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Private Sector Involvement and International Financial Crises

An Analytical Perspective

MICHAEL CHUI and PRASANNA GAI

Foreword by Franklin Allen

PRIVATE SECTOR INVOLVEMENT AND INTERNATIONAL FINANCIAL CRISES

To Our Parents

Private Sector Involvement and International Financial Crises: An Analytical Perspective

MICHAEL CHUI AND PRASANNA GAI

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Foreword

How should the international financial architecture be designed? This book provides a theoretical framework to answer this important question. It starts with an accessible account of the literature on financial crises. There are two types of explanation for the occurrence of financial crises. These are the *sunspot-based* and *fundamentals-based* explanations. According to the sunspot-based approach, there are multiple equilibria. If people believe there will be no crisis then this belief is self-fulfilling. On the other hand if people believe there will be a crisis then these beliefs will also be self-fulfilling. What determines which equilibrium will occur? One way of modelling this is to suggest that an exogenous event such as a sunspot will be the coordinating device. This is not a very satisfactory explanation of equilibrium selection. The second approach is based on the business cycle. If people believe the economy is going to enter a recession they worry about the ability of banks and other agents to make payments on debt contracts. In order to ensure that they can receive the full amount they are owed they demand early payment and this leads to a crisis.

The book does a nice job of showing how these two approaches can be reconciled using developments in the recent literature on global games. The weakness of the sunspot-based approach is the equilibrium selection mechanism. If there is a lack of common knowledge about future economic prospects then it can be shown that a unique equilibrium exists even when there exist common knowledge multiple equilibria. When on average signals about future economic prospects are above some critical level there will not be a crisis, but when they are below there will be. This approach underlines the importance of leading economic indicators for crisis prediction. The first part of the book closes with a critical examination of this literature.

The second part of the book considers how the international financial architecture should be reformed. Sovereign bankruptcy is at the centre of this debate. *Ex ante* it is desirable to provide good incentives for debtors to repay creditors by having tough penalties in the event of default. *Ex post* it is desirable to try and work out defaults with the minimum waste of resources possible. These two goals are usually in conflict and the policy problem is to balance them in a sensible way.

Similarly to the models in the first part of the book, an important aspect of the *ex post* problem is creditor coordination in the event of financial distress. There are two approaches. The *contractual* approach relies on collective action clauses that allow a qualified majority of creditors to change the contractual terms of sovereign debt contracts in the event of repayment problems. The *statutory* approach involves the creation of institutional structures to determine whether a debtor can lower or cease debt repayments as in US chapter 11 bankruptcy law. The authors provide an excellent explanation of the subtleties and complications involved in choosing between the two approaches. As they make clear there are no easy answers.

One of the interesting issues underlying the existence of the problem of default on sovereign debt is the use of foreign currency denominated debt. This is the so-called problem of 'original sin'. If sovereign debt was in domestic currency a country could always print money to satisfy its obligations. The problem of inflation risk if countries borrow significant amounts in domestic currency is addressed at length.

This book should be read by all those who wish to understand the nature of the debate about the international financial architecture at a serious level. It does not shy away from explaining the ideas that underlie the debate while at the same time highlighting the important issues.

Franklin Allen

Preface

This monograph offers an analytical perspective on recent debates about the design and reform of the international financial architecture. It is aimed at graduate students taking courses in international finance, policymakers in central banks and similar institutions with some technical background, and at researchers interested in a more organised treatment of the literature on financial crisis management. Existing books in the area often adopt a non-technical approach, concentrating on policy issues without elucidating the underpinnings necessary for a solid understanding of the architecture debate. Alternatively, there is a tendency to focus on a particular type of model in ways that are not readily amenable to the overall policy discussion. We attempt to bridge this gap by drawing together the key theoretical strands and highlighting their relevance for crisis management. The material stems from our own research while at the Bank of England, and from a course of lectures given to Masters students in economics at the Australian National University and the University of Oxford.

We owe a great many thanks to friends and colleagues at the Bank of England for the intellectual environment and support that has extended far beyond the ideas in this monograph. In particular, we are deeply grateful to Andy Haldane, Simon Hall, Simon Hayes, Adrian Penalver, Ashley Taylor, and Paul Tucker for advice and stimulus. Our intellectual debt to Hyun Song Shin deserves special mention—his steadfast encouragement and guidance has been invaluable to our research and to the development of the manuscript. We should also like to thank Patrizia Baudino, Stefan Gerlach, Paul Levine, Warwick McKibbin, Joe Pearlman, Georges Pineau, Kang Yong Tan, and David Vines for helpful comments and suggestions. It has been a pleasure for us to work with the Oxford University Press, and we are grateful to Andrew Schuller for his help throughout this enterprise. Last, but not least, we would like to express our gratitude to the Research School of Pacific and

Asian Studies of the Australian National University, the European Central Bank, and the Hong Kong Monetary Authority for their support. The views expressed, and the errors that remain, are ours alone.

M. K. F. C. and P. S. G.
Canberra and Hong Kong

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Introduction

1.1 THE MODERN DEBATE ON THE INTERNATIONAL FINANCIAL ARCHITECTURE

The spate of financial crises in emerging market economies as diverse as Brazil, Korea, Mexico, Russia, and Turkey, during the 1990s has focused attention on the importance of improving the policy framework for the management and prevention of crises. A distinctive feature of these modern crises has been the role of imbalances in the national balance sheet. Maturity, currency, and capital structure mismatches meant that the capital account took centre-stage, with large external financing gaps emerging as a result of unparalleled reversals of capital flows. Foreign investors wanted, and attempted, to withdraw from these countries at the same time, much like a run by depositors on a bank. Once sentiment soured sufficiently so that a critical mass of investors rushed to withdraw their claims, the crises became self-fulfilling as others found it rational to join the herd. And since the balance sheet imbalances were in the form of public liabilities, or private-sector liabilities guaranteed by governments, exchange rate and banking sector problems created by the rapid withdrawal of capital were soon transformed into sovereign debt crises.

The central issue for policymakers has, thus, been the design of measures to help fill the external financing gap of a country once a financial crisis occurs. Domestic policy adjustment by the debtor to reduce the current account deficit is one counterpart to private capital outflows. Financing by official creditors, such as the IMF, is another. But the capacity of the IMF to cushion the effects of financial crises has diminished as international capital markets have become increasingly integrated. Moreover, there are limits on the extent to which domestic policy adjustment can spur nervous foreign investors to willingly return to a country in crisis. This raises a third possibility, namely that private capital flows might be harnessed in a way that provides insurance in the event of a crisis. The implicit insurance in private foreign lending is constrained by the legal enforceability of sovereign debt contracts as well as the difficulty of defining financial crises with sufficient precision. By agreeing to a suspension or reduction in repayments, however, private creditors can reduce both the required current account adjustment and the need for official financing. The burden of the financing gap and the costs of crises is, thus, shared among all parties.

Private sector involvement (PSI) in crisis resolution can take many forms. At one extreme, Krueger (2002*a*) makes the case for sovereign debt reorganisation as a means of filling the financing gap, and calls for a statutory framework analogous to corporate insolvency regimes like the US bankruptcy court. At another, Eichengreen (2000) advocates a contractual approach where collective action clauses in debt contracts facilitate debt restructuring. And, in the middle, are proposals in which sovereign debt standstills—an officially sanctioned temporary suspension of debt payments—are a key instrument of policy, serving to forestall a country run in much the same way as a payments suspension ameliorates bank runs (King, 1999). These positions have been reflected in a vigorous academic and policy debate on what has become known as the 'reform of the international financial architecture'. There are many facets to this debate. What are the causes and costs of crisis? How does one gauge the likelihood of crisis? What should be the role of the IMF? What are the ramifications, for debtors and creditors, of different approaches to crisis management? And why are emerging market countries unable to avoid balance sheet mismatches by borrowing internationally in their own currency?

At root, private sector involvement is about resolving a coordination problem among private creditors. Creditors impose externalities on each other, and on debtor countries, as they race to withdraw their funds. These coordination problems result in disorderly workouts and/or a premature liquidation of assets which generate deadweight losses that are potentially costly *ex post*. But the threat of a run also acts as an important discipline for debtors that limits the moral hazard implicit in sovereign lending. Public policy measures towards crisis management must, therefore, strike a balance. They should encourage adherence to the *ex ante* provisions of loan contracts while seeking to maximise the *ex post* value of the debtor in the event that the terms cannot be met. In this monograph, we argue that attention to the *ex ante* and *ex post* efficiency tradeoff, and an understanding of the strategic basis of coordination failure, are critical to a serious assessment of proposals put forward by financial architects.

Dealing with creditor coordination problems is not a panacea for managing financial crises, however. If measures to bind in investors involve potential losses, there can be adverse effects. For example, short-term creditors may become skittish and attempt a hasty exit while they have a chance. An anticipated 'rush for the exits' may, thus, exacerbate an already fragile situation by encouraging creditors to seek debt with extremely short maturities. It raises the question of whether official financing can, instead, provide a 'catalytic' impetus to the resumption of private capital flows. To serve such a role, official financing must be large enough in relation to stock imbalances, and disbursed appropriately, to leverage private sector credit. But official sector rescues can, in turn, potentially fan the flames of future crises by generating moral hazard, that is, blunting the incentives of debtors and creditors to manage risks prudently. The academic literature on financial crises and sovereign debt has yet to resolve these issues at all satisfactorily. They lie at the heart of reforms to the international crisis management framework and have polarised academics and policymakers alike.

1.2 SETTING THE SCENE—KOREA, 1997–98

The Korean capital account crisis of 1997–98 illustrates well the key themes and issues of the international financial architecture debate. As Figure 1.1 shows, private capital inflows to emerging market

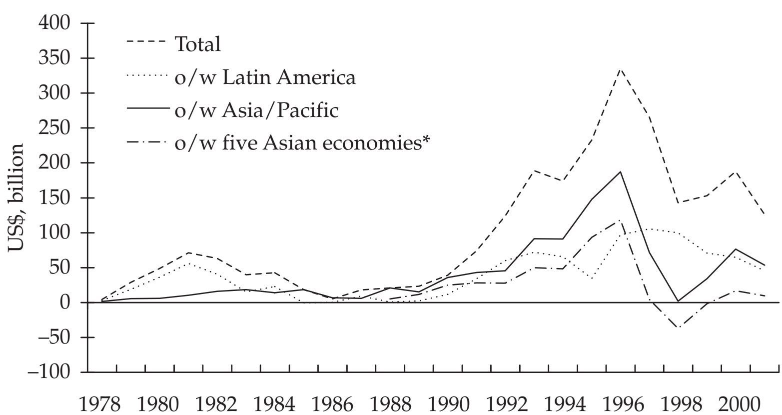

Figure 1.1. *Net private capital flows to emerging market economies*
* Indonesia, Korea, Malaysia, the Philippines, and Thailand.
Source: Institute of International Finance.

economies rose sharply during the first half of the 1990s, reflecting increased integration of global capital markets following financial liberalisation in these countries; the resolution of the sovereign debt problems of the 1980s; and a perception that rapid economic growth in East Asia had ushered in an era of macroeconomic stability characterised by low inflation and strong public finances.

Balance of payments developments in Korea were broadly similar to those of other prominent emerging market borrowers during this period. Net private capital inflows rose from around 1.1% of GDP in 1990 to a peak of 4.1% in 1996, and were matched by current account deficits of similar orders of magnitude (Figure 1.2). Despite the large size of the current account deficit in 1996, external debt appeared to be on a sound footing and Korea's solvency was not in question. Evidence from Korea's credit rating and its borrowing spreads—a broad indicator of the probability of default—support this view. In the ten years leading up to the crisis, Korea's sovereign debts had been consistently rated as upper investment grade by Standard & Poor's. Also, the yield spread of Korea Development Bank's ten-year US$ bond (a state-guaranteed bond) over comparable US Treasury bonds had been stable until late October 1997 (Figure 1.3).

Unlike the international debt crisis of the previous decade, where private capital inflows took the form of medium-term syndicated bank debt with maturities of seven years or longer, the external debts of

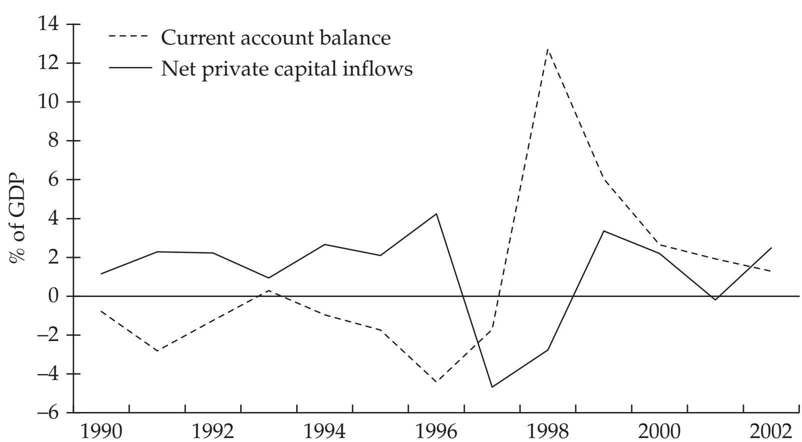

Figure 1.2. *Korean current account balance and net private capital inflows*
Source: IMF World Economic Outlook.

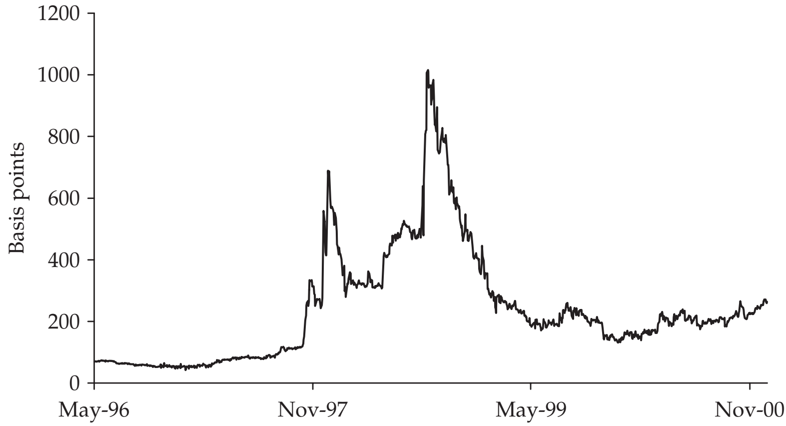

Figure 1.3. *Korea Development Bank bond yield spread*

Source: Bloomberg.

Table 1.1. *Structure of emerging market external debt, 1997*

% of GDP	Korea	Brazil[a]	Indonesia	Philippines	Thailand
Total external debt	28.1	30.7	63.3	61.6	72.3
By maturity					
Medium and long-term	15.7	27.3	36.0	47.6	47.0
Short-term[b]	12.4	3.4	27.3	14.0	25.3
By type of creditor					
Official creditors	3.3	11.7	24.7	26.7	15.9
Banks	18.9	1.8	35.8	16.1	26.0
Other private creditors	6.1	17.2	2.8	18.9	30.4

[a] 1998 data; [b] original maturity.

Sources: IMF World Economic Outlook and BIS–IMF–OECD statistics on external debt.

many emerging market economies, including Korea, were short-term with maturities often less than a year (Table 1.1). The precise reason for this shift in maturity structure remains uncertain. Some policymakers may have preferred short-term debt in order to increase incentives to pursue tight fiscal policy and enhance the credibility of reform programmes. But for other borrowers, short-term debt may have been the only (cheap) debt available since creditors may have regarded it as more likely to be serviced than long-term debt.[1] In Korea's case, the authorities actively promoted short-term capital flows ahead of longer-term flows as part of a gradual capital account liberalisation programme.

One key consequence of the shift to shorter-term debt was that emerging market economies were exposed to the risk of maturity mismatches in a way they had not been before. In the event of any loss of confidence, holders of short-term paper were able to demand repayment rather than rolling over their claims, forcing the issuer to meet debts by prematurely liquidating longer-dated assets. Fears that liquidity could run out meant, therefore, an economy-wide scramble for assets. With longer-term debt, by contrast, a sudden increase in perceived credit risk did not necessitate demands for immediate repayment. A creditor was always able to sell the obligations to other creditors and continuing financing the projects of healthy borrowers, while avoiding troubled financial or corporate entities. The end result was more likely to be a credit crunch—rather than a liquidity crisis—with a more limited impact on the real economy.

In Korea, restrictions on access to long-term foreign capital by the conglomerates (or 'chaebol') allowed Korean banks, through their overseas branches, to act as intermediaries raising short-term capital from foreign banks and bond investors. This meant that Korean banks faced a maturity mismatch between their foreign currency assets and liabilities, while firms faced a currency mismatch since their loans were denominated in foreign currency and were not fully hedged against currency risk. With a high level of short-term debt and moderate international reserves, the economy was vulnerable to a decision by foreign lenders to foreclose their loans. Concerns about the financial health of a number of Korean banks in late 1997 caused banks to face difficulties rolling over their short-term foreign currency liabilities. A government guarantee meant that the central bank began to use foreign reserves to meet the banks' obligations and the won fell sharply (Figures 1.4 and 1.5). Since the majority of corporate debt was of extremely short maturity, concern about the impact of higher interest rates on cash flows limited the scope of the authorities to defend the exchange rate. By the end of 1997, the won had depreciated by 47% against the US dollar over the year and usable reserves (i.e. total foreign exchange reserves minus deposits in overseas bank branches),

[1] Rodrik and Velasco (1999) offer an analysis of the prevalence of short-term emerging market debt in the 1990s.

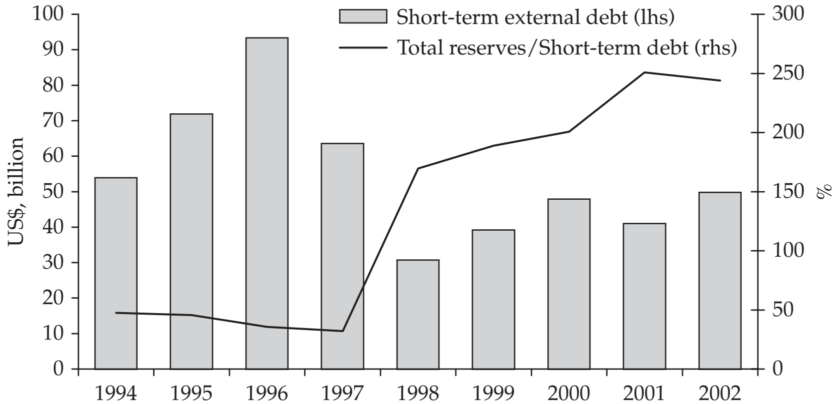

Figure 1.4. *Short-term debt and reserves in Korea*

Source: Bank of Korea.

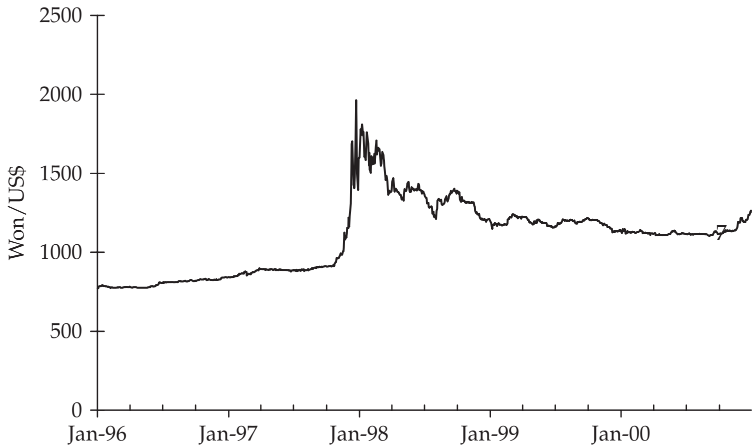

Figure 1.5. *Korean won–US Dollar exchange rate: 1996–2000*

Source: Bloomberg.

at around US$7 billion, were unable to cover the country's maturing short-term debt.

Table 1.2 illustrates Korea's balance of payments and financing requirements at the time of crisis. In 1997, funds were needed to cover the current account deficit (US$8 billion), and capital outflows (US$28 billion), resulting in a sharp decline in reserves (US$21 billion). The major drain on the capital account was bank debt repayment, with the financing gap of US$16 billion being met by official financing from the IMF and the major industrial countries. Given that the roots of the crisis

Table 1.2. *Korea—Balance of payments and financing requirements*

US$, billion	1997	1998
Current account (*a*) [− = outflow]	−8	40
Capital account (*b*) [− = outflow] of which	−28	−15
Portfolio investment	14	−1
Banks[a]	−27	9
Change in reserves (*c*) [− = increase]	21	−40
Financing gap ($a + b + c$)	**−16**	**−10**
Provided by official financing	16	10
Market borrowing by government	0	4

[a] Adjusted to include foreign currency liquidity support by central bank to overseas branches of Korean banks.
Source: IMF Independent Evaluation Office (2003).

lay in liquidity (rather than solvency) concerns, there were hopes that the announcement of official sector support would encourage private sector creditors to voluntarily rollover their loans, ensuring a re-flow of private capital to meet the financing gap in following years.

In the event, however, a catalytic private sector response failed to materialise. The financing gap in 1998 was met by a massive adjustment in the current account (see also Figure 1.2). In addition, foreign creditors were pressed by industrial country policymakers into agreeing to a coordinated rollover of short-term claims in order to maintain their exposures to Korea. Rollover ratios recovered from near zero at the end of 1997 to around 80–90% by late January. Foreign loans were rolled into 1–3 year claims and refinanced at rates that were 150–200 basis points higher than pre-crisis lending rates. The rollover operation—a case of concerted private sector involvement—succeeded in limiting capital outflows. The plan was enhanced by the role of the IMF in facilitating communication between creditors and in certifying that the policies pursued by the Korean authorities was appropriate. But despite the coordinated rollover of claims, a significant financing gap remained and was met by further official financing.

The resolution of the Korean crisis marked a watershed in attempts to reform the international financial architecture. The success of the coerced rollover encouraged some policymakers to advocate sovereign debt standstills as a routine part of the toolkit for ensuring that private creditors maintained their exposures to countries facing liquidity crises. They argued that clearer rules on private sector involvement would limit the need for IMF bailouts. Unsurprisingly, creditor groups, whose ability to exit was restricted by such measures, demurred and were joined by policymakers who preferred intervention on a case-by-case basis that allowed for the option of exceptional financing by the official sector. Eichengreen (2002) presents a lucid account of the fierce argument sparked by these events.

The management of subsequent capital account crises has reflected both the lessons learned in Korea and the failure to establish an international consensus on private sector involvement. For instance, in Brazil and Turkey, concerns about public debt sustainability brought the sustainability of the exchange rate peg into question, and capital outflows again took the form of a closing-out of credit lines. In each case, private sector involvement took the form of informal pressure on international banks to maintain their exposures to help fill large financing gaps. The limited success of this voluntary and piece-meal approach to creditor coordination rekindled concern about the appropriate mechanism to deal with sovereign debt problems. Despite a number of proposals, namely a statutory Sovereign Debt Restructuring Mechanism (SDRM) and collective action clauses in debt contracts (CACs), debate on the best way to involve the private sector in the international financial architecture remains wide open.

1.3 METHOD AND PLAN

An exhaustive treatise on financial crises and their policy implications would be very thick indeed. Such is not our ambition here. Our goal is to provide the basic analytical tools that will allow a reader to navigate their way through the burgeoning academic and policy literature on the international financial architecture. Noticeably, the monograph eschews a detailed macroeconomic analysis of crisis. We regard the misalignment of debtor–creditor incentives and strategic interactions as being central to the welfare costs of crisis. This means that normative questions about crisis management policy are posed in a microeconomic setting. We present what we regard as the key models in the literature on financial crises, and demonstrate their relevance for policy issues. While the monograph does not claim a complete coverage of topics, the material (and the list of associated references) is sufficiently rich so as to allow readers to study in detail those aspects of the architecture debate that they are interested in.

The monograph is in two main parts. Part I establishes the analytical armoury necessary for a critical assessment of proposed reforms to the international financial architecture. We address the positive question of the causes of crisis and draw the important distinction between 'sunspot-based' and 'fundamentals-based' explanations. Since capital account crises involve doubts about the exchange rate and the creditworthiness of the national balance sheet, we provide a primer on currency crises, bank runs, and sovereign debt default. The analysis stresses the important role played by the creditor coordination problem in exacerbating balance sheet mismatches and sparking the costly liquidation of assets. Moreover, it shows how two, seemingly disparate, views of crisis can be reconciled with insights from the recent literature on global games and related to earlier work on the theory of sovereign risk. We conclude with a critical examination of the empirical literature on leading indicators of crisis, evaluating several approaches with emphasis on the variable selection process and econometric methodology.

Part II draws on these positive foundations to study the design of crisis management policy. It explores how reforms that facilitate international financial rescues set the deadweight losses of crisis against the costs posed by a debtor's strategic incentives to default on its obligations. Various proposals that seek to promote crisis resolution are examined in some depth. In particular, we compare contractual and statutory solutions to managing sovereign debt workouts. We also consider some perceived limitations of policies aimed at private sector involvement, and analyse the important role of the IMF in influencing the strategic incentives of creditors and debtors from a theoretical and empirical perspective. A key finding is that there is no simple relationship between *ex post* crisis management and *ex ante* moral hazard. Part II concludes by considering whether domestic capital market development may be a more promising way of encouraging private sector involvement. In particular, we examine why emerging market debtors have been unable to borrow internationally in their own currency—the so-called 'original sin' problem—and analyse how inflation credibility problems influence the currency composition of sovereign debt.

Although our exposition lays stress on analytical modelling, the mathematical requirements for reading the monograph are modest.

Elementary calculus and statistics at first-year undergraduate level should be sufficient to grasp most of the formal logic, including some of the more advanced notions of non-cooperative game theory. Appendices provide additional details of mathematical methods for readers that might need them.

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PART I

THE ANALYTICS OF CRISIS

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Overview: Causes, Costs, and Prediction

"Panics do not destroy capital: they merely reveal the extent to which it has previously been destroyed by its betrayal into hopelessly unproductive works."

J. S. Mill, Address to Manchester Statistical Society,
11 December 1867.

Before considering ways of dealing with international financial crises, it is first necessary to understand why they arise, what role they play in international capital markets, and whether they can be detected. In Part I, we examine some key models in the theoretical and empirical literature on financial crises and discuss their characteristics and implications.

The academic literature typically articulates two views on the causes of capital account crises.[2] On one perspective, countries can be driven into crisis independently of the real economy, that is, by extraneous variables or 'sunspots'. Sound fundamentals, on any definition, are neither a sufficient nor, indeed, a necessary condition for averting crisis. So there may be a range of seemingly robust fundamentals over which an economy is susceptible to crisis. The crisis mechanism lies in the self-fulfilling beliefs of international lenders and results in multiple equilibria. If no one believes that a crisis is about to occur, there will be no speculative run. But if everyone believes that a crisis is about to occur, it becomes optimal for each creditor to liquidate his positions if others do. An economy can thus be *pulled* into a crisis by coordination problems between creditors.

The Obstfeld (1996) model of currency crises, and the Diamond and Dybvig (1983) model of bank runs are the leading examples of

[2] The taxonomy in the literature often refers to *first* (fundamental-based) and *second* (sunspot-based) generation models of crisis, following Eichengreen *et al*. (1996*b*). Since our focus is on a 'cross-generational' perspective, we resist adopting terminology stressing the chronology of model development.

this view.[3] Obstfeld (1996) demonstrates how the contingent nature of policymaking can give rise to situations where a fixed exchange rate regime is sustainable in some circumstances, but not in others. Multiple equilibria arise because, while a government may have motives to defend a fixed exchange rate, it can also have reasons to opt out of such a system. For example, defending a currency peg by raising interest rates in adverse circumstances may entail large costs because of rising bankruptcies. If the cost of defending a fixed exchange rate increases when investors expect that the fixed exchange rate will be abandoned, the tension in policymaking creates a circularity. Under one equilibrium, the fixed exchange rate is consistent with fundamentals. But a sudden worsening of expectations may lead to changes in policies that result in the collapse of the fixed exchange rate regime, hence validating investors' expectations (another equilibrium).

The importance of policy switching in generating self-fulfilling crises is illustrated by the collapse of the European Exchange Rate Mechanism (ERM) in 1992/93. The shock of German re-unification created pressures on other European economies to raise interest rates. The rising unemployment that arose as a consequence led financial market participants to question whether governments facing particularly high unemployment and debt burdens were willing to remain within the ERM. As a result, speculators attacked the currencies of those countries whom they thought would be most likely to opt out of the ERM when placed under pressure. The actions of the speculators were mutually reinforcing—it became more attractive to attack if others were also attacking.

Diamond and Dybvig (1983) highlight the role of maturity mismatches in generating multiple equilibria. Banks have liquid liabilities (deposits), illiquid assets (loans), and are often in a position of having insufficient resources to meet all their commitments. If depositors reach the bank's teller on a first-come, first-served basis, those who withdraw initially will receive more than those who wait. If no one believes the bank will fail, only those with immediate need for liquidity will withdraw their funds. Assuming that banks have sufficient liquid assets to meet these demands, there is no run. But on the other hand, if everyone believes that a banking collapse is about to occur, all depositors have an incentive to withdraw immediately. Again, the

[3] Other examples include the papers by Bryant (1980), Sachs *et al.* (1996*b*), Velasco (1996); and Calvo (1988) in the context of sovereign debt crises.

strategic actions of depositors are reinforcing. And since the bank has insufficient liquid assets to meet this demand, the result is premature liquidation at a loss, or outright closure. Banking crises remain a feature of the modern financial landscape. Scandinavia was severely hit by a banking crisis in the early 1990s, and many crisis countries have experienced banking sector problems.

A second view of crisis emphasises the importance of a secular deterioration in fundamentals, such as a declining level of foreign reserves or a downturn in the business cycle, as the key trigger. Runs need not be ascribed to the beliefs of market participants but can be explained, instead, by the very rationality of their expectations. Crises are never panic-based since, whenever investors run, they would do so even if others did not. Such arguments accord well with the experiences in Latin America during the 1970s and 1980s, where stabilisation programmes featuring a fixed exchange rate regime collapsed in the face of over-expansive macroeconomic policies. The actual and expected deterioration of fundamentals—often in the form of uncontrolled credit expansion by the central bank—*pushes* the economy into crisis. When rational investors observe these leading indicators, the crisis is anticipated and brought forward to a point in time where speculators are unable to take advantage of arbitrage possibilities. Crises are thus, to use the literary allusion of Calvo and Mendoza (1996), chronicles of a death foretold.

Representative of this position are the models of Krugman (1979) and Allen and Gale (1998).[4] Krugman (1979) assumes that government policy is exogenous and, unlike Obstfeld (1996), does not address the question of where such policies originate. A government attempts to finance a large budget deficit by money creation. The increase in credit generated by the central bank leads, in turn, to a gradual depreciation of the 'shadow' exchange rate, the (flexible) exchange rate that would have prevailed in the absence of a fixed exchange rate regime. The central idea is that a run is an equilibrium if, and only if, private investors expect it to be associated with a devaluation, that is, if the shadow rate exceeds the fixed rate. Since speculators know that the peg will be abandoned before the date on which the reserves will be exhausted in the absence of a speculative attack,

[4] See also Flood and Garber (1984), Buiter (1987), and Burnside *et al.* (2001). Flood and Marion (1999) provide a survey of the main macroeconomic models of currency crisis. Fundamental models of banking panics include Gorton (1988) and Chari and Jagannathan (1988).

the attack does not occur then. If it were to occur at that date, it would involve a jump in the exchange rate and present an incipient arbitrage opportunity as creditors could profit from knowing in advance the date of attack. Rational backward induction implies that the attack occurs exactly when the shadow rate equals the fixed parity.

Allen and Gale (1998) construct a model that relaxes several standard assumptions in Diamond and Dybvig (1983). They show how an economic downturn reduces the value of bank assets, raising the possibility that banks will be unable to meet their obligations. If depositors receive information about the downturn, they anticipate financial difficulties in the banking sector and try to withdraw their funds precipitating a crisis. Bank runs are an equilibrium phenomenon. A key insight is that the welfare cost of financial crises is associated with the inefficient liquidation of assets and sub-optimal risk-sharing, and not with crises *per se*. In the absence of costs of early withdrawal, Allen and Gale show that a banking system which is vulnerable to crises can achieve the first-best allocation of risk and investment. When real costs of early withdrawal are assumed, however, a bank run is inefficient because it forces early, and excessive, liquidation of the safe asset. In such circumstances, the first-best allocation cannot be attained and there is a role for public intervention.

Summers (2000) observes that real-life crises contain elements of both belief-driven and fundamentals-based attacks. It is difficult to point to a financial crisis driven entirely by sunspots: the likelihood of crisis is often determined by the extent of fundamental weaknesses that call into question the sustainability of domestic policies. At the same time, the rapid shift from a benign equilibrium to a malign state accompanied by rapid outflows suggests that bank-run psychology does take hold in international capital markets. Attempts to develop a canonical model (e.g. Chang and Velasco, 2001) often assume that the probability of a belief-based run is exogenous, and the reason why market participants coordinate on a sunspot is left unexplained. The inability to analyse equilibrium selection satisfactorily means that little can be said about the welfare costs of the creditor coordination problem and, consequently, the policies that should be followed to 'manage' capital account crises. In particular, when many equilibria can be generated by sunspots, it is difficult to compare outcomes against a first-best world where coordinated behaviour is assumed possible.

Recent work by Morris and Shin (1998, 2003*b*) suggests that it is possible to resolve the problem of indeterminacy in beliefs, and capture the key elements of the two views of crisis. They highlight two shortcomings of multiple equilibria models. First, economic fundamentals are assumed to be common knowledge; and second, creditors are assumed to be certain about others' behaviour in equilibrium. Once disparities in the information sets of market participants are allowed, a creditor's decision to withdraw depends on his private signal about fundamentals and his assessment of the probability that other creditors have received a better signal. If the signal is below a certain trigger value (determined in equilibrium), then it is optimal to run. And if a sufficient number of creditors have signals below the trigger value, a critical mass of withdrawals is reached starting a crisis. The weaker the fundamentals, the more fragile the situation becomes in the sense that fewer participants are required to trigger a crisis. The reasoning is an application of the theory of global games, first studied by Carlsson and van Damme (1993).

The advantage of the global games approach is that it permits a unique mapping between the realisation of economic fundamentals and the beliefs of creditors. This means that signals about fundamentals serve as a device that coordinates beliefs on a particular outcome. The coordination device is not some random sunspot, but a payoff-dependent variable that matters to investors. Since private signals cannot be directly observed, an abrupt shift from one equilibrium to another can still occur without any change in *observable* fundamentals. Chui *et al*. (2002) use the global games framework to reconcile the sunspot and fundamental views in a model of sovereign liquidity crises.[5] Panics can still arise once a change in the nature of the game is anticipated by investors, and the costs of coordination failure are manifest in premature liquidation. But the uniqueness of equilibrium means that it is possible to conduct meaningful comparative statics—allowing a rich set of policy alternatives to be explored. In particular, the effects of a stay on payments and prudent liquidity management on the probability of a 'belief'-based run is made amenable to analysis.

In most emerging market economies, government liabilities or government-guaranteed liabilities dominate the national balance sheet. So coordination failure, by driving speculative runs on the exchange rate and the banking sector, can allow financial crises to

[5] Other applications include bank runs (Goldstein and Pauzner, 2002), the pricing of debt (Morris and Shin, 2004), and currency attacks (Chan and Chiu, 2000). Corsetti *et al*. (2004) consider the effect of large players in global games.

ultimately manifest themselves as a sovereign debt problem. Sovereign debt lacks collateral and the judicial contract enforcement that typifies domestic lending so, as a result, countries are able to decide whether to repay their creditors or declare outright default. A country's willingness to pay may thus determine repayment, long before its ability to repay acts as a binding constraint.[6] Eaton and Gersovitz (1981) formalise this notion in a model where sovereign debt facilitates consumption smoothing. They show that the debtor only pays as much as it is worth to avoid some threatened sanctions by creditors. Such sanctions might include a permanent embargo on new loans in the event of non-payment or refusal to roll over lines of credit. Countries choose to repay because they realise that, at some point in the future, they will likely face situations where they need to borrow.

Bulow and Rogoff (1989*b*) question whether the threat of exclusion from world capital markets alone is sufficient to ensure debt repayment. Using an arbitrage argument, they show how a country can default at any point in time and use the money saved to purchase insurance contracts that achieve the future consumption smoothing function at lower cost. The threat of exclusion from capital markets loses its strength and the reputational equilibrium unravels. Although the idea that countries are able to approach an insurance company following default and purchase insurance to hedge future income fluctuations seems remote, the analysis suggests that creditors may need to invoke direct sanctions to deter strategic default. It means that the up-front costs of crisis, whether in the form of inefficient liquidation of assets or a cut-off in lending, serve as penalties that sustain sovereign borrowing. In other words, financial crises are a market solution to the problem of debtor moral hazard. They are a necessary aspect of the effective functioning of international capital markets.

The disciplining role of the threat of a financial crisis can be costly and indiscriminate, however. If a debtor's financial condition is weak through adverse conditions rather than mismanagement, then the severe punishment meted out by creditors may be no fault of the debtor. As a result, policymakers attach considerable importance to identifying symptoms of financial crises ahead of time. And since crises can quickly spread between countries, knowledge of the ways in which financial distress is transmitted across borders also becomes important since it allows policymakers to anticipate possible 'second round' casualties of crisis.

[6] See Kletzer (1988) and Eaton and Fernandez (1995) for authoritative surveys.

The empirical literature on financial crises has attempted to identify a set of leading indicators that can be used to help spot countries that are seemingly vulnerable to crises. Work by Eichengreen *et al*. (1995), Kaminsky *et al*. (1998), and others suggests that certain variables, such as the extent of real exchange rate misalignment and the short-term debt/reserve ratio, are consistently useful in predicting crisis. Another strand of the literature, notably Eichengreen *et al*. (1996*a*) and Forbes and Rigobon (2001), considers the spillover effects of crisis. These papers concentrate on the notion of 'contagion', and tackle the broad question of whether contagion actually exists and, if so, how it propagates.

Chui (2002) surveys and evaluates both types of study. He argues that the forecasting performance of so-called 'early warning systems' is mixed. The poor predictive power reflects a number of factors: difficulties in defining the dependent variable (or a crisis), changes in the structural relationships in an economy, overemphasis on some crisis-specific indicators, and technical problems such as data quality and revision. The findings of the spillovers literature is extremely sensitive to the definition of contagion and the nature of the channel through which shocks are transmitted. These qualifications suggest that, although useful for practical surveillance purposes, these empirical models are best viewed with caution.

