s, a wave of crises hit the emerging economies in Asia, including Thailand, South Korea, Indonesia, Philippines, and Malaysia. A clear feature of these crises was the combination of the collapse of fixed exchange rate regimes, capital flows, financial institutions, and credit.[20] As a result, many researchers felt that the first two generations of models of currency crises, which were described in the previous two subsections, were not sufficient for analyzing the events in Asia. There was a strong need to incorporate banking panics and credit frictions into these models. This led to extensive research on the interplay between currency crises and banking crises, sometimes referred

[19] For a broad review of the global–games methodology and its various applications, see Morris and Shin (2003). There is also a large literature that followed the original developments, analyzing conditions under which the unique-equilibrium result fails to hold. See, e.g., Angeletos and Werning (2006) and Hellwig, Mukherji, and Tsyvinski (2006).
[20] For a broad description of the events around the Asian Crisis and the importance of capital flows in conjunction with the collapse of the exchange rate see Radelet and Sachs (1998) and Calvo (1998).

to as the *twin crises*, and between currency crises and credit frictions.[21] Such models are often referred to as the ‘third-generation models of currency crises’. In the context of this survey, it is important to note that such models bring together elements from the early currency crises literature described in Subsections 4.1 and 4.2 with elements from the vast literatures on banking panics and credit frictions described in Sections 2 and 3, respectively.

One of the first models to capture this joint problem was presented in Krugman (1999). In his model, firms suffer from a currency mismatch between their assets and liabilities: their assets are denominated in domestic goods and their liabilities are denominated in foreign goods. Then, a real exchange rate depreciation increases the value of liabilities relative to assets, leading to deterioration in firms’ balance sheets. Because of credit frictions as in Holmstrom and Tirole (1997), described in Section 3, this deterioration in firms’ balance sheets implies that they can borrow less and invest less. The novelty of the Krugman’s paper is that the decrease in investment validates the depreciation in a general equilibrium setup. This is because the decreased investment by foreigners in the domestic market implies that there will be a decrease in the aggregate demand for the local goods, relative to foreign goods (the Keynes-Ohlin “transfer problem” in international trade), leading to real depreciation. Hence, the system has multiple equilibria with high economic activity, appreciated exchange rate, and strong balance sheets in one equilibrium, and low economic activity, depreciated exchange rate, and weak balance sheets in the other equilibrium. Other models that extended and continued this line of research include: Aghion, Bacchetta, and Banerjee (2001),

[21] For empirical evidence on the twin crises, see Kaminsky and Reinhart (1999).

Caballero and Krishnamurthy (2001), and Schneider and Tornell (2004). The latter fully endogenize the currency mismatch between firms' assets and liabilities.

A different line of research links currency problems with the bank runs described in Section 2. Chang and Velasco (2001) and Goldstein (2005) model the vicious circle between bank runs and speculative attacks on the currency. On the one hand, the expected collapse of the currency worsens banks' prospects, as they have foreign liabilities and domestic assets, and thus generates bank runs. On the other hand, the collapse of the banks leads to capital outflows that deplete the reserves of the government, encouraging speculative attacks against the currency.

Accounting for the circular relationship between currency crises and banking crises is important for policy analysis, as it makes some well-received conclusions much less appealing. For example, traditional banking models may advocate a lender-of-last-resort policy or other expansionary policies during a banking crisis to mitigate the bank-run problem. However, accounting for the circularity between bank runs and currency attacks, it is shown that such policies might backfire as they deplete the reserves available to the government, making a currency crisis more likely, which in turn might further hurt the banking sector that is subject to a currency mismatch problem.

As we mentioned in Section 4.2, there is a strong link between currency-crises models and sovereign-debt models, exemplified by the Cole and Kehoe (2000) framework. Hence, the models reviewed in this subsection, tying banking and credit problems with currency crises, can be very helpful in analyzing the connection between banking crises and sovereign-debt crises. This seems to be a very relevant and timely avenue for research given the current situation in Europe, where the faith of governments is intertwined with that of banks due to the various connections between banks' balance sheets and governments' balance sheets.

4.4 Contagion of Currency Crises

In Section 2.6, we reviewed theories of contagion focused on the contagion of crises across different banks. The forceful transmission of crises across countries generated a large literature of international financial contagion, which is very strongly related to the literature reviewed in Section 2.6. Kaminsky, Reinhart, and Vegh (2003) provide a review of the theories behind such contagion.[22] They define contagion as an immediate reaction in one country to a crisis in another country.