In what follows, we set out the analytics of financial crisis in some detail. We begin by examining the strategic interactions between agents that form the basis for coordination games and outline the representative models of the sunspot view. We then examine the role of fundamentals in driving financial crises, before introducing the concept of global games. The role played by financial crises in generating incentives to repay sovereign debt is then discussed, allowing us to draw a link between the modern literature on crises and the antecedent literature on sovereign debt. A final chapter concludes with an assessment of the early warning literature.

3

Sunspot-Based Models

3.1 BASICS OF COORDINATION GAMES

Coordination games formalise the notion of self-fulfilling expectations and provide a framework that allows abrupt switches between equilibria without a corresponding change in economic fundamentals. For example, the onset of the Asian financial crisis in 1997 was sudden and unforeseen. There was no radical change in economic fundamentals commensurate with the scale of crisis, nor did financial markets anticipate the devaluations that initiated the crisis. The mechanics of these events can be illustrated with the following example due to Morris and Shin (2003*b*). Consider two creditors deciding whether to continue investing in a country. There is a safe action (flee) that yields a payoff of zero, while a risky action (invest) yields $\theta - 1$ if the other creditor flees but θ if he invests. Payoffs are given by the following matrix:

		Creditor B	
		invest	flee
Creditor A	invest	θ, θ	$\theta - 1, 0$
	flee	$0, \theta - 1$	$0, 0$

If θ is known to the creditors, there are three possibilities. For $\theta > 1$, the equilibrium in which both creditors choose to invest is a dominant strategy equilibrium. Similarly, if $\theta < 0$, fleeing is dominant for both players. Coordination problems arise when $\theta \in [0, 1]$. In this case, there are two pure strategy Nash equilibria: both invest and both flee. Note that the investment equilibrium is socially optimal relative to the fleeing equilibrium (both creditors do better)—the inability to coordinate actions can lead players to be 'stuck' at an inefficient equilibrium. Furthermore, in this symmetric case, a higher action by one creditor (invest) increases the *marginal* return to the higher action by the other. The increased payoff for creditor A in switching from flee to invest is $\theta - 1$ when creditor B chooses to flee, but θ when creditor B chooses to invest. Such positive feedback and *strategic complementarity* between players' actions (Bulow *et al*. 1985), is central to the characterisation of coordination games.

Which equilibrium is selected in this coordination game? One could argue that the pay-off dominant Nash equilibrium in which both creditors choose to invest is a natural focal point. But since investment is 'risky' and leads to loss in the event that the other creditor does not also invest, choosing to flee is a risk-dominant equilibrium. If there is significant doubt in the minds of the players about the likely action of their opponent, they might choose to play safe and opt to flee the country. As we will see later, when we allow for incomplete information about θ, the risk-dominant equilibrium is invariably selected in the limit as the amount of incomplete information goes to zero. Notice also that if a government were to guarantee full compensation to creditors unable to withdraw, the fleeing equilibrium can be eliminated and investment becomes the dominant strategy. Provided that it is credible, the promise of government intervention can steer beliefs away from the pessimistic outcome.[7]

The relationship between strategic complementarity, multiplicity, and the welfare ordering of Nash equilibria can also be illustrated diagramatically. Suppose that a fixed number of identical agents, $i = 1, 2, \ldots, n$, each provide effort (x) into a joint production process such that per capita output is given by $y_i = f(x_i, \bar{x})$. The variable $\bar{x}$ represents the average effort provided by agents other than i. Assume that there are returns to scale (positive spillovers) created by the efforts of other agents, that is, $dy_i/d\bar{x} > 0$. Strategic complementarity then implies that an increase in effort by all agents other than agent i increases the *marginal* return to the latter's effort.

Let $\phi(x_i, \bar{x})$ be the best response function (reaction curve) of a representative agent if all others select $\bar{x}$. In equilibrium, the best response of agent i must be equal to his own effort. Graphically, this is the point where the reaction curve cuts the 45-degree line. From the definition of strategic complementarity, the positive slope of a reaction curve guarantees an equilibrium. But for multiple intersections to occur, the reaction function must somewhere have slope greater than unity, implying that agent i's action increases at least one-for-one with other agent's actions. By contrast, under strategic substitutability, a negatively sloped reaction function will give an unique equilibrium

[7] The financial guarantee provided to Mexico by creditor country governments during the crisis of 1994–95 can be viewed in this light. Subsequent discussion considers the unwelcome side effects of such a policy (moral hazard).

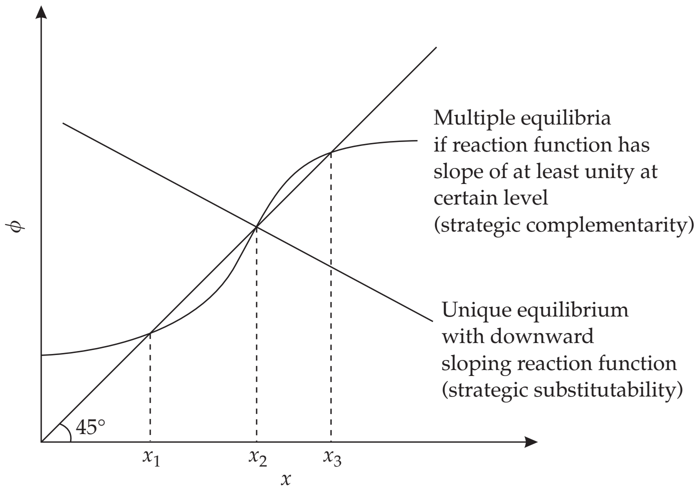

Figure 3.1. *Reaction function slopes and multiple equilibria*

(Figure 3.1). Furthermore, in the presence of increasing returns to scale, equilibrium with higher effort, x_3, is preferred to x_2 and x_1 by all agents, that is, x_3 is Pareto-superior. *Coordination* failure occurs when all agents are stuck at x_1 even though 'better' equilibria such as x_2 and x_3 exist.

With more than one equilibrium, the evaluation of comparative statics becomes difficult. If we start at one equilibrium and change an underlying parameter we cannot say where, in the new set of equilibria, the outcome will lie. In the absence of an equilibrium selection criterion, little can be said about the policy implications of such a framework. Cooper (1999) provides a rigorous treatment of the structure of coordination games.

3.2 CURRENCY CRISES

Obstfeld (1996) provides the seminal application of coordination failure models to currency crises. Strategic complementarities arise because the actions of speculators are mutually reinforcing—currency speculation is more attractive when others have launched a speculative attack. If agents expect the government to abandon a fixed exchange rate commitment in favour of an inflationary monetary policy, crises can become self-fulfilling. The framework follows the Barro–Gordon tradition and highlights the time inconsistency of government policy (Barro and Gordon, 1983). The policymaker can commit to a peg in order to gain the benefits of anti-inflationary credibility, but can always exercise an escape clause if the benefits of fixing are outweighed by the costs.

Consider a small open economy governed by a policymaker who minimises the following loss function

$$L = (y_t - \tilde{y})^2 + \Psi\pi_t^2 + C(\pi_t), \tag{3.1}$$

where y_t and $\tilde{y}$ are real and target output, π_t is the rate of inflation, $\Psi \in (0, 1)$ weights the cost of inflation relative to that of suboptimal output, and $C(\cdot)$ is the fixed cost of opting out of the fixed exchange rate arrangement.[8]

Assume purchasing power parity holds so that, upon normalising foreign prices, the inflation rate corresponds to the realised rate of currency depreciation, that is, $\pi_t = e_t - e_{t-1}$, where e is defined as foreign price of the local currency. Output is described by an expectations-augmented Phillips curve,

$$y_t = \bar{y} + (\pi_t - \pi_t^e) - \varepsilon_t, \tag{3.2}$$

where $\bar{y}$ is the natural level of output, ε_t is a conditional i.i.d. supply shock with zero mean, and the superscript e denotes an expectation variable. In keeping with the time inconsistency literature, we assume that the government's target output level is higher than the natural level of output, that is,

$$\tilde{y} - \bar{y} = k > 0. \tag{3.3}$$

Note that the positive wedge k arises because the natural level of output is 'inefficiently low' (perhaps due to an insider–outsider problem), creating a dynamic consistency problem for the policymaker. Substituting (3.2) and (3.3) into (3.1), we have

$$L = (\pi_t - \pi_t^e - \varepsilon_t - k)^2 + \Psi\pi_t^2 + C(\pi_t). \tag{3.4}$$

The opting-out cost $C(\pi_t)$ is assumed to take the following form. If there is a devaluation (implying $\pi_t > 0$), the government faces a cost $C(\pi_t) = \bar{c}$. A revaluation leads to a cost of $C(\pi_t) = \underline{c}$. If there is no change in the exchange rate, $C(\pi_t) = 0$. The costs can be interpreted as the loss of reputation associated with a devaluation, or as the costs from retaliatory 'beggar-thy-neighbour' actions from other countries. Devaluation costs might also reflect the impact of currency mismatches in the balance sheets of firms and households. Following a devaluation,

[8] We use lower-case letters to denote logs of the variables.

a rise in foreign currency liabilities could induce domestic bankruptcy and adversely affect the loss function of the policymaker.

In the absence of the fixed cost term, the policymaker can choose π_t on a discretionary basis so as to minimise (3.4), and the first-order condition is:

$$\pi_t = \frac{k + \varepsilon_t + \pi_t^e}{1 + \Psi}. \tag{3.5}$$

Substituting (3.5) back into (3.4), we obtain the *ex post* policy loss

$$L^D = \frac{\Psi}{1 + \Psi}(k + \varepsilon_t + \pi_t^e)^2. \tag{3.6}$$

If the policymaker could, however, commit to a fixed exchange rate rule (i.e. $\pi_t = 0$), the policy loss would be

$$L^R = (k + \varepsilon_t + \pi_t^e)^2. \tag{3.7}$$

Comparing (3.7) and (3.6), it is obvious that $L^R > L^D$. So absent a mechanism for enforcing a promise of no devaluation, the policymaker will never find the promise to fix optimal *ex post*, that is, set $\pi(t) = 0$.

If a fixed cost is allowed for (i.e. adding back C to equation 3.6), the policy-maker devalues only when the shock is sufficiently high. Specifically, the shock must be large enough so that $L^R - L^D > \bar{c}$. Similarly, revaluations take place only when ε_t is low enough to make $L^R - L^D > \underline{c}$. Thus devaluation occurs when $\varepsilon_t > \bar{\varepsilon}$, where

$$\bar{\varepsilon} = \sqrt{\bar{c}(1 + \Psi)} - k - \pi_t^e$$

and revaluation when $\varepsilon_t < \underline{\varepsilon}$, where

$$\underline{\varepsilon} = \sqrt{\underline{c}(1 + \Psi)} - k - \pi_t^e.$$

For shock realisations $\varepsilon_t \in [\underline{\varepsilon}, \bar{\varepsilon}]$ the fixed exchange rate is maintained. In other words, the policymaker defends the exchange rate against all but very large shocks.

In light of this escape-clause, the rational expectation of depreciation (inflation) in the next period given the expectations of market participants π_t^e, is

$$\text{E}\pi = \text{E}[\pi_t \mid \varepsilon_t < \underline{\varepsilon}] \Pr(\varepsilon_t < \underline{\varepsilon}) + \text{E}\,[\pi_t \mid \varepsilon_t > \bar{\varepsilon}] \Pr(\varepsilon_t > \bar{\varepsilon}). \tag{3.8}$$

Note that both $\bar{\varepsilon}$ and $\underline{\varepsilon}$ are functions of expected inflation, so expected inflation influences the rate of inflation chosen by the policymaker conditional on realignment choice, as well as the probability of a realignment. The fact that *ex post* inflation might depend on π_t^e in a non-linear function means that there can be more than one expected inflation rate in equilibrium. If we suppose that ε_t is uniformly distributed on $[-\mathcal{E}, \mathcal{E}]$, then

$$\Pr(\varepsilon > \bar{\varepsilon}) = \frac{\mathcal{E} - \bar{\varepsilon}}{2\mathcal{E}}, \quad \Pr(\varepsilon \mid \varepsilon > \bar{\varepsilon}) = \frac{1}{\mathcal{E} - \bar{\varepsilon}}, \quad \mathrm{E}(\varepsilon \mid \varepsilon > \bar{\varepsilon}) = \frac{\mathcal{E} + \bar{\varepsilon}}{2} \tag{3.9}$$

$$\Pr(\varepsilon < \underline{\varepsilon}) = \frac{\mathcal{E} + \underline{\varepsilon}}{2\mathcal{E}}, \quad \Pr(\varepsilon \mid \varepsilon < \underline{\varepsilon}) = \frac{1}{\mathcal{E} + \underline{\varepsilon}}, \quad \mathrm{E}(\varepsilon \mid \varepsilon > \bar{\varepsilon}) = \frac{-\mathcal{E} + \underline{\varepsilon}}{2} \tag{3.10}$$

Combining (3.5), (3.9), and (3.10) gives

$$\mathrm{E}\pi = \frac{1}{1 + \Psi}\left[(k + \pi^e)\left(1 - \frac{\bar{\varepsilon} - \underline{\varepsilon}}{2\mathcal{E}}\right) - \frac{\bar{\varepsilon}^2 - \underline{\varepsilon}^2}{4\mathcal{E}}\right]. \tag{3.11}$$

It is obvious that the solution of (3.11) involves multiple equilibria, and that the reaction function of the policymaker will intersect the rational expectations (45-degree) line $\mathrm{E}\pi = \pi_t^e$ in several places (Figure 3.2). Currency crises depend on beliefs. If speculators regard the probability of devaluation as small, low inflation expectations mean lower output for a given realisation of ε_t, and the policymaker is less likely to devalue. Conversely, if devaluation is perceived as likely, high inflation expectations mean that the policymaker is more likely to devalue.

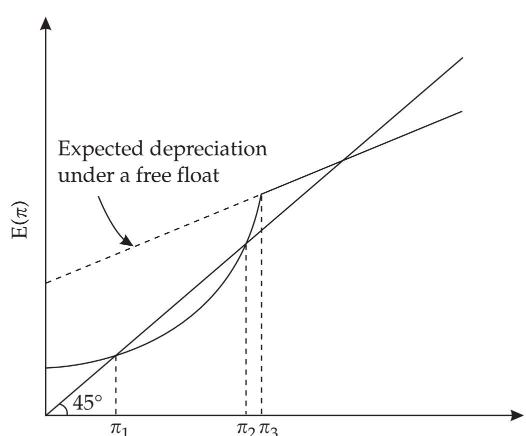

Figure 3.2. *Multiple equilibria in the Obstfeld (1996) model*

3.3 BANK RUNS

The Diamond and Dybvig (1983) model lies at the core of most modern models of financial crisis. A bank promises depositors a fixed payment if they withdraw early. If too many depositors withdraw there is nothing left for those who withdraw late, particularly if the obligations of the bank to early withdrawers are large relative to its liquid reserves. Again there is coordination failure—if a depositor believes that others will withdraw from the bank, it becomes optimal for him to do likewise.

There are three dates, $t = 0, 1, 2$ and a continuum of n agents in the model. All agents are endowed with one unit of a good at $t = 0$ and decide whether to invest their unit endowment themselves or to deposit them in a bank. [9]Two types of asset with constant returns to scale allow the transfer of the good from one date to another. A *liquid* asset takes one unit of the good at date t and converts it into one unit at $t + 1$. An *illiquid* asset takes one unit of good at $t = 0$ and provides a return of $R > 1$ at $t = 2$. But an early liquidation of this illiquid long-term technology at $t = 1$ will incur a cost, $\tau \in [0, 1]$, leaving the agent $1 - \tau$ unit of the initial investment.[10]

Agents in the economy are *ex ante* identical, but subject to liquidity shocks, at the beginning of $t = 1$. With probability λ, the agent is an impatient consumer who only values consumption at date 1; whereas with probability $1-\lambda$, he is patient and values consumption at the later date. These consumption needs are private information. All agents have the same utility *ex ante*,

$$u(c_1, c_2) = \lambda u(c_1) + (1 - \lambda)u(c_2), \tag{3.12}$$

where $c_t \geq 0$ denotes consumption at dates $t = 1, 2$, and $u(\cdot)$ is increasing and strictly concave. In every state of nature, the fraction of patient and impatient consumers is always λ and $1 - \lambda$ respectively, so there is no aggregate uncertainty.

First, consider the case under autarky, that is, there are no banks in the economy and agents do not interact with each other. Let the level

[9] In what follows, we will use the terms depositor, investor, and consumer interchangeably.

[10] Note that in Diamond–Dybvig, $\tau = 0$. Here we follow Cooper and Ross (1998) to include these liquidation costs which, together with the introduction of an explicit liquid asset into the optimisation problem, can weaken the runs condition reported by Diamond–Dybvig.

of illiquid investment at $t = 0$ be i, then an impatient agent who needs to consume early will get

$$\begin{aligned} c_1 &= (1 - i) + (1 - \tau)i \\ &= 1 - \tau i \leq 1, \end{aligned} \tag{3.13}$$

with equality when $i = 0$. Similarly, a patient agent's consumption at $t = 2$ is,

$$c_2 = (1 - i) + iR \leq R, \tag{3.14}$$

with equality holds at $i = 1$. In other words, under autarky, the best possible consumption path each agent can attain is $(c_1, c_2) = (1, R)$.[11]

In sum, investors' uncertainty creates a preference for liquidity. If an individual holding the illiquid asset turns out to be an impatient consumer, he will lack liquidity. If he holds the liquid asset and is revealed to be patient, his returns will be low. There is a maturity mismatch—investors have a preference for liquidity, but profitable opportunities take a long time to pay off. Investors cannot insure themselves against their uncertain demand for liquidity by holding a mixture of the two assets.

Now we will see how banks provide an insurance function, promising a combination of liquidity and high returns that an individual cannot attain on his own. Suppose that a bank can collect the endowments of the agents (deposits) and invests in a portfolio (X, Y) consisting of X units of the illiquid asset and Y units of the liquid asset. It offers a deposit contract at that specific amount that can be withdrawn at each date $t = 1, 2$ for a unit of deposit at $t = 0$. Denote this by (c_1, c_2). Competition means that banks act to maximise *ex ante* expected utility subject to a zero profit constraint. Accordingly, the bank's problem is

$$\begin{aligned} \max \quad & \lambda u(c_1) + (1 - \lambda)u(c_2) \\ \text{s.t.} \quad & X + Y \leq 1, \\ & \lambda c_1 \leq Y, \\ & (1 - \lambda)c_2 \leq RX. \end{aligned} \tag{3.15}$$

[11] Formally, under autarky, an agent will maximise (3.12) subject to (3.13) and (3.14). The first-order condition is $u'(c_1)/u'(c_2) = \tau\lambda/[(1 - \lambda)(R - 1)]$.

Note that the resource constraint can be rearranged as

$$\lambda c_1 + (1-\lambda)\frac{c_2}{R} \leq 1$$
$$c_2 \leq \frac{R(1-\lambda c_1)}{(1-\lambda)}, \tag{3.16}$$

which is equation (1c) in Diamond–Dybvig. Intuitively, the constraint specifies that average consumption at $t = 2$ equals to the long-term payoff of illiquid investment, $R(1 - \lambda c_1)$, divided by the number of late consumers, $(1 - \lambda)$. The first-order condition of problem (3.15) is

$$u'(c_1^*) = Ru'(c_2^*), \tag{3.17}$$

where $*$ denotes the level under an optimal contract. Since $u(\cdot)$ is strictly concave and $cu'(c)$ is decreasing, $c_2^* > c_1^*$. Also, $R > 1$ implies that $1u'(1) > Ru'(R)$, so in general, the autarkic consumption profile of $(c_1, c_2) = (1, R)$ can be improved by bank providing an *optimal contract* stipulating a type-specific return per unit of period 0 investment of $(c_1^* > 1, c_2^* < R)$.[12] The optimal deposit contract is more efficient because it allows for the higher returns from the illiquid asset to be shared between consumers, that is, provide a more even consumption profile. The optimal deposit contract is a Nash equilibrium in the sense that under $c_2 > c_1$, a patient consumer will only be worse off by misrepresenting his type when all other patient consumers play 'truth-telling' and stick with late consumption.

However, there could also be a second equilibrium—a bank run—in which all patient agents claim to be impatient and withdraw at date $t = 1$ such that the bank does not have enough resources to meet its obligations. On a first-come, first-served basis, anyone that claims to be impatient can withdraw c_1^* from the bank until it has no further resources. At the same time, those who wait until the final period gets nothing. Suppose there are n^r depositors receiving c_1^* under a run, then under the optimal deposit contract, the bank's resource constraint (3.16) becomes,

$$n^r c_1^* = n(1-X) + nX(1-\tau)$$
$$= n(1-\tau X). \tag{3.18}$$

[12] For the case of constant relative risk aversion utility (parameterised by σ) and no liquidation costs, the autarkic consumption profile of $(1, R)$ will also be optimal if and only if $\sigma = 1$.

By definition, a runs equilibrium occurs when the bank cannot serve all its depositors, that is, $n^r/n < 1$. But under the optimal contract, $c_1^* = (1 - X)/\lambda$, thus

$$\frac{n^r}{n} = \frac{\lambda(1 - \tau X)}{(1 - X)} < 1. \tag{3.19}$$

From (3.19), it is obvious that the runs condition depends on the size of the liquidation cost and the level of illiquid asset held by the bank (which depends on the depositors' preferences). In particular, other things equal, the higher the liquidation costs, the more likely a runs will occur. In the extreme case when cost of liquidation is 100%, or $\tau = 1$, $n^r/n = \lambda < 1$, and a bank runs equilibrium exists for all concave utility. Furthermore, Cooper and Ross (1998) show that with a logarithmic utility function, a runs equilibrium can still exist if $\tau > 0$.

A natural way to prevent the instability caused by coordination failure is to insure depositors. The idea of deposit insurance is that the government promises to collect taxes and provide liquidity to the bank in the event of financial distress. Patient consumers know that if they wait, they will receive their promised return independently of the number of consumers who withdraw. But deposit insurance also generates moral hazard. When the bank designs the optimal contract, it does not internalise the costs of the taxes that might be required to pay the insurance. It has an incentive to over-exploit the deposit insurance by promising short-term returns that are higher than the socially optimal level.

Another approach might be to require that the maturity structure of banks' assets be perfectly matched with their liabilities. For example, liquid reserves could be set equal to the maximum possible amount of withdrawals at $t = 1$. This means that the deposit contract must satisfy $c_1 \leq 1 - X, c_2 \leq RX$. As a result, the constraint to the bank's problem above becomes

$$c_1 + \frac{c_2}{R} \leq 1, \tag{3.20}$$

instead of

$$\lambda c_1 + (1 - \lambda)\frac{c_2}{R} \leq 1, \tag{3.21}$$

which is clearly more restrictive and hampers the provision of liquidity insurance.

A further response to the problem of inefficient bank runs is to suspend convertibility, that is, refuse to pay out depositors after a certain threshold of withdrawals is reached. As long as patient consumers know that the bank can satisfy them at $t = 2$, they will have no incentive to withdraw at $t = 1$. The threat of a run disappears. But while a suspension of payments may be able to prevent the deadweight loss caused by the premature liquidation of the illiquid asset, it may not allow full liquidation even in cases where it is efficient to do so. That is, when the long-term return R is below the short-term return of 1, the bank will not liquidate the whole long-term asset but, rather, only a portion of it.

Our discussion suggests that although policy measures can limit the effects of crisis, they are likely to be associated with potentially significant costs. A drawback of sunspot-based models is that they cannot identify factors that trigger a run. The emphasis on investor psychology crowds out consideration of the important underlying role played by the deficiencies of policy and fundamental weaknesses in the economy. This limits the applicability of such models as the cause of a run is key to assessing the relative merits of crisis management proposals.

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4

Fundamentals-Based Models

4.1 TIMING OF CRISES

The Krugman (1979) model takes the view that fixed exchange rates are abandoned because of unsound fundamentals and government policies inconsistent with the exchange rate regime. In its simplest form, the government insists on running excessively expansionary policies that speculators know will ultimately exhaust the foreign exchange reserves. A currency crisis is treated as a run on reserves at the central bank. The increase in credit by the central bank implies a gradual depreciation in the 'shadow' exchange rate—the flexible exchange rate that would have prevailed in the absence of a peg. A run is an equilibrium if, and only if, speculators expect it to be associated with a devaluation, that is, if the shadow exchange rate exceeds the fixed rate. The interesting feature of the model is that, with perfect foresight, the timing of crisis is predictable.

Consider a small open economy with a money demand function given by

$$\frac{M(t)}{P(t)} = a_0 - a_1 i(t), \quad a_0, a_1 > 0, \tag{4.1}$$

where M, P, and i are the nominal money stock, price level, and interest rate respectively.

Let R be the book value of central bank reserves, and D be total domestic credit, so the money supply can be written as

$$M(t) = R(t) + D(t). \tag{4.2}$$

Further, assume that the purchasing power parity and uncovered interest rate parity relationships hold, so that

$$P(t) = P^*(t)S(t), \tag{4.3}$$

$$i(t) = i^*(t) + \left[\frac{\dot{S}(t)}{S(t)}\right], \tag{4.4}$$

where S is the spot exchange rate defined as the domestic price of foreign currency. We use an asterisk ($*$) to denote foreign variables, which are assumed to be exogenous for the small country case.

Finally, assume that the central bank is following a domestic credit growth policy such that

$$\dot{D}(t) = \mu, \tag{4.5}$$

where μ is a fixed constant. This might reflect a policy of financing a large fiscal deficit by money creation. Importantly, government policy is treated as exogenous in the model.

Money market equilibrium can be obtained by equating money demand and money supply. Substituting (4.3) and (4.4) into (4.1) means that money demand becomes

$$\begin{aligned} M(t) &= [a_0 P^*(t) - a_1 i^*(t) P^*(t)] S(t) - a_1 P^*(t) \dot{S}(t) \\ &= \beta S(t) - \alpha \dot{S}(t), \end{aligned} \tag{4.6}$$

where $\beta = [a_0 P^*(t) - a_1 i^*(t) P^*(t)]$ and $\alpha = a_1 P^*(t)$. So money market equilibrium can be expressed as

$$R(t) + D(t) = \beta S(t) - \alpha \dot{S}(t). \tag{4.7}$$

What happens when the exchange rate is fixed? Under a fixed exchange rate, $S(t) = \bar{S}$ and $\dot{S}(t) = 0$. So foreign reserves are equal to

$$R(t) = \beta \bar{S} - D(t). \tag{4.8}$$

Under a policy of continuous domestic credit expansion, reserves will dry up in finite time as

$$\dot{R}(t) = -\dot{D}(t) = -\mu. \tag{4.9}$$

We now consider the timing of a speculative attack. Under perfect foresight speculators will find it profitable to attack the currency on a date before the one at which reserves completely dry up. This is because, if the attack occurred on the date at which reserves were scheduled to dry up, speculators would have an incipient arbitrage opportunity and profit from knowing the date of attack in advance. So the date of the attack is brought forward to a point where the shadow exchange rate equals the fixed parity.

To see this, let z be the time at which the reserves are exhausted, and z_+ and z_- be points in time right after and just before the attack respectively. Assuming that the post-attack exchange rate is freely floating, at

$t = z_+$, we have

$$M(z_+) = \beta S(z_+) - \alpha \dot{S}(z_+). \tag{4.10}$$

Equation (4.10) is a first-order differential equation that can be solved as follows. First, we conjecture the solution to be $S(t) = \lambda_0 + \lambda_1 M(t)$.[13] But at the instant right after the attack, reserves are completely depleted, so $R(z_+) = 0$, and $M(z_+) = D(z_+), \dot{M}(t) = \dot{D}(t) = \mu$.[14] Therefore $\dot{S}(t) = \lambda_1 \mu$. Combining this with (4.10) gives

$$S(t) = \frac{\alpha \lambda_1 \mu}{\beta} + \frac{1}{\beta} M(t). \tag{4.11}$$

By comparing (4.11) with our conjectured solution, we find $\lambda_1 = 1/\beta$ and $\lambda_0 = \alpha\mu/\beta^2$. Thus, the shadow exchange rate is given by

$$S(t) = \frac{\alpha\mu}{\beta^2} + \frac{M(t)}{\beta}, \quad t \geq z. \tag{4.12}$$

To deduce the exact time of attack, we need to establish the level of the exchange rate at the moment of an anticipated attack on foreign reserves, $S(z_+)$. Consider the case of a discrete currency depreciation, $S(z_+) > \bar{S}$, in which a speculator who launches an attack will profit by the amount $[S(z_+) - \bar{S}]R(z_-)$. So whenever a speculator expects a discrete exchange rate increase, he has an incentive to pre-empt his competitors by launching an attack an instant before z. Therefore launching an attack at z and a discrete exchange rate change are contradictory. On the other hand, if $S(z_-) > \bar{S}$, speculators who attack the currency will experience a loss of $[S(z_+) - \bar{S}]R(z_-) < 0$, and have no incentive to attack. Under this no-arbitrage condition, we can conclude that, at the moment of attack, the shadow exchange rate must be equal to the fixed rate (see Figure 4.1), that is, $S(z_+) = \bar{S}$. Substituting this condition and the fact that $M(t) = D(t) = D(0) + \mu t$ into (4.12), we have

$$z = \left[\frac{\beta\bar{S} - D(0)}{\mu}\right] - \frac{\alpha}{\beta} = \frac{R(0)}{\mu} - \frac{\alpha}{\beta}. \tag{4.13}$$

From (4.13) we immediately see that the larger the stockpile of reserves, the later is the attack date. And a decrease in the rate of

[13] See Appendix A for a more general solution.

[14] Here, for simplicity, we assume that the eventual collapse of the exchange rate occurs at the time when foreign reserves are completely depleted. This condition is not limiting and the lower bound can be treated as a positive constant.

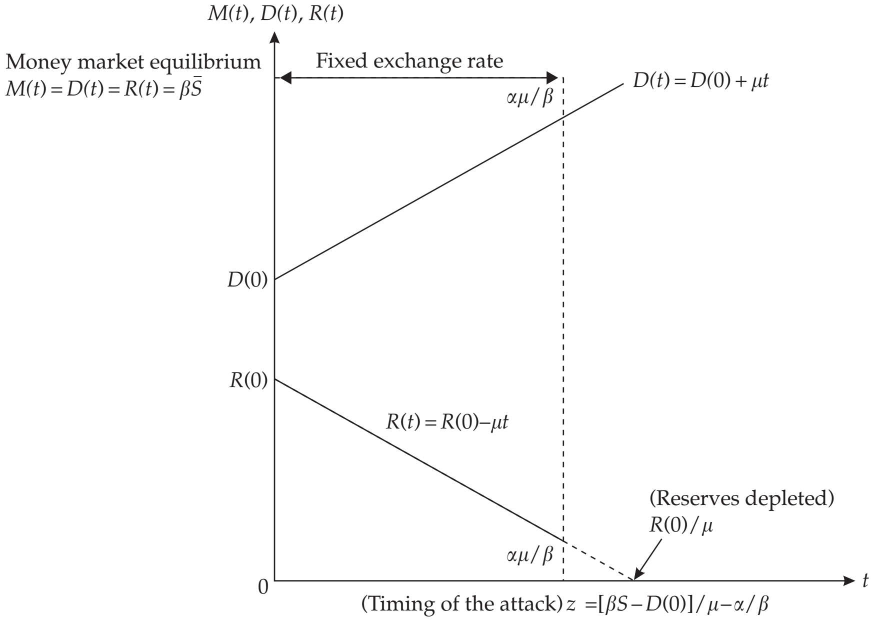

Figure 4.1. *Timing of the speculative attack*

Source: Blackburn and Sola (1993).

credit expansion, μ, forestalls the crisis. Although the lessons from sunspot-based models suggest that the timing of crisis is more unpredictable than suggested by this stylised model, it sheds light on the sorts of fundamental variables that might be important in triggering a run. For example, fiscal and financial variables such as the fiscal deficit/GDP ratio, the ratio of government consumption to GDP, and the growth in broad money can act as leading indictors of crisis. Agénor *et al*. (1992) extend the framework to allow expansionary policy to create higher demand for traded and non-traded goods. The former causes a deterioration of the trade balance, while the latter generates a real appreciation of the exchange rate. So external variables, such as trade/current account balances and the real exchange rate, can also be regarded as leading indicators of financial crisis.

4.2 OPTIMAL CRISES

Allen and Gale (1998) show how cyclical fluctuations in fundamentals can lead to bank runs. The model adopts the same assumptions about technology and preferences as Diamond and Dybvig (1983), but differs in two key respects. First, the long-term illiquid asset is risky, with a random return that is perfectly correlated across banks. Second, there is no first-come, first-served assumption. The insolvent bank shares its liquid assets equally among depositors who withdraw at the interim stage. Bank runs can be efficient, that is, allow first-best risk-sharing between impatient and patient depositors. But when costly liquidation is introduced, bank runs no longer fulfil their risk-sharing function.

Time is divided into three periods, $t = 0, 1, 2$. There is a consumption good, and two types of asset with constant return to scale technologies that allow the good to be transferred from one date to another. The *safe* asset takes one unit of good at date t and transforms it into one unit at $t+1$. The *risky* asset takes a unit of the good at $t = 0$, and transforms it into $R > 1$ units at $t = 2$. The variable R is random, with a probability density function $f(R)$.

A continuum of *ex ante* identical consumers (depositors) have an endowment, W, of the consumption good at $t = 0$. They invest in the risky and safe assets to provide for future consumption, but are uncertain about their time preferences. With probability $1/2$, the consumer is impatient and only values consumption at $t = 1$; and with probability $1/2$, the consumer is patient, wanting to consume at $t = 2$. The utility function $U(c_1, c_2)$ is

$$U(c_1, c_2) = \begin{cases} u(c_1) & \text{with probability } 1/2, \\ u(c_2) & \text{with probability } 1/2. \end{cases} \tag{4.14}$$

where c_t denotes consumption at date t. The functions $u(\cdot)$ are assumed to be increasing, strictly concave, and twice continuously differentiable. A consumer's type is not always observable, so a patient consumer can always pretend to be impatient.

All uncertainty is resolved at the beginning of $t = 1$. Each consumer discovers whether he is patient or impatient. He also observes a signal that predicts, with perfect accuracy, the value of R that will be realised at $t = 2$. The signal can be regarded as a leading indicator which conveys precise information about the return to the risky asset.

Banks make investments on behalf of consumers because only they can properly distinguish genuinely risky assets from those without value. By pooling the assets of a large number of consumers, banks offer insurance against uncertain liquidity demands. Free entry into the banking sector induces banks to maximise expected utility for the consumer. Thus

$$\begin{aligned} \max \quad & \mathrm{E}\{u[c_1(R)] + u[c_2(R)]\}, \\ \text{s. t.} \quad & X + Y \le W, \\ & c_1(R) \le Y, \\ & c_2(R) \le RX + [Y - c_1(R)], \\ & c_1(R) \le c_2(R), \end{aligned} \tag{4.15}$$

where X and Y denote the bank's holdings of the risky and safe asset respectively. The deposit contracts, $c_1(R)$ and $c_2(R)$, give the consumption of the impatient and patient types conditional on the return to the risky asset.

The first three constraints are the budget constraints at each date. First, the total amount invested must be less than or equal to the amount deposited. Second, holdings of the safe asset must be sufficient to provide for the consumption of impatient types. And third, the value of the risky asset plus the amount of the safe asset left over after providing for impatient consumers must meet the consumption of the patient type.

The final constraint is an incentive compatibility constraint. A patient consumer can potentially imitate an impatient one, obtaining $c_1(R)$ at $t = 1$ and investing in the safe asset outside the banking system to obtain $c_1(R)$ at $t = 2$. It will be desirable to do this unless $c_1(R) \le c_2(R)$ for all R. In order to ensure that an investor will always want to hold some amount of the risky asset, and that the optimal portfolio contains both types of asset, we assume

$$\mathrm{E}[R] > 1, \quad u'(0) > \mathrm{E}[u'(RW)R]. \tag{4.16}$$

To solve the problem, we simplify it by first removing the incentive compatibility constraint and examining the relaxed problem, namely

$$\begin{aligned} \max \quad & \mathrm{E}\{u[c_1(R)] + u[c_2(R)]\}, \\ \text{s. t.} \quad & X + Y \le W, \\ & c_1(R) \le Y, \\ & c_2(R) \le RX + [Y - c_1(R)]. \end{aligned} \tag{4.17}$$

A necessary condition for a solution is that for each value of R, $c_1(R)$, and $c_2(R)$ must solve

$$\begin{aligned} \max \quad & u[c_1(R)] + u[c_2(R)], \\ \text{s. t.} \quad & c_1(R) \le Y, \\ & c_2(R) \le RX + [Y - c_1(R)]. \end{aligned} \tag{4.18}$$

The first-order conditions imply

$$u'[c_1(R)] \geq u'[c_2(R)], \tag{4.19}$$

and a necessary condition for the optimum is that the consumption of the two types be equal. If the feasibility condition $c_1(R) \leq Y$ is binding, then $c_1(R) = Y$ and $c_2(R) = RX$, so that $c_1(R) < c_2(R)$. Thus $c_1(R) = c_2(R)$ only when $c_1(R) < Y$. So the incentive compatibility constraint is automatically satisfied when we optimise subject to the first three budget constraints.

Notice that the critical value of the return on the risky asset at which the liquidity constraint begins to bind is

$$\overline{R} = \frac{Y}{X}. \tag{4.20}$$

So the situation $c_1(R) = Y$ and $c_2(R) = RX$ can only arise if $R \geq Y/X$. Otherwise, if $R < Y/X$, the available funds are split on an equal basis so that $c_1(R) = c_2(R) = (RX + Y)/2$. This allows the optimal risk-sharing problem to be written as

$$\begin{array}{ll} \max & \displaystyle\int_0^{\overline{R}} 2u\left(\frac{RX+Y}{2}\right) f(R)dR + \int_{\overline{R}}^{\infty} [u(Y) + u(RX)]f(R)dR, \\ \text{s. t.} & X + Y \leq W, \end{array} \tag{4.21}$$

and the associated first-order condition for an interior solution

$$\mathrm{E}\{u'[c_1(R)]\} = \mathrm{E}\{u'[c_2(R)]R\}, \tag{4.22}$$

uniquely determines the optimal values of Y and X and, in turn, the values $\overline{R}, c_1(R)$, and $c_2(R)$.

The optimal contract is illustrated in Figure 4.2. When the signal indicates that R will be high at $t = 2$ (i.e. above $\overline{R}$), then impatient types consume the maximum amount available to them, Y. The patient types consume $RX > Y$. At $\overline{R}$, impatient types consume Y and patient types consume $\overline{R}X$. For weak values of the signal below the liquidity threshold, it is efficient to equate consumption given the form of the objective function. At $R = 0$, both types consume $Y/2$ as this is all that is available. As R increases between 0 and $\overline{R}$, both groups consume more, that is, $(RX + Y)/2$.

We now allow for a deposit contract which promises a fixed amount at each date, and shares out assets in the event that the bank is unable to meet its obligations. Specifically, let $\bar{c}$ be the fixed payment promised to impatient consumers. The deposit contract promises either $\bar{c}$ or an

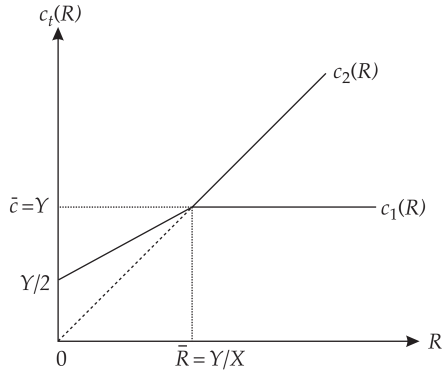

Figure 4.2. *The optimal contract in the Allen and Gale (1998) model*

equal share of the liquid assets, Y, in the event of a crisis. The optimal risk-sharing problem now becomes

$$\begin{aligned} \max \quad & \mathrm{E}\{u[c_1(R)] + u[c_2(R)]\} \\ \text{s. t.} \quad & X + Y \leq W \\ & c_1(R) \leq Y \\ & c_2(R) \leq RX + (Y - c_1(R)) \\ & c_1(R) \leq c_2(R) \\ & c_1(R) \leq \bar{c} \text{ and} \\ & c_1(R) = c_2(R) \text{ if } c_1(R) < \bar{c}. \end{aligned} \tag{4.23}$$

In other words, we introduce an additional constraint which requires that the impatient consumers are paid the promised amount, $\bar{c}$, or else patient and impatient consumers get the same payment.

The extra constraint captures the equilibrium conditions imposed by the possibility of runs. Suppose first, that $\bar{c} \leq Y$, so the bank can always pay the impatient consumers the promised amount unless there is a run. If there is a run, early running patient types and impatient types are treated the same way. So if $\alpha(R)$ denotes the proportion of patient types who join the run at $t = 1$, then

$$c_1(R) + \alpha(R)c_{21}(R) = Y, \tag{4.24}$$

where $c_{21}(R)$ is the consumption of a patient type who withdraws early at $t = 1$. Since $c_{21}(R) = c_1(R)$, we have

$$c_1(R) = \frac{Y}{1 + \alpha(R)}. \tag{4.25}$$

Patient consumers who retain their positions until $t = 2$ receive the returns from the risky asset, that is,

$$[1 - \alpha(R)]c_{22}(R) = RX, \tag{4.26}$$

which can be re-written as

$$c_{22}(R) = \frac{RX}{1 - \alpha(R)}. \tag{4.27}$$

In equilibrium, it must be the case that patient consumers are indifferent between joining the run and waiting, that is,

$$c_1(R) = \frac{Y}{1 + \alpha(R)} = \frac{RX}{1 - \alpha(R)} = c_2(R). \tag{4.28}$$

Provided there is a positive value of the risky asset, $RX > 0$, there must be a positive fraction of patient consumers who do not flee. Otherwise $c_{22}(R)$ would be infinite. Bank runs in the model are partial, reflecting the total illiquidity of the risky asset. Patient consumers are residual claimants and always receive something at $t = 2$. Patient consumers who withdraw early, by contrast, share Y with the impatient types and carry it over to $t = 2$ using the safe asset outside the banking system.

The banking system with deposit contracts can achieve the same level of efficiency as the unconstrained optimal risk-sharing problem. Comparing the form of the optimal consumption functions from the two problems, we have

$$\begin{aligned} c_1(R) &= \min\left[\frac{1}{2}(Y + RX), Y\right], \\ c_2(R) &= \max\left[\frac{1}{2}(Y + RX), RX\right], \end{aligned} \tag{4.29}$$

and

$$\begin{aligned} c_1(R) &= \min\left[\frac{1}{2}(Y + RX), \bar{c}\right], \\ c_2(R) &= \max\left[\frac{1}{2}(Y + RX), Y + RX - \bar{c}\right]. \end{aligned} \tag{4.30}$$

Clearly the two are identical if $\bar{c} = Y$.

Figure 4.2 also illustrates the optimal deposit contract with $\bar{c} = Y$. For $R < \overline{R}$, the optimal degree of risk-sharing is achieved by increasing $\alpha(R)$ towards one as R tends to zero. Risk-sharing occurs because the lower the value of the leading indicator (and hence R), the greater is the proportion of patient types who withdraw early. And less is consumed by patient and impatient types. In other words, equilibrium runs facilitate the allocation of resources in a way that imposes some risk on the people who withdraw early.

4.3 THE ROLE OF COSTLY LIQUIDATION

The result that bank runs can be optimal is a special one. It presumes, in particular, that default by the bank does not generate any deadweight losses. Allen and Gale (1998) therefore relax this feature of the model to allow for costs of premature liquidation. In particular, they consider what happens when there is a cost to holding the liquid asset outside the banking system. Let $r > 1$ denote the value of the safe asset held by banks between dates 1 and 2. If one unit of consumption stored by a consumer at $t = 1$ produces one unit at $t = 2$, the costs of premature liquidation of the safe asset are $r - 1 > 0$. Assume that the risky asset is, on average, more productive than the safe asset, that is,

$$\mathrm{E}[R] > r. \tag{4.31}$$

Let $\bar{c}$ once again be the amount promised by the bank to anyone withdrawing at $t = 1$, and $\alpha(R)$ be the proportion of patient consumers who withdraw early. The deposit contract, therefore, requires that the bank either pay depositors $\bar{c}$ or share out liquid assets. Formally,

$$c_1(R) \leq \bar{c} \ \text{ or } \ c_1(R) + \alpha(R)c_2(R) = Y \quad \text{if} \quad c_1(R) < \bar{c}, \tag{4.32}$$

and since withdrawers are treated equally,

$$c_1(R) = c_2(R) \ \text{ if } \quad \alpha(R) > 0. \tag{4.33}$$

The bank's optimisation problem is now

$$\begin{aligned}
\max \quad & \mathrm{E}\{u[c_1(R)] + u[c_2(R)]\}, \\
\text{s. t.} \quad & X + Y \leq W, \\
& c_1(R) + \alpha(R)c_2(R) \leq Y, \\
& [1 - \alpha(R)]c_2(R) \leq RX + r[Y - c_1(R) - \alpha(R)c_2(R)], \\
& c_1(R) \leq \bar{c}, \\
& c_1(R) + \alpha(R)c_2(R) = Y \ \text{ if } \ c_1(R) < \bar{c}, \\
& c_1(R) = c_2(R) \quad \text{if} \quad \alpha(R) > 0, \\
& c_1(R) \leq c_2(R).
\end{aligned} \tag{4.34}$$

The problem is simplified by noting that patient and impatient consumers share the assets when there is a run, that is, when R falls below a critical liquidity threshold, R^*. Since runs occur if and only if $c_1(R) < \bar{c}$, R^* is implicitly defined by

$$\bar{c} = r(Y - \bar{c}) + R^* X. \tag{4.35}$$

Thus, if there are no runs and impatient consumers are paid the promised amount, there is just enough left to provide patient consumers with a level of consumption that satisfies the incentive compatibility constraint. So the problem becomes

$$\begin{aligned} \max \quad & \int_0^{R^*} 2u\left(\frac{RX+Y}{2}\right) f(R)dR \\ & + \int_{R^*}^{\infty} [u(\bar{c}) + u(r(Y-\bar{c}) + RX)] f(R)dR, \\ \text{s. t.} \quad & Y + X \leq W, \\ & R^* = \frac{(1+r)\bar{c} - rY}{X}. \end{aligned} \tag{4.36}$$

Allen and Gale (1998) discuss the solution to this problem in greater detail. There are two possibilities. First, $\bar{c} = Y$ and the solution is the same as the one considered earlier. Second, $\bar{c} < Y$ and an amount $Y - \bar{c}$ is held over until $t = 2$ if a run does not occur and there is a loss of $(r-1)(Y - \bar{c})$ from premature liquidation in the event of a run. This is illustrated in Figure 4.3. The inefficiency of equilibrium with bank runs arises from the fact that liquidating the safe asset at $t = 1$ and storing the proceeds until $t = 2$ is less productive than keeping the safe asset within the bank.

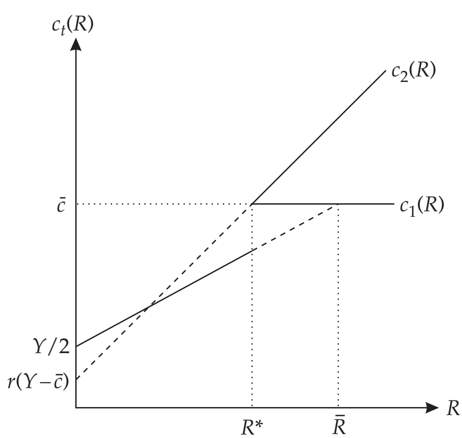

Figure 4.3. *Costly liquidation in the Allen and Gale (1998) model*

A natural criticism of models based on a Diamond and Dybvig-style framework is that they assume that the monies leaving the project when creditors flee cannot be replaced. Would a secondary market resolve the problem of deadweight losses associated with foreclosure? After all, if assets are sold during a run there is a transfer of value, not an economic cost. The insights from Allen and Gale (1998) suggest otherwise. If banks are forced to liquidate the illiquid asset in order to meet their obligations, the price of the asset is forced down making the crisis worse. But suboptimal risk-sharing leads to transfers being made only in worst states of the world when consumption is already low. Rather than providing insurance that provides depositors with a transfer in bad states, the secondary market does the opposite. Financial crises are not costly because of runs *per se* but, rather, because of the costs of premature liquidation and disorderly workouts.

Fundamentals-based models provide another partial explanation of real-life crises. While the likelihood of crisis is likely to be influenced by deteriorating fundamentals, the role of investor beliefs in international capital markets is set aside. Moreover, the tendency of such models to portray policymakers as passive and mechanistic is unrealistic. Models that span both the fundamental and sunspot views are, therefore, needed to better understand the origins and management of financial crises.

5

Reconciling the Two Views

5.1 BASICS OF GLOBAL GAMES

We now capture more formally the idea that economic agents opt for a particular course of action because of their belief that others are taking such actions. Global games analysis offers a vehicle for equilibrium selection through perturbations. Once a more realistic assumption of incomplete information is allowed for, the equilibrium for a symmetric binary action coordination game is the limit of the equilibrium of an incomplete information game that is 'nearby'. The interesting feature is that as information becomes more precise, the risk-dominant equilibrium is selected.

Recall the coordination game discussed in Chapter 3. As before, two creditors decide between lending and fleeing according to the payoffs:

		Creditor B	
		lend	flee
Creditor A	lend	θ, θ	$\theta - 1, 0$
	flee	$0, \theta - 1$	$0, 0$

Now suppose that there is incomplete information about the fundamentals of this economy. In particular, creditors only observe a private signal about θ, $x_i = \theta + \varepsilon_i$, where $\varepsilon_i \sim N(0, \sigma_\varepsilon^2)$. The noise term obscures the payoffs in the matrix, requiring the creditor to draw inferences about the payoffs and the likely strategy of the other creditor. The action chosen by a creditor must maximise his expected payoff conditional on the best available information, given the strategy followed by the other creditor. Note that the payoff to fleeing is non-random (i.e. zero).

The expected payoff to lending, conditional on receiving a signal x_i is

$$\mathrm{E}[\theta - 1 \times \psi | x_i], \tag{5.1}$$

where

$$\psi = \begin{cases} 0, & \text{if other creditor lends,} \\ 1, & \text{if other creditor flees.} \end{cases} \tag{5.2}$$

A natural strategy to consider is one where a creditor takes a risky action only if his private signal exceeds some threshold level, $\hat{x}$:

$$s(x_i) = \begin{cases} \text{lend,} & \text{if } x_i > \hat{x}, \\ \text{flee,} & \text{if } x_i \leq \hat{x}. \end{cases} \tag{5.3}$$

Morris and Shin (1998, 2003*b*) refer to this as a switching strategy around $\hat{x}$. If the other creditor also uses a switching strategy with threshold $\hat{x}$, then $\psi = 1$ if, and only if, $x_2 < \hat{x}$. Thus

$$\mathrm{E}(\psi | x_1) = \Pr(x_2 < \hat{x} | x_1). \tag{5.4}$$

Suppose that θ is normally distributed with mean μ_θ and variance σ_θ^2. Since the noise term is also normal, the posterior distribution of θ given x_1 will also be normally distributed with mean and variance,[15]

$$\begin{aligned} \mathrm{E}[\theta | x_1] &= \frac{\mu_\theta \sigma_\varepsilon^2 + x_1 \sigma_\theta^2}{\sigma_\theta^2 + \sigma_\varepsilon^2}, \\ \mathrm{Var}[\theta | x_1] &= \frac{\sigma_\theta^2 \sigma_\varepsilon^2}{\sigma_\varepsilon^2 + \sigma_\varepsilon^2}. \end{aligned} \tag{5.5}$$

If ε_1 and ε_2 are independent, the distribution of the other creditor's signal conditional on x_1 is normally distributed as well. The mean is $\mathrm{E}[\theta | x_1]$ and the variance in this instance is

$$\frac{\sigma_\varepsilon^2 (2\sigma_\theta^2 + \sigma_\varepsilon^2)}{\sigma_\theta^2 + \sigma_\varepsilon^2}. \tag{5.6}$$

So the conditional probability of the other creditor choosing to flee can be expressed as

$$\Pr[x_2 < \hat{x} | x_1] = \Phi \left[\sqrt{\frac{\sigma_\theta^2 + \sigma_\varepsilon^2}{\sigma_\varepsilon^2 (2\sigma_\theta^2 + \sigma_\varepsilon^2)}} \left(\hat{x} - \frac{\mu_\theta \sigma_\varepsilon^2 + x_1 \sigma_\theta^2}{\sigma_\theta^2 + \sigma_\varepsilon^2} \right) \right], \tag{5.7}$$

where $\Phi(\cdot)$ is the c. d. f. of the normal distribution.

[15] The properties of normal distributions are discussed in Appendix B.

Given the switching strategy, the expected payoff to lending conditional on signal x_1 is

$$v(x_1, \hat{x}) \equiv \frac{\mu_\theta \sigma_\varepsilon^2 + x_1 \sigma_\theta^2}{\sigma_\theta^2 + \sigma_\varepsilon^2} - 1 \times \Phi(\cdot).$$

In equilibrium, we expect the lender to be indifferent between issuing credit and fleeing. So the optimal strategy is to switch around x_1^*, where x_1^* is the solution to

$$v(x_1^*, \hat{x}) = 0, \tag{5.8}$$

since the payoff to fleeing is zero. As the game is symmetric, both creditors follow the same switching strategy and the uniqueness of equilibrium will depend on the number of solutions to (5.8). In particular, equilibrium is unique provided the noise in the signal is small relative to the underlying uncertainty (i.e. $\sigma_\varepsilon^2 \to 0$). As Figure 5.1 shows, the switching point obtains at the intersection between the 45-degree line and the cumulative normal.

The unique equilibrium in switching strategies is also the only equilibrium in the incomplete information game. To see this, recall that if $\theta < 0$, fleeing is dominant. If a lender receives a signal $x_i < 0$, then his conditionally expected payoff will be negative if he chooses to issue credit, that is, $\mathrm{E}[\theta | x_i] < 0$. Similarly, if $\theta > 1$, lending is a dominant strategy. The two dominance regions represent extreme scenarios where fundamentals are so forceful that they determine uniquely what creditors will do. One can think of $\theta < 0$ as representing outcomes that are synonymous with the fundamental-based crises of the sort highlighted by Krugman (1979) and Allen and Gale

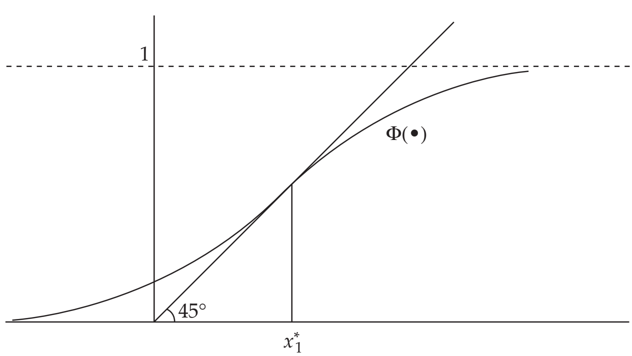

Figure 5.1. *The switching point*

(1998) discussed in the previous chapter. Fundamentals are so weak that fleeing is the only course of action. For $\theta > 1$, lending is the preferred action irrespective of the expectations of other creditors—the economy is robust enough to withstand a run.

In between these bounds, there is an intermediate region where a lender's optimal strategy depends on his beliefs regarding others' actions. Belief-driven crises of the Obstfeld (1996) and Diamond and Dybvig (1983) variety occur in this region. But unlike the sunspot-approach, these beliefs are no longer arbitrary. Since creditors only observe noisy signals of the fundamentals, they do not know exactly the signals that the other has observed. So, in the choice of the equilibrium action at a given signal, the creditor must take into account the equilibrium action at nearby signals. These actions, in turn, depend on the equilibrium actions taken at further signals, and so on.

Consider an iterative process which eliminates strongly dominated strategies for each player. At each step in the process, a strategy is eliminated for creditor i if it is strongly dominated by another strategy for i for all strategy combinations left after the iterative deletion process. Suppose, for instance, that the creditor receives a signal $\underline{x}_2$ stronger than the lower dominance threshold signal, that is, $\underline{x}_2 > 0$. The creditor knows that his opponent will flee if he gets a signal below 0. For lending to be dominant at $\underline{x}_2$ the conditional expected payoff must be greater than zero. By symmetry, the other lender thinks the same way and will also lend seeing a signal like $\underline{x}_2$. Since the payoff to lending is increasing in the incidence of lending by the other creditor, a strategy of issuing credit for signals lower than $\underline{x}_2$ will be dominated.

As we increase the signal, we can generate a sequence $0 < \underline{x}_2 < \cdots < \underline{x}_k$, where any strategy to lend for signal less than $\underline{x}_k$ does not survive. By similar reasoning, a strategy of fleeing for signals larger than $\bar{x}_k$ also does not survive. As we increase the signal from below and lower it from the upper dominance bound, there will be a point where, after assigning a conditional probability to the action of the other creditor, the creditor is just indifferent between the two actions. In the model above, the unique equilibrium occurs at the cut-off $\hat{x} = 1/2$. As loans are made if, and only if, $x = \theta + \varepsilon \geq 1/2$, the two creditors coordinate on (lend, lend) whenever $\theta \geq 1/2$, and (flee, flee) when $\theta < 1/2$. In other words, as $\sigma_\varepsilon^2 \to 0$, the risk-dominant equilibrium is selected.[16]

[16] Morris and Shin (2003*b*) provide a formal discussion of the iterated deletion of strongly dominated strategies.

The key point of the model is that the beliefs of creditors are uniquely determined by the realisation of fundamentals. Fundamentals do not determine agents' actions directly, but serve as a device to coordinate expectations. Unlike the analysis in Chapter 3 the coordination device is not a sunspot but, rather, a payoff dependent variable. Together with the dominance regions, this forces a unique outcome where agents cannot possibly ignore their signals about the state of the economy.[17]

5.2 SOVEREIGN LIQUIDITY CRISES

Chui *et al*. (2002) apply global game arguments to sovereign liquidity crises. Unlike the two player case, there is a group of creditors that is large in number. This gives meaning to the notion of 'critical mass' as, once we know the realisation of θ, we can calculate the *proportion* of creditors who flee. And since a critical proportion of creditors must be needed to trigger default, we take into account both the debtor's solvency constraint and the indifference condition between fleeing and staying. The model also provides a framework with which to explore the costs of premature liquidation in more detail.

There are three dates, $t = 0, 1, 2$. A country invests in a project that takes two periods to complete. At date $t = 0$, the project is financed from the debtor's own resources (illiquid assets, E) and from foreign borrowing, L. Production is based on a constant returns to scale technology which is risky, needs time to mature, and is realised only at $t = 2$. Specifically, output is given by

$$\theta(E + L), \tag{5.9}$$

where θ is a random productivity shock that is distributed normally with mean μ_θ and variance σ_θ^2. Foreign lenders are small in that an individual creditor's stake in the project is negligible as a proportion of the whole. Each creditor lends an exogenous amount, L, to the debtor at an interest rate of r_L which the debtor agrees to repay at $t = 2$.

At the interim stage, $t = 1$, before the final realisation of the project, lenders review their investment. They may choose to either rollover their loan till maturity at $t = 2$, or foreclose on the loan in favour of a risk-free international asset. In other words, the project is financed with short-term debt that needs to be rolled over. If creditors choose to foreclose or 'flee', they face an exit cost, $0 < \tau < 1$. If creditors

[17] See Allen and Gale (2003) for an alternative attempt at spanning the fundamental and sunspot approaches.

choose to stay for the full term of the loan, 'rollover', then they receive payment with interest if the debtor is solvent ('repay'), but nothing if the debtor is insolvent and forced to 'default'. The payoff matrix for the representative creditor under the four scenarios is thus

			Debtor	
		Time of payoff	**Repay**	**Default**
Creditor	**Flee**	$t = 1$	$L(1 - \tau)$	$L(1 - \tau)$
	Rollover	$t = 2$	$L(1 + r_L)$	0

The debtor's ability to repay depends crucially on the productivity shock, θ, and the proportion of creditors that flee in the interim period, λ. Suppose that the debtor has a stock of liquid reserves, A, paying a rate of interest, r_A, that it can use to meet the demands of fleeing creditors. Debt obligations at $t = 2$ thus depend on the proportion of creditors who flee at $t = 1$, the final net reserve position, and the value of production. In the spirit of Allen and Gale (1998), suppose also that premature liquidation causes disruption to the production process. The severity of disruption is λkL, where k is the marginal disruption to output caused by a single fleeing creditor. So the solvency constraint facing the debtor at the end of the game can be expressed as

$$\theta(E + L) - k\lambda L + (1 + r_A)(A - \lambda L) \geq (1 - \lambda)(1 + r_L)L. \qquad (5.10)$$

The critical proportion of creditors needed to trigger default is

$$\lambda^*(\theta) = \frac{\theta(E + L) + (1 + r_A)A - (1 + r_L)L}{(k + r_A - r_L)L}. \qquad (5.11)$$

So the decision rule for the debtor is to declare default only if the observed fraction of fleeing creditors is greater than the critical mass $\lambda^*(\theta)$ in the prevailing state θ. Note that the stronger the fundamentals and/or the larger the proportion of rollovers, the greater the likelihood of the debtor repaying its obligations.

We can use the solvency constraint in (5.10) to determine the dominance regions of 'strong solvency' and 'fundamental insolvency'. Denote by $\bar{\theta}$, that value of θ such that the debtor is able to repay debts even if all other creditors flee. So if $\lambda = 1$,

$$\bar{\theta} = \frac{kL + (1 + r_A)L - (1 + r_A)A}{E + L}. \qquad (5.12)$$

If $\theta > \bar{\theta}$, fundamentals are so strong that the sovereign will always repay, so rolling over is a dominant strategy for creditors. But if fundamentals are particularly weak, there will be values of θ for which fleeing is dominant. Let $\underline{\theta}$ be that value of θ such that the debtor is unable to meet its obligations even if all creditors were to rollover their loans, that is, $\lambda = 0$:

$$\underline{\theta} = \frac{(1 + r_L)L - (1 + r_A)A}{E + L}. \tag{5.13}$$

At the interim date, $t = 1$, creditors can observe a noisy private signal of fundamentals

$$x_i = \theta + \varepsilon_i, \tag{5.14}$$

where $\varepsilon_i \sim N(0, \sigma_\varepsilon^2)$ and is independent from θ and ε_j for all $i \neq j$. Denote by $\upsilon(x)$ the proportion of creditors who flee when the value of the signal is x. Let $s(\theta, \upsilon)$ be the proportion of creditors who flee, given the aggregate strategy υ, when the state of fundamentals is θ. Formally

$$s(\theta_j, \upsilon) \equiv \int_{-\infty}^{\infty} \upsilon(x)\phi(x|\theta_j)dx, \tag{5.15}$$

where $\phi(x|\theta_j)$ represents the density function of signals for some state of fundamentals, θ_j. Note $\phi(x|\theta_j) \sim N(\theta_j, \sigma_\varepsilon^2)$.

We once again consider switching strategies, where every creditor flees if and only if he receives a signal $x < \hat{x}$. In other words, the aggregate strategy υ is given by the indicator function

$$I_{\hat{x}} = \begin{cases} 0, & \text{if } x \geq \hat{x} \\ 1, & \text{if } x < \hat{x}. \end{cases} \tag{5.16}$$

Substituting (5.16) into (5.15) implies:

$$\begin{aligned} s[\theta, I(\hat{x})] &= \int_{-\infty}^{\hat{x}} 1 \cdot \phi(x|\theta)dx + \int_{\hat{x}}^{\infty} 0 \cdot \phi(x \mid \theta)dx \\ &= \int_{-\infty}^{\hat{x}} \phi(x|\theta)dx \\ &\equiv \Phi[(\hat{x} - \theta)/\sigma_\varepsilon] = \text{prob}(x > \hat{x}). \end{aligned} \tag{5.17}$$

At an equilibrium switching point when the state of fundamentals is $\hat{\theta}$, it must be the case that the proportion of fleeing creditors, s, equals the critical mass necessary to cause default. So from the solvency constraint

$$\hat{\theta}(E + L) - ksL + (1 + r_A)(A - sL) = (1 - s)(1 + r_L)L,$$

or

$$\hat{\theta} = \frac{(1+r_L)L - (1+r_A)A + (k + r_A - r_L)L\left[\Phi\left(\frac{\hat{x}-\hat{\theta}}{\sigma_\varepsilon}\right)\right]}{E+L}. \tag{5.18}$$

For the switching point to occur at the interim stage, it must also be the case that the creditor is indifferent between fleeing and rolling over at that point. So

$$\int_{\hat{\theta}}^{\infty} L(1+r_L)\phi[\theta \mid \hat{x}]d\theta = L(1-\tau), \tag{5.19}$$

or

$$\frac{r_L + \tau}{1+r_L} = \Phi\left[\frac{(\hat{\theta} - \tilde{\theta})\sqrt{\sigma_\varepsilon^2 + \sigma_\theta^2}}{\sigma_\varepsilon \sigma_\theta}\right], \tag{5.20}$$

where $\tilde{\theta} = [\mu_\theta \sigma_\varepsilon^2 + x_j \sigma_\theta^2]/[\sigma_\theta^2 + \sigma_\varepsilon^2]$ is the mean of the distribution $\phi(\theta|x = x_j)$. Rearranging the expression for the mean to write x_j in terms of $\tilde{\theta}$ and when $x_j = \hat{x}$, gives

$$\hat{x} = \frac{\sigma_\theta^2 + \sigma_\varepsilon^2}{\sigma_\theta^2}\tilde{\theta} - \frac{\sigma_\varepsilon^2}{\sigma_\theta^2}\mu_\theta. \tag{5.21}$$

Substituting this expression for the creditor signal into the solvency condition and the creditor indifference condition yields a simultaneous equation system with two equations and two unknowns, $\tilde{\theta}$ and $\hat{\theta}$. This can be solved to yield the value of the fundamentals at the switching point:

$$\hat{\theta} = \underline{\theta} + (\bar{\theta} - \underline{\theta})\Phi\left[\frac{\sigma_\varepsilon}{\sigma_\theta}\left(\frac{\hat{\theta} - \mu_\theta}{\sigma_\theta}\right) - \frac{\sqrt{\sigma_\varepsilon^2 + \sigma_\theta^2}}{\sigma_\theta}\Phi^{-1}\left(\frac{r_L + \tau}{1+r_L}\right)\right]. \tag{5.22}$$

Equation (5.22) shows how the trigger point for fundamentals depends on the insolvency boundary, $\underline{\theta}$, plus an adjustment which depends on the scale of the coordination problem $(\bar{\theta} - \underline{\theta})$, and on the creditor's assessments of the expected payoffs, given the actions of the other creditors. Note that when $\Phi(\cdot) = 0$, that is, the creditor perceives that there is no possibility of others ever receiving a signal that encourages them to rollover, then the trigger point is at the lowest value of fundamentals, that is, $\hat{\theta} = \underline{\theta}$. Runs are simply due to extremely bad fundamentals. At the other extreme, as $\Phi(\cdot) \to 1$, the trigger point for a crisis is at the upper dominance boundary and runs occur whenever $\theta < \bar{\theta}$. Runs are, thus, belief driven.

5.3 COSTS OF COORDINATION FAILURE

The global games framework allows us to assess the impact of policy measures aimed at mitigating the creditor coordination problem. Figure 5.2 classifies the fundamentals of the model, θ into zones of fundamental and belief-based crises. As we have already seen, the lower dominance region—the area under the normal density function $\phi(\theta)$ to the left of $\underline{\theta}$—depicts values of 'fundamental insolvency' for the debtor. And the area to the right of $\bar{\theta}$ depicts a range of θ for which the economy is considered 'strongly solvent'. The unique equilibrium, $\hat{\theta}$ lies above $\underline{\theta}$, and the shaded area defines the zone where belief-based crises strike.[18]

The coordination inefficiency identified in Figure 5.2 arises from lost production at $t = 2$ due to the disruption caused by fleeing creditors as otherwise value-enhancing investments end up being liquidated or shelved. Policy measures that attempt to resolve the coordination

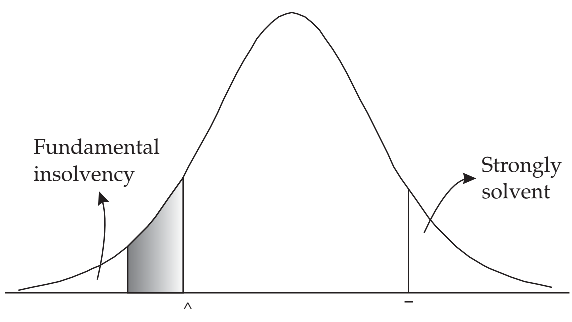

Figure 5.2. *The tri-partite classification of fundamentals*

[18] Note that the existence of an upper dominance region is required for the uniquencess of equilibrium. Without an upper dominance region, the model has multiple equilibria. One is an equilibrium in which agents run on any signal. Another is the switching equilibrium. We cannot preclude the existence of other equilibria in which agents run at signals below $\hat{\theta}$. But the assumption of an upper dominance bound is relatively weak and the zone between $\hat{\theta}$ and $\underline{\theta}$ can be regarded as a reasonable representation of the costs of crisis. Goldstein and Pauzner (2002) discuss how the switching equilibrium survives other selection criteria in greater detail.

problem can induce changes in the trigger value of fundamentals, $\hat{\theta}$, and thus affect the likelihood of a belief-based crisis. But they can also induce changes in $\underline{\theta}$, and affect the likelihood of a fundamentals-based crisis. The framework thus allows us to disentangle the effects of policy measure on the probability of both types of crisis.

In a first-best world, absent any coordination problems, expected output for the debtor is

$$\int_{-\infty}^{\underline{\theta}} [\theta(E+L) - kL]\phi(\cdot)d\theta + \int_{\underline{\theta}}^{\infty} [\theta(E+L)]\phi(\cdot)d\theta, \tag{5.23}$$

whereas expected output in an environment with coordination failure is

$$\int_{-\infty}^{\underline{\theta}} [\theta(E+L) - kL]\phi(\cdot)d\theta + \int_{\underline{\theta}}^{\hat{\theta}} [\theta(E+L) - k\lambda(\theta)L]\phi(\cdot)d\theta + \int_{\hat{\theta}}^{\infty} [\theta(E+L)]\phi(\cdot)d\theta. \tag{5.24}$$

The function $\lambda(\theta)$ denotes the (*ex ante*) critical proportion of creditors needed to induce the planner to default in states of the world between $\underline{\theta}$ and $\hat{\theta}$. The cost of coordination failure is simply the difference between the two outcomes, that is,

$$\begin{aligned} C &= kL \int_{\underline{\theta}}^{\hat{\theta}} \lambda(\theta)\phi(\cdot)d\theta \\ &= k\left[\frac{(\hat{\theta} - \underline{\theta})(E+L)}{k + r_A - r_L}\right]. \end{aligned} \tag{5.25}$$

Denoting ΔC as the change in costs following a policy action, we can write

$$\Delta C = [(\hat{\theta}' - \hat{\theta}) - (\underline{\theta}' - \underline{\theta})]\frac{k(E+L)}{k + r_A - r_L}, \tag{5.26}$$

where $\hat{\theta}$ and $\underline{\theta}'$ are the value of the threshold and the insolvency boundary after the policy change. The first term on the right-hand side of (5.26) quantifies the impact of the policy change on the probability of a belief-based crisis, and the second the impact on the probability of a fundamentals-based crisis.

Chui *et al.* (2002) assess the impact of various policy measures, using illustrative values of the parameters in the model. The size of the cost depends importantly on the parameter, k, the marginal disruption cost of a creditor run. When $k = 0.06$, that is, every dollar withdrawn reduces the return on the investment by 6 cents, the costs of coordination failure are around 10% of debtor country output. If $k = 0.4$, the costs rise to 66% of output. Although the deadweight losses posed by a creditor run are difficult to pin down precisely, such results appear plausible. Direct empirical attempts to evaluate the output costs of financial crises suggest that the costs of crisis often lie between 10% and 20% of annual pre-crisis GDP and may even be larger.[19]

Fane (2000) argues that the costs of premature liquidation are felt most keenly in countries with under-developed bankruptcy procedures. The ineffectiveness of bankruptcy law leads to informal credit networks guided by unwritten understandings and mutually consistent expectations that are prone to coordination failure. He suggests that Malaysia experienced lower crisis costs partly as a result of the fact that its bankruptcy system, which had been inherited from the British, was more effective than those in Thailand and Indonesia. The moribund nature of formal bankruptcy procedures in emerging market countries, and their implications for the costs of crisis, is one reason why IMF crisis programmes frequently emphasise new bankruptcy laws.

Two policy proposals to manage liquidity crises are the management of sovereign debt so as to match assets and liabilities and payment suspensions. These derive directly from the Diamond and Dybvig (1983) analysis considered earlier. We assess them briefly in the context of the model, referring the interested reader to Chui *et al*. (2002) for more detail and analysis of other policy proposals.

5.3.1 *Liquidity Management*

Policymakers frequently emphasise the importance of prudent liquidity management in averting crisis. For example, Greenspan (1999) proposes that, as a rule of thumb, countries should hold enough foreign exchange reserves to cover a year's maturing external debt obligations. And, as we will see later, recent empirical work shows that the ratio of short-term debt to reserves is a very effective predictor of crises (e.g. Berg and Pattilo, 1999*a*). Figure 5.3 illustrates the effects of gradually reducing the short-term debt reserve ratio from 150% (around the level in some countries before crisis) to 100% (as suggested by Greenspan). As can be seen, the policy mitigates the cost of coordination failure quite substantially. Moreover, lowering the ratio has two

[19] E.g. see Allen and Gale (1998), Hoggarth *et al*. (2002), and IMF (1998).

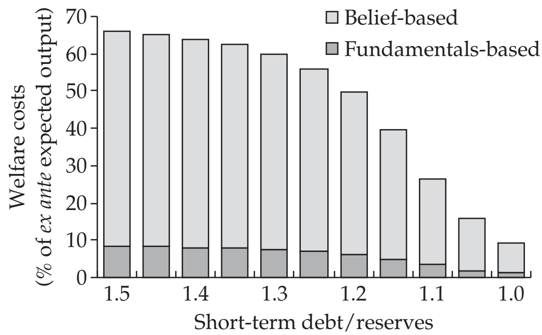

Figure 5.3. *Effects on welfare of a simple rule*

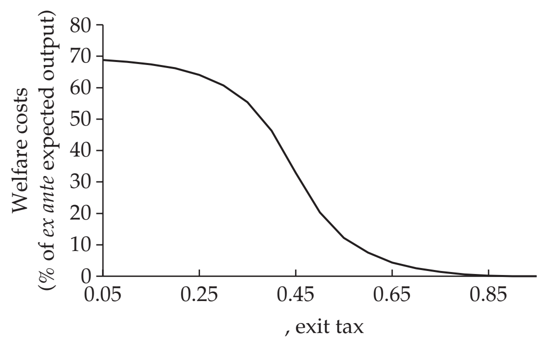

Figure 5.4. *Welfare effects of increasing exit taxes*

effects. It improves fundamentals, because the trigger for solvency crisis depends on net liquidity. It also reduces the probability of belief-based crises by shaping expectations of repayment. The decomposition in Figure 5.3 suggests that much of the efficiency gain from such a policy stems from its impact on the probability of belief-based crises.

5.3.2 *Payment Suspensions and Capital Controls*

Payment suspensions or sovereign debt standstills can be thought of as the limiting case of controls on capital outflow, where the effective tax rate, $\tau = 1$.[20] Figure 5.4 shows the effects on the *ex post* costs of coordination failure of changes in the exit tax. Small values of the exit tax deliver only a small gain. But with larger values a payment standstill proves effective at mitigating the *ex post* costs of coordination

[20] Miller and Zhang (2000) also assess the role of payments standstills in sovereign liquidity crises.

failure. If the proceeds of the exit tax are assumed to be unavailable to the planner, controls on capital outflows do not affect the probability of a fundamentals-based crisis. Rather, they impact directly on the trigger value of fundamentals, $\hat{\theta}$, and the probability of a belief-based crisis. The sharp fall in the costs reflects the non-linearity of the distribution function. But regardless of functional form, the costs are eliminated only at high exit tax rates. The result raises questions about ability of modest controls or 'sand in the wheels of international finance' to effectively limit financial instability.

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6

Crisis Costs and Incentives to Repay Sovereign Debt

6.1 WILLINGNESS TO PAY

Sovereign debt is, with few exceptions, not collateralised and sovereign immunity means that such debt lacks the judicial contract enforcement accorded to domestic lending. The *willingness* of sovereign debtors to abide by the terms of debt contracts therefore depends on the degree to which default can be penalised, and on the resolve of lenders to impose penalties. The penalties available include exclusion from future access to credit, a refusal to roll over lines of credit, interference with trade and, in the extreme, gunboat diplomacy. The nature of penalties—and the costs of crisis—is crucial to our understanding of international crisis resolution, since it identifies the incentives for the borrower, to repay, and for creditors to continue lending. The interplay between crisis costs and debtor discipline is sketched out more fully in Part II.