As we wrote in Section 2.6, there are several theories that link such contagion to fundamental explanations. The clearest one would be that there is common information about the different countries, and so the collapse in one country leads investors to withdraw out of other countries, see e.g. Calvo and Mendoza (2000). Models of the connections of portfolios across different countries, e.g., Allen and Gale (2000b), Kodres and Pritsker (2002), Dasgupta (2004), and Goldstein and Pauzner (2004) also shed light on such international contagion. An explanation that is more directly related to currency depreciation is proposed by Gerlach and Smets (1995). If two countries compete in export markets, the devaluation of one's currency hurts the competitiveness of the other, leading it to devalue the currency as well.

Empirical evidence has followed the above theories of contagion. The common information explanation has vast support in the data. Several of the clearest examples of contagion involve countries that appear very similar. Examples include the contagion that

[22] For a broader review, see the collection of articles in Claessens and Forbes (2001).

spread across East Asia in the late 1990s and the one in Latin America in the early 1980s. A vast empirical literature provides evidence that trade links can account for contagion to some extent. These include Eichengreen, Rose, and Wyplosz (1996) and Glick and Rose (1999). Others have shown that financial linkages are also empirically important in explaining contagion. For example, Kaminsky, Lyons, and Schmukler (2004) have shown that US-based mutual funds contribute to contagion by selling shares in one country when prices of shares decrease in another country. Caramazza, Ricci, and Salgado (2004), Kaminsky and Reinhart (2000) and Van Rijckeghem and Weder (2001) show similar results for common commercial banks.

5. *Concluding Remarks*

The global financial crisis that started in 2007 and has not been resolved yet took much of the economic profession by surprise. Explaining the forces behind the crisis and coming up with suggestions for policymakers on how to solve it and fix the system going forward have become top priorities for many economists, some of whom are new to the topic of financial crises.

As we argue in this paper, many of the forces in play in the current and recent turmoil have been featured in the literature on financial crises for more than three decades now. Hence, it is important to go back to the main streams of this literature and summarize them to better understand the main forces behind crises, how they interact, how they apply to current and recent events, and what they imply for future policy. In this paper, we attempted to achieve these goals.

The paper covers three main streams of models of financial crises: 1. Banking crises and panics; 2. Credit frictions and market freezes; 3. Currency crises. The studies of these topics, as they are reviewed here, evolved almost in parallel for many years, until more recently, they have been integrated to account for the connections between the different types of crises in real-world events. For each one of these topics, we introduced a simple analytical framework that provides a formal description of the forces at work. We then reviewed the developments in the literature, describing the interactions between the forces, the implications for policy, and the connection to empirical evidence from the recent turmoil and before it.

While the survey presented in this paper is extensive, it should not be viewed as a comprehensive survey of research on financial crises. The theoretical literature on financial crises is simply too large for such a comprehensive survey. Hence, we focused on identifying three main streams and describing the insights they generate. We provide many references along the way that the interested reader can use to deepen his/her understanding of financial crises. In addition, we did not cover all types of theories on crises; while we mention sovereign debt crises and asset-market bubbles and crashes, there is certainly room to elaborate more on them.

As we mention above, a main benefit of this survey is that it puts together some of the basic insights on financial crises from a literature of more than three-decades old, so that people interested in studying the topic in light of recent events will have easier access to it and will know how current events are already reflected in existing literature. However, while we believe that existing literature does cover a lot of ground, there are still many open questions that leave room for a lot of future research. Along the way in this survey, we pointed out some of these open questions. In particular, regarding policy issues, we pointed out several times how the tools reviewed here can be expanded and used to analyze optimal policies to avoid and solve crises. While there is research in this direction in the literature, it is still mostly in its early stages.

A major challenge in policy analysis going forward is to incorporate the frictions highlighted in this survey – coordination failures, incentive problems, and asymmetric information – into a macroeconomic model that can be calibrated and provide quantitative output as to the optimal mix and magnitudes of policies. Some work is being done in this direction in the context of credit frictions, which we review here, but not so much in different contexts. Developing such models is an important challenge for future research.

In addition, as the reader can observe, while there are many models discussing different forces, integrative models that combine the various forces together are lacking (although some exceptions have been reviewed here). This remains a major challenge to researchers going forward, since only with an integrative model, one can understand the relative contribution of different forces and the interaction between them, and this is crucial for empirical work and for the design of policy to move forward.

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TABLE 1

Ex-post payments to agents in a model of bank runs: The table is based on Goldstein and Pauzner (2005) and describes the payments agents expect to get when demanding their money at Period 1 vs. Period 2. Here, n is the proportion of agents who demand their money at Period 1; r_1 is the promised return to agents at Period 1; R is the return that the bank's asset yields at Period 2 in case it is successful, and $p(\theta)$ is the probability it will be successful.