Here we set out the general structure of models with penalties, along the lines of Eaton *et al*. (1986). There are two periods. A loan of amount B is made at the start of the first period, with an obligation to repay an amount $R(B)$ in the second. If the borrower defaults, he suffers a penalty P. Borrower welfare is denoted by the function $u(B, x)$ which increases with the amount borrowed, B, and decreases in the loan obligation x, where:

$$x = \begin{cases} R(B), & \text{if repayment occurs,} \\ P, & \text{if default occurs.} \end{cases} \tag{6.1}$$

The borrower chooses to repay if and only if the utility from repaying is at least as great as the utility from defaulting, that is,

$$U_R = U[B,\ R(B)] \geq U_D = U(B, P). \tag{6.2}$$

This comparison of alternatives is central to the willingness to pay approach.

The assumption of risk neutral, competitive lenders implies that the repayment which lenders require is given by

$$R(B) = (1 + i)B, \tag{6.3}$$

where i denotes the opportunity cost of funds. Substituting (6.1), (6.2) into (6.3) implies that repayment occurs for

$$B \leq \frac{P}{1 + i}. \tag{6.4}$$

There are a number of immediate implications. First, credit may be rationed. If the borrower wishes to borrow more than $P/(1 + i)$, he cannot. Second, if the borrower wants to borrow more, he benefits from an increase in the size of the penalty, P. Finally, if there is no penalty, international lending cannot occur.

The rudimentary framework sketched out above has an important failing. The size of the penalty is exogenously given, and does not depend on debtor–creditor characteristics. The literature on sovereign risk has adopted two strategies to model these penalties. One approach suggests that the primary incentive for a country to repay is the threat of financial autarky.[21] Creditors offer the debtors the *'carrot'* of continued access to capital markets in return for loan repayment. The debtor, in turn, has an incentive to make repayments in order to preserve its reputation as a good borrower. An alternate approach emphasises the *'stick'* of economic interference with the debtor's international transactions—for example, sanctions, seizure of assets, liquidation procedures, etc. Lindert and Morton (1989) find that defaulting nations in the 1930s were allowed normal access to international credit markets by the 1960s. This raises questions about the credibility of capital market access as an incentive mechanism for good debtor behaviour. As we shall see in this chapter, Bulow and Rogoff (1989*b*) demonstrate conditions under which lending to sovereigns must be supported by direct sanctions available to creditors, and under which lending cannot be supported by the threat of financial autarky alone.

[21] Examples of this view are Eaton and Gersovitz (1981), and Grossman and van Huyck (1988).

6.2 EXCLUSION FROM FUTURE ACCESS TO CREDIT

The motivation for repayment in the Eaton and Gersovitz (1981) model is of the *carrot* variety. Our exposition follows Freixas and Rochet (1997) who assume that there is a small country with stochastic output, $y_t = \tilde{y}_t$, and an objective function

$$U = \mathrm{E}\left[\sum_{t=0}^{\infty} \beta^t u(c_t)\right], \tag{6.5}$$

where c_t denotes consumption at date t, $u(\cdot)$ is a utility function with the usual properties, and $\beta < 1$ is a discount factor. The country borrows short-term debt to smooth consumption, accessing credit markets on even dates and repaying in the subsequent period (odd dates).

Let B be the amount borrowed from lenders on international capital markets, and suppose that the punishment for default (however partial) is a loss of access to credit forever after (i.e. a *trigger strategy* punishment). In the event of default, the country is resigned to consuming its random output in the future as though under autarky. The continuation payoff associated with default is therefore

$$U_D = \mathrm{E}\left[\sum_{t=0}^{\infty} \beta^t u(\tilde{y}_t)\right] = \frac{\mathrm{E}[u(\tilde{y}_t)]}{1-\beta}. \tag{6.6}$$

For a country to strategically default, it must have the incentives to do so. In particular, the utility from repaying the loan has to be inferior to the utility from defaulting. That is

$$u(y) + \beta U_D > u(y - R) + \beta V_R, \tag{6.7}$$

where R denotes the amount repaid, and V_R is the continuation payoff from repayment. Rearranging gives

$$u(y) - u(y - R) > \beta(V_R - U_D). \tag{6.8}$$

This condition is satisfied only if output is less than some critical level $y < f(R)$. Since $u(\cdot)$ is concave, increasing in its arguments, and has the properties $u' > 0, u'' < 0$, we can write

$$g(y, R) = u(y) - u(y - R). \tag{6.9}$$

where $\partial g/\partial y < 0$, and $\partial g/\partial R > 0$.

At the critical threshold,

$$g[f(R), R] = \beta(V_R - U_D). \tag{6.10}$$

It follows, therefore, that

$$f'(R) = \frac{-\partial g/\partial y}{\partial g/\partial R} \quad \text{and} \quad f'(R) > 0. \tag{6.11}$$

In other words, strategic default is more likely to occur when output is low or when the burden of debt is high.

International capital markets are populated by atomistic risk-neutral lenders. If lenders face a risk-free rate, i, then a zero-profit condition for lending suggests that

$$R(B) = \frac{(1+i)B}{\Pr[\tilde{y} > f(R(B))]}. \tag{6.12}$$

We can now characterise the optimisation problem for the debtor. The country will borrow an amount, $B(y)$, that solves

$$\max \left[u(y+B) + \beta \mathrm{E}\left[\max\{u(y') + \beta U_D, u(y' - R(B)\} + \beta V_R\right]\right], \tag{6.13}$$

where $R(B)$ is the repayment function, and y' denotes unknown future output. An equilibrium in the credit market is characterised by a borrowing decision, B, a repayment function, $R(B)$, and a critical default threshold, $f(R)$. In equilibrium, the country either pays the full amount or nothing. Strategic default occurs when current output is low relative to outstanding debt. The gains from consumption smoothing are lost when a default occurs. After a default, lenders cease to lend and the debtor returns to a state of autarky.

An obvious drawback of the model is that it assumes that penalties are always enforced following a default. The renegotiation of debt contracts may, however, be more desirable from the standpoint of both creditors and debtors. The possibility that debtors and creditors might abandon the trigger strategy punishment in favour of mutually beneficial renegotiation raises doubts about the credibility of a threat of permanent exclusion from world capital markets. Bulow and Rogoff (1989*a*) apply the insights of the Rubinstein (1982) bargaining game to this issue. In their model, the only collateral for sovereign lending is the debtor's gains from trade. The debtor can bargain because creditors can receive nothing until the country is able to export its goods. Also, while negotiations are proceeding, goods depreciate and creditors forgo interest—debt negotiation is costly. Rescheduling arises in the context of a *perfect* equilibrium, where either party agrees to a rescheduling proposal if that proposal offers at least as much in discounted present value as can be hoped by waiting, given the strategies of the other party.

6.3 DIRECT SANCTIONS AND REPUTATION

An important assumption in the model above is that the debtor is unable to enter into alternative financial arrangements after a default. Bulow and Rogoff (1989*b*) relax this assumption and show that the threat of exclusion from capital markets, *on its own*, is insufficient motivation for a country to repay its debt. Implicit in their critique is the existence of 'Swiss bankers' who are endowed with a commitment technology that allows them to honour any contract signed by the debtor and, hence, are immune from seizure by creditors.

The intuition behind the Bulow and Rogoff argument is as follows. Once the (discounted) value of foreign debt is sufficiently high, the country has an incentive to default, especially if it can obtain the market rate of return by investing in a Swiss bank account. When the value of debt is at a maximum, the present value of future repayments from then on will be positive. In other words, the country can generate 'savings' by operating an interest-bearing account. There is then no longer any period in which creditors can lend an amount that the country cannot self-finance. Using its savings, the country can place itself on a better consumption path than that implied by a policy of repayment. This makes default preferable as an option and, as a result, creditors are unwilling to extend loans.

Following Eaton and Fernandez (1995), consider an endowment economy with access to a 'Swiss' bank account that provides a gross rate of return, r, equal to that demanded by creditors. Let $M > 0$ be the upper bound above which creditors will not allow the country's debt to exceed. Denote by s the date at which the country's debt equals M.

Suppose that the debtor places an investment, A_t, in the Swiss bank account at date t, and let G_t be the return from that investment in period t. If the country deviates from its strategy of repayment as of period s, then it is able to take the amount promised to creditors, $\tilde{R}_s$, and invest it in the Swiss account. The country also deposits in the Swiss account any additional investment, $\tilde{A}_s$, that it might have made in period s. Variables with a $\sim$ denote values of variables when the country follows its specified repayment path.

Once the upper bound of debt is attained,

$$\tilde{B}_s = M. \tag{6.14}$$

And in period $s + 1$, the debt burden is

$$\tilde{B}_{s+1} = r(\tilde{B}_s - \tilde{R}_s) \leq M. \tag{6.15}$$

Rearranging the above expression we have

$$\tilde{R}_s \geq M(r - 1)/r > 0. \tag{6.16}$$

In other words, the repayment amount paid into the Swiss account is positive.

In the following period, the country receives the returns from its bank account. In particular, it obtains

$$G_{s+1} = r(\tilde{A}_s + \tilde{R}_s) = \tilde{G}_{s+1} + r\tilde{R}_s. \tag{6.17}$$

The country continues with its modified strategy, making a further payment of $\tilde{R}_{s+1}$ into the Swiss account. As a result,

$$A_{s+1} = \tilde{A}_{s+1} + r\tilde{R}_s + \tilde{R}_{s+1}. \tag{6.18}$$

Now

$$r\tilde{R}_s + \tilde{R}_{s+1} = rM - (\tilde{B}_{s+1} - \tilde{R}_{s+1}) \geq rM - (M/r) > 0. \tag{6.19}$$

By continuing to invest in this fashion in every period following s, the country's consumption is unchanged from that under a policy of repayment, and its savings τ periods later are

$$\tilde{A}_{s+\tau} + Mr^{\tau} - M/r, \tag{6.20}$$

which is larger than the original amount. Thus, a country can increase consumption above the amount called for by a policy of repayment by defaulting, placing the amount in a Swiss account, and using the subsequent saving to improve its utility. The only value of M that can be maintained as an equilibrium is $M = 0$, that is, there is no international borrowing. Put differently, there is always a way to obtain the same risk diversification through holding assets instead of debts, so that an inability to borrow (because of a past default) does not entail a real cost. The threat of a cutoff of future credit alone is insufficient to sustain lending, suggesting that loans to sovereigns may only be possible if direct sanctions are available to creditors.

At first glance, the Bulow and Rogoff model appears somewhat farfetched. A country like Korea cannot simply approach a Swiss bank with monies due to, say, Citibank and use these resources as an insurance against future income fluctuations. But the value of the model lies in the fact that it highlights the limitations of *'carrots'* in ensuring good debtor behaviour. The *'stick'* of costly liquidation may be a more effective tool in deterring strategic default. It suggests quite forcefully that the cost of crisis sparked by creditor coordination failure is, in the final analysis, a market solution to the lack of contract enforcement at the sovereign level. The threat of a creditor run thus becomes an integral part of the smooth functioning of the international capital market. As we will see in Chapter 9, this issue occupies a central position in the architecture debate.

Cole and Kehoe (1995) argue that the Bulow and Rogoff critique is valid only in a complete information environment. They suggest that more insights into the theory of sovereign risk may be gained from models of reputation that incorporate incomplete information.[22] Following Kreps and Wilson (1982), they model a small country facing risk-neutral lenders. The debtor country government is risk neutral and comes in two types: a 'normal' government that discounts the future at rate β, and defaults if it is economically rational to do so; and an 'honest' government which evaluates consumption streams in the same way as a 'normal' government, but assigns a large disutility to breaking the debt contract. More formally, the preferences for the two types of government are:

$$U_{\text{normal}} = \sum_{t=0}^{T} \beta^t c_t, \tag{6.21}$$

$$U_{\text{honest}} = \sum_{t=0}^{T} \beta^t c_t - (1 - z_t)M, \tag{6.22}$$

where c_t is consumption at time t, $z_t = 1$ if the government repays and $z_t = 0$ corresponds to default, and M is a large positive number. The horizon is infinite and the government knows its own type. Lenders hold subjective beliefs about what type the government is, and they update these beliefs after seeing the actions of the government. In particular, lender's beliefs are summarised by a conditional probability at time t that the government is honest. We denote this probability by p_t and call it the *reputation* of the government.

[22] Kletzer and Wright (2000) make an alternative case for reputation in sovereign lending which does not rely on incomplete information.

In the Kreps–Wilson model, reputation evolves according to Bayes' rule. Let σ denote the probability that the government repays. The Bayesian equilibrium that Cole and Kehoe compute has two requirements: at every possible state, each agent acts optimally given the strategies and beliefs of the other agents, and beliefs are updated according to Bayes' rule. Since the honest government never defaults, Bayes' rule implies that the probability that the government is honest at $t+1$, conditional on repayment at t (and all previous repayments) is[23]

$$p_{t+1} = \frac{p_t}{p_t + (1 - p_t)\sigma_t}. \tag{6.23}$$

The model is solved by backwards induction, and illustrates how a 'normal' government has an incentive to establish a reputation for honour. Since creditors do not know what kind of government they face, the debtor has an incentive to appear honest by choosing not to default during the early periods of the game. During the second phase of the game, the government adopts a randomising or 'mixing' strategy over whether to repay or not, and the probability of default gradually increases over time.[24] In the final period, the (normal) debtor repudiates for sure. Therefore, a very small prior probability of honesty ensures a mutually beneficial outcome for most of the time, if the horizon is sufficiently long (albeit finite).

Although direct application of the Kreps–Wilson argument suggests that reputation may be key to sustaining international lending, Cole and Kehoe demonstrate that the framework is only able to support a small amount of lending. They develop a variant in which the debtor has multiple-trust relationships. They build on the previous analysis by adding another agent, domestic residents, who have a contract with the government (e.g. a dam building project). The honest government now attaches a positive disutility to breaking either of its two contracts—that with the lenders, or that with the workers. In such an environment, there can be reputational spillovers. For example, domestic agents who see a government failing to honour a contract with a foreign lender may think that a similar fate will befall them.

[23] Bayes' rule implies that:

$$\Pr[H_{t+1} \mid \text{repayment}] = \frac{\Pr[\text{repayment} \mid H] \cdot \Pr[H]}{\Pr[\text{repayment} \mid H] \cdot \Pr[H] + \Pr[\text{repayment} \mid N] \cdot \Pr[N]},$$

where H is honest and N is normal.

[24] Fischer (1990) criticises this aspect of the Kreps–Wilson construct, on the grounds that governments do not randomise when making decisions.

Such spillover effects increase the incentive for the debtor to maintain good relations with international creditors.

The obvious appeal of reputational theories of international lending is that they appear to be robust to institutional detail. There is little need to speculate on the legal rights of creditors, or on their ability to take retaliatory measures. But there are several problems with modelling penalties using reputation-based models alone. In most cases, the models generate a multiplicity of equilibria, and the qualitative nature of these equilibria are extremely sensitive to informational assumptions. Models underpinned by a more 'direct' penalty structure and explicitly incorporating the enforceability problem are therefore more amenable to analysis.

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7

Spotting Financial Crises

7.1 EARLY WARNING MODELS

The theoretical analysis of the earlier chapters provides the basis for the design of an early warning system. We have seen how weak economic fundamentals, private agents' expectations or, indeed, a mixture of both, are the main causes of financial crisis. It is natural, therefore, to ask if some variables are particularly useful in predicting crises. Researchers have identified a large number of variables, ranging from standard macro and financial variables, such as GDP growth and real interest rates, to political stability indices as potential indicators of crisis. The aim has been to develop empirical models that rank the vulnerability of countries and/or predict future crisis within a well-defined statistical framework. To do this, the majority of models simply evaluate a set of indicators to reflect all potential causes of a crisis suggested by theoretical analyses. An important justification for this selection approach is the observational equivalence of sunspot and fundamentals-based models.[25]

There are, in general, three different types of approach to building an early warning system: signalling, discrete-choice, and structural approaches (see Figure 7.1). While structural models are built around a particular crisis and, hence, are possibly more suited to monitoring/early warning purposes, discrete-choice, and signalling models are used for forecasting crises as well. Regardless of approach, however, most models share two common features. First, they mainly analyse currency crises, using an exchange rate pressure measure to identify a crisis. Second, the models are estimated with a panel of multi-country data covering a period of time before a major international crisis. Kaminsky *et al*. (1998) examine twenty-eight studies on

[25] As pointed out by Eichengreen *et al*. (1995), while the absence of differences in some indicators in the run up to speculative attacks is consistent with sunspot models, it is also consistent with a restrictive class of fundamentals-based models when the policy shift is expected with certainty.

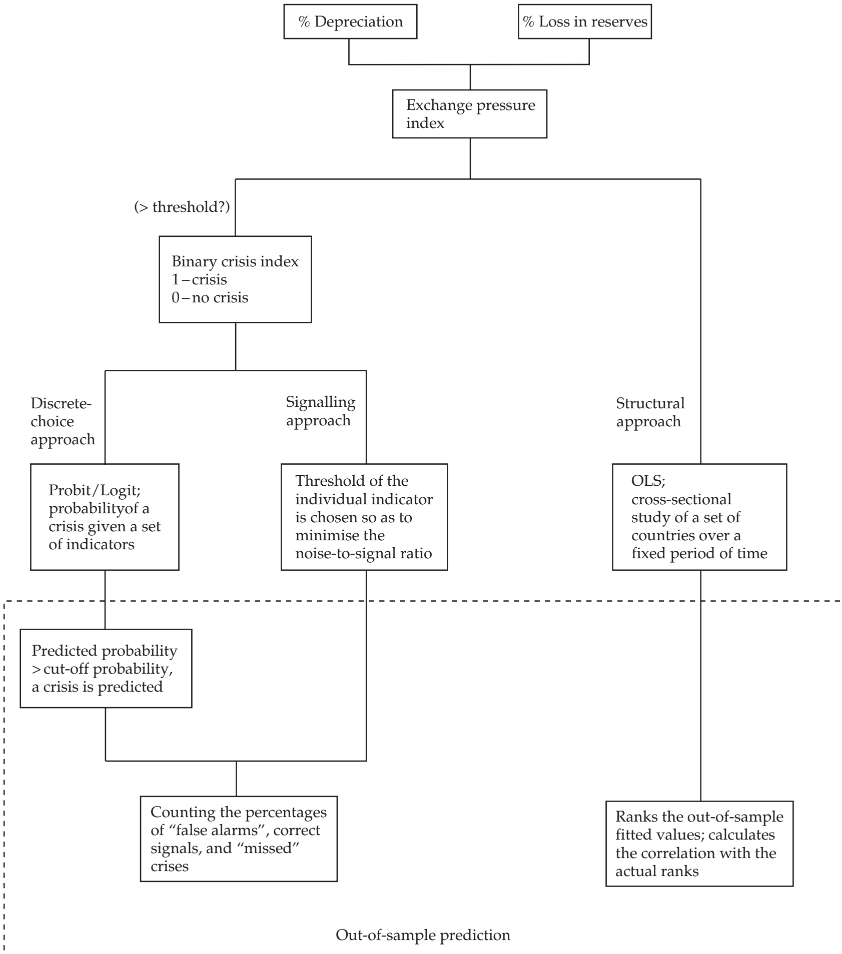

Figure 7.1. *Comparing the three approaches in building indicator models*

currency crisis conducted before the Asian crisis and summarise the indicators used into ten different categories (see Table 7.1). A total of 46 variables were examined by the authors, ranging from standard economic fundamentals to some political stability and institutional measures.

7.1.1 *The Signalling Method*

In the 'signalling' approach, certain key economic variables, such as the real exchange rate or the debt to GDP ratio, are used as indicators and evaluated against certain threshold levels. Once the

Table 7.1. *Potential indicators of crisis*

Category	Variables[a]	Comments
Capital account	Foreign Exchange reserves, capital flows, short-term capital flows, FDI and interest rate differential. (5)	These variables are mostly related to the fundamentals-based.
Debt profile	Public foreign debt, private debt, short-term debt, debt service and foreign aid. (5)	The debt-profile gives a broad picture of burden of debt-service, liquidity risks and the robustness of a country's foreign exchange reserves.
Current account	Real exchange rate, current account balance, trade balance, exports, imports, terms of trade, price of exports, savings, investment, and regional trade links. (11)	Current account relates to the economic fundamentals. Regional trade links can be used as proxy variables for contagion.
International variables	Foreign real GDP growth, interest rates and price level. (3)	This is especially important for the structural approach discussed in Section 7.1.3, for example the state of the German economy is crucial for the ERM crisis study.
Financial liberalisation	Credit growth, change in the money multiplier, real interest rates, and spread between lending and deposit rates. (4)	Incomplete and uncontrolled financial liberalisation is said to be among the causes of moral hazard.
Other financial variables	Central bank credit to the banking system, money growth, bond yields, parallel market rate premium. (4)	Play rather a minor role.
Real sector	Real GDP growth, output, output gap, employment or unemployment, wages, and changes in stock prices. (7)	Mainly based on the fundamentals-based.
Fiscal variables	Fiscal deficit, government consumption, and credit to the public sector. (3)	Ditto.
Political variables	Political stability index. (1)	Affecting agents' expectations.
Institutional factors	Openness, exchange controls, duration of the fixed-rate periods. (3)	Can relate to any type of model.

[a] Figures in brackets are the number of variables.

thresholds are breached, they signal the possibility of a future crisis. The optimal threshold is chosen on an indicator-by-indicator basis, so as to balance out the risks of failing to predict the crisis and giving a false signal of an impending crisis. Representative of this method are Kaminsky *et al*. (1998), henceforth KLR for currency crises, and Kaminsky and Reinhart (1999) for both currency and banking crises together. Berg and Pattillo (1999*a*) and Edison (2000), in evaluating and further developing this line of attack, re-estimate the KLR results with revised data.

In KLR, a crisis is defined as a situation in which an attack on the currency leads to a sharp depreciation, a large decline in foreign reserves, or both. They create an exchange rate pressure index, p which is a weighted average of percentage devaluation and changes in reserves, measured in US dollars.[26] The index attempts to capture the actual depreciation of a currency and the scale of unsuccessful speculative attacks (measured by decreases in reserves). Thus p is constructed as

$$p = \frac{\Delta e}{e} - \frac{\sigma_e}{\sigma_r}\frac{\Delta r}{r} = \frac{\Delta e}{e} - \alpha\frac{\Delta r}{r}, \tag{7.1}$$

where e is the nominal bilateral exchange rate (normally against the US dollar) and r is total international reserves. The weight is chosen arbitrarily and, in the above equation, is the ratio of the sample standard deviation of the two components. A minus sign is attached to the weight so that the higher is p, the stronger the pressure on the currency. The exchange rate pressure index is then converted into a binary variable, c, of crises '(1)' and tranquil periods '(0)'. A simple rule is that whenever p exceeds its sample mean, μ_p, by several multiples (ϕ, arbitrarily chosen) of its sample standard deviation, σ_p, a crisis is recorded,

$$\text{crisis}, c = \begin{cases} 1, & \text{if } p > \mu_p + \phi\sigma_p, \\ 0, & \text{otherwise.} \end{cases} \tag{7.2}$$

KLR choose sixteen indicators based on theoretical reasoning and the availability of monthly data (see Table 7.2). Apart from real

[26] KLR take into consideration the distortionary effects created by a 'very' high inflation rate. They subdivide the whole sample into two, then calculate the sample mean, variance and weights according to whether inflation in the previous six months exceeds 150%.

Table 7.2. *Noise-to-signal ratios of currency crisis indicators*

	KLR	Berg–Pattillo's rerun	Edison's rerun
Real exchange rate	0.19	0.25	0.22
Banking crises	0.34	—	—
Export growth rate	0.42	0.46	0.52
Stock price index growth rate	0.47	1.75	0.57
M2/international reserves (level)	0.48	0.45	0.54
Industrial production growth rate	0.52	1.24	0.57
'Excess' M1 balances	0.52	0.67	0.60
International reserves growth rate	0.55	0.47	0.57
M2 multiplier growth rate	0.61	0.82	0.89
Domestic credit/GDP growth rate	0.62	0.70	0.63
Real interest rate	0.77	0.75	0.69
Terms of trade growth rate	0.77	1.45	—
Real interest differential	0.99	1.99	1.20
Import growth rate	1.16	1.20	1.20
Bank deposits growth rate	1.20	1.60	1.05
Lending rate/deposit rate	1.69	1.51	2.30

Note: An indicator is said to be useful when the noise-to-signal ratio is < 1.

exchange rate overvaluation (measured as deviation from trend), 'excess' real M1 balances,[27] interest rates and banking crises variables, the other indicators are expressed as seasonally adjusted year-on-year percentage changes to allow for international comparison. For each indicator, a country-specific threshold is defined according to the percentiles of the distribution of that indicator. A crisis signal is generated whenever the value of the indicator exceeds its threshold. And a signal is said to be 'good' if it is followed by a crisis within a signalling horizon (arbitrarily chosen as 24 months in most studies using monthly data), otherwise, it is a 'bad' signal or noise. The 'optimal' set of thresholds (i.e. the percentiles) is chosen to minimise the noise-to-signal ratio.[28]

27 This variable is defined as real M1 (deflated by consumer prices) minus an estimated demand for money, with the latter being a function of real GDP, inflation and time.

28 This could, of course, in principle be different for each indicator as well as each country.

	Crisis within twenty-four months	**No crisis within twenty-four months**
Signal was issued	A	B
No signal was issued	C	D

In the matrix above, A represents the number of months in which the indicator generates a good signal, B is the number of months in which the indicator issues a bad signal or 'noise', C is the number of months in which the indicator fails to issue a signal, which would have been good, and D is the number of months in which the indicator did not issue a signal that would have been bad. The noise-to-signal ratio is defined as the ratio of the share of bad signals to the share of good signals, that is,

$$\text{Noise-to-signal ratio} = \frac{B}{B+D}\bigg/\frac{A}{A+C}.$$

The indicator is said to be 'useful' if the noise-to-signal ratio is less than one.[29] Minimising the signal is equivalent to minimising B/A, since $(A+C)/(B+D)$ is a function of the frequency of crises in the data and, hence, does not depend on the threshold.

The KLR results (together with the re-runs by Berg and Pattillo, 1999*a*; and Edison, 2000) are summarised in Table 7.2. The three sets of results are rather similar except that KLR find 13 out of 16 indicators to be useful, whereas the other analyses find fewer useful indicators. Two current account indicators—the deviations of the real exchange rate from trend and export growth—appear to be the most useful in all three studies. The usefulness of real sector indicators such as stock price and industrial production appears to be more mixed, however.

Edison (2000) expands the KLR study to include eight additional countries (Korea, Portugal, South Africa, Greece, India, Pakistan, Sri Lanka and Singapore) as well as seven extra indicators (annual growth in US and G-7 countries' income, year-on-year changes in the US three-month Treasury bill rate, oil prices and short-term debt (BIS)

[29] Another way to determine the effectiveness of an indicator is to compare the conditional probability of a crisis on a signal being issued, $A/(A+B)$, with the unconditional probability of a crisis, $(A+C)/(A+B+C+D)$. If the former is higher, the indicator is informative. In fact, it is easy to prove that this condition is equivalent to the less-than-unity noise-to-signal condition. First assume $B/(B+D) = kA/(A+C)$, so that the noise-to-signal ratio condition implies that $k < 1$. Substituting into the conditional probability condition, we can see that the conditional probability is larger than the unconditional probability.

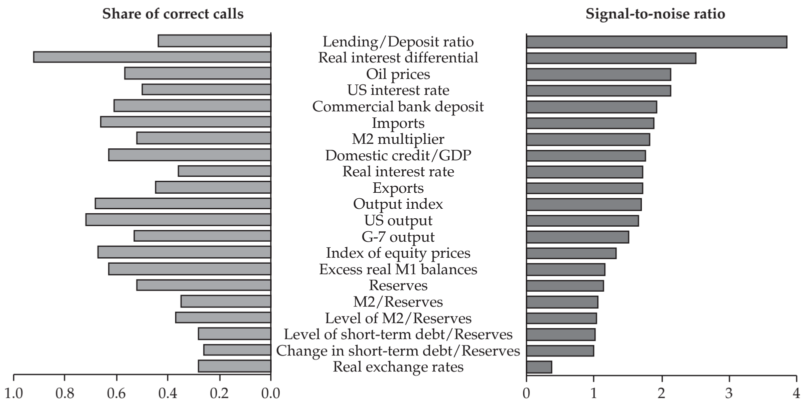

Figure 7.2. *Performance of the indicators*

Source: Edison (2000).

to foreign exchange reserves, and the levels of the M2/reserves and short-term debt/reserves ratios) over a longer sample period (from January 1970 to April 1995).[30] Her results are broadly similar to KLR and all extra indicators are informative (i.e. with noise-to-signal ratio below one). But the expanded coverage affects the selection of the optimal threshold since the latter is sample dependent (chosen as the minimum noise-to-signal ratio for an indicator across all countries).

Edison (2000) compares the 'performance' of the indicators on the basis of the inverse of the noise-to-signal ratio (i.e. the ratio of good signals to noise) with that of the share of crises called correctly (see Figure 7.2). Interestingly, while the real exchange rate overvaluation indicator is ranked first on the basis of having the highest signal-to-noise ratio, the measure is ranked fifteenth using the share of correct calls criterion. The high noise-to-signal ratio may reflect the fact that, prior to the crisis, the real exchange rate was overvalued for extended periods and may have yielded a high noise-to-signal ratio. And for many crises the real exchange rate did not issue any signal at all, resulting in a low ranking on the basis of share of correct calls.

Kaminsky and Reinhart (1999) apply signalling methods to analyse banking and currency crises in parallel. They calculate the probability of currency crises conditional on there having been a banking crisis

[30] Edison drops the last eight months of 1995 from the sample to evaluate the predictive capabilities (on the basis of twenty-four month signalling horizon) of the model for the 1997 Asian crisis.

within the past twenty-four months and vice versa, before comparing these with the unconditional probabilities. They find that problems in the banking sector normally precede a currency crisis, and that a currency crisis, in turn, could increase the risk of a banking crisis.

Kaminsky (1999) aggregates the information provided by all the indicators to assess the overall likelihood of an impending crisis. The simplest method is to count the number of signals issued by the different indicators of the economy at a particular point in time and, the larger the number of signals, the higher the likelihood of a crisis. In this simple aggregation, all indicators have equal importance in crisis inference. To allow for different indicator performances, Kaminsky suggests a composite index, I_t, at time t for each country, which is a weighted average of the number of indicators which give out a signal,

$$I_t = \sum_{j=1}^{n} \frac{S_t^j}{\omega^j},$$

where S_t^j equals to one if indicator j issues a signal at t, n is the total number of indicators, and ω^j is the noise-to-signal ratio of indicator j. Such composite indices (simple aggregation and weighted by noise-to-signal ratio) provide information on the vulnerability of a country at a particular point in time and, by looking at a series of these snapshots, we can assess whether a country has become more or less vulnerable during the time period studied. It is also possible to use these indices to calculate the probability of a future crisis. For example, the probability that a crisis will occur within h months from t, given that the composite index lies between a particular range of values, say, $\underline{I}$ and $\bar{I}$ is

$$\text{Prob}\left(\text{crisis}_{t,t+h} | \underline{I} < I_t < \bar{I}\right) = \frac{\text{no. of months with a crisis occurs between } t, t+h \text{ given } \underline{I} < I_t < \bar{I}}{\text{number of months with } \underline{I} < I_t < \bar{I}}.$$

7.1.2 *The Discrete-Choice Approach*

While the signalling approach aims to extract a 'crisis signal' from each individual indicator, the discrete-choice approach evaluates directly the conditional probability of a crisis, given a set of indicators.[31]

[31] Discrete-choice theory has long been popular among psychologists and biologists analysing human behaviour and biological experiments respectively (see Finney, 1971, for a survey of historical developments).

The idea is to separate different countries and time periods into two discrete episodes: a crisis and a tranquil period. By mapping a set of indicators, as suggested *a priori* by theory, into a known probability distribution of these episodes, we can evaluate the likelihood of a crisis using Logit/Probit methods.

Let y denote the crisis variable that takes a value of either 1 (if a crisis occurs) or 0 (otherwise). Let x be a vector of potential indicators and $\boldsymbol{\beta}$ be a vector of parameters. We can then write the probability of having a crisis as:

$$P(y = 1) = f(\boldsymbol{\beta}'\mathbf{x}),$$

where $f(\cdot)$ is a probability distribution function. Assuming a logistic distribution, then

$$P(y = 1) = \frac{\exp(\boldsymbol{\beta}'\mathbf{x})}{1 + \exp(\boldsymbol{\beta}'\mathbf{x})}, \qquad P(y = 0) = \frac{1}{1 + \exp(\boldsymbol{\beta}'\mathbf{x})}.$$

The parameter vector $\boldsymbol{\beta}$ is estimated by maximum likelihood and the regression is a standard Logit one.[32]

Studies adopting this approach include Goldman Sachs' GS-WATCH,[33] J. P. Morgan's Event Risk Indicator (ERI), Frankel and Rose (1996), and Kumar *et al*. (1998) for currency crises, and Demirgüç-Kunt and Detragiache (1998) for banking crises. The differences between them stems from their treatment of three important issues: (i) the definition of a crisis; (ii) sample selection (both frequency and number of countries selected); and (iii) the variables used.

Crisis definition

As with signalling models, discrete-choice studies define a crisis on the basis of some form of exchange rate pressure exceeding its threshold. But as we can see from Table 7.3, the exchange rate variable chosen varies, ranging from straight nominal depreciation to a composite index using changes in reserves and depreciation.[34] The threshold level chosen also differs between studies.

Discrete-choice studies, with the exception of GS-WATCH, test for robustness by varying their respective threshold levels. GS-WATCH, by contrast, adopts a technique called the self-exciting threshold

[32] The decision to use Logit or Probit (normal distribution) is purely arbitrary since the logistic and normal distributions are quite similar. [33] See Ades *et al*. (1998).

[34] Other researchers such as Eichengreen *et al*. (1995) attempt to fine tune the index by taking into account domestic interest rate changes and high inflation periods, but encounter significant data availability problems.

Table 7.3. *Definition of currency crisis*

Study	Definition of crisis	Sample freq. and results
Goldman Sachs GS-WATCH	The weighted average of three-month changes in trade-weighted real exchange rate and reserves. Weights are chosen by the inverse of their standard deviations. A crisis is defined as a period when the index is above its threshold (determined by a signalling autoregression).	Monthly data; data starting from 1983; 27 emerging economies.
JP Morgan ERI	A fall in the real bilateral exchange rate of over 10% over the course of one month or 22 business days.	Monthly data; 1980 : 1–1994 : 12, 14 crashes; 1995 : 1–1997 : 12, 14 crashes. Two thresholds being tested (8% and 12%); 25 countries.
Frankel and Rose (1996)	A nominal exchange rate depreciation of at least 25% that also exceeds the previous year's change in the exchange rate by 10%.	Annual data; 1971–1992: 70 crashes out of the total of 803 episodes; 105 countries.
Kumar *et al.* (1998)	Currency depreciations (nominal) of at least 5%, 10%, and 15%; depreciations can be either total or unanticipated (i.e. adjusted for interest rate differentials between the relevant domestic currency and the US dollar).	Monthly data; 1985 : 1–1998 : 3 covering 32 emerging markets. Number of crisis episodes varies.

autoregression (SETAR) to extract the optimal threshold levels for the crisis index y_t (measured as a weighted average of three-month changes in the trade-weighted real exchange rate and reserves). In general form, a SETAR $(1, d, r)$ is specified as:

$$
\begin{aligned}
y_t = {} & \alpha_1 + \alpha_2 1(y_{t-d} > r) \\
& + [\phi_1 + \phi_2 1(y_{t-d} > r)]y_{t-1} + [\psi_1 + \psi_2 1(y_{t-d} > r)]\varepsilon_t,
\end{aligned}
$$

where ε_t are i.i.d. with mean zero and unit variances; $1(A)$ is an indicator function which is equal to one if the event A occurs and zero otherwise, d is a delay parameter, and r is a threshold parameter.[35] GS-WATCH consider a simplified SETAR by choosing a one-period lag, that is,

$$y_t = \alpha_1 + \alpha_2 1_t + \phi_1 y_{t-1} + \phi_2 1_t y_{t-1} + \varepsilon_t \tag{7.3}$$

and the value of the threshold is chosen so that the model has the lowest standard error in maximum likelihood estimation.

Sample selection

The choice of sample frequency varies between studies. Frankel and Rose (1996) choose annual data on the basis of data availability. But the majority of the studies (GS-WATCH, J. P. Morgan's ERI, and Kumar *et al*. 1998) opt for monthly data to obtain frequent and up-to-date early warning signals. The selection of annual data allows Frankel and Rose (1996) to cover a larger number of heterogeneous countries (105 developed and emerging market economies), whereas models with monthly data are confined to examining a much smaller group of emerging market economies.

Variables

The number of variables tested/used also differs. The model that examines the greatest number (a total of thirty-two) is Kumar *et al*. (1998), who classify them according to the following twelve categories: (1) output and inflation; (2) money and credit; (3) fiscal variables; (4) domestic financial market; (5) trade and current account; (6) capital flows and debt; (7) reserves, terms of funds, and the real exchange rate; (8) policy environment; (9) global output, inflation, and liquidity; (10) global financial markets; (11) international commodity prices; and (12) regional effects. The other three studies are more parsimonious, and examine the much smaller set of variables summarised in Table 7.4.

7.1.3 *Structural Models*

An alternative empirical approach has been to develop structural models to explain the causes of currency crises in terms of characteristics which make a country more vulnerable to speculative attacks. Papers in this spirit include Dornbusch *et al*. (1995), Sachs *et al*. (1996*a*), and Bussiére and Mulder (1999).

Dornbusch *et al*. (1995) is largely a descriptive study. Using a mixture of annual and quarterly data covering the period 1975–95,

[35] Potter (1995) provides a summary of various approaches to estimate the noise parameters d and r.

Table 7.4. *Leading indicators for currency crises*

	GS-WATCH	J. P. Morgan	Frankel and Rose
Capital flows and debt Current account/GDP			•
Current account + amortisation	•		
Reserves/M2	•		
Reserves/debt		•	
Reserves/imports			•
Public sector debt			•
Total debt/GDP			•
Government budget deficit/GDP			•
Short-term debt			•
Commercial bank lending	•		•
Concessional lending			•
Debt at variable interest rate			•
IFI lending			•
FDI/debt stock			•
Current account Overvaluation	•	•	•
Real sector GDP growth		•	•
Export growth	•		•
International variables OECD output growth			•
Developed countries' interest rates	•		•
Financial variable Equity index	•		
Domestic credit growth			•
Contagion dummy	•	•	
Political risk	•		

Note: GS-WATCH first transforms all the explanatory variables (except export growth and political risk) into signals as specified in equation (7.3).

they compare the pre and post-crisis behaviour of the following variables: (1) the real exchange rate; (2) real interest rates; (3) GDP growth; (4) inflation; (5) fiscal deficit/GDP ratio; (6) credit growth; (7) trade balance/GDP ratio; (8) current account/GDP ratio; (9) international reserves; and (10) debt/GDP ratio. The focus of the discussion is on the common patterns observed in the periods leading up to currency crises in Argentina, Brazil, Chile, Finland, and Mexico. These crises are identified as stemming from a combination of negative external shocks, such as the sharp rise in US interest rates, and deteriorating economic fundamentals, such as fiscal deficits and overvaluation of the real exchange rate.

Sachs *et al*. (1996*a*) consider a cross-section of 20 emerging markets during the 1994 Mexican crisis. Using monthly data, they create a crisis pressure index (IND)—a weighted sum of the percentage decrease in foreign exchange reserves, and the percentage depreciation of the exchange rate between the end of November 1994 and the end of each of the first six months of 1995. But unlike the discrete-choice and signalling approaches, which convert the index into a binary variable, Sachs *et al*. (1996*a*) regress this (continuous) crisis index against a set of explanatory variables. The explanatory variables are a lending boom variable (LB), an overvaluation measure (RER), and dummies for low reserves and weak fundamentals. The lending boom variable, used to proxy the strength of the banking system or 'fundamentals', is measured by the growth in loans in the private sectors between 1990 and 1994. Real exchange rate misalignment is taken as the average real effective exchange rate depreciation of 1986–89 to that of 1990–94. Dummies are introduced to test whether a country suffers more severe speculative attacks when its international reserves are low and/or fundamentals are weak. Reserves, measured as the M2/reserves ratio, are said to be 'low' (DLR $= 1$) when they lie in the lowest quartile in the sample. And 'weak' fundamentals (DWF $= 1$) is defined as the case when the exchange rate depreciation is in the lowest three quartiles *and* the lending boom variable is in the highest three quartiles. They estimate the following regression:

$$\begin{aligned}\text{IND} = \beta_1 &+ \beta_2(\text{RER}) + \beta_3(\text{LB}) \\ &+ \beta_4(\text{DLR} \times \text{RER}) + \beta_5(\text{DLR} \times \text{LB}) \\ &+ \beta_6(\text{DLR} \times \text{DWF} \times \text{RER}) \\ &+ \beta_7(\text{DLR} \times \text{DWF} \times \text{LB}) + \varepsilon.\end{aligned}$$

Table 7.5. *The Sachs et al. (1996a) hypothesis testing matrix*

		Fundamentals	
		Strong (DWF = 0)	Weak (DWF = 1)
	High ($DLR = 0$)	$\beta_2 = 0,$ $\beta_3 = 0.$	
Reserves	Low ($DLR = 1$)	$\beta_2 + \beta_4 = 0,$ $\beta_3 + \beta_5 = 0.$	$\beta_2 + \beta_4 + \beta_6 < 0,$ $\beta_3 + \beta_5 + \beta_7 > 0.$

Dummies: DLR = 1 when reserves are low,
DWF = 1 when fundamentals are weak.

Table 7.5 sets out some of the null hypotheses considered by Sachs *et al*. (1996a). The hypotheses suggest that countries with strong fundamentals but low reserves are unlikely to be attacked, ($\beta_2 + \beta_4$ and $\beta_3 + \beta_5$ are not significantly different from zero when DLW = 1 and DWF = 0). Also for those countries with weak fundamentals (DWF = 0) and low reserves (DLW = 1), a more devalued real exchange rate or a smaller lending boom leads to a smaller crisis pressure index ($\beta_2 + \beta_4 + \beta_6 < 0$, $\beta_3 + \beta_5 + \beta_7 > 0$). Corsetti *et al*. (1999) adopt a similar framework to examine the Asian crisis and find that variables—such as non-performing loans in the banking system, the current account, and M1—which proxy for the strength of fundamentals and the position of reserves, are also significant explanatory variables.

Bussiére and Mulder (1999) evaluate the power of such models (estimated with data up to 1997) in predicting crisis out-of-sample (the 1998 Russian crisis). To do so, they compute the rank correlation between the in-sample predictions and actual values, and compare these with the out-of-sample correlation. The out-of-sample prediction of the Russian crisis based on the Sachs *et al*. (1996*a*) specification is poor, and the rank correlation coefficient of the predicted and the actual rankings of exchange pressure index is negative. On this basis, they argue that the complete set of variables in Sachs *et al*. (1996*a*) behaves as a 'contra-indicator'. Moreover for the recovering Asian crisis countries, with banking systems still on the mend, the persistent high values of the lending boom variable appear to exaggerate the predicted exchange pressure index.

Bussiére and Mulder (1999) also consider five indicators featured in an early warning system developed by the IMF—Developing Country Studies Division Model (DCSD).[36] Three variables score particularly well in predicting the 1998 crisis out-of-sample. These include short-term debt to reserves, the change in the real exchange rate and ratio of current account deficit/GDP. In particular, the short-term debt to reserves ratio appears to be by far the best liquidity indicator, outperforming money-based (e.g. M2/reserves) and import-based ratios, in predicting the Mexican, Asian, and Russian crises. But the other two indicators tested—the change in the rate of export growth and the percentage change in reserves—were statistically insignificant.

7.1.4 *Leading Indicators*

Regardless of the approach adopted, an interesting conclusion from these empirical analyses is that a particular set of indicators seems to emerge as being particularly informative (see Tables 7.2 and 7.4). Apart from the 'usual' macroeconomic variables, such as GDP growth, export growth, and fiscal deficit/GDP, some other variables appear particularly relevant for the capital account crises of the 1990s. These can be grouped into three categories: real exchange rate overvaluation, liquidity problems, and weaknesses in the banking sector.

Real exchange rate misalignment

Almost all studies find real exchange rate misalignment to be a useful predictor of crises. Overvaluation can be seen as a summary variable, reflecting economic imbalances in a country. But a key question concerns the measure of misalignment. While some studies (e.g. Sachs *et al*. 1996*a*) measure the real exchange rate as a weighted average of the bilateral real exchange rates of a country with respect to three major currency blocs (US$, DM, and Yen), others simply adopt a CPI-based real effective exchange rate index as defined by the IMF Information Notice System (INS, a direct trade-weighted system). As Bussiére and Mulder (1999) point out, INS does not capture fully third-party effects and, hence, neglects the effects of entrepôt trade (that constitutes a substantial part in some Asian countries' total trade) on relative price movements.

[36] The IMF DCSD is based on Berg and Pattillo (1998), and is a discrete-choice based model.

Goldfajn and Valdés (1998) use three different measures of real exchange rate misalignment to investigate the effects of overvaluation in predicting future currency crises: deviations from a simple time trend, deviations from a Hodrick-Prescott filtered series, and deviations from fundamental equilibrium (based on a regression on productivity, terms of trade, government spending, and openness). They find that the 'best' results come from the simplest method, that is, detrending the real exchange rate. Their results imply that, as a summary variable, overvaluation is a good predictor of crisis on both the three-month and six-month ahead horizons.

Chinn (2000) cautions against the presumption that real exchange rates must always be over-valued in the run-up to crisis. He tests the real exchange rate for cointegration with drift terms to determine whether a currency is, in fact, over/undervalued leading up to the period before a crisis occurs. In doing so, he concludes that overvaluation is not a general phenomenon ahead of a crisis. Indeed, the won appeared undervalued prior to the crisis in Korea.

Liquidity problems

A feature of the theoretical analysis in Chapters 3–5, was that liquidity problems lie at the root of a number of crises. Thus, a set of variables that together reflect internal and external liquidity, such as low international reserves and high short-term debt ratio, could be useful predictors of crisis. The most commonly cited external vulnerability indicator is the current account balance. In most cross-country analysis, it is either scaled by GDP to reflect the size of the economy, or by the total value of trade to reflect the degree of openness. The former is usually more significant by a wide margin.

Calvo and Mendoza (1996) suggest two further measures of vulnerability: the M2/reserves and the external short-term debt/reserves ratios.[37] The first measures the adequacy of the reserves to cover the domestic liabilities of the central bank and the banking system, the second the adequacy of reserves to cover short-term debt amortisation. Bussiére and Mulder (1999) find that the short-term debt/reserves ratio serves better as an indicator of illiquidity than most other measures. By examining various liquidity measures, including imports over reserves and three money-based measures (M0, M1, and

[37] One may argue that foreign exchange debt is a better measure of external vulnerability than external debt, but owing to data availability, researchers tend to use external debt instead.

M2 over foreign reserves), they observe that when the short-term debt/reserves ratio is included, neither the imports/reserves ratio nor any of the four money-based measures are significant or have the expected (positive) sign.

Weakness in the banking sector

Sachs *et al*. (1996*a*) argue that the lending boom variable, measured by the increase in banking sector credit to the private sector, served as a useful indicator of both the Mexican and Asian crises. This is because the larger the ratio of banking sector credit to the private sector, the more likely it is that the banking system has incurred a high proportion of bad loans. As we have already discussed, the lending boom variable may, however, be a 'contra-indicator' out of sample (e.g. as the Asian economies recovered). Other indicators of weakness in the banking sector include the ratio of non-performing loans in total loans, net interest margins and balance-sheet mismatches, but lack of good quality data mean that these factors have not yet been adequately examined.

7.2 EVALUATION OF EARLY WARNING MODELS

7.2.1 *Crisis Definition*

The definition of a crisis is crucial to all models. In a narrow sense, a currency crisis takes place when a country is forced to abandon its pegged exchange rate because of speculative attacks. To gauge the vulnerability of a country's exchange rate to attack, however, we should also include 'failed' attacks—when policymakers successfully fend off speculators by using international reserves. As we have seen, most leading indicator models represent a crisis by an exchange pressure index. With no theoretical guidance on the 'optimal' weights, the weights for the rate of depreciation and the change in reserves are chosen as the precision (i.e. the inverse of the sample variance) over some arbitrary period. The higher is the index, the larger the speculative pressure on the country. Apart from being sample-dependent, choosing the precision over a period that spans two different exchange rate regimes can result in information loss and bias the exchange pressure index.

The structural approach uses the pressure index as a continuous dependent variable, whereas signalling and discrete-choice models convert the index into a dichotomous variable. In these latter models, a crisis episode is defined as an instance where the pressure index exceeds an arbitrary threshold value. For example, KLR define a crisis to be a situation where the pressure index exceeds its mean by three standard deviations. The results of most studies are seemingly robust to changes in thresholds.[38]

To illustrate the robustness of crisis definition, we follow Edison (2000) to construct c (equation 7.2) from the following data source:

$\Delta e/e$: monthly percentage change of *end-period* nominal bilateral exchange rate, IMF International Financial Statistics (IFS) line ae.

$\Delta r/r$: monthly percentage change of total foreign reserves, minus gold, IFS line 1l.d.

ϕ: the arbitrary constant in crisis threshold is chosen as 2.5. That is, the crisis threshold equals 2.5 times sample standard deviation plus sample mean.

Figure 7.3(a) and (b) show the Mexican exchange rate pressure index and its threshold with sample statistics calculated (all σ's and μ's) for the periods of January 1970–December 1995 and January 1970–December 1999 respectively. Since the Mexican peso was relatively stable between January 1995 and December 1999, the identified crisis episodes in both cases are largely the same (except the latter sample just identifies July 1985 as a crisis).

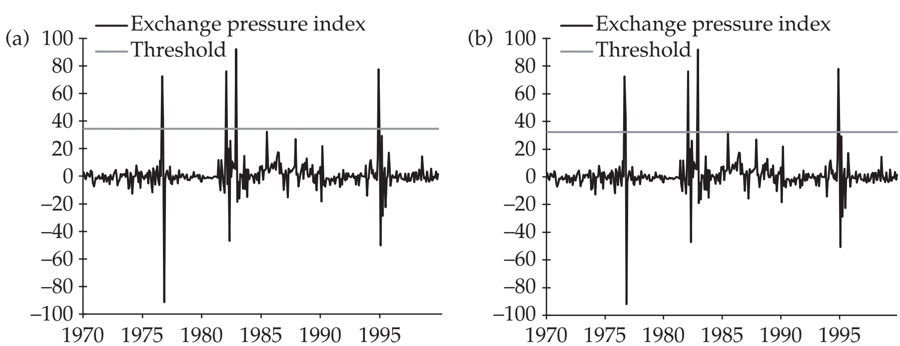

Figure 7.3. *Exchange rate pressure index—Mexico, sample statistics: (a) January 1970 to December 1995; (b) January 1970 to December 1999.*

Sources: IMF, own calculations.

[38] Notice that this is the threshold for determining whether a crisis has occurred or not, and is different from the indicator threshold in signalling models, or the threshold above which the predicted value is classified as a crisis in discrete-choice models.

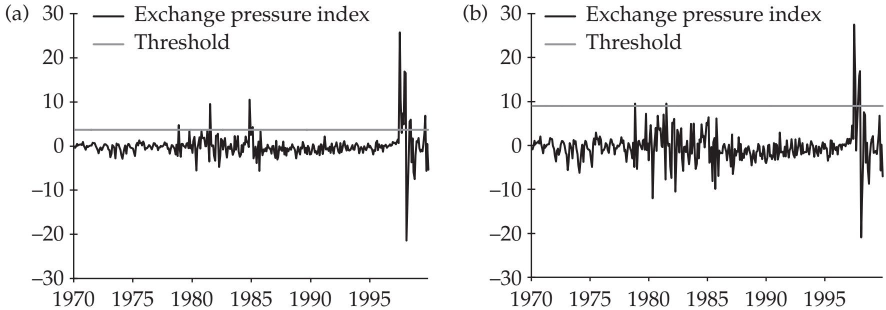

Figure 7.4. *Exchange rate pressure index—Thailand, sample statistics: (a) January 1970 to December 1995; (b) January 1970 to December 1999.*
Sources: IMF, own calculations.

But, the number of identified crisis episodes can be quite different when the exchange rate pressure index is very volatile in the extended sample period (see Figure 7.4(a) and (b) for the case of Thailand). Inclusion of extra data from January 1995 to December 1999 increases the sample standard deviation of p (equation 7.1) from 1.8 to 3.6, raising the threshold to 9 from 3.7. As a result, some of the crisis episodes identified in the smaller sample (November 1984 and February 1985) are no longer 'crises'.

In addition to problems with data sample selection, the crisis index is also sensitive to the nominal exchange rate data used. The above example uses end-period figures. But others, for example, Eichengreen *et al*. (1995), adopt period averages (IMF, IFS line rf) in calculating p. We must therefore compare the exchange pressure index using both end-period and period average data. In most cases, the resulting crisis episodes are the same, but on occasions, a crisis in September, say, is identified as an October crisis. Also, the sample standard deviation of period average data is generally smaller, resulting in a lower crisis threshold.

GS-WATCH's more sophisticated time series technique is also open to criticism. It chooses a lag structure of one rather than determining the number of lags statistically (as in other SETAR models). And the non-linear nature of the approach suggests cautious interpretation.

7.2.2 *Forecasting*

Out-of-sample prediction

In terms of forecasting performance and/or issuing accurate signals, the studies described above perform well in-sample. Berg and Pattillo (1999*a*) attempt a further evaluation in terms of out-of-sample predictive power. They suggest two types of test. The first focuses on the ability of the models to identify the vulnerabilities of a set of countries to currency crisis. One way to do this is to examine the Spearman rank correlation between the actual and predicted exchange rate pressures/probabilities of the countries. The second type of test captures the ability to predict the timing of an impending crisis. It therefore applies only to the signalling and discrete-choice approaches and is measured by the out-of-sample goodness of fit, that is, counting the number of false alarms and missed crises.

Berg *et al*. (1999) evaluate KLR, Frankel and Rose (1996), Sachs *et al*. (1996*a*), and the IMF's DCSD on this basis. They find that the rankings generated from all four models' predictions were positively correlated with the actual rankings in 1997. The correlation is not high, ranging from 12% to 53%, with the two models using monthly data (KLR and DCSD) having higher correlation. But it should be borne in mind that the results are not directly comparable since crisis definitions differ between models.

In applying the out-of-sample goodness of fit test to the discrete choice and signalling models, two main results emerge. First, Berg and Pattillo (1999*b*) find that, according to the Frankel and Rose definition, there is no actual crisis in 1997 and therefore nothing to predict. They argue that the deficiency arises from the use of annual data in building leading indicator models—crises tend to happen within a rather short period of time. Second, in comparing the results of KLR (a signalling model) with DCSD (a discrete-choice model), which both have a maximum forecasting horizon of 24 months, they find that the out-of-sample performance of KLR is inferior to that of DCSD. These results are summarised in Table 7.6. With the low cut-off probability at 25% (and hence more crises predicted), the KLR model correctly signals only 34% of the crisis observations, as opposed to almost one-half within sample. About one half of the crisis signals are false alarms and crises are missed 24% of the time. Notice also that by increasing the cut-off point to 50%, KLR do not forecast any crisis over the next 24 months, that is, between May 1995 and December 1997. By contrast, the DCSD model fares much better out-of-sample. With a 25% cut-off, its accuracy in predicting a crisis is 73%, while that of false alarms is at 41%. Berg and Pattillo (1999b) suggest that the better performance of DCSD may reflect the fact that it was formulated post-Asian crisis and, hence, takes into account key variables, such as short-term external debt.

Table 7.6. *Out-of-sample predictive power of KLR and DCSD*

	KLR		**DCSD**	
Cut-off probability	**25%**	**50%**	**25%**	**50%**
% of observations correctly called	70	70	79	74
% of pre-crisis periods correctly called	34	0	73	3
% of tranquil periods correctly called	86	100	81	100
False alarms as % of total alarms	51	N.A.[a]	41	0
Probability of crisis given				
An alarm	49	0	59	100
No alarm	24	29	11	27

[a] No crisis predictions
Source: Berg *et al*. (1999).

Optimal cut-off

Designing a good forecasting model requires balancing two types of error: the number of false alarms (predicted crises that do not materialise) and the number of failures (unanticipated crises). In a discrete choice model, the expected value of crisis, given a set of indicators, is a probability measure. However, the predicted probability (a continuous variable) is clearly not an *admissible* prediction since the dependent variable takes values of only 0 or 1. For an admissible predictor we need a decision rule (normally involving a threshold) that attaches 0 or 1 to these probabilities. A natural choice is to choose 0.5 as the threshold above which a 1 is assigned. But if the sample is relatively unbalanced (in most of the crisis studies, there are far more tranquil periods than crises), then this decision rule might bias towards predicting a crisis. One can always adjust the threshold accordingly, but in doing so, it can reduce the probability of missing a crisis while increasing the probability of a false alarm and *vice versa*. Greene (2003) observes that there is no correct answer as to the optimal cut-off level.

Problems with forecasting

A first objection to using these models to forecast is based on the Lucas critique. While theoretical models such as Krugman (1979) and Obstfeld (1996) are free from the Lucas critique, reduced-form empirical models that are estimated over different policy regimes are not. This is because while we can deduce some useful information from indicators before a crisis, once a crisis occurs, the government and international

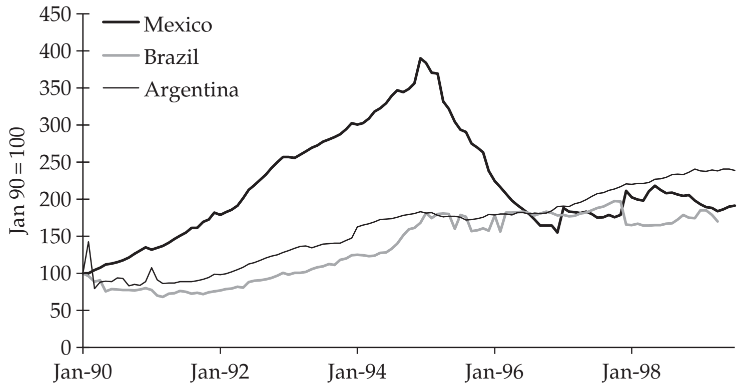

Figure 7.5. *Real private lending—Latin America*

Sources: IMF, own calculations.

institutions may impose different policy measures such that all the estimated parameters change. As we will see in Part II, if the authorities are conscious of crisis they may adopt some emergency policy actions to prevent the problems developing out of hand. In that case, a signal might be registered as an out-of-sample false alarm.

Structural parameters might also change due to shifting demand and supply conditions, rendering the estimates of some of these models (especially those that are built around a particular crisis) inappropriate.[39] Figures 7.5 and 7.6 show real private lending for three Latin American and the five Asian countries.[40] We can see that growth in private lending is very strong in both sets of countries before the Mexican and Asian crises respectively, so a positive relationship is expected between the lending boom and crisis. But after the crisis, the lending boom moderates and even collapses in Indonesia, where financial risks remained considerable. This was partly due to the shrinking credit supply post-crisis. Choosing the most appropriate forecast horizon poses a further problem. In signalling and discrete choice models, a 'good' call is usually defined as a signal issued that is followed by a crisis within a certain period of time, say 24 months. There has been very little analysis of this issue, and most investigators arbitrarily define

[39] One may argue that most econometric models suffer from the same problem, but it is particularly problematic for leading indicator models since they are built around particular crises.

[40] We follow Sachs *et al.* (1996*a*) and calculate real private lending by taking out the claims on government from the total domestic credit, then dividing the difference by the consumer price index.

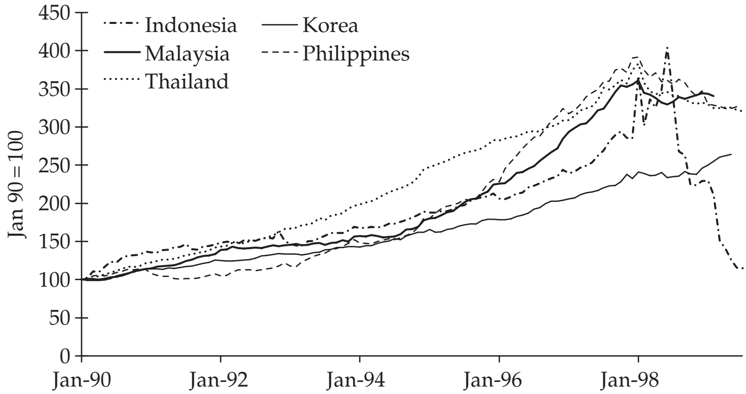

Figure 7.6. *Real private lending—Asia*

Sources: IMF, own calculations.

this period as 24 months (see Edison, 2000). But given that the number of good calls can be very sensitive to this decision, the choice of forecast horizon is open to debate.

An issue that only applies to discrete-choice models relates to the probabilistic nature of the method. In most other disciplines, the principal purpose of discrete-choice models is to obtain results that can be generalised to larger aggregates rather than predicting the probability of an individual event.[41] Therefore, it would be unsurprising if predicted probability of a particular country at a particular time, given a set of indicators, is quite different from the actual one. Cramer is extremely pessimistic about predicting individual outcomes:

> Predicting the state that will obtain at a given regressor vector *x* is tantamount to predicting the outcome of a single statistical experiment like the throw of a die, and almost as futile.
>
> (Cramer 1990, p. 90).

Some analyses adopt a relatively guarded tone on the forecasting ability of leading indicator models. For example, Bussiére and Mulder (1999) warn against the use of structural models: 'as with investing in stock market funds, crisis models require a clear warning: "past performance is no guarantee for future performance" '. In Kaminsky's (1999) words, 'while forecasting the exact timing of crises is likely to

41 A discussion of the difference between aggregate forecasting and individual forecasting is beyond the scope of this chapter. See Cramer (1990) and Ben-Akiva and Lerman (1985) for details.

continue to remain an elusive goal, ... we can construct a warning system that helps to monitor whether a country may be slipping into a situation that is bound to end up in a crisis.'

7.2.3 *Other Issues*

The availability of good quality data, especially in emerging market economies, poses a major obstacle to detailed empirical analysis. When Berg and Pattillo (1999*a*) re-estimated KLR's work, they found only 8 useful indicators, instead of the 13 reported by KLR. The authors suggest that revisions of data by the IMF was one reason for the difference, underlining the sensitivity of empirical studies of crisis to data quality.

Lack of internationally comparable data also hinders the development of these models. One specific example is data on non-performing loans (NPLs). Different countries have different criteria for defining NPL status, for example, 90 days in one country and 180 days in another. In addition, countries have different minimum initial provisioning for NPLs, ranging from 0%–1% in Malaysia to 50%–60% in Chile.[42] Data provided by national sources sometimes show large discrepancies from those cited by the Bank for International Settlements.[43] Another example occurred in June 2000 when the Bank of Thailand released a new series of external liabilities—the total external debt was revised up from around US$70 billion to above US$90 billion.

The decision on data frequency is also important. The speed with which financial crises can spread has led researchers to use higher frequency (monthly) data in their models. But most macroeconomic data (e.g. GDP) are only available on a quarterly basis at best. Moreover, in order to justify leading indicator models, some researchers use the lags of the indicators rather than the contemporaneous levels in their discrete-choice models. Again, the decision of the lag depends on the frequency of the data and lacks objective judgment. For example, Esquivel and Larrain (1998) adopt annual data with one lag (one year) in their indicators. As noted earlier, Frankel and Rose, using annual data, fail to recognise an actual crisis in 1997.

42 See Caprio, Jr. (1998) for detailed analysis on banking supervision.

43 Since 1997, the IMF has been promoting the Special Standards for Data Dissemination (SDDS) which encourages countries to follow a particular standard in data reporting. Consequently, some national authorities have recalculated some of their old data on the basis of new international standards.

A final issue affecting out-of-sample prediction is causality. Unlike time-series analysis, where one can include lags and/or leads to test for Granger causality, the nature of the signalling and discrete-choice approaches offers little scope for tackling these issues. In selecting the indicators, the analyst already implicitly imposes some causal relations. However, if the causal relations assumed were actually in the opposite direction, the changes in the indicators would be caused by the crisis itself instead.

Despite all these limitations, we should bear in mind that the empirical literature is relatively young and there is much room for improvement. So far, the focus has mainly been on the predictive power of these models. Relatively little has been said about the estimated coefficients (apart from being summarised in tables). One should be particularly careful when interpreting discrete-choice results. Unlike time-series models, we cannot directly read the individual influence of variables from the coefficient. This is because the probability on the left-hand side is obtained by mapping a particular probability density on to a linear combination of variables, so that any change in a variable will affect the probability by the margin of the coefficient while keeping other variables constant. If $\Phi(\cdot)$ and $\phi(\cdot)$ are the normal distribution and density functions respectively, then

$$P = \Phi(\boldsymbol{\beta}'\boldsymbol{x}),$$

and

$$\frac{\partial P}{\partial x_i} = \phi(\boldsymbol{\beta}'\boldsymbol{x})\beta_i \tag{7.4}$$

The right-hand side of equation (7.4) is sometimes called the quasi-elasticity of x_i, which can be read as the change in the likelihood of a crisis with respect to a change of a particular indicator given that it was evaluated at a particular value.[44]

Improvements to the estimation method are also needed. At present, most models are estimated with panel data using ordinary Logit or Probit, and fail to take into account the serial correlation within the data. The panel data discrete-choice model is most appropriate when

[44] This interpretation becomes more complicated when a particular variable appears more than once in the right-hand side, for example, the GDP term appears in output growth, reserves/GDP ratio.

observations are independent both over the countries and over time.[45] Special estimation methods are therefore desirable to counter serial correlation (see Amemiya 1985, for other estimation methods) and improve the predictive power of such models.

7.3 ANTICIPATING CRISIS SPILLOVERS

7.3.1 *Characterising Contagion*

The term 'contagion', despite being widely used in theoretical and empirical research, is ill-defined. In its broadest sense, it refers to the sudden increase in cross-market linkages after a crisis in a country (or group of countries). Masson (1998) offers an early and systematic characterisation. He distinguishes three effects: 'monsoonal' effects, spillovers, and jumps. Monsoonal effects result from a common external cause such as a rise in US interest rates that impacts on all dollar-indebted countries. Spillovers relate to the interdependence among the countries involved, which could be trade and/or financial in nature. Finally, jump or pure contagion refers to the effects of a shift in agents' expectations that are not based on changes in a country's macroeconomic fundamentals. Masson (1998) develops a simple two-country model to demonstrate the existence of all the three effects, with pure contagion represented by jumps between different equilibria.

Forbes and Rigobon (2001) suggest a slightly different taxonomy: crisis-contingent (shift-contagion) and non-crisis-contingent (real linkages) models. In the former, a crisis causes a structural shift in the economy so that shocks are propagated via a channel which does *not* exist pre-crisis. An obvious example is a model with multiple equilibria. Other examples include financial spillovers, particularly the so-called 'common lender' effect—during a crisis, if the common lenders fail to cash their claims for *liquidity* in one country, they will seek for it in a second country. For instance, shortly after Finland had devalued the markka during its currency crisis in 1992, German banks that had relatively heavy exposures to Finland were forced to re-evaluate their portfolios, withdrawing their liquidity from other European countries. Drawing on the model discussed in Chapter 4, Allen and Gale (2000) consider the overlapping claims of different regions within the international banking system. When one region

[45] Since the exchange rate pressure index is constructed as a weighted average of reserves and exchange rate and the latter are also included as indicator variables, the problem of endogeneity is clear.

suffers a banking crisis, the other regions suffer a loss because their claims on the troubled region fall in value. In extreme cases, a crisis can pass from region to region. Financial spillovers can also be due to the *incentive* structure for individual agents. For example, a shock in one country can induce investors to sell off their holdings in other similar countries so as to maintain certain proportions of a country or region's stock in their portfolios. Drazen (1999) studies the political pressure on other central banks to abandon their pegs if one has switched to a floating exchange regime recently.

Non-crisis-contingent models, by contrast, assume that the transmission channels after an initial shock are not significantly different from pre-crisis. So the high cross-market correlations that follow a crisis are just a continuation of the 'real linkages' that already existed before the crisis. Gerlach and Smets (1995) extend a fundamentals-based crisis model to a three-country setting to show how a speculative attack and depreciation of one currency spills over to trade partners. In their model, a forced depreciation of one currency affects the competitiveness of the other economies whose currencies are fixed, and this can increase speculative pressure and potentially lead to the collapse of their currencies. They show that spillover effects are more potent the stronger are trade linkages, and the lower is the degree of real and nominal wage flexibility. Trade factors drive the propagation mechanism for shocks. The extent of wage flexibility, on the other hand, characterises the vulnerability of economies to transmitted shocks.[46]

Other models, Chari and Kehoe (2000) among others, adopt herding models in the spirit of Banerjee (1992) and Bikchandani *et al.* (1992) to analyse contagion. For Chari and Kehoe, the root of a currency attack lies in information cascades. Each investor has some information about the state of the economy and decides sequentially, and publicly (in contrast with Morris and Shin's assumption of imperfect information among investors), whether to sell the currency. So if the first n investors receive bad signals about the state of the economy and sell the currency, the $n + 1$ investor will disregard his own information—no matter how good—and sell the currency. The investor decision is purely based on the revealed information of those who came before him. Calvo and Mendoza (2000) relax the assumption of sequential decision-making and assume that investors form their decision simultaneously. They show that herding becomes more prevalent as the world capital market expands, and as investors have fewer incentives

[46] See also Corsetti *et al.* (1999).

to collect country-specific information. For example, a sudden crisis in one country may lead investors to re-evaluate the potential for crisis elsewhere. Such 'wake-up calls' may lead uninformed investors to withdraw funds independent of developments in fundamentals. As a result, small rumours trigger herding behaviour among investors, shifting the economy from a good equilibrium to a bad one.

7.3.2 *Empirical Evidence on Spillovers*

The lack of a precise definition of contagion means that empirical studies of crisis spillovers vary considerably. In general, these studies are motivated in two ways. The first examines the role of contagion in identifying potential crises and establishing the conditional probability of crisis, given the effects of contagion. The second tests whether contagion actually exists, by examining co-movements in asset returns and capital flows pre- and post-crisis.

In the discrete-choice models discussed above, there is often a proxy for contagion that can affect the probability of a future crisis. The contagion variables are either chosen by statistical means or attempt to capture regional linkages. Esquivel and Larrain (1998) simply create a regional dummy for each of the countries in Europe, Latin America, Asia, and Oceania. The J. P. Morgan Event Risk Indicator uses two variables to measure contagion: a 'risk appetite' variable to capture the change in investors' preferences before a crisis occurs, and a cluster variable to measure the importance of contagion after the first few crises occur. They assume that the likelihood of financial contagion is higher when investors' risk appetite is falling. Risk appetite is simply the rank correlation between market returns and risk (measured as a weighted combination of long-term average interest rate differential and deviation of the real effective exchange rate from its long-term average). And the cluster variable is a weighted measure of the number of crises that have occurred within the past six months in either of the two currency blocs (dollar- and euro-bloc). GS-WATCH adopts an agnostic approach, relying on the data to reveal the extent to which speculative pressures in one currency transmit to another. Their country contagion variable is a weighted-average of other countries' crisis pressure index. The weights are chosen according to the historical correlation of the crisis indices across countries.

Glick and Rose (1999) estimate a Probit model and find evidence of contagious speculative attacks caused by trade links but not by macroeconomic and financial influences. Eichengreen *et al*. (1995) and Hernandez and Valdés (2001) obtain similar results. Chui *et al*. (2004) suggest that the findings of the first two may reflect the inclusion in these studies of developed market crises where trade interlinkages have historically been stronger than in emerging economies. It may also reflect lower relative levels of financial integration in previous decades.

Studies focusing explicitly on the recent experience of emerging market economies appear to find a greater role for financial interlinkages. In the absence of good data on financial interlinkages across economies, the focus of attention has been on cross-border bank lending linkages, particularly those operating via major common lenders. For example, Caramazza *et al*. (2000) find that common bank creditor indicators have a significant impact on the probability of crises while the trade channel is weak. Van Rijckeghem and Weder (2001) also observe common lender effects during the Thai, Mexican, and Russian crises. Kaminsky and Reinhart (2000) employ a signalling model to argue that financial linkages help explain spillovers to Argentina and Brazil in the 1994 Mexican crisis, and to Indonesia after the 1997 Thai devaluation. But they note that it is difficult empirically to differentiate between the impact of financial and trade linkages as most countries that are linked in trade are also linked in finance.

While the above models treat contagion as an explanatory variable, other approaches ask whether contagion really exists. Early attempts include studies that analyse cross-market correlation coefficients. These measure the correlation in asset and equity returns between two markets during a tranquil period and then test for a significant increase in this correlation coefficient after a shock. Calvo and Reinhart (1996) and Baig and Goldfajn (1999) find significant increases in the correlation of asset returns for the Mexican and Asian crises respectively. Froot *et al*. (2001) study whether foreign capital outflows lead to price overreaction and contagion. Using daily data, they find that portfolio flows have a strong correlation across regions (which increased during the Asian crisis, although not during the Mexican crisis). Moreover, these flows seem related to past returns in the recipient economy. Kaminsky *et al*. (2001, 2004) find similar evidence in emerging market mutual fund flows, with spillovers to some Latin American countries during the Mexican crisis and broader spillovers following the Thai devaluation.

Table 7.7. *Empirical evidence on crisis spillovers*

Study	Data and Methodology	Results
Caramazza *et al.* (2000)	20 industrialised economies and 41 EMEs; from 1990 to 1998. Pooled probit with exchange market pressure (EMP) indicator.	Common creditor indicators and financial weakness (particularly reserve adequacy) have significant impact on the probability of a crisis having controlled for fundamentals and trade linkages.
Eichengreen *et al.* (1996*a*)	20 industrialised economies; from 1959 to 1993. Pooled probit with EMP crisis indicator.	Contagious currency crises spread mainly as a function of trade links rather than through macro similarities.
Glick and Rose (1999)	161 countries (developed and EME); covering crisis episodes 1971 to 1997/98. Pooled probit with EMP crisis indicator and OLS regression on continuous EMP indicator.	Trade channel appears consistently important in explaining the incidence of crisis and also, from the regression on a continuous EMP indicator, the intensity of crisis.
Hernandez and Valdés (2001)	17 EMEs for equity indices and 8–14 countries for EMBI data. Three months of weekly data around each of the Thai, Russian, and Brazilian crises. Pooled regression of financial market variables on corresponding variables in other economies weighted by a transmission channel indicator.	Bond spreads and local equity prices are used as dependent variables. Using bond spreads: With competing channels, trade competition coefficient is not significant from zero. Common creditor effects are a more important channel. The absolute competition for funds measure is most relevant for the Thai crisis; the relative measure is more relevant for crises in Russia and Brazil. Using equities: financial competition effects are significant in all crises. Trade and regional effects important in the Thai and Brazilian crises.

Table 7.7. *(Continued)*

Study	Data and Methodology	Results
Kaminsky and Reinhart (2000)	20 countries (Asian and Latin American EMEs and 5 industrialised economies); from 1970 to 1998. Signalling (score-based) approach.	When there is a high proportion (over 50%) of contemporaneous crises, conditioning on financial interlinkages provides the greatest increase in probability of crises (with the common creditor greatest then market correlation measures). The improvement from conditioning on bilateral trade linkages is less. Third party trade linkages provide a relatively small improvement on the probability conditional on crises elsewhere.
Van Rijckeghem and Weder (2001)	42–85 EMEs (varying sample size) with data covering Mexican, Thai, and Russian crises. Pooled probit using EMP crisis indicator.	Probit: Common creditor indicators are significantly associated with a higher contagion probability. Trade links are less significant (not significant at all in the Asian crisis once common creditor channels have been controlled for).

Source: Chui *et al*. (2004).

Another approach to contagion estimates the (variance-covariance) transmission mechanism across countries with an ARCH or GARCH model. Edwards (1998) examines the propagation across bond markets after the Mexican crisis. He estimates an augmented GARCH model and shows that there were significant spillovers from Mexico to Argentina, but not from Mexico to Chile. Other studies test for contagion by examining the changes in the co-integrating vector between stock markets instead of any short-run changes after a shock (e.g. Longin and Slonik 1995). If tests show that the cointegrating relationship increased over time, this could be a permanent shift in cross-market linkages instead of contagion. But cointegration analysis may not be an accurate test for contagion due to the long time periods under consideration.

Forbes and Rigobon (2001) point out that tests for contagion in the presence of heteroskedasticity are inaccurate. This is because the presence of heteroskedasticity biases the results towards finding contagion even when the underlying propagation mechanism is constant and no shift-contagion actually occurs. Similarly, Loretan and English (2000) point to an important result of probability theory: when the movements of random variables are more volatile, sampling correlations between those variables will be elevated even if the underlying data generating process remains unchanged. It suggests that one should be careful in interpreting the fluctuations in correlations during periods of market volatility as true changes in the distribution of asset returns. They reach a cautious conclusion—rather than dismissing it entirely, contagion, as measured by increased sample correlations between asset returns, may be no more than a by-product of high sampling volatilities.

Table 7.7 summarises the empirical evidence on crisis spillovers. An important lesson from this body of work is that the results are sensitive to the specification of propagation mechanisms and the definition of contagion. The breadth of theoretical approaches to the topic and the ambiguous nature of the evidence means that the effective anticipation of crisis spillovers requires policymakers to monitor a very broad range of indicators.