Period	$n < 1/r_1$	$n \geq 1/r_1$
1	r_1	$\begin{cases} r_1 & prob \quad \frac{1}{nr_1} \\ 0 & prob\ 1 - \frac{1}{nr_1} \end{cases}$
2	$\begin{cases} \frac{(1-nr_1)}{1-n}R & prob \quad p(\theta) \\ 0 & prob\ 1 - p(\theta) \end{cases}$	0

TABLE 2

Project outcomes in a model of moral hazard in the credit market: The table is based on Holmstrom and Tirole (1997). An entrepreneur can choose among three projects. The good project yields no private benefits and succeeds (i.e., yields *R*) with probability p_H (otherwise, it fails and yields 0). There are two bad projects that succeed with probability p_L. They differ in the amount of private benefits they generate to the entrepreneur which can be either *b* or *B*.

Project	Good	Bad (low private benefit)	Bad (high private benefit)
Private benefit	0	b	B
Probability of success	p_H	p_L	p_L

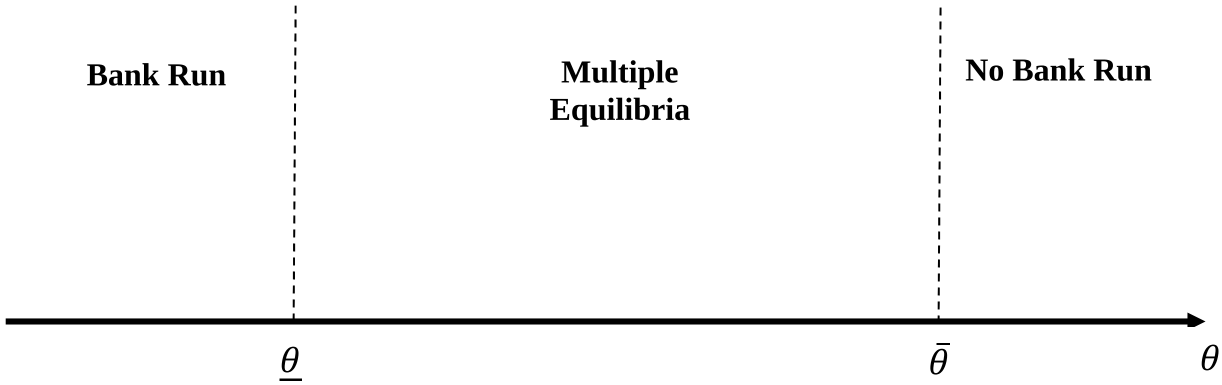

FIGURE 1: BANK RUNS WITH COMMON KNOWLEDGE: TRIPARTITE CLASSIFICATION OF THE FUNDAMENTALS (FROM GOLDSTEIN (2012), BASED ON MORRIS AND SHIN (1998) AND GOLDSTEIN AND PAUZNER (2005)).

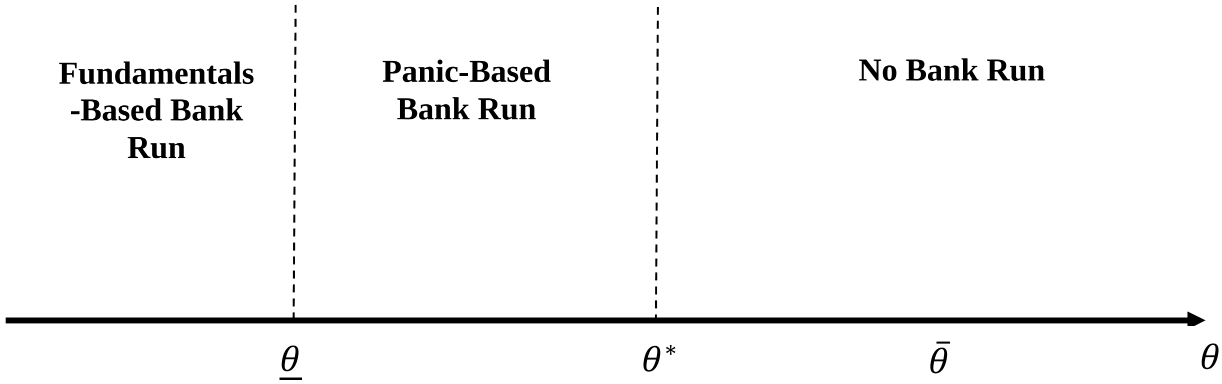

FIGURE 2: EQUILIBRIUM OUTCOMES IN A BANK-RUN MODEL WITH NON-COMMON KNOWLEDGE (FROM GOLDSTEIN (2012), BASED ON MORRIS AND SHIN (1998) AND GOLDSTEIN AND PAUZNER (2005)).