PART II

REFORMING THE INTERNATIONAL FINANCIAL ARCHITECTURE

8

Overview: Dealing with Crises

> The indulgence of the laws to those who have made themselves unable to pay their just debts is usually defended on the plea that the sole object should be . . . not to coerce the person of the debtor, but to get at his property, and distribute it fairly among the creditors . . .. Imprisonment at the discretion of a creditor was really a powerful engine for extracting from the debtor any property which he had concealed or otherwise made away with; and it remains to be shown by experience whether, in depriving creditors of this instrument, the law, even as last amended, has furnished them with a sufficient equivalent.
>
> J. S. Mill, *Principles of Political Economy*, Book V, Chapter IX.

The modern policy debate on the international financial architecture has responded to the debt problems spawned by creditor coordination failure by largely focusing on sovereign bankruptcy reform. Two broad strategies have been proposed in order to facilitate orderly debt restructuring while balancing both creditor and debtor rights. On one view, a *contractual* approach encourages the IMF and G7 governments to promote the inclusion of collective action clauses (CACs) in bond contracts. Such clauses attempt to establish clear procedures for debt restructuring and allow a qualified majority of creditors to alter the terms of the contract in the event of debt problems (see Eichengreen and Portes, 1995; Taylor, 2002). A second view adopts a more *statutory* approach in line with domestic bankruptcy principles such as chapter 11 of the US code.[47] It proposes legal structures to resolve disputes, with the official sector playing an important role in determining whether a debtor can suspend payments. The most prominent proposal of this kind has been the IMF's Sovereign Debt

[47] Schwarcz (2000) and White (2002) critically assess the relevance of US bankruptcy law as a guide for sovereign bankruptcy. Sachs (2002) makes an influential case for a bankruptcy mechanism as means of managing capital account crises.

Restructuring Mechanism (SDRM), details of which are articulated by Krueger (2002*b*).

Despite appearances to the contrary, the issue is not new. Debt restructuring inefficiencies induced by collective action problems among creditors received considerable attention during the debt crisis of the 1980s and led, at the time, to many calls for a centralised resolution to sovereign debt crises.[48] To some extent, the renewed enthusiasm for sovereign bankruptcy reform reflects the fact that the collective action problem among creditors—the cost of default—has become more severe as capital flows to emerging markets have taken the form of short-term bonds held by a diffuse group of creditors rather than medium-term loans by a small number of international banks.[49] But it also reflects a desire to involve the private sector in the resolution of crises as the scale of financial rescues by the official sector and the industrialised countries becomes unbearably large. Table 8.1 compares IMF crisis lending to troubled debtors in the 1980s with the 1990s. As can be seen, financing arrangements agreed between the IMF and debtor countries were of the order of 6% of GDP during the financial crises of the 1990s, compared with some 1.5% of GDP during the crises of the 1980s. Indeed, limiting official finance has been a key objective of some recent policy proposals (e.g. Haldane and Kruger 2001).

Creditor coordination problems in sovereign debt restructuring manifest themselves in two ways. Chapter 5 has already described one example of how coordination failure can lead to inefficiencies *ex post*. If one creditor fails to renew its loans with the debtor, then all creditors will do likewise. A 'country run' means that creditors as a whole may fail to extend new finance or rollover loans, even when it is in their collective interest to do so. A second aspect of creditor coordination failure arises in bargaining over restructuring. Each creditor has an incentive to 'hold out' in the hope of obtaining payment according to the original terms of the contract, rather than agreeing to a collective settlement. Rogue or 'vulture' creditors, who pursue their claims aggressively in the courts, are particularly problematic in

[48] The key contribution is that of Sachs (1995). For analyses of international debt facilities, the reader is referred to Corden (1989). Rogoff and Zettelmeyer (2002) provide a comprehensive historical review of the debate.

[49] For a dissenting view, see Roubini (2003). He points to debt restructuring episodes in Pakistan, Ukraine, and Ecuador as examples where creditor heterogeneity did not prove problematic. In each of these cases, the unilateral partial repayment offers of the debtor—'exchange offers'—were readily accepted by most creditors.

Table 8.1. *IMF arrangements with selected countries 1983–2002*

	Programme[a]	Funds available[b]	
		% of quota	% of GDP[c]
Post-1995			
Argentina 2000	SBA with SRF[d]	800	7.8
Turkey 1999	SBA with SRF[e]	1,560	10.5
Brazil 1998	SBA with SRF	600	2.3
Korea 1997	SBA with SRF	1,938	4.4
Indonesia 1997	SBA	557	5.2
Thailand 1997	SBA	505	2.6
Mexico 1995	SBA	688	6.3
Early 1980s			
Argentina 1984	SBA	106	1.0
Korea 1983	SBA	124	0.7
Brazil 1983	EFF	528	3.0
Philippines 1983	SBA	100	1.0
Argentina 1983	SBA	187	1.5
Mexico 1983	EFF	425	2.4

[a] SBA: Stand-By Arrangements; SRF: Supplemental Reserve Facility.
[b] Funds available include augmentations to initial amount announced.
[c] Relative to GDP in year of initial programme announcement.
[d] SRF approved January 2001.
[e] SRF approved December 2000.

Sources: IMF and IMF World Economic Outlook.

these instances.[50] Reforms to sovereign bankruptcy tackle both types of coordination failure. A payments standstill or a stay on litigation can prevent creditor grab races, and the agreement of well-defined procedures under super-majority voting can mitigate the hold out problem by allowing a qualified majority to pursue restructuring despite the objections of a dissenting minority. Regardless of whether the approach adopted is contractual or statutory, bankruptcy reforms bind the private sector into crisis resolution, thereby sharing the burden of crisis amongst private creditors, the debtor, and the official sector.

[50] The recent literature cites the case of Elliot Associates who were able to delay Peru's debt restructuring through litigation. Hold-out problems were also a significant feature of debt reduction deals in the late 1980s. Gai (1994) discusses how small creditors obstructed debt forgiveness by US money-centre banks in Bolivia during this period.

The central problem in designing a crisis management framework is whether smoother debt workout procedures that limit creditor collective action problems *ex post*, undermine debtor incentives *ex ante* by creating moral hazard problems. A possible consequence is higher borrowing costs and/or lower capital flows. As we have already seen, the painful ramifications of non-payment are the creditor's response to a lack of meaningful contract enforcement at the sovereign level. The normative issue of policy design thus throws up a number of analytical challenges. What forces underpin the *ex ante* versus *ex post* tradeoff? Can intervention by a third party that mitigates default costs improve the lot of debtors and creditors? And, if intervention is desirable, should collective action problems be dealt with by statutory or contractual means?

Gai *et al*. (2004) characterise the tradeoff between ensuring that sovereign borrowers adhere to contracts when they have the means to repay and the avoidance of large default costs.[51] After defining a laissez faire benchmark, where creditors rely on high default costs to ensure a debtor's willingness to repay, they introduce a third party (the 'IMF') into the analysis. The official sector acts in a dual capacity as a 'fire fighter' (trying to reduce crisis costs) and as a 'whistle blower' (monitoring the debtor's ability to repay). The analysis supposes that the IMF receives a noisy signal on whether default is strategic or arises from bad luck. If default is perceived as reflecting bad luck, an IMF announcement activates a crisis resolution mechanism to limit the costs of crisis that would otherwise ensue. The form of the intervention to smooth the workout is kept general and may be interpreted as a statutory restructuring mechanism such as the SDRM, an officially sanctioned standstill on debt payments, or a stay on creditor litigation.

The model shows that third party intervention can, indeed, improve welfare under plausible circumstances. Whether this happens depends on two factors. The first is the quality of monitoring. The better able is the IMF to distinguish between bad luck and strategic default, the greater the discipline on the debtor and the higher the lending extended by private creditors. The second factor is the efficacy of the sovereign bankruptcy procedure. If the IMF is a reasonable monitor, welfare is increasing in the degree to which default costs are alleviated by public policy. But beyond some point, the lower discipline that arises from the reduction in crisis costs offsets the extra discipline

[51] Other papers that model this tradeoff include Jeanne (2001) and Bolton and Rosenthal (2002).

from IMF monitoring. The official sector must therefore perform a balancing act between its whistle blowing and fire fighting functions. Strategic behaviour is discouraged by better monitoring, but bankruptcy reforms that lower default costs increase the incentive for the debtor to act strategically.

Haldane *et al.* (2004) consider the ability of contractual devices to secure an orderly workout of sovereign debt. They show that, if creditors and debtors have complete and common information on each others' preferences, collective action clauses can overcome the inefficiencies posed by intra-creditor coordination problems. But when the common information assumption is weakened, the efficacy of these clauses is diminished. This is because, even though collective action clauses resolve intra-creditor issues, the informational asymmetry between debtors and creditors creates additional inefficiencies in bargaining. Uncertainty over payoffs leads to incentives for strategic behaviour that cannot be addressed by the mere invocation of contractual mechanisms. Their results imply that collective action clauses alone are insufficient to secure an efficient debt workout and may need to be augmented by statutory devices. But as Gai *et al.* (2004) note, for a statutory authority to be genuinely effective in securing a debt restructuring, adequate information and enforcement powers during debt renegotiations are paramount.[52]

A potential problem with attempting to bind private sector creditors into crisis resolution is that it can have the opposite effect, reducing the maturity of debt and bringing forward the timing of crisis. On this view, creditors have an incentive to 'rush for the exits', that is, pre-emptively seek shorter and shorter maturities in the hope of avoiding being caught up in a payments suspension and the ensuing debt workout.[53] Anecdotal evidence from the crisis in Brazil during 1998 offers support for these concerns. After witnessing the payments suspension imposed by the official sector on creditors during the (earlier) crisis in Korea, the maturity of credit lines to Brazil were cut in anticipation of a stay on payments. The possibility of such strategic behaviour by creditors limits the scope for a policy regime that accords a central role to private sector involvement as a means of managing financial crises.

52 Bulow and Rogoff (1990) argue that third-party intervention in debt bargaining may complicate debtor–creditor negotiations leading to less flexible bargaining positions. Wells (1993) suggests otherwise.

53 See, in particular, Geithner (2000).

Gai and Shin (2004) argue that such logic need not be general. They model the 'rush for the exits' as a pre-emption game among creditors. A debtor country undertakes an N-period project and creditors choose where, within the maturity spectrum, they prefer to extend credit. The fruits of the project, which are taken by long-term claimholders so long as premature liquidation is avoided, depend on the size of the funding gap and on the maturity structure of the debt—the shorter the maturity, the greater the probability of financial crisis. Creditors face two conflicting incentives. There is a desire to be first in the queue (the shortest debt maturity) so as to be able to escape the losses associated with crisis. But if all creditors behave in this fashion, this maximises the chance of crisis. So some creditors choose longer maturities in the hope that funding problems do not arise. The balance of the two generates an equilibrium debt maturity profile for the project.

A debt workout has two effects on the choice of maturity. First, it gives rise to a loss to those caught up in the workout. But second, the workout serves to boost recovery values in the event of a crisis. There is a direct effect increasing incentives to hold longer-term debt, the returns to which are now higher. And there is an indirect strategic effect, as the higher recovery rates reduce the incentive to engage in pre-emption in the first place. The overall implication of a debt workout regime for the maturity structure is ambiguous. In particular, if workouts, payments standstills, and the like are short-lived and have a modest positive effect on recovery values, they are unlikely to seriously distort the maturity structure of debt. In general, there can be no firm presumption that creditors will always 'rush for the exits'.

The potential limits of debt workout mechanisms, nevertheless, raise the question of whether there are other means by which the official sector can galvanise private sector involvement. Policymakers frequently argue that official financing in the wake of recent capital account crises has spurred private capital inflows (for instance, Geithner, 2000). The idea that official sector crisis lending imparts a 'catalytic' impetus to the resumption of capital flows rests on a supposition that official lending and private finance are, in some sense, strategic complements. In other words, the provision of official assistance induces private sector creditors to rollover their claims, thereby alleviating the external financing gap. Again, however, there is the question of whether such assistance exacerbates debtor country moral hazard.

Morris and Shin (2003*a*) apply the *ex ante* moral hazard versus *ex post* coordination inefficiency framework to the debate on catalytic finance. They add a prior effort decision of the debtor to a global games model to pin down the basic trade-off. Morris and Shin argue that for catalytic finance to be effective, IMF assistance must be a strategic complement to both the adjustment effort of the debtor country and the rollover decisions of private sector creditors. If IMF finance is, instead, a strategic substitute for one or both of the decisions of the interested parties, *ex post* bailouts crowd out actions that would mitigate the crisis. Their results imply that catalytic finance is most likely to work in situations where the deterioration in fundamentals is modest. In such circumstances, a debtor can use IMF assistance to make the necessary adjustment effort and induce creditors to rollover the loans. But for other values of fundamentals, the effects of debtor moral hazard dominate.

The lack of a simple theoretical relationship between *ex post* official intervention and *ex ante* moral hazard suggests that gauging the potential impact of an official sector financial safety net on debtor incentives is, ultimately, an empirical matter. Gai and Taylor (2004) specify and estimate a probit model to explore whether recent policy measures to facilitate financial rescues have influenced debtors' reliance on official sector resources. They highlight the systemic importance of debtors as a key characteristic driving access to official sector funds. The analysis entails three key steps. First, a binary dependent variable is constructed which takes the value one if a country is in an IMF programme and makes a drawing on official resources, and is zero otherwise. The debtor's decision to use IMF resources is a directly observable action that permits inferences about changes in debtor behaviour.[54] Second, the set of factors that influence the decision on whether or not to undertake a programme is specified. These economic fundamentals include the short-term debt reserve ratio and the level of the real exchange rate. Importantly, the variables selected reflect demand-side considerations. The final step is to examine if there is a change in the debtor's incentives to participate in a programme, conditional on the set of fundamentals, following a change in policy regime.

The empirical results suggest that a shift of policy regime in favour of one that facilitates international financial rescues by the official sector

[54] This is in contrast to other empirical analyses which rely on observed asset prices to indirectly assess moral hazard (e.g. Lane and Phillips, 2000; Dell' Ariccia, *et al*. 2002; Haldane and Scheibe, 2004).

Figure 8.1. *Average purchases (GRA) per year (excluding reserve tranches)*[a]

Note: Total sample is 171 countries.

Sources: IMF IFS, Dec. 2002 and authors' calculations.

[a] up to 2002 Q3.

results in a greater probability of IMF loan use, for given fundamental determinants of crisis. Moreover, the increased propensity to borrow is greater the more systemically important the country. The findings point to an increase in the degree of debtor moral hazard during the 1990s, and corroborate the pattern of borrowing from the official sector. Figure 8.1 illustrates the evolution of credit purchases from the IMF's General Resources Account (GRA) through programmes involving conditionality. The average annual purchase of those countries accessing such resources rose sharply to almost US$2.5 billion in 2002, from around US$150 million in the 1980s. But when the prominent crisis countries of the 1990s are excluded, the pattern of purchases is more benign. Figure 8.2 shows that there has also been a general rise in the relative scale of resource usage. Purchases of IMF GRA resources, as a percentage of the total GDP of those countries accessing credit tranches rose in the 1990s after being broadly stable in the previous twenty years. The greater use of official resources by a relatively small number of countries belies the notion that the large size of recent rescues reflects a general rise in real hazard due to the greater integration of emerging market economies into international capital markets.[55]

An alternative method of dealing with financial crises may be to tackle the problem of balance sheet mismatches directly. Since the

[55] Mussa (1999) discusses the real hazards facing emerging market countries in their interactions with the global financial system.

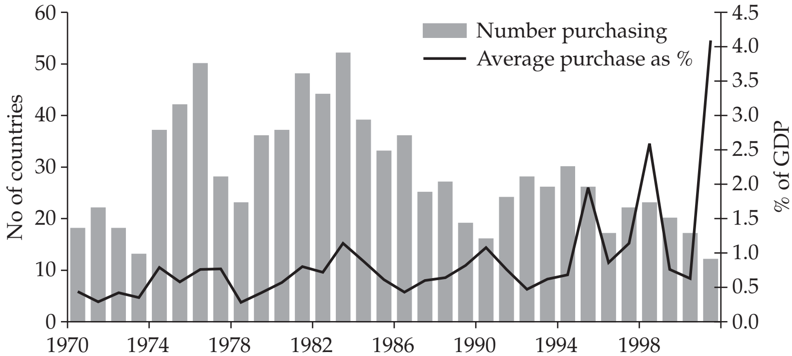

Figure 8.2. *Number of GRA purchases (excluding reserve tranches) and their scale relative to GDP*

Note: Total sample is 165 countries.

Sources: IMF IFS, June 2002 and WEO April 2002 database.

external debt of most emerging market economies is denominated in foreign currency, these countries are exposed to large-scale currency mismatches—a currency crisis can produce a large increase in debt servicing costs and trigger economy-wide bankruptcy. And since much of the debt is short-term in nature, raising interest rates to defend the currency is no solution as it merely exacerbates the rollover (or maturity mismatch) problems highlighted in Part I. To sidestep these mismatches, it would seem desirable for emerging market countries to borrow abroad, and long-term, in their domestic currency. But as Table 8.2 shows, present shares of emerging market debt denominated in own currency are extremely small, especially when compared with industrialised economies. Indeed, very few countries have been able to issue bonds in local currency terms since the start of the twentieth century.[56] The reasons for the inability of emerging countries to borrow in local currency terms are unclear, and have led Eichengreen and Hausmann (1999) to dub this the 'original sin' problem.

One interpretation of original sin is that it reflects inadequacies in global capital markets and, therefore, necessitates international solutions to promote domestic capital market development in emerging market countries. Eichengreen and Hausmann (2002) argue that, to eliminate currency mismatch, the international community should establish a unit of account—an EM index—based on a diversified set of

56 Bordo and Flandreau (2003) suggest that the number has increased to about twenty-five, from eight countries in 1914.

Table 8.2. *Share of external bonded debt denominated in domestic currency*

(%, end-1999)	Corporate sector	Financial sector	Public sector
Asia Pacific			
China	0	0	0
Indonesia	2	0	0
Korea	0	0	0
Latin America			
Argentina	3	1	2
Chile	2	0	0
Mexico	0	0	0
Eastern Europe			
Russia	0	0	0
Poland	12	0	0
Industrial World			
Japan	44	28	16
United Kingdom	44	36	13
United States	78	83	95

Sources: Hawkins and Turner (2000).

emerging market and industrial world currencies. The unit would be indexed to the consumer price level of each country in order to eliminate any incentives for the debtor to debase the currency. Their proposal hinges on the international financial institutions using their AAA credit ratings to issue debt in the EM index to promote a liquid bond market in that instrument. Once high-grade foreign investors issue debt in the unit, they can swap their currency exposures with local borrowers in order to reduce their own exposure to a currency mismatch. A step in this direction has already been taken in the Asia-Pacific. To promote local bond markets, countries in that region have established a US$1 billion fund to purchase sovereign and quasi-sovereign US dollar denominated bonds issued by some countries in the pool. The fund is managed by the Bank for International Settlements, with capital from the reserves of the major regional central banks, including Japan, Australia, and Hong Kong.

Another factor inhibiting the development of liquid domestic debt markets is the perceived weakness of the monetary framework and the credibility of monetary institutions in emerging market countries. Eichengreen and Hausmann (1999) note that some countries (e.g. Australia) were able to develop domestic debt markets and create a constituency against opportunistic management of the exchange rate, whereas others (e.g. Argentina) found it difficult to do so. A history of high inflation and depreciation is thus a key reason behind creditors' unwillingness to lend in a unit that the borrower can manipulate. Reputation in one sphere of policy (the monetary framework) can spill over to other spheres (capital market access) with long-lasting implications. If this is indeed the case, then solutions to financial crises may ultimately rest on improving 'policy fundamentals', namely the pursuit of sensible macro-prudential policies and the development of credible institutions that are transparent and accountable.[57]

Gai and Tan (2004) examine how monetary policy reputation influences a country's ability to borrow internationally in domestic currency by extending the Obstfeld (1996) framework outlined in Chapter 3 to allow for reputational factors. They show that 'original sin' can be regarded as the inflationary track record of one's predecessors. A policymaker's current incentives to manage the exchange rate are affected by his past behaviour and, because his track record is imperfectly observed by other agents in the economy, by the behaviour of his predecessors as well. This generates incentives for policymakers to try and fix the exchange rate to build a reputation for financial probity and to distinguish themselves from those who would try to opportunistically manipulate the exchange rate. The complementarity between past and present behaviour means that there is hysterisis in the updating behaviour of creditors, which leads them to be wary about extending credit in domestic currency. The time taken to build sufficient trust in order for domestic debt markets to develop may, therefore, be substantial.

The rest of Part II draws on the insights gained from the previous chapters to discuss these models in greater detail. We begin by examining the basic tradeoff between *ex ante* and *ex post* efficiency, and analyse how third party intervention can prove beneficial. We then compare contractual and statutory solutions to managing sovereign debt workouts, and consider the potential problem of 'rushes for the exits'. The role played by official finance in catalysing private sector involvement and influencing debtor moral hazard is then examined. A final chapter considers the problem of 'original sin'.

[57] King (1999) makes a forceful case for transparent and credible institutions as a means of dealing with financial crises.

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9

Sovereign Debt Workouts

9.1 BALANCING CRISIS COSTS AND MORAL HAZARD

Gai *et al*. (2004) examine the tradeoff between *ex ante* and *ex post* efficiency in the sovereign debt context. They assess how public intervention in sovereign debt crises can affect the scale of capital flows and the welfare of borrowers and lenders by comparing a regime with policy intervention against one without. Two key factors to emerge are the official sector's ability to judge the predominant cause of crisis, and the effectiveness with which it can limit costly liquidation. The official sector is cast in the twin roles of *'whistle-blower'* and *'fire fighter'*. The first role helps reinforce discipline on the debtor *ex ante* by curtailing strategic default, while the second mitigates the *ex post* costs of crisis in the event of a default caused by bad luck.

A single debtor country faces a continuum of small creditors. The debtor has no resources of its own and can produce only if it is able to obtain loans. Time is divided into three periods, $t = 0, 1, 2$. At the initial date, the debtor is granted a loan, L, and promises to repay interest and principal, rL, at $t = 1$. When the loan amount is invested at $t = 0$, a project generates an interim output at $t = 1$, which is used to repay the creditors. Final output at $t = 2$ depends on the amount repaid to the creditors at the interim stage. If the debtor pays the full amount, the project is allowed to mature without intervention from the creditors. But if there is a shortfall in the amount repaid, creditors can force costly liquidation commensurate with the amount of the shortfall. The damage caused by forced liquidation depends on factors such as the extent of collateralisation of the debt, or the amount of debtor assets that can be seized in the creditor country. If x is the amount repaid by debtor at $t = 1$, the *proportional discretionary shortfall*, s, is the amount repudiated as a proportion of the amount owed, that is,

$$s = \frac{rL - x}{rL}. \tag{9.1}$$

Output at $t = 2$ is assumed to be a function of the scale of initial investment, L, and the extent of costly liquidation arising from s at $t = 1$. Specifically, suppose that output is strictly decreasing in s and takes the form

$$y(L, s) \equiv (1 - \alpha s)L^{\lambda}, \tag{9.2}$$

where $0 < \alpha < 1$ and $0 < \lambda < 1$. The formulation captures, in reduced form, the costs associated with disorderly liquidation. As stressed in Part I, liquidation or the termination of lending is costly, and acts as a way of inducing the debtor country to repay creditors instead of diverting resources to itself. So the output loss in the final period can be regarded as the cost of creditor coordination failure. The parameter α captures the extent of the damage done by premature liquidation by the creditors at the interim date. If there is repudiation of an amount, s, output at $t = 2$ is reduced by αs. The parameter λ determines the elasticity of final output with respect to the size of the initial loan, L.

The debtor can choose to repay the full amount if interim output is sufficiently large, or opt to repudiate some or all of its obligations. But if interim output is insufficient to meet repayments, rL, then the debtor is forced into defaulting on some of its debt. Thus there is the possibility that a payment shortfall is due to genuine bad luck. Whether non-payment is intentional or the result of bad luck is not verifiable for the purpose of the loan contract between the debtor and the creditors.

Let the interim output of the debtor be a random variable, $\tilde{x}$, that takes the value rL with probability π, but is uniformly distributed on the interval $[0, rL]$, with probability $1 - \pi$. In other words, there is a probability π that the debtor has sufficient resources to repay in full. However, with probability $1 - \pi$, there are insufficient resources to repay. In this event, the amount of the shortage in resources is uniformly distributed over the possible range. If we define the size of the *proportional natural shortfall* in resources at the interim date to be

$$z = \frac{rL - \tilde{x}}{rL}, \tag{9.3}$$

then z is a random variable that takes the value of 0 with probability π and is uniformly distributed on the unit interval with probability $1 - \pi$. The shortfall in the amount repaid may be larger than z (since the debtor may choose not to repay all of the output), but the shortfall in actual repayment cannot be smaller than z, since repayment cannot exceed more than can be afforded.

The optimal size of the loan, L, maximises the expected output net of repayment costs, taking into account the possible disruption costs of premature liquidation. The optimal contract selects the loan size that maximises

$$\mathrm{E}[y(L,z) - (1-z)rL] \tag{9.4}$$

subject to a participation constraint that requires the debtor to be better off with the contract than without, that is,

$$\mathrm{E}[y(L,z) - (1-z)rL] \geq 0, \tag{9.5}$$

and an incentive compatibility constraint

$$y(L,z) - (1-z)rL \geq y(L,s) - (1-s)rL. \tag{9.6}$$

This means that if there is no resource shortage, that is, $z = 0$, then the debtor has an incentive to pay back the full amount to the lender. It also ensures that if there is a resource shortage, then the debtor has no incentive to keep anything back from the creditors.

First consider the debtor's decision on the discretionary shortfall, s, in the repayment to the creditors, given the realised shortage in resources z, and the requirement that s be no smaller than z. The debtor's problem is to maximise

$$(1-\alpha s)L^{\lambda} - (1-s)rL \tag{9.7}$$

subject to $s \geq z$. The debtor would choose to repay all of the available resources at the interim date if $\alpha L^{\lambda} > rL$, but would choose to repudiate if $\alpha L^{\lambda} < rL$. So the set of incentive compatibility constraints in (9.6) reduces to a single condition on the size of the loan. The initial loan must be small enough so that $\alpha L^{\lambda} \geq rL$. Rearranging gives

$$L \leq \left(\frac{\alpha}{r}\right)^{1/(1-\lambda)}. \tag{9.8}$$

Now consider the unconstrained maximisation of the objective function (9.4). This entails solving for L that maximises

$$\pi[L^{\lambda} - rL] + (1-\pi)\left\{[1-\alpha\mathrm{E}(z \mid z>0)]L^{\lambda} - [1-\mathrm{E}(z \mid z>0)]rL\right\},$$

where $\mathrm{E}(z \mid z > 0)$ is the expectation of z conditional on its being strictly positive. Since z is uniformly distributed on the unit interval, $\mathrm{E}(z \mid z > 0) = 1/2$. The solution to the unconstrained maximisation can therefore be obtained from the first-order condition:

$$\lambda L^{\lambda-1}\left[\pi + (1-\pi)\left(1-\frac{\alpha}{2}\right)\right] - r\left[\pi + \frac{1-\pi}{2}\right] = 0, \tag{9.9}$$

which yields

$$L = \left\{\frac{\lambda}{r} \times \frac{[2-\alpha(1-\pi)]}{1+\pi}\right\}^{1/(1-\lambda)}. \tag{9.10}$$

So the incentive compatibility constraint (9.8) fails to bind if and only if

$$\alpha \geq \frac{2\lambda}{1+\pi+\lambda(1-\pi)}. \tag{9.11}$$

In other words, if α is large enough, there are no impediments to borrowing the *ex ante* optimal amount. The threat of premature liquidation serves to discipline the borrower into repaying as much as possible and, knowing this, creditors are willing to extend the full amount. But if α is small, incentive problems limit the extent of borrowing. As Dooley (2000) and Cline (2000) have observed, it implies that policies to promote orderly workouts may inadvertently lower aggregate capital inflows by weakening the punishment structure.

To complete the solution of the optimal contract, the participation constraint must also be satisfied. Since the production function satisfies $\lim_{L\to 0} \partial y/\partial L \to \infty$, the optimal loan is given by an interior solution. So the solution to the optimal contract is

$$L_* = \min\left\{\left(\frac{\alpha}{r}\right)^{1/(1-\lambda)}, \left[\frac{\lambda}{r} \times \frac{[2-\alpha(1-\pi)]}{1+\pi}\right]^{1/(1-\lambda)}\right\}. \tag{9.12}$$

9.2 THE ROLE OF THE OFFICIAL SECTOR

Although the disciplining role of the threat of premature liquidation permits greater access to credit, it comes at a significant cost. If the debtor is genuinely unlucky and is forced into default through adverse circumstances, then the damage that default costs inflict on the real and financial sectors of the economy may be grave. Simply focusing on the punishment mechanism understates the beneficial role that the official sector can play in dealing with financial crises. Public policy has a twofold effect. First, increased scrutiny from the official sector might substitute for private sector discipline by distinguishing between 'bad luck' and 'strategic' defaults. Second, if the framework for dealing with sovereign bankruptcy is effective, policymakers may be able to mitigate *ex post* coordination costs. This might be achieved, for example, by mediating in workouts via a mechanism such as the SDRM, by endorsing collective action clauses in bond contracts, or sanctioning temporary controls on capital outflows. Indeed, public sector actions that mitigate the costs of disorderly liquidation are capable of generating similar levels of lending as the regime in which the threat of sanctions by private creditors is the only source of discipline.

We now introduce a third party, the 'IMF' for short, that comes into play during the interim period. The IMF is assumed to have access to an imperfect signal concerning the state of the borrowers interim finances. The signal tells the IMF whether the debtor has sufficient resources to repay the creditors in full—that is, whether z is zero or positive. Upon receiving this information, the IMF makes a pronouncement of its view of the current state of fundamentals and reaches a judgment about the need for official intervention. If the IMF's message space consists of only two messages {Good, Bad}, the joint distribution over messages and underlying fundamentals, z, can be described by the following matrix:

		Message that fundamentals are	
		Good	**Bad**
Fundamentals	**Good** $(z = 0)$	$\pi(1 - \varepsilon)$	$\pi\varepsilon$
	Bad $(z > 0)$	$(1 - \pi)\varepsilon$	$(1 - \pi)(1 - \varepsilon)$

The IMF's signal is imperfect in two respects. First, the message space is coarse and merely tells policymakers whether fundamentals are good or bad. Second, the signal suffers from noise. Conditional on $z = 0$, the IMF gets the incorrect message that fundamentals are 'bad' with probability ε. Assume that $\varepsilon < 0.5$, so that the signal has some information value.

If there is a shortfall in repayments to creditors, the announcement by the IMF that fundamentals are bad prompts the implementation of policies that offset the destructive effects of creditor liquidation. The effects of these actions are captured in a reduced-form fashion by the parameter σ, which reflects the extent to which policy action mitigates the output losses generated by premature liquidation. Intervention has four main effects:

First, the policy intervention attenuates the effects of the parameter, α. In particular, output in the final period given the shortfall, s, when the

IMF intervenes is $(1 - \sigma\alpha s)L^{\lambda}$, where $0 \leq \sigma \leq 1$.

Second, when the IMF correctly intervenes (represented by the bottom right-hand side of the matrix), the debtor's true resources, $\tilde{x}$, become known, so that creditors are informed of the true value of $\tilde{x}$. Thus, the realised payment shortfall, s, is equal to the true shortage of resources as represented by the random variable, z. The IMF is able to provide discipline consistent with the incentive compatibility constraint;

Third, if the IMF mistakenly intervenes—that is, it erroneously declares that a bad luck default has occurred in an instance where the shortfall is actually due to a diversion of funds (represented by the top right-hand side of the matrix)—then creditors are inappropriately locked into a workout process. The result is that the debtor cheats successfully and benefits from the IMF's actions to mitigate the costs of crisis;

Finally, when the IMF mistakenly fails to intervene (the bottom left-hand cell of the matrix), it makes the opposite error. Even though the shortfall is due to bad luck, the IMF pronounces that the debtor is engaging in strategic default. The failure to intervene exposes the country to the full impact of a creditor grab race.

The consequences of IMF intervention are as follows. On one hand, by reducing the costs of disorderly workouts, it can mitigate output losses when fundamentals are poor. But there is also a welfare impact from the reduced disciplining effect of default, which leads to a sub-optimal level of initial credit. The net benefit of public sector intervention arises only if the first effect outweighs the second.

Let us now consider the incentives facing the borrower with sufficient resources to pay in full, that is, where $z = 0$. Conditional on $z = 0$, the IMF will mistakenly intervene with probability, ε, while with probability, $1 - \varepsilon$, there is no intervention. The debtor's maximisation problem is to choose s to maximise

$$(1-\varepsilon)[(1-\alpha s)L^{\lambda} - (1-s)rL] + \varepsilon[(1-\sigma\alpha s)L^{\lambda} - (1-s)rL], \quad (9.13)$$

which can be written as

$$L^{\lambda}\left[1 - s\underbrace{\alpha[(1-\varepsilon)+\sigma\varepsilon]}_{\hat{\alpha}}\right] - (1-s)rL. \quad (9.14)$$

Compared with equation (9.7), the effect of the IMF's presence in the debtor's optimisation problem is to multiply the factor, α, by $(1-\varepsilon)+\sigma\varepsilon$, which is strictly less than one. Thus, the incentive compatibility constraint for a debtor with $z = 0$ analogous to (9.8) is

$$L \leq \left(\frac{\hat{\alpha}}{r}\right)^{1/(1-\lambda)}. \tag{9.15}$$

Now consider the debtor with $z > 0$. The debtor knows that the IMF will intervene correctly with probability $1-\varepsilon$. In this case, the IMF verifies the true realisation of s, and enforce payment of the true available resources. So the only event in which the debtor's choice of s matters is when the IMF fails to intervene. As a result, net expected output is given by

$$\varepsilon[(1 - \alpha s)L^{\lambda} - (1 - s)rL] + (1 - \varepsilon)[(1 - \sigma\alpha z)L^{\lambda} - (1 - z)rL], \tag{9.16}$$

and the objective is to again choose $s \geq z$ to maximise this expression. It leads, as before, to the expression:

$$L \leq \left(\frac{\alpha}{r}\right)^{1/(1-\lambda)}. \tag{9.17}$$

The incentive constraint is identical to the one facing the debtor in the regime without the IMF. Since $\hat{\alpha} < \alpha$, this second constraint never binds in the optimal contract in the presence of the IMF. The reason for this is as follows. When $z = 0$, the debtor knows that the IMF may intervene incorrectly, in which case there is a positive gain from cheating. As long as this possibility exists, the temptation to cheat weakens the disciplining effects of disorderly liquidation, and the debtor's access to credit is curtailed. In contrast, when $z > 0$, the debtor realises that the IMF will intervene correctly with high probability, in which case true resources are revealed and disorderly liquidation is averted. The only circumstance where cheating has an effect is when the IMF *mistakenly* fails to intervene. But then, there is no respite from the damaging effect of disorderly liquidation, and the incentive not to cheat is as high as in the regime without the IMF.

It remains to determine when the incentive compatibility constraint (9.17) binds. Note that the solution to the unconstrained problem is identical to the one without the IMF, since the IMF does not affect the fundamental features of the economy. And, as before, the participation constraint does not bind, so the solution to the optimal contracting problem with the IMF is the level of the loan given by

$$\hat{L}_{*} = \min\left\{\left(\frac{\hat{\alpha}}{r}\right)^{1/(1-\lambda)}, \left[\frac{\lambda}{r} \times \frac{[2 - \alpha(1 - \pi)]}{1 + \pi}\right]^{1/(1-\lambda)}\right\}. \tag{9.18}$$

Comparing (9.18) with (9.12), we can see that the presence of the IMF reduces the amount of credit available to the borrower. The difference between L_* and $\hat{L}_*$ depends on two factors: the quality of the IMF's judgment regarding fundamentals, represented by ε; and the efficacy of the sovereign bankruptcy regime, represented by σ. The two factors work in different ways. On the one hand, as the IMF's judgment tends to perfection ($\varepsilon \to 0$), the discipline of IMF surveillance effectively substitutes for market discipline, and lending in the regime with the IMF approaches the market solution ($\hat{\alpha} \to \alpha$, so that $\hat{L}_* \to L_*$). On the other hand, the lower the effectiveness of the bankruptcy regime in limiting the costs of crisis ($\sigma \to 1$), the less relevant is the official sector in determining debtor and creditor payoffs and $\hat{L}_* \to L_*$. In between these two extremes, the borrower's access to credit is lower than under the laissez faire solution.

Although the amount of the loan is smaller in the presence of the IMF, the same cannot be said of expected output and welfare. The debtor's objective function is expected output net of the repayment costs, while the lender's payoff is the expected repayment proceeds. If we define welfare as the sum of the payoff functions of the two parties, then the welfare effects of the IMF's involvement can be expressed in terms of total gross expected output.

Denote by W the *ex ante* total expected output in the regime without the IMF, and by $\widehat{W}$, the *ex ante* total expected output in the presence of the IMF. Then from the expressions for the optimal loan amounts (9.12) and (9.18), and making use of the fact that $\mathrm{E}(z \mid z > 0) = 1/2$:

$$W = L_*^{\lambda} \left\{ \pi + (1-\pi) \left(1 - \frac{\alpha}{2}\right) \right\}, \tag{9.19}$$

$$\widehat{W} = \hat{L}_*^{\lambda} \left\{ \pi + (1-\pi) \left(1 - \frac{\alpha}{2}[\varepsilon + \sigma(1-\varepsilon)]\right) \right\}. \tag{9.20}$$

Although $\hat{L}_* < L_*$, we also have $\alpha[\varepsilon + \sigma(1-\varepsilon)] < \alpha$, so there is no general ranking of expected output in the two cases. Notice that expected output in the absence of the IMF does not depend on ε. By contrast, $\widehat{W}$, depends on ε, both because the level of the loan is affected by it, and because ε affects the degree of mitigation of the harmful effects of bad luck default. From (9.18), $\hat{L}_*$ is decreasing in ε, while $\varepsilon + \sigma(1-\varepsilon)$ is increasing in ε. Thus for both reasons, the expected output in the presence of the IMF is a strictly decreasing function of ε. The result is intuitive. When ε is large, the scope for errors of judgment by the IMF is significant. It reduces access to the credit market for the debtor and also makes *ex post* intervention less effective after default. In the extreme case where the IMF never gets it wrong, $\varepsilon = 0$, we know that

$$\hat{L}_* = L_*, \tag{9.21}$$

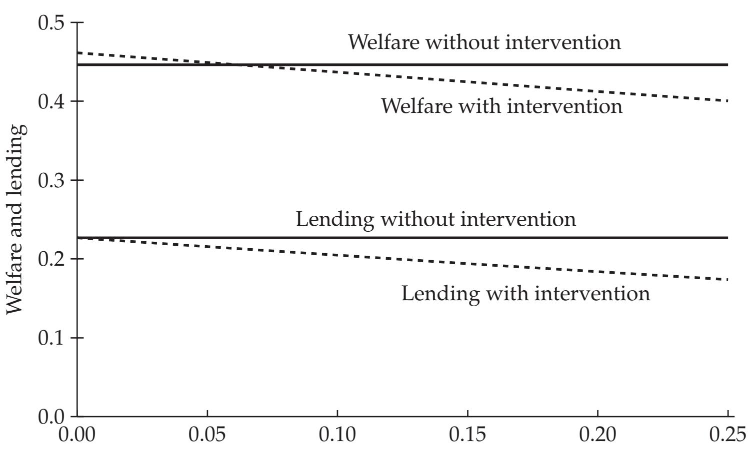
but as $\sigma\alpha < \alpha$,

$$\widehat{W} > W. \tag{9.22}$$

Since $\widehat{W}$ is a continuous function of ε, it implies that for sufficiently small ε, the IMF has a net beneficial effect. The question is how small ε has to to be for such a result to hold. Denoting by $\hat{W}(\varepsilon)$ the expected output in the IMF regime, expressed as a function of ε, we can solve for ε from the equation

$$\widehat{W}(\varepsilon) = W. \tag{9.23}$$

The non-linear nature of this equation means that closed form solutions are difficult to obtain. But we can gain intuition from some numerical examples. Figure 9.1 shows how, for chosen benchmark levels, lending and expected output differ in a regime with and without official intervention. If the ability of the IMF to judge the state of the debtor country's finances is perfect ($\varepsilon = 0$), the level of lending in the two regimes is the same. Expected output is, however, higher because the



Other parameters: $\alpha = 0.5$, $\lambda = 0.5$, $\rho = 0.05$, $\pi = 0.75$ and $\sigma = 0.5$.

Figure 9.1. *The impact of policy intervention on lending and welfare*

official sector is correctly able to stem a country run in the case of 'bad luck' default. As the quality of judgment declines, both lending and expected output fall and, for sufficiently high values of ε, a sovereign bankruptcy framework may prove welfare-reducing. But if judgment error is relatively small, intervention is beneficial. Moreover, as Figure 9.2 shows, the benefits of intervention are high when the real cost of the creditor coordination problem (α) is greater.

Figure 9.3 highlights the importance of the IMF's dual role as 'whistle blower' and 'fire fighter'. Again we compare the expected output in

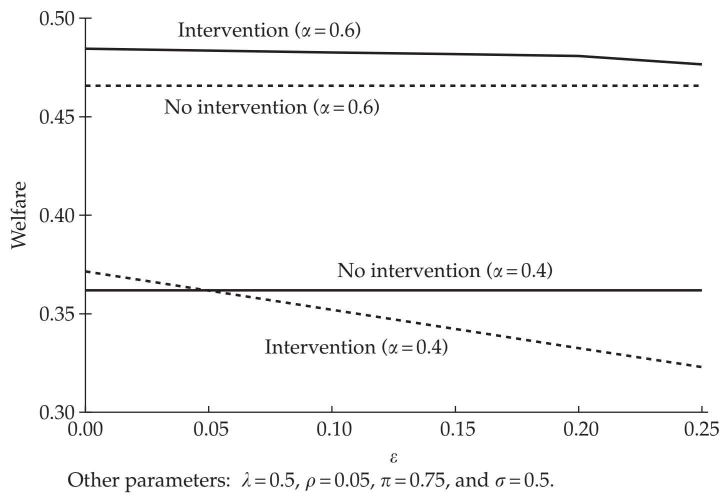


Figure 9.2. *Welfare and the costs of crisis*

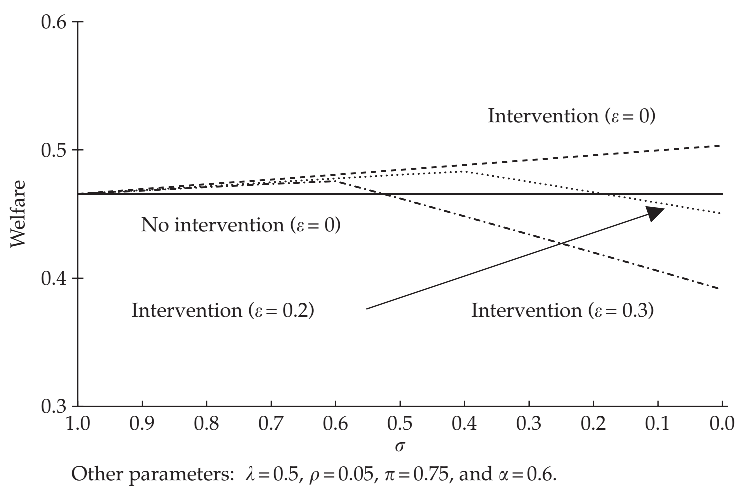


Figure 9.3. *Welfare and the efficacy of measures to mitigate crisis costs*

a regime with the IMF against expected output in a regime without. Now, however, we vary the efficacy of crisis management policies (σ), for given levels of judgment error (ε) and default costs (α). As can be seen, in the case where judgment is perfect, but the ability of official intervention to mitigate the costs of crisis is poor ($\sigma \rightarrow 1$), expected output in the two regimes is the same. But as the ability of the official community to contain the costs of crisis improves ($\sigma \rightarrow 0$), expected output in a regime with intervention rises above that in a regime without. If the IMF is less than perfect in exercising judgment (i.e. $\varepsilon = 0.2$ or $\varepsilon = 0.3$), expected output may, nevertheless, also be higher. The value of a reduced cost of crisis outweighs the effects of lower lending. But if $\sigma \rightarrow 0$, expected output falls below that in a no-IMF world. This is because the moral hazard effects, created by the combination of weak public monitoring and effective crisis management, overwhelm the gains from elimination of the *ex post* creditor coordination problem.

The Gai *et al*. (2004) model shows how official sector intervention based on systematic guidelines can deliver welfare benefits. Although bankruptcy reforms such as the SDRM or CACs may reduce the level of capital flows *ex ante*, it could compensate for this by ameliorating the disruptive effects of crises *ex post*. But the benefits are most likely to accrue if the official sector is capable of identifying the source of financial problems and intervening in workouts effectively. And the greater the transparency and accountability of debtor governments, the more effective public monitoring is likely to be as a disciplining device. The analysis, thus, highlights the potentially important role played by IMF surveillance and data disclosure by debtor countries in facilitating crisis management.

9.3 CONTRACTUAL MECHANISMS

The analysis, so far, has left open the question of the best way to remedy creditor collective action problems. Haldane *et al*. (2004) examine the efficacy of collective action clauses (CACs) in mitigating *ex post* coordination inefficiencies.[58] Their model has an *ex post* focus and, unlike the model of the previous two sections, does not address the *ex ante* issue of strategic default and moral hazard. But it helps clarify

[58] See Kletzer (2003) for a related model. Eichengreen and Mody (2000) and Becker *et al*. (2003) provide empirical analyses of the effects of CACs on cost of borrowing. These studies show that such clauses tend to lower (or at least not raise) borrowing costs for emerging market borrowers. So reforms to sovereign bankruptcy may not be associated with nearly as large a contraction of capital inflows (or a rise in borrowing costs) as suggested by critics of such proposals.

the nature of the hold-out problem in sovereign debt workouts and the conditions under which CACs resolve coordination inefficiencies.

We again consider a single debtor country facing a continuum of foreign creditors, each holding a unit of a bond. The debtor is presumed to already be in trouble. It lacks the resources to repay its obligations in full, and so makes an offer to all creditors to write down the value of outstanding debt. Assume that the debtor's initial resources are y_0, which is less than the total outstanding face value of the bond, $1 + r$.

The debtor can augment the total resources available to repay its creditors by exerting effort, e. If the debtor exerts effort, total resources are given by $y(e)$. If no effort is expended, then total resources remain at y_0. These resources reflect the total value of claims that can be seized by the creditors in the jurisdiction in which the bond is issued. A court is assumed to uphold the original claim at face value if $y(e)$ is high enough, and allocates $y(e)$ on a pro rata basis among the remaining creditors if the resources are insufficient to pay the original claims. Effort is costly and is given by $c(e)$. The net surplus $y(e) - c(e)$ is a single peaked function which is concave and differentiable in e.

Since the debtor cannot repay in full, it offers $\omega(1 + r)$, to each creditor, $0 < \omega < 1$. Creditors who participate in the offer receive this payment. But they may also hold out in an effort to receive the full value of their claim, $1 + r$, and so prolong the restructuring process. Each creditor i has a private legal cost, l_i, of holding out. The legal cost per unit of debt, l_i, uniquely characterises the 'type' of each creditor. These costs are given by

$$l_i = \bar{l} + \varepsilon_i \tag{9.24}$$

where $\bar{l} \geq 0$ is the average cost across creditors and ε_i is a random variable with mean zero, cumulative distribution function $F(.)$, and support $[\underline{\varepsilon}, \bar{\varepsilon}]$. Legal costs are non-negative, so that the lowest possible realisation of l_i is also non-negative. The distribution of legal costs across creditors is assumed to be common knowledge.

Events proceed as follows. The debtor offers a payment $\omega(1 + r)$ to each creditor, who then vote to accept the offer or to hold out. Upon learning the outcome of the vote, the debtor chooses policy effort, e, and total resources $y(e)$ are realised. Resources are then distributed. Creditors who accept the offer receive $\omega(1+r)$. By contrast, those who reject the offer receive either the face value of the claim $1+r$, net of legal costs, if $y(e)$ is large enough or an equal share of remaining resources, net of legal costs.

As in Section 9.2, welfare is given by the sum of the debtor's and creditor's payoffs. In this instance, the metric is the output surplus net of the legal costs paid by the holdout creditors. In other words,

$$W = y(e) - c(e) - \int_{\bar{l}+\underline{\varepsilon}}^{l_h} zf(z)dz$$

where l_h is the marginal holdout creditor. The socially optimal outcome is obtained when there are no holdouts, that is $l_h = \bar{l} + \underline{\varepsilon}$, and the adjustment effort solves

$$y'(e) = c'(e).$$

To highlight the role of CACs, first consider contractual arrangements that require the consent of all creditors to adjust financial terms.[59] The worst scenario for all parties is one where the debtor makes offers that no creditor finds attractive. This leads to zero adjustment effort and immediate foreclosure by creditors. To rule this scenario out, the offer on the table must exceed the initial level of resources attachable by creditors net of the highest legal costs, that is,

$$\omega(1+r) > y(0) - \bar{l} - \bar{\varepsilon}. \tag{9.25}$$

The payoff to a holdout creditor, j, is given by

$$\min\left\{(1+r) - l_j, \frac{y(e) - \omega(1+r)(1-h)}{h} - l_j\right\}. \tag{9.26}$$

In other words, if there are resources sufficient to pay each holdout creditor in full, the creditor receives the face value of the bond net of his legal costs or, if debtor resources are insufficient, a pro-rated share of residual output. The payoff to accepting creditors (in proportion $1-h$) is $\omega(1+r)$.

The objective of the debtor is to choose an offer $\omega(1+r)$ to maximise $y(e) - c(e)$ net of the total payout to creditors based on (9.26). One option is to make an offer that every creditor would accept. The lowest feasible offer, consistent with $h = 0$, calls for repayments to be consistent with the fallback option of the creditor with the lowest legal costs. In other words, total repayments are

$$(1+r) - \bar{l} - \underline{\varepsilon}. \tag{9.27}$$

59 Such unanimity is the market convention for international bonds issued under New York law.

But the debtor may be able to do better by paying some creditors in full and offering lower repayments to accepting creditors. If the marginal creditor who accepts the deal has legal costs of $\bar{l} + \tilde{\varepsilon}$, the total repayments are

$$h(1 + r) + (1 - h)[(1 + r) - \bar{l} - \tilde{\varepsilon}]. \tag{9.28}$$

Clearly, when (9.28) < (9.27), total repayments by the debtor are lower than when no creditor holds out. It, in turn, implies

$$\tilde{\varepsilon} - \underline{\varepsilon} > \frac{h}{1 - h}(\bar{l} + \underline{\varepsilon}). \tag{9.29}$$

If legal costs are uniformly distributed, the proportion of holdouts is given by

$$h = \frac{\tilde{\varepsilon} - \underline{\varepsilon}}{\bar{\varepsilon} - \underline{\varepsilon}}. \tag{9.30}$$

Substituting into (9.29), it follows that (9.28) < (9.27) when

$$\bar{\varepsilon} - \underline{\varepsilon} - \tilde{\varepsilon} > \bar{l}. \tag{9.31}$$

Now the toughest creditor has legal costs associated with the parameter value, $\underline{\varepsilon}$. Evaluating the above inequality at $\tilde{\varepsilon} = \underline{\varepsilon}$ allows us to consider the incentives for the debtor to pursue such a repayment strategy. If $\bar{\varepsilon} - 2\underline{\varepsilon} > \bar{l}$, the debtor will prefer to pay out some creditors in full and will prefer to do this until $\tilde{\varepsilon} = \bar{\varepsilon} - \underline{\varepsilon} - \bar{l}$. The proportion of holdout creditors is thus

$$h = 1 - \frac{\bar{l} + \underline{\varepsilon}}{\bar{\varepsilon} - \underline{\varepsilon}}. \tag{9.32}$$

This condition is most likely to be met when the distribution of legal costs is widely dispersed relative to its mean. If the debtor does prefer to repay some creditors in full, then holding out is an attractive strategy for some creditors. The model thus provides a rationale for the presence of 'vulture funds' in sovereign debt restructuring.

The two repayment options limit total payments to creditors and motivate the debtor to then subsequently exert a socially optimal level of effort. But this is only feasible if average legal costs are very high. If legal costs decline, the number of holdouts increases, and the second argument of (9.26) binds. In equilibrium, the payoff to holding out and accepting must be equalised for the marginal creditor, l_h, that is,

$$\omega^*(1+r) = \frac{y(e) - \omega^*(1+r)(1-h)}{h} - l_h, \tag{9.33}$$

implying

$$\omega^*(1+r) = y(e) - hl_h. \tag{9.34}$$

The debtor's payoff is given by

$$\begin{aligned} y(e) - c(e) - (1-h)\omega^*(1+r) - h\left[\frac{y - \omega^*(1+r)(1-h)}{h}\right] \\ = y(e) - c(e) - (1-h)[y(e) - hl_h] \\ - y(e) - (1-h)[y(e) - hl_h] \\ = -c(e), \end{aligned} \tag{9.35}$$

which is maximised at $e = 0$. Total resources are exhausted in repaying creditors, and the debtor has no incentive to exert effort. Economic inefficiencies arise due to the legal costs incurred by creditors and the exertion of suboptimal effort by the debtor. As Haldane *et al.* (2004) stress, the minimum additional effort exerted is not literally zero, however, and can be scaled up to a positive amount.

Collective action clauses (CACs) permit a suitable majority of bondholders to change the financial terms of a debt contract. Let κ be the critical voting threshold written into the bond. Under English Law, this majority is typically 75% of outstanding principal at a meeting of bondholders. If the incidence of creditors who vote for the debtor's offer is greater than, or equal to, κ, then the offer applies to all creditors, including those who dissent. If the offer fails, because fewer than κ creditors accept the offer, creditors may pursue their claims legally each eventually receiving a share of total output less the resources spent on legal costs.

In the event that the deal falls through, the debtor does not obtain any surplus, and so does not exert any effort. As a result, the creditor expects to receive $y(0) - l_i$ by going to court. If the offer is accepted, the debtor has incentives to exert effort as it can secure a surplus. The debtor's payoffs are

$$\begin{cases} y(e) - \omega^*(1+r) - c(e), & \text{if } \kappa \text{ or more creditors accept,} \\ 0, & \text{otherwise.} \end{cases} \tag{9.36}$$

Similarly, the payoff to creditors in the $(1-\kappa)$th quantile of the distribution of legal costs is

$$\begin{cases} \omega(1+r), & \text{if } \kappa \text{ or more creditors accept,} \\ y(0) - l_{1-\kappa}, & \text{otherwise,} \end{cases} \tag{9.37}$$

and creditors will vote to accept the offer provided $\omega(1+r) \geq y(0) - l_{1-\kappa}$.

The weakly dominant action for the debtor is to make an offer that just persuades a proportion κ to accept the offer, that is,

$$\omega^*(1+r) = y(0) - l_{1-\kappa}. \tag{9.38}$$

So CACs always elicit the socially efficient level of hold-outs: zero. Moreover, this offer induces the debtor to exert optimal effort. To see this, note that debtor surplus is given by

$$y(e) - y(0) + l_{1-\kappa} - c(e), \tag{9.39}$$

which is maximised when

$$y'(e) = c'(e), \tag{9.40}$$

yielding the socially optimal level of effort.

Changing the threshold affects the outcome. Since

$$y(e^*) - c(e^*) - y(0) + l_{1-\kappa} > 0 \tag{9.41}$$

socially optimal effort will always be achieved. A range of threshold values, κ, can satisfy *ex post* efficiency. Lowering κ transfers surplus from creditors to the debtor through a reduction in the equilibrium offer. Debtors clearly prefer a lower value of κ *ex ante*, because it increases their share of the surplus. Creditors, by contrast, prefer a higher value of κ as this raises the debtor's offer. Note that since (9.41) is satisfied, a bankruptcy court or a statutory device such as the SDRM is redundant. The debtor is always able to make an offer that is acceptable to the requisite majority of creditors, and which elicits the socially optimal level of effort. Coordination inefficiencies are mitigated without the need for formal institutions.

Haldane *et al.* (2004) also consider the more realistic situation in which there is an information asymmetry between the creditors and the debtor. Specifically, the debtor's surplus when exerting effort and the creditor's returns from legal action are treated as private information. The introduction of such frictions creates an environment in which debtor–creditor inefficiencies compound the intra-creditor coordination problem. As stressed by the literature on bargaining theory (see Osborne and Rubinstein, 1990), voluntary solutions to the bargaining problem under imperfect information are sub-optimal because the parties in the bargain are unable to maximise the gains from trade. Although CACs resolve the intra-creditor problem, they are unable to tackle the inefficiencies generated by debtor–creditor conflict. The implication is that contractual mechanisms such as CACs are, *on their own*, insufficient as a means of managing sovereign debt restructuring problems. A role may still remain for statutory third-party intervention to support an efficient outcome. But as we have already seen, the ability of a third party to do this depends critically on its ability to monitor. The literature is yet to establish a clear consensus on the effects of a third party in sovereign debt renegotiations.[60]

[60] See Bulow and Rogoff (1988), Klimenko (2002), and Wells (1993) for detailed analyses.

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10

Open Issues

10.1 RUSHES FOR THE EXITS

In addition to concerns that crisis management policies reduce the quantum and raise the cost of capital flowing into emerging markets, there is also the possibility that creditors will respond pre-emptively to the imposition of a regime of bankruptcy courts and payments standstills. Some commentators (e.g. Geithner, 2000) suggest that, in anticipation of an announcement of payments stays, creditors will merely move down the maturity spectrum to avoid being caught up in a debt workout. Official intervention in crisis resolution may, thus, increase the very probability of a crisis happening in the first place by skewing a country's debt to the very short-term. Anecdotal evidence from the Brazilian crisis in 1998 seems to accord with such a view—there was a 'rush for the exits' as the maturity of credit lines was cut in anticipation of international intervention.[61]

The literature on financial crises and sovereign debt has yet to tackle this issue satisfactorily. Debt maturity structure cannot be considered in isolation from the issue of the pricing of risky debt. And, in general, it is not possible to study the two simultaneously, as the failure rate of a project and the pricing relationship are both endogenous and dependent on each other. The recent literature in finance focuses on asset pricing issues, taking the maturity profile as given.[62] But to examine the effects of crisis management measures on the maturity profile, it is necessary to focus on the complementary issue, namely the failure rate of a project that is implied by a given pricing structure.

Following Gai and Shin (2004), suppose that investors can choose to be equityholders or lend to the entrepreneur of a risky project.

[61] Mathieson *et al*. (2000) provide a detailed description of these events.

[62] In reduced form credit models (e.g. Jarrow and Turnbull, 1995; Duffie and Singleton, 1999), default is treated as an event that is entirely governed by an exogenously specified failure rate for default. This, together with assumption on the recovery of payment after a default, provides enough structure to determine bond prices.

Those who choose to lend must also decide on the maturity of the debt contract, which can range from one period to T periods. The per capita value of the project at the initial date is 1. The value in the next period depends on the amount of debt that matures at that date. To provide the additional structure necessary to analyse the debt maturity profile, the notional forward rate is constant and given by R, so that the notional yield on debt maturing at date t is given by R^t.[63]

We assume that debtor is passive and that the probability of the project failing before maturity depends on the incidence of short-term debt. Specifically, the probability of failure is given by the incidence of the shortest maturity debt as a proportion of capital outstanding. Thus, conditional on having succeeded up to date $t-1$, the project fails at date t with probability:

$$\gamma(t) \equiv \frac{p(t)}{p(T+1) + \sum_{s=t}^{T} p(s)}, \tag{10.1}$$

where $p(t)$ is the size of the debt that matures at date t and $p(T+1)$ is the size of the equity holding. In other words, the probability of project failure depends on the amount of maturing debt as a proportion of the total capital of the project.[64]

The value of the project increases over time. The longer the project is allowed to continue, the greater is the break-up value of the project. If the project were to fail before the maturity of the project, liquidation costs are incurred that reduce the return to claimholders. So when the project fails between t and $t-1$, the project is liquidated for θR^t and all creditors receive this liquidation value. The parameter θ represents the liquidation value. The equityholders receive nothing. But if the project survives date t, then lenders whose debt matures at date t receive the full notional value R^t. In order that short-term debt is not dominated by long-term debt, we impose the condition that $0 < \theta < 1/R$. If the

[63] In conventional pricing models of debt, the hazard rate is defined as the probability that the borrower will default in period t, conditional on having survived till $t-1$. It is treated as exogenous and the task is to calculate the price, given this hazard rate. Here, both the hazard rate and the price are endogenous. Since one depends on the other, the *ex ante* equilibrium choice of debt maturity structure and the notional forward rate cannot both be tied down unless we impose additional structure to the problem. Assuming a constant notional forward rate fixes the pricing relationship in the simplest way possible.

[64] The empirical literature on the pricing of defaultable debt supports this assumption. For instance, the well-known implementation of the Merton model of the pricing of defaultable debt by KMV Corporation builds this feature into their pricing model (see Crouhy *et al.*, 2001).

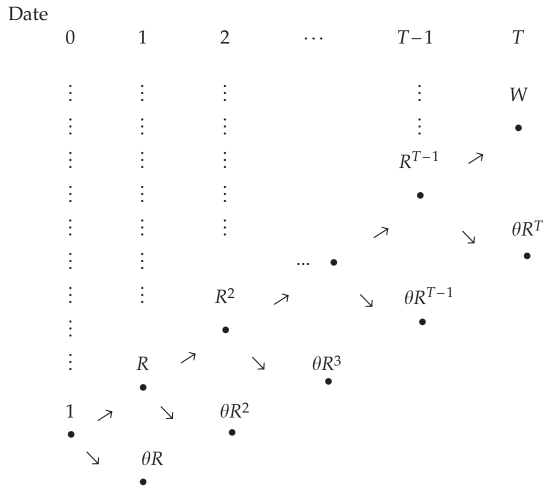


Figure 10.1. *The value of the project*

project never fails and so succeeds at the terminal date T, then the value of the firm is W. The equityholders receive the residual payoff

$$W - R^T, \tag{10.2}$$

and all debtholders are paid in full. Figure 10.1 illustrates the evolution of the value of the project.

The payoffs of the claimholders as a function of the date of the project failure can thus be represented in terms of the following matrix:

		Project failure date							
		1	2	3	4	5	$\cdots$	T	Never
Debt maturing	1	θR	R	R	R	R	$\cdots$	R	R
		θR	θR^2	R^2	R^2	R^2	$\cdots$	R^2	R^2
	3	θR	θR^2	θR^3	R^3	R^3	$\cdots$	R^3	R^3
	4	θR	θR^2	θR^3	θR^4	R^4	$\cdots$	R^4	R^4
	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$
	T	θR	θR^2	θR^3	θR^4	θR^5	$\cdots$	θR^T	θR^T
Equity		0	0	0	0	0	$\cdots$	0	$W - R^T$

The action set of the individual is denoted by $\{1, 2, \ldots, T, T+1\}$ where $T+1$ indicates investing as an equityholder, while $t \leq T$ indicates lending at maturity t. In general, the payoff to a particular action depends on how far the risky project progresses. Equity and longer maturity debt do better if the project reaches an advanced stage. For creditors, the payoffs have the feature that each creditor has an incentive to be 'one step closer to the door' than other creditors, in the sense that if all other creditors are of maturity t, then the best reply is to choose maturity $t-1$. The only exception is when everyone chooses debt of maturity 1. In this case, creditors are indifferent between any maturity from 1 to T.

Normalising the measure of investors to 1, denote by $p(t)$ the measure of investors who take action t, so that the vector

$$[p(1), p(2), p(3), \ldots, p(T), p(T+1)]$$

gives the capital structure of the risky project, where the terms sum to one.

In order to assess the expected payoffs to the investment decisions, we focus on the probability distribution over outcomes. The probability that the project fails at date t is given by

$$\begin{aligned} &[1-p(1)]\left[1-\frac{p(2)}{\sum_{s=2}^{T+1} p(s)}\right]\cdots\left[1-\frac{p(t-1)}{\sum_{s=t-1}^{T+1} p(s)}\right]\frac{p(t)}{\sum_{s=t}^{T+1} p(s)} \\ &\quad = \sum_{s=2}^{T+1} p(s)\cdot\frac{\sum_{s=3}^{T+1} p(s)}{\sum_{s=2}^{T+1} p(s)}\cdots\frac{\sum_{s=t}^{T+1} p(s)}{\sum_{s=t-1}^{T+1} p(s)}\cdot\frac{p(t)}{\sum_{s=t}^{T+1} p(s)} \\ &\quad = p(t). \end{aligned} \tag{10.3}$$

Thus, the expected payoff of each class of claimholder is obtained as the expectation of the payoff with respect to the probability density $[p(1), p(2), \ldots, p(T+1)]$. The expected payoff of the equityholder is

$$V(T+1) = p(T+1)\cdot(W-R^T), \tag{10.4}$$

while the expected payoff of the creditor with debt of maturity t is given by

$$V(t) = \sum_{s=1}^{t} p(s)R^{s-2} + R^t \sum_{s=t+1}^{T+1} p(s). \tag{10.5}$$

If the expected payoff from one type of claim is strictly smaller than another, no rational investor would hold such a claim, and its incidence in equilibrium would be zero. In turn, the incidence of the various types of claims determines the capital structure of the project and, hence, determines the expected payoffs of the claims. The equilibrium capital structure is one that equalises the expected payoff to each type of claimholder, and in which all types of claims are used in equilibrium.[65] We therefore seek the capital structure for which

$$V(1) = V(2) = \cdots = V(T) = V(T+1). \tag{10.6}$$

More formally, denote by M the matrix of payoffs, and denote by p the column vector

$$p = \begin{bmatrix} p(1) \\ p(2) \\ \vdots \\ p(T) \\ p(T+1) \end{bmatrix}.$$

The expected payoff to the claimholder of maturity t is given by the tth entry of the vector:

$$Mp.$$

In order for all claimholders to have the same expected payoff, we must have

$$Mp = k$$

for some constant vector k. It can be verified that M is non-singular, so that the equilibrium capital structure p is obtained as

$$p = M^{-1}k, \tag{10.7}$$

where the elements of the column vector, p, sum to one.

Increasing the recovery rate

Since the general solution to (10.7) is cumbersome and uninformative, we highlight the effects of changes in the recovery rate for the equilibrium debt maturity profile using numerical examples. Consider the case where the maturity of the debt contract ranges from one to four periods, and where project value, W, and the forward rate, R, take the

65 There are two trivial fixed points of the mapping in which only one type of claim is used. One is where only equity is used. In this case, the project always progresses to completion (since $p(t) = 0$ for all $t \leq T$), so that the best reply is to be an equity investor. The other trivial fixed point is when only debt of maturity 1 is used. If everyone else uses debt of maturity 1, then the project always fails at date 1 (since $p(1) = 1$), and one cannot do better than to follow suit.

values 20 and 1.2 respectively. In this instance, the matrix, M, of payoffs of all the claimholders as a function of the date of project failure is:

		Project failure date				
		1	2	3	4	5
	1	θR	R	R	R	R
Asset	2	θR	θR^2	R^2	R^2	R^2
maturing	3	θR	θR^2	θR^3	R^3	R^3
date	4	θR	θR^2	θR^3	θR^4	R^4
	5	0	0	0	0	$20 - R^4$

The maturity profile can be obtained directly from equation (10.7). Since, in equilibrium, the expected payoff to each type of claimholder is equalised, it is particularly convenient to emphasise the expected payoff of the equityholder, that is,

$$V(T+1) = p(T+1)(W - R^T) = f(\theta). \qquad (10.8)$$

Figure 10.2 shows how the equilibrium expected payoff varies with the recovery rate for the assumed numerical values. As can be seen, the expected equilibrium payoff is increasing in θ and lies above the 45 degree line in the relevant range, $0 < \theta < 1/R$. In other words, marginal improvements in the recovery rate lead to a more than one-for-one increase in the expected payoff. This reflects two separate factors. First, there is a *direct* effect—an increase in the recovery rate

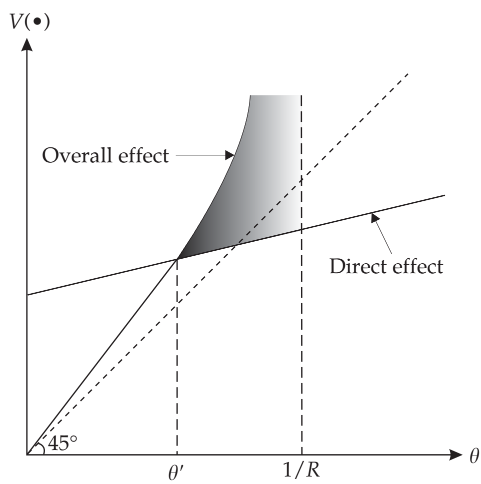


Figure 10.2. *Equilibrium expected payoff*

increases the amount that can be recovered by the bondholder in the event of a default. So, conditional on the occurence of default, the equilibrium payoffs to claimholders are increased. Second, there is a *strategic* effect that arises from the pre-emptive nature of creditor behaviour. The increase in the recovery rate reduces the incentive to engage in pre-emption, at the margin. If all other creditors are of maturity t, an increase in θ lowers the payoff from choosing maturity $t-1$. To the extent that the *strategic* effect reduces the tendency of creditors to liquidate early, it improves the chances of the project succeeding and progressing to the next date.

Increases in the recovery rate amplify the role played by the *strategic* effect. Figure 10.2 also illustrates how the *direct* effect influences the expected payoff on its own. As θ exceeds the reference point, θ', the wedge between the overall and *direct* effects becomes larger. So an increase in expected payoffs from higher recovery rates need not just reflect improved debt collection—creditor behaviour is also altered. Intuitively, if the amount that can be recovered in the event of default is sufficiently high, the desire to pre-empt one's opponent diminishes.

The duration of crisis management measures

The increase in θ can be regarded as a reduced form metaphor for measures that seek to improve the recovery process for bondholders. The precise impact on the maturity profile depends on the length of time that the policy measure is in place and the assumptions for the recovery rate. Three cases can be distinguished and compared with a regime without policy intervention. In the first, the debt workout process permanently raises (lowers) the recovery rate relative to a world without such measures. In the second, creditors are locked into accepting a lower recovery rate at the time of the workout, but face the prospect of higher recovery rates thereafter—the reorganisation is a temporary one. In the final case, the workout lasts for more than one period. It locks in creditors with obligations due at the time of project failure, as well as creditors with obligations due in the subsequent period. We discuss each in turn.

Case 1 (permanent changes in the recovery rate). Figure 10.3 shows the effects of a permanent change in the recovery rate, θ, on the maturity profile. The value of the recovery rate in the 'no intervention regime' is taken to be $\theta^N = 0.6$, and the values for W and R are the same as before. As can be seen, if the recovery rate is permanently lowered ($\theta = 0.5$), the maturity structure is biased even further towards the

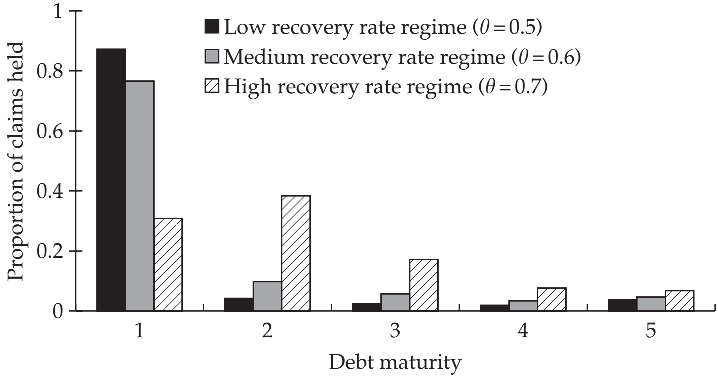


Figure 10.3. *Recovery rate regimes and the maturity profile (permanent measure)*

shorter term. By contrast, if crisis management measures are viewed as effective and improve the scope for creditors to recover their investments, then the strategic incentives of the creditors are altered. The direct and strategic effects highlighted above reinforce each other. If the recovery rate is permanently raised ($\theta = 0.7$), then the maturity profile is no longer skewed to the short term, relative to the regime without policy intervention.

Case 2 (temporary debt workout measures). Suppose that, at the time of project failure, a temporary policy measure is put in place that locks creditors in for one period. The creditors whose obligations are due in that period receive an amount θR^t as part of the debt workout. But other creditors, those with a longer-term interest in the project, face the prospect of an improved ability to pay in the future following the debt workout. In such circumstances, the payoff matrix for claimholders takes the following form:

		Project failure date				
		1	2	3	4	5
Asset maturing date	1	θR	R	R	R	R
	2	ϕR	θR^2	R^2	R^2	R^2
	3	ϕR	ϕR^2	θR^3	R^3	R^3
	4	ϕR	ϕR^2	ϕR^3	θR^4	R^4
	5	0	0	0	0	$20 - R^4$

The effect of such a temporary measure on the equilibrium maturity profile is shown in Figure 10.4. The ‘no intervention’ regime is again shown for comparison. The numerical values for the recovery rate under the ‘temporary’ scenario are taken to be $\theta = 0.5$ and $\phi = 0.7$. Thus,

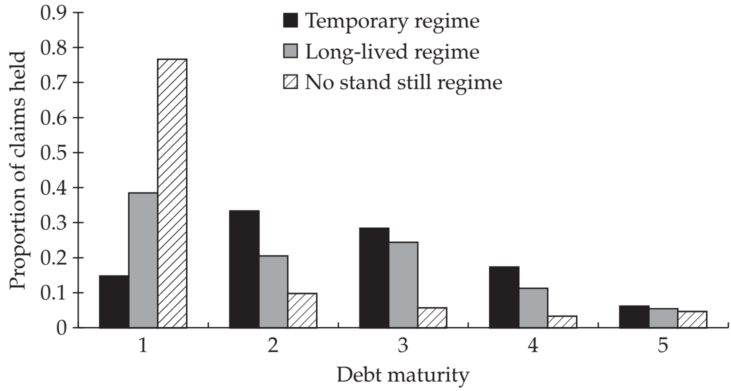


Figure 10.4. *Recovery rate regimes and the maturity profile (temporary measure)*

although creditors face a more limited recovery of their obligations at the time of default relative to a regime with no policy intervention, those with longer maturity claims face the prospect of higher recovery rates (ϕ) in the future. As Figure 10.4 shows, the proportion of debt held is evenly spread across the different maturities. So policy measures which provide the debtor with temporary relief against unforseen liquidity shocks need not necessarily skew maturities towards the short end.

Case 3 (longer-lived workouts). If debt workouts are protracted, they can inadvertently lock-in creditors with more longer-dated claims. Suppose that, in the event of project failure, the creditors whose obligations fall due during the period of the default receive θR^t. But, in addition, protracted reorganisation results in additional creditors—those with obligations falling due in the subsequent period—being affected by the workout as well. In this case, both types of creditor confront a recovery rate of θ. The creditors with much longer-term interests, however, benefit from the improved payments prospects eventually brought about by the workout and face a higher recovery rate ϕ. The matrix of payoffs in this instance becomes:

		Project failure date				
		1	2	3	4	5
	1	θR	R	R	R	R
Asset	2	θR	θR^2	R^2	R^2	R^2
maturing	3	ϕR	ϕR^2	θR^3	R^3	R^3
date	4	ϕR	ϕR^2	θR^3	θR^4	R^4
	5	0	0	0	0	$20 - R^4$

The effect of such a long-lived workout on the equilibrium maturity profile is also shown in Figure 10.4. To aid comparison with the other cases, the numerical values for the recovery rate are again taken to be $\theta = 0.5$ and $\phi = 0.7$. As can be seen, compared with the temporary regime, the profile under the long-lived workout exhibits a tendency to be 'double peaked'—creditors with debt maturing in period 2 are forced to opt for either shorter or longer maturities. The choice depends on the relative benefit from pre-empting or staying put, that is, on the precise parameter values that determine the payoffs to the claimholders.

The table below summarises the three cases. Although these numerical examples should not be taken too literally, they serve to illustrate how the equilibrium capital structure is extremely dependent on the assumptions being made about the recovery rate following the public sector intervention. If orderly workouts, concerted rollovers, and the like are able to improve the recovery rate on sovereign debt, then the equilibrium maturity profile need not necessarily be skewed towards the short term. The desire to pre-empt can be diluted by material improvements to the recovery rate. But even if public intervention can improve recovery rates, the length of time that such measures are held in place is important. If creditors believe that they will be locked into a protracted workout procedure, they can be confronted with a choice between very short maturities or very lengthy ones.

	Measure	**Duration**	**Implication for maturity profile**
Case 1a	$\theta < \theta^N$	permanent	skewed to short end
Case 1b	$\theta > \theta^N$	permanent	shift away from short end, due to strategic effect
Case 2	$\theta < \theta^N < \phi$	temporary	evenly distributed
Case 3	$\theta < \theta^N < \phi$	long-lived	double-peaked

Note that this model contains no scope for strategic behaviour by the debtor. If moral hazard concerns are dominant, then the efficacy of public intervention in improving recovery rates may well be diminished. Indeed, recovery rates could even be lowered. In such circumstances, public intervention in the form of rollovers and other debt workout measures can make a 'rush for the exits' more likely.