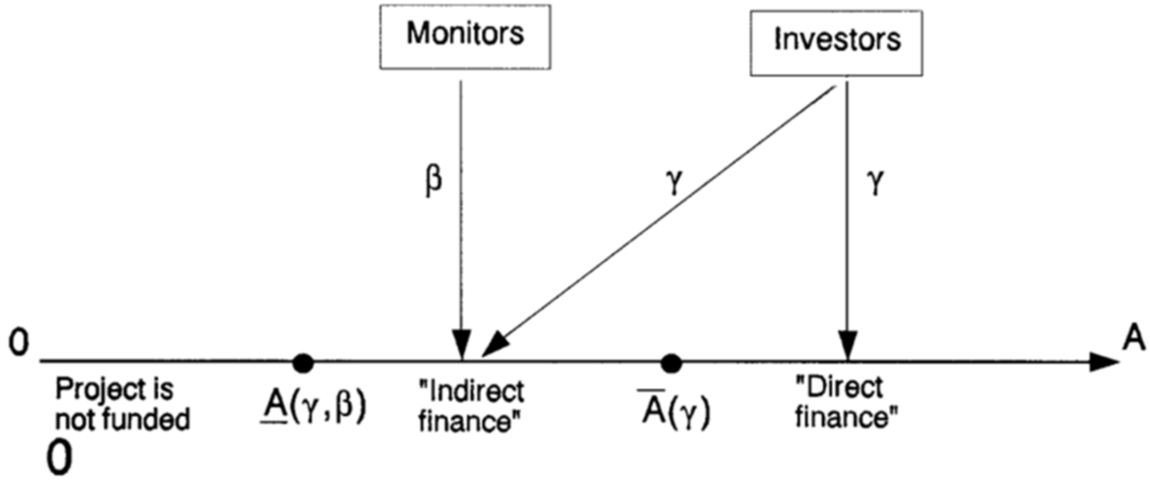

FIGURE 3: DIRECT AND INDIRECT FINANCING OF INVESTMENT (FROM HOLMSTROM AND TIROLE (1997)).

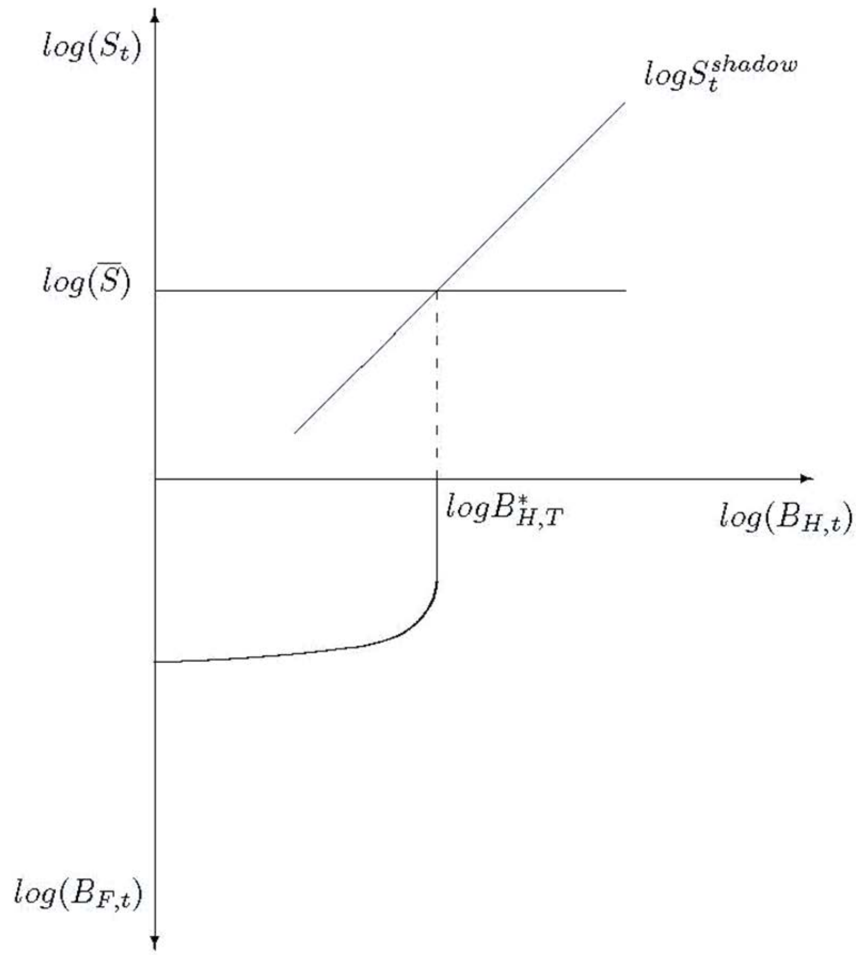

FIGURE 4: CURRENCY-REGIME SWITCH (BASED ON KRUGMAN (1979) AND FLOOD AND GARBER (1984)).