10.2 IS OFFICIAL LENDING CATALYTIC?

The possibility of creditor pre-emption and the difficulties with statutory and contractual approaches to sovereign bankruptcy reform means that the policymaker may need other ways of galvanising private sector involvement. A number of policy documents express the view that official sector assistance is 'catalytic' in nature. By soothing the nerves of jittery private sector creditors, it is argued, official finance encourages the rollover of short-term loans, thereby alleviating the financing gap facing the debtor country. Morris and Shin (2003*a*) examine this issue by merging the logic of global games with the *ex ante* versus *ex post* efficiency framework highlighted in Chapter 9.[66] Their results suggest that the circumstances when official finance is catalytic may be rather limited. As in Chapter 9, there is again an absence of a simple relationship between *ex post* IMF intervention and *ex ante* debtor moral hazard.

Morris and Shin (2003*a*) develop a simpler version of the sovereign liquidity crisis model of Chui *et al*. (2002) examined in Chapter 5. A debtor country is presumed to face a funding need of

$$L + \lambda S, \tag{10.9}$$

where L denotes interest payments on long-term debt, and λ is the proportion of short-term creditors who decline to rollover short-term debt, S, that is due to mature in the current period. The country is able to draw on its own resources, θ, which is a random variable that is normally distributed with mean $\phi + e$, and variance $1/\alpha$. The variables ϕ and e represent the strength of underlying fundamentals, and the additional adjustment effort expended by the country to generate funds respectively.

The country's finances are viable provided its resources are sufficient to cover the interest payments on its long-term borrowing. All creditors are repaid in this situation, so the country is fundamentally solvent if

$$L \leq \theta. \tag{10.10}$$

If θ is large enough to meet both long and short-term obligations, $L + S$, then there are no financing difficulties. But if θ falls in the intermediate range, $L < \theta < L + S$, a coordination problem arises

66 Other recent attempts to analyse this question include Corsetti *et al*. (2003) and Penalver (2004).

and a financial crisis may occur depending on the actions of short-term creditors. If they all rollover, resources, θ, are sufficient to meet the country's obligations. If, however, a critical mass opt to flee a crisis occurs.

The game is in two stages. First, nature draws fundamentals, ϕ, from a known density function $g(\cdot)$. The draw is common knowledge to all players. Based on the realisation of ϕ, the debtor chooses its level of adjustment effort, e. This effort level is also observed by the players. In particular, a third party ('the IMF') can base its lending decision upon ϕ and e. It chooses whether or not to intervene by providing additional funds, m, to the debtor in order to assist with the financing gap.

The second stage is familiar from our analysis of global games. Nature draws θ from a normal density and the players are unable to observe the true realisation of this variable. Short-term creditors, however, have access to a private signal

$$x_i = \theta + \varepsilon_i, \tag{10.11}$$

which they consult in deciding whether to stay or flee. As before, $\varepsilon_i \sim N(0, 1/\beta)$ and is independent from θ and ε_j for all $i \neq j$. Following the rollover decision of the short-term creditors, the debtor repays if it is able to. We solve backwards and focus initially on the rollover decision of short-term creditors, before proceeding to tackle the IMF and debtor country decisions.

We begin by specifying payoffs. Normalising debt repayments L and S so that

$$L = 0 \quad \text{and} \quad L + S = 1$$

means that the debtor country will default on its debt if, and only if, resources θ and IMF assistance are insufficient to meet the demands of the creditors who flee, that is,

$$\theta + m < \lambda. \tag{10.12}$$

The creditor who flees has access to a safe foreign investment which gives a payoff, ψ, where $0 < \psi < 1$. If he opts to remain in the country, his payoff is uncertain. If there is a default, he receives nothing. But if he is repaid, his payoff is 1. So the payoff of a creditor who rolls over a short-term loan is

$$\upsilon(\theta, m, \lambda) = \begin{cases} 1, & \text{if } \theta + m \geq \lambda, \\ 0, & \text{if } \theta + m < \lambda. \end{cases} \tag{10.13}$$

We assume that the debtor's interests coincide with those of short-term creditors who rollover—both would like to minimise the probability of crisis (or, equivalently, get paid). But the debtor also experiences a disutility of adjustment effort. So the debtor's payoff is

$$\upsilon(\theta, m, \lambda) - c(e), \tag{10.14}$$

where $c(e)$ is an increasing convex function. The IMF's interests also coincide with those of the debtor and staying creditors except for the disutility of providing assistance. In particular, the IMF payoff function is

$$\omega(\theta, m, \lambda) = \begin{cases} \upsilon(\theta, m, \lambda) - bm, & \text{if } \theta \geq 0, \\ -bm, & \text{if } \theta < 0. \end{cases} \tag{10.15}$$

Note that the role of the IMF in the analysis is limited to that of '*fire fighter*'. The IMF only seeks to intervene when the country is sound, that is, in a situation where there is a liquidity crisis, not a solvency crisis ($\theta \geq 0$). The objective of the IMF is, thus, to minimise the probability of crisis, conditional on it being a liquidity crisis, minus the cost of assistance.

Chapter 5 provides a detailed account of the solution to the second-stage global game. We once again restrict attention to *switching strategies*, where creditors flee if and only if they receive a signal higher than some threshold. Noting that the posterior distribution of θ is normal with mean

$$\xi_i = \frac{\alpha y + \beta x_i}{\alpha + \beta} \tag{10.16}$$

and precision $\alpha + \beta$, we can find the critical threshold signal,

$$\hat{x} = \frac{\alpha + \beta}{\beta}\xi - \frac{\alpha}{\beta}y, \tag{10.17}$$

where $y \equiv \phi + e$.

At the equilibrium switching point, two conditions need to be met. First, the proportion of fleeing creditors must equal the critical mass necessary to cause default. The country will be on the margin between defaulting and repaying when

$$\theta + m = \lambda, \tag{10.18}$$

where λ is the proportion who flee if they have received a signal below $\hat{x}$. If θ^* is the critical level at which default occurs, then

$\lambda = \Phi[\sqrt{\beta}(\hat{x} - \theta^*)]$, where $\Phi(.)$ is the c.d.f. for the normal distribution. We can therefore write

$$\begin{aligned}\theta^* + m &= \Phi(\sqrt{\beta}(\hat{x} - \theta^*)) \\ &= \Phi\left[\sqrt{\beta}\left(\frac{\alpha+\beta}{\beta}\xi - \frac{\alpha}{\beta}y - \theta^*\right)\right].\end{aligned} \tag{10.19}$$

Second, creditors must be indifferent between staying and fleeing. In other words, the expected payoff to staying, conditional on receiving a signal x_i must equal the payoff from investing in the safe asset overseas. Thus

$$1 - \Phi\left[\sqrt{\alpha+\beta}(\theta^* - \xi)\right] = \psi$$

i.e.,

$$\theta^* - \xi = \frac{\Phi^{-1}(1-\psi)}{\sqrt{\alpha+\beta}}. \tag{10.20}$$

From (10.19) and (10.20), we solve for the two unknowns, θ^* and ξ. Solving for θ^*,

$$\theta^* + m = \Phi\left[\frac{\alpha}{\sqrt{\beta}}\left(\theta^* - y + \Phi^{-1}(\psi)\frac{\sqrt{\alpha+\beta}}{\alpha}\right)\right]. \tag{10.21}$$

As the private creditor's signal becomes very precise, $\beta \to \infty$. Therefore the critical value of fundamentals in the limit is

$$\theta^* = \psi - m.$$

So if $\psi > m$, there can exist states when default can occur—even though the country is fundamentally sound, that is, $\theta > 0$. Figure 10.5 illustrates the situation by characterising the unique equilibrium and classifying fundamentals in a manner akin to Chapter 5.

We now turn to the decision of the IMF in choosing the size of assistance, m, and the country's choice of effort, e. Since the IMF knows the values ϕ and e, and is aware that $\theta \sim N(y, 1/\alpha)$, we can express its expected payoff as

$$\begin{cases} \Phi[\sqrt{\alpha}(\theta^* - y)] - bm, & \text{if } \theta^* \geq 0, \\ -bm, & \text{if } \theta^* < 0. \end{cases} \tag{10.22}$$

In other words,

$$\omega(\theta, m, \lambda) = \Phi[\sqrt{\alpha}(\max(0, \psi - m) - y)] - bm. \tag{10.23}$$

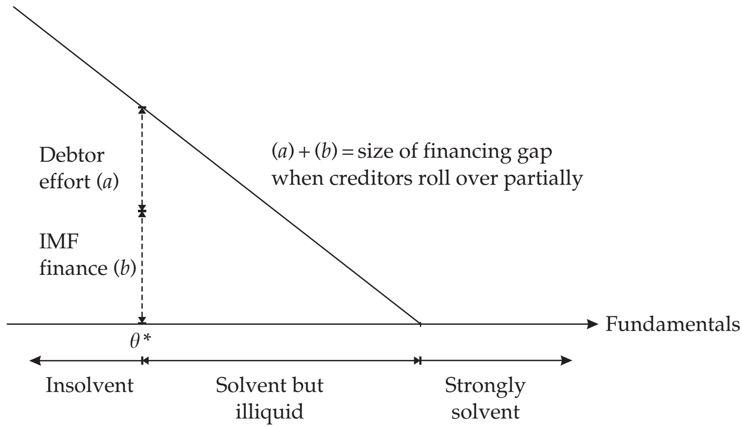


Figure 10.5. *Catalytic finance in a global games framework*

The IMF chooses m to maximise (10.23). When y is either very small or very large ($y \to -\infty, \infty$), the IMF chooses not to intervene. The optimal choice in this situation is $m = 0$. When the expected value of debtor resources is large, assistance is not needed, while assistance is wasted when resources are expected to be extremely low. For intermediate values of y, however, IMF assistance can be beneficial.

An explicit solution for the optimal value of assistance can be obtained in the case where the variance of θ is extremely small ($\alpha \to \infty$). The IMF's expected payoffs then become

$$\begin{cases} 1 - bm, & y \geq 0 \text{ and } \psi - m - y > 0, \\ 0.5 - bm, & y \geq 0 \text{ and } \psi - m - y = 0, \\ -bm, & \text{otherwise.} \end{cases} \tag{10.24}$$

The optimal value of m can be thought of as that value which sets $\psi - m - y = 0$, provided that $0 < y < \psi$. In other words,

$$m^*(y) \simeq \begin{cases} 0, & \text{if } y < 0, \\ \psi - y, & \text{if } 0 \leq y < \psi, \\ 0, & \text{if } y \geq \psi. \end{cases} \tag{10.25}$$

The intuition is as follows. When the country is fundamentally sound, $y \geq 0$, but faces a coordination problem that can lead to default, $y < \psi$, IMF assistance can prevent a crisis. In particular, the amount of official finance together with domestic resources is sufficient to meet debt obligations, that is,

$$m + y = \psi. \tag{10.26}$$

Given the IMF decision rule (10.25), the debtor country anticipates IMF intervention whenever $0 \leq y < \psi$, that is, whenever $0 \leq \phi + e < \psi$. Thus the payoff for the debtor will be

$$\begin{cases} 1 - c(e), & \text{if } \phi + e \geq 0, \\ -c(e), & \text{otherwise.} \end{cases} \tag{10.27}$$

The debtor chooses e to maximise (10.27). If $c(e) = e^2$, then the optimal choice is given by

$$e^*(\phi) = \begin{cases} -\phi, & \text{if } -1 \leq \phi < 0, \\ 0, & \text{otherwise.} \end{cases} \tag{10.28}$$

Thus the adjustment effort declines linearly in fundamentals, ϕ, and is maximised when $\phi = -1$.

It remains to compare debtor country adjustment effort in world with the IMF against adjustment effort in a world without. Absent the IMF, $m = 0$, so the critical state $\theta^* = \psi$. In the limiting case, $\alpha \to \infty$, the expected payoff of the debtor without the IMF is

$$\begin{cases} 1 - c(e), & \text{if } \phi + e \geq \psi, \\ -c(e), & \text{otherwise.} \end{cases} \tag{10.29}$$

The difference between (10.29) above and (10.27) reflects the extent of the resources needed to avoid default. Without the IMF, the country requires $\phi + e \geq \psi$. But in the presence of the IMF, $\phi + e \geq 0$, and the own resources needed to avoid default are lower. The value of e that maximises (10.29) is

$$e^*(\Phi) = \begin{cases} \psi - \phi, & \text{if } -(1 - \psi) \leq \Phi < \psi, \\ 0, & \text{otherwise.} \end{cases} \tag{10.30}$$

Comparing (10.28) and (10.30), adjustment effort cannot be unambiguously ranked across the two regimes and depends—crucially—on the strength of fundamentals, ϕ. Morris and Shin (2003*a*) distinguish two cases:

- When $-1 \leq \phi < -(1 - \psi)$, the country puts in more adjustment effort when it anticipates IMF finances than in a regime without. Fundamentals are relatively weak, so that absent the assistance, the debtor has no incentive to exert any adjustment effort to stave off default. But with the assistance, the debtor is able to cross the default threshold and can, therefore, expend effort that will not be wasted;

- When $-(1-\psi) \leq \phi < \psi$, the debtor country exerts less effort than under a regime without the IMF. Fundamentals are relatively strong, and the debtor can avoid default without IMF assistance. But anticipating additional finances, the debtor is less willing to exert costly effort. Moral hazard effects thus dominate.

The implication of the model is that, for catalytic finance to work, the actions of the IMF must be strategic complements with *both* the rollover decisions of the creditors and the effort decision of the debtor. To induce private sector involvement, official finance must spur additional adjustment effort from the debtor. If the effort is forthcoming, private creditors have enough incentive to rollover their claims. But if the actions of the IMF and the debtor are strategic substitutes, conventional moral hazard concerns dominate—the reduced adjustment effort of debtors makes it more desirable for creditors to flee. The results serve to confirm the earlier lesson of Chapter 9, namely there is no simple theoretical relationship between official sector lending and *ex ante* debtor moral hazard. Nevertheless, the suggestion that catalytic finance is most likely to succeed only when fundamentals are in a very limited range, implies that official sector financial rescues may have a tendency to increase the degree of debtor country moral hazard.

10.3 EFFECTS OF INTERNATIONAL RESCUES ON DEBTOR MORAL HAZARD

The issue of whether large-scale official rescues distort debtor and creditor incentives is, ultimately, an empirical matter.[67] The most common approach is to use observed borrowing costs to infer the impact on incentives. The idea is straightforward. IMF loans mitigate the downside risks of default, so official intervention should result in a fall in the equilibrium cost of borrowing between debtors and creditors. That, in turn, may provide incentives for lending and borrowing beyond prudent levels. Examining the behaviour of spreads on either side of episodes of IMF intervention should, therefore, shed light on risk-taking incentives.

[67] Or, as Tirole (2002) rhetorically asks, 'Where is the body'?

The conclusions of such studies are, however, far from emphatic. Zhang (1999) examines borrowing spreads on either side of the Mexican IMF package, but does not detect any significant effects. Kamin (2002) also compares spreads over recent years with those prior to the Mexican crisis and finds few differences between the two periods. Dell' Ariccia *et al*. (2002) focus on a different event—the 'non-bailout' of Russia in 1998—and find evidence that the level of spreads rose in response and that the distribution of spreads widened. They interpret this as implying that the IMF's decision not to intervene reduced expectations of future bailouts, casting doubt over the 'international financial safety net'. Taken together, these findings suggest while there may be some moral hazard in international capital markets, the degree of moral hazard could well be dwindling.[68]

Empirical analyses of moral hazard must contend with a number of identification challenges. First, a fall in borrowing costs is consistent with the view that IMF loans mitigate the real hazards of crisis. So a lowering of spreads around an IMF intervention need not reflect a moral hazard issue. Second, by focusing on the behaviour of asset prices, risk-taking behaviour is gauged indirectly. Given the vagaries of asset price behaviour, it would seem desirable to examine risk-taking more directly by looking at the observed actions of debtors and creditors. And third, IMF interventions (or non-interventions) may not be truly exogenous. The intervention may be a purposeful response to an increased incidence of crisis, rather than reflecting a clear shift in the intention to provide an international safety net.

Gai and Taylor (2004) explore the effects of official sector intervention on the marginal incentives of debtor countries, taking these considerations into account. Rather than use observed asset prices as an indirect proxy, they examine a direct action (the debtor's use of IMF resources) to infer behavioural shifts induced by changes in IMF lending practices. Following the Mexican crisis, concerns that increased resources might be needed to respond to capital account crises prompted industrial countries to supplement existing IMF resources. A Supplemental Reserve Facility (SRF) was introduced in 1997 to provide emergency large-scale short-term financing in the event of a capital account crisis.[69] If debtors perceived this measure to be regularising access

68 See also McBrady and Seasholes (2000) and Lane and Phillips (2000).

69 The SRF has similar features to a domestic lender of last resort, including interest rate surcharges (ranging from 300 to 500 basis points). While the surcharges are designed to limit moral hazard, they do not appear penal compared with secondary market spreads at the time of crisis.

to exceptional funding above normal limits, then an increase in moral hazard (and usage of IMF resources) might be expected.

Incentive effects are easiest to detect when there are exogenous changes in the incentive structure, such as through an exogenous policy 'event' where the responses of a 'test' and 'control' group can be compared. The test group is affected by the policy change, while the control group is not. The estimated effect of the policy change can then be inferred from the difference in the outcomes between these two groups, controlling for other factors. But the shift in IMF lending practices was a response to the crises in Mexico and Asia. Nor are IMF facilities restricted *ex ante* to a specific group of countries. So to surmount the problems posed by policy endogeneity and the lack of an explicit control group, a suitably defined proxy variable must be constructed.[70]

The SRF was designed to contain the systemic impact of capital account crises. The resultant safety net might therefore be expected to have a greater impact on incentives, the more 'systemic' the country. It suggests that a measure of systemic importance might be used to proxy for the factors driving the potential for enhanced access.[71] In other words, the official sector decision to provide a safety net can be described as:

$$P_{it} = f(\lambda_{i,t-1}), \tag{10.31}$$

where P_{it} is a binary policy decision variable, and $\lambda_{i,t-1}$ is a measure of the systemic importance of country i, lagged one quarter to reflect delays in data availability.

Suppose that the IMF participation decision of country i at time t, I_{it}, is a binary variable which equals one if the country is in an IMF arrangement *and* draws upon those funds at some point during the programme. I_{it} is zero otherwise. The incidence of a debtor country's claims on IMF resources is given by a latent variable, I^*_{it}, that

[70] See, for example, the discussion in Blundell and MaCurdy (1999), and Besley and Case (2000).

[71] The SRF was to be 'utilised in cases where the magnitude of the outflows may create a risk of contagion that could pose a potential threat to the international monetary system', IMF (2002). Industrial countries agreed 'to make loans to the IMF when supplementary resources are needed to forestall or cope with an impairment of the international monetary system, or deal with an exceptional situation that poses a threat to the stability of the system' (IMF Press Release 97/5, 27 January 1997).

is governed according to the relationship,

$$I_{it}^* = (\alpha + \lambda_{i,t-1}\alpha' + D_t P_{i,t}\Delta\alpha' + D_t\alpha) + \sum_{k=1}^{K}[\beta_k + \lambda_{i,t-1}\beta_k' + D_t\Delta\beta_k + D_t P_{i,t}\Delta\beta_k']X_{ik,t-1} + \varepsilon_{it}. \quad (10.32)$$

The specification in (10.32) can be viewed as a reduced form model that reflects both the demand and supply of IMF loans. The vector $X_{ik,t-1}$, denotes the k country-specific economic fundamentals that influence a country's decision to seek, or the IMF's decision to offer, assistance. D_t is a temporal dummy that equals one in the period following the announcement of the SRF. Policy following the safety net is described by P_{it}. Lagged values of X_{ik} and λ_i are used to address possible simultaneity issues (e.g. the fact that country is in a programme might affect its ratings). The lags also help account for gaps between programme implementation and the availability of information about the debtor.

From (10.31), we assume a simple linear relation between lending policy (following extension of the safety net) and the systemic index. The index is exogenous to the participation decision and uncorrelated with $X_{ik,t-1}$. Substituting this instrument into (10.32) gives

$$I_{it}^* = (\alpha + \lambda_{i,t-1}\alpha' + D_t\Delta\alpha + D_t\lambda_{i,t-1}\Delta\alpha') + \sum_{k=1}^{K}[\beta_k + \lambda_{i,t-1}\beta_k' + D_t\Delta\beta_k + D_t\lambda_{i,t-1}\Delta\beta_k']X_{ik,t-1} + \varepsilon_{it}. \quad (10.33)$$

And the decision rule that determines whether a country has entered a programme on which it draws during the programme period is

$$I_{i,t} = \begin{cases} 1, & \text{if } I_{it}^* > 0, \\ 0, & \text{if } I_{it}^* \leq 0. \end{cases} \quad (10.34)$$

Equation (10.33) decomposes the constant and marginal coefficient terms into a number of components.[72] The coefficient α' reflects the probability of programme participation across the whole time period that is due to the debtor's systemic characteristics; $\Delta\alpha$ represents the general structural shift in the probability of participation following the policy event; and $\Delta\alpha'$ reflects any additional shift, post-policy,

72 The discussion is framed in terms of the coefficients as the marginal effect. This is for ease of exposition since, in the non-linear probit model, the coefficients do not necessarily indicate the marginal effect of the fundamentals.

conditioning for the systemic nature of the country. The coefficients β'_k, $\Delta\beta_k$, and $\Delta\beta'_k$ analogously decompose the sensitivity of programme participation to fundamentals, $X_{ik,t-1}$.

If the SRF increases moral hazard then the more systemic the country, the less sensitive is the debtor's IMF programme participation decision to fundamentals. Notice that, given the reduced form of (10.33), the observed sensitivity of programme participation to fundamentals could yet reflect supply-side incentives. So the null hypothesis of moral hazard has two necessary, but not sufficient, conditions:

- There is a change in incentives, following the policy measure, in proportion to the systemic importance of the economy, that is, $\Delta\beta'_k \neq 0$;
- This change in incentives is such that it is in the reverse direction of any *a priori* economic relationship between fundamentals and participation. For example, we might expect *a priori* that a country with a lower reserve coverage of short-term debt would be more likely to seek IMF assistance. But under the null of moral hazard, the opposite incentives occur. This implies that conditioning the differences, in the sensitivity to fundamentals which are observed post-policy change, on the systemic nature of the economy should suggest that participation is associated with stronger fundamentals (e.g. higher reserve coverage).

Although the first condition can be tested formally, the second must be examined for each individual control variable and depends on the significance of the coefficients. The null hypothesis does not place restrictions on whether there are structural changes post-policy ($\Delta\alpha \neq 0$, $\Delta\alpha' \neq 0$), or whether there is a general change in incentives post-policy ($\Delta\beta_k \neq 0$).

Data

The sample consists of 19 middle-to-lower income developing countries over the period 1995–2001.[73] It is drawn from the major emerging market asset price indices (the Morgan Stanley equity index and the J. P. Morgan EMBIG bond index) and so covers most countries with access to private external finance. The countries are broadly similar in

[73] These are Argentina, Brazil, Chile, China, Colombia, Czech Republic, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Pakistan, Philippines, South Africa, Thailand, Turkey, Uruguay, and Venezuela.

terms of economic development, and account for more than half of all IMF credit outstanding during the period in question.

Systemic importance

The empiricial literature on currency crises and early warning systems considered in Chapter 7 suggests that the risk of contagion is likely to be greater the more important a country is in international capital markets, the larger the international bank exposure to the country, and the greater its importance in international trade.[74] Gai and Taylor (2004) therefore construct a 'systemic index' comprising the relative size of a country's outstanding international debt securities, BIS reporting banks' foreign claims on the country, and total trade.[75] The average values for this index (which is bounded by zero and one) and its components are shown in Table 10.1. The ranking obtained, which is relatively stable over time, appears consistent with other recent analyses (e.g. Kamin, 2002).

The endogenous variable

The dependent variable is a binary $(0-1)$ index that takes the value one if a country is under an IMF programme (SBA, EFF, or SRF) in any quarter *and* makes drawings upon IMF resources during the arrangement. Table 10.2 provides summary statistics of the IMF programmes (SBA, EFF, or SRF), focusing on changes post-SRF. The size of funds agreed relative to quota appear to increase sharply, following the introduction of the SRF. The average programme duration also appears to lengthen somewhat. The sample can be broken into two, broadly defined as more or less systemic relative to the median value of the country average index over time. Both sub-samples experience similar proportional changes, post-SRF, in terms of the average and maximum programme sizes relative to quota. In absolute terms, the increases are much larger for the more systemic sub-sample, however.

74 Although the exact definition of the interlinkage varies, trade and financial channels have been widely tested in the contagion literature. For example, Kaminsky and Reinhart (2000) consider trade linkages (bilateral and via third markets) and financial linkages (via bank exposures and capital market correlations).

75 The components and equal weightings applied in this index and its linear construction are open to debate. But the index does capture key financial and trade propagation mechanisms. Explicit geopolitical indicators are not considered (although clearly there may be a correlation between such indicators and our choice of index). Barro and Lee (2002) examine the impact of such indicators on IMF lending decisions.

Table 10.1. *Systemic index components*

	Average systemic index	Merchandise trade as % of world total	Foreign claims on EME as foreign claims on countries	International debt securities outstanding as % of developing country total
Mexico	0.81	2.21	8.47	15.05
Korea	0.80	2.46	7.99	13.42
Brazil	0.65	0.99	10.10	10.89
China	0.61	3.09	5.63	5.04
Argentina	0.52	0.44	6.20	13.26
Thailand	0.37	1.07	5.43	3.78
Malaysia	0.31	1.37	2.91	3.39
Indonesia	0.30	0.79	4.54	3.38
Turkey	0.26	0.61	2.83	5.00
Median	**0.19**	**0.61**	**2.83**	**3.38**
India	0.19	0.69	2.70	1.53
Hungary	0.18	0.39	1.55	4.30
Philippines	0.17	0.61	1.59	2.80
South Africa	0.15	0.49	1.93	1.56
Chile	0.15	0.30	3.09	0.89
Venezuela	0.13	0.34	1.53	2.34
Czech Rep.	0.11	0.48	1.50	0.51
Colombia	0.11	0.22	1.55	1.57
Pakistan	0.05	0.17	0.72	0.19
Uruguay	0.03	0.05	0.52	0.37

Note: Average quarterly values 1995 Q1–2001 Q4.

Sources: BIS, IMF Direction of Trade Statistics and authors' calculations.

Table 10.3 provides summary statistics on country participation in IMF programmes. In the seven-year period there were 176 quarterly programme participations. The average number of participations per country per quarter shows a somewhat different pattern across the two illustrative subsamples. The frequency of programme participation rises, on average, following the SRF for the more systemic countries. The same does not appear to be the case for the rest of the sample.

Exogenous variables

The incidence of claims on IMF resources depends, to a large extent, on domestic economic conditions and external vulnerabilities. Gai and Taylor (2004) follow the literature on the determinants of sovereign

Table 10.2. *IMF programmes announced in sample countries*

	Full sample		Subsample with average index above median (9 countries)		Subsample with average index below median (10 countries)	
	Pre-SRF	Post-SRF	Pre-SRF	Post-SRF	Pre-SRF	Post-SRF
No. of programmes						
Total, o/w	10 (2)	14 (3)	4 (0)	9 (1)	6 (2)	5 (2)
SBA	9 (2)	5 (1)	4 (0)	1 (0)	5 (2)	4 (1)
EFF	1 (0)	4 (2)	0 (0)	3 (1)	1 (0)	1 (1)
SRF with SBA or EFF	n.a.	5 (0)	n.a.	5 (0)	n.a.	0 (0)
Amount agreed relative to quota (%)						
Mean	212	494	449	709	53	108
Max	688	1,938	688	1,938	74	253
Average time to expiration/ cancellation (years)	1.8	2.2	1.9	2.3	1.8	1.9

Number of programmes which were undrawn in brackets.

Sources: IMF and authors' calculations.

Table 10.3. *Endogenous variable: sample summary*

	No. of quarterly programme participations[a]	Programme participations per quarter (sample average)
Full sample		
Pre-SRF[b]	55	0.263 (0.441)
Post-SRF[c]	121	0.375 (0.485)
Countries with average systemic index above median		
Pre-SRF[b]	26	0.263 (0.442)
Post-SRF[c]	79	0.516 (0.501)
Countries with average systemic index equal or below median		
Pre-SRF[b]	29	0.264 (0.443)
Post-SRF[c]	42	0.247 (0.433)

[a] Defined as a quarter in which a country is in a SBA or EFF programme (with or without SRF) and makes a drawing under that programme at some point before the end of the programme.

[b] Pre-SRF period is 1995 Q1 to 1997 Q3.

[c] Post-SRF period is 1997 Q4 to 2001 Q4.
Standard deviation in brackets.

Sources: IMF and authors' calculations.

spreads and IMF arrangements (e.g. Knight and Santaella, 1997) and choose variables that influence the demand and supply of IMF loans (see Table 10.4). A country's demand for IMF resources is likely to depend on variables such as real GDP growth, inflation, the extent of real effective exchange rate (REER) misalignment, the level of indebtedness, and the cost of alternative financing.[76] On the supply side, the approval of an arrangement is likely to depend, in part, on credit growth and the fiscal stance. The incidence of credit disbursal also relates to exchange rate policy—a devaluation is either a prior action of a programme or a reason for IMF support. Given that absolute ratings are likely to be correlated with the above variables, the residual of a regression of credit ratings against other country fundamentals is also included (see Dell'Ariccia *et al.*, 2002). This summary variable potentially incorporates information relevant to a country's capacity, and ability, to repay that is not captured by other control variables.

Results

Estimation is based on a pooled probit approach. Since the approach ignores the panel nature of the data (and yields consistent, but inefficient, estimators) we use robust errors 'clustered' by country.[77] This allows for correlation within country observations due, for example, to omitted country-specific characteristics. Ignoring such correlation would result in underestimation of standard errors, rendering our hypothesis testing inaccurate.

In order to identify the exogenous variables to be included, a basic pooled probit model that excludes the variables relating to the policy measures and systemic importance is initially estimated (see Table 10.5). The full set of independent variables is jointly significant. The signs of the coefficients for reserve coverage of short-term debt, fiscal balance, GDP growth, and liquidity variables are as expected—a lower reserve coverage, lower fiscal surplus, lower growth, and tighter external financing conditions all increase the likelihood of a country participating in an IMF programme. One might also expect a weaker export position, higher domestic price inflation and large

[76] Changes in the cost of alternative financing could reflect changes in incentives through creditor moral hazard raising the possibility of endogeneity. However, this variable is insignificant and does not test positive for endogeneity if included in the base model.

[77] Clustering by individuals is widely used in labour economics, and clustering by country has been employed in some studies of currency crises (see Esquivel and Larrain, 1998) and of IMF programme participation (see Barro and Lee, 2002).

Table 10.4. *Exogenous variables*

Variable	Definition	Units
Macroeconomic position		
Inflation	Consumer price index inflation	Proportional change year-on-year of rolling average index
Growth	Real GDP growth	Proportional change year-on-year of four quarter rolling sum
Domestic vulnerabilities		
Credit	Real domestic credit growth	Proportional change year-on-year of four quarter rolling average
Fiscal	Government fiscal balance relative to GDP	Four quarter rolling fiscal balance as proportion of four quarter rolling nominal GDP
External vulnerabilities		
Export	Growth rate of merchandise exports	Proportional change year-on-year of four quarter rolling sum
Reserve cover	International reserves (excluding gold) to short-term BIS external debt	Ratio
Depreciation	Dummy equal to 1 if nominal depreciation exceeding 5% over previous quarter, 0 otherwise	Binary variable
REER	Real effective exchange rate deviation from trend (1990–2001 where data available)	Proportional deviation relative to trend
External liquidity		
Liquidity	Spread of yield to maturity of Merrill Lynch High Yield Master Index over 10-year US Treasury yield	Percentage points
Ratings		
Rating (Residual)	Residual of OLS regression by country of Moody's long-term foreign currency ceiling for bonds and notes on all above exogenous variables. Rating converted into numerical index (ranging from 1 for C rating to 23 for Aaa1).	

Note: When underlying quarterly data not available, linear interpolation from annual values used.

Sources: IMF, J. P. Morgan Chase, Moody's, Thomson Financial Datastream, and national authorities.

Table 10.5. *Pooled probit estimation: basic model specification*

	Coefficient	Marginal effect at means	Robust standard error[a]	Pr > |z|
Base model				
REER	−3.39**	−1.11	1.51	0.03
Reserve Cover	−0.62***	−0.20	0.22	0.00
Rating (Residual)	−0.27***	−0.09	0.09	0.00
Constant	0.49		0.39	0.21
Observations	532	Wald χ^2	14.30	
Degrees of freedom	3	Prob > χ^2	0.00	
Log likelihood	−276.0	Pseudo R^2	0.18	
Adjusted Pseudo R^2	0.17	Accuracy ratio[b]	73.7%	
Full model				
Reer	−3.42**	−1.09	1.53	0.03
Reserve Cover	−0.71***	−0.23	0.25	0.00
Fiscal	−3.81	−1.21	5.48	0.49
Growth	−3.20	−1.02	2.50	0.20
Export	1.91*	0.61	1.11	0.09
Inflation	−0.09	−0.03	0.18	0.61
Depreciation[c]	−0.16	−0.05	0.19	0.40
Credit	−1.05	0.34	1.11	0.34
Liquidity	0.06	0.02	0.07	0.40
Rating (residual)	−0.27***	−0.09	0.08	0.00
Constant	0.27		0.49	0.59
Observations	532	Wald χ^2	47.90	
Degrees of freedom	10	Prob > χ^2	0.00	
Log likelihood	−263.9	Pseudo R^2	0.22	
Adjusted Pseudo R^2	0.19	Accuracy ratio[b]	74.8%	

[a] Robust standard errors clustered on EME.
[b] The proportion of participation decision correctly predicted.
[c] Marginal effect is for discrete change of dummy from 0 to 1.
***, **, and * indicate significance at 1%, 5% and 10% confidence levels respectively.
All independent variables at $t-1$.

Source: Gai and Taylor (2004).

nominal depreciation to increase the probability of a country entering an IMF programme. But the estimated coefficients on these variables were of the opposite sign.[78]

[78] The sign of these coefficients could reflect some endogeneity. For instance, the presence of a programme could be associated with a restoration of export growth and reduction in inflation. However, the signs remain the same with lags of up to six

The signs of the other remaining variables, real domestic credit growth, the ratings residual and the deviation of the real exchange rate from trend, are open to interpretation. Although a rapid expansion of credit could create banking sector stress and precipitate a crisis, it could also reflect a deepening of the domestic financial sector which may reduce reliance on external finance. Similarly, while ratings residuals could reflect some form of ratings error conditioned on fundamentals, they may also represent additional indicators of creditworthiness and we would expect a negative coefficient. The estimate obtained in Table 10.5 is consistent with this view, though the caveat must be borne in mind. If deviations of the real exchange rate from trend are driven by private capital flows, then an over-valuation may imply little need for international financial support. Likewise, if deviations are below trend and a programme is initiated following downward pressure on the exchange rate, we might expect a negative coefficient. This is borne out by the estimates of Table 10.5 and is treated as the base interpretation.[79]

The coefficient estimates for real GDP growth, fiscal balance, inflation, exchange rate dummy, and real domestic credit growth variables are jointly insignificant at the 5% level. Sequential elimination of these variables produces the core model, the fit of which is broadly comparable with the univariate specification of Knight and Santaella (1997). Importantly, all the supply-side variables used by Knight and Santaella are insignificant, suggesting that the key fundamental variables that explain IMF participation are largely on the demand side.

Inserting the fundamental variables identified by the core model into the specification of (10.33) allows us to examine the effects of the SRF (see Table 10.6). The fit of the model is improved relative to the core model and the coefficients are jointly significant.[80] The significance of $\Delta\alpha$ suggests that there is a general upward shift in the probability of programme participation for all countries, following

quarters. Interestingly, Barro and Lee (2002) look explicitly at the impact of IMF lending on country growth and find that the contemporaneous relationship is insignificant but that there is a significant negative effect on growth in the next five-year period.

[79] A real exchange rate overvaluation could also indicate the potential for future exchange rate corrections and could encourage a debtor to seek IMF support. This suggests that a positive coefficient is also plausible. But the sample evidence suggests that such countries do not actually seek to draw on official resources, so the base interpretation seems more in keeping with definitions of participation.

[80] The accuracy ratio under the moral hazard specification is 77.3% and the adjusted pseudo R^2 is 0.257 compared with 73.7% and 0.171 respectively under the core model.

Table 10.6. *Pooled probit estimation: moral hazard test specification*

	Coefficient	Marginal effect at means	Robust standard error[a]	Pr > |z|
Structural effects[b]				
α	−0.08		0.72	0.91
$\lambda_{i,t-1}\alpha'$	1.00	0.28	1.83	0.58
Marginal change post-SRF				
$D_t\Delta\alpha$	1.28**	0.32	0.64	0.05
$D_t\lambda_{i,t-1}\Delta\alpha'$	−1.63	−0.46	2.37	0.49
Sensitivity to fundamentals				
β_k:				
REER	0.48	0.13	6.14	0.94
RESERVE COVER	0.09	0.03	0.44	0.83
RATING (RESIDUAL)	−0.84	−0.24	0.53	0.11
$\beta'_k = \beta_k \times \lambda_{i,t-1}$:				
REER	−22.42**	−6.30	10.75	0.04
RESERVE COVER	−3.03	−0.85	2.34	0.20
RATING (RESIDUAL)	0.25	0.70	1.25	0.84
Marginal change post-SRF				
$\Delta\beta_k = D_t \times \beta_k$:				
REER	−0.99	−0.28	6.06	0.87
RESERVE COVER	−1.46*	−0.41	0.57	0.01
RATING (RESIDUAL)	0.95	0.27	0.63	0.13
$\Delta\beta'_k = D_t \times \beta'_k$:				
REER	18.87*	5.30	10.50	0.07
RESERVE COVER	4.53*	1.27	2.71	0.10
RATING (RESIDUAL)	−1.01	−0.29	1.37	0.46
Observations	532	Wald χ^2	164.8	
Prob > χ^2	0.00	Log likelihood	−234.9	
Pseudo R^2	0.30	Adjusted Pseudo R^2	0.26	
Accuracy ratio[c]	77.3%			

[a] Robust standard errors clustered on EME.
[b] Marginal effect is for discrete change of dummy from 0 to 1.
[c] The proportion of participation decisions correctly predicted.
** and * indicate significance at 5% and 10% confidence levels respectively.
All independent variables are at $t-1$.

Sources: Gai and Taylor (2004).

the introduction of the SRF. There does not appear to be a significant change in the probability of programme participation solely due to the systemic nature of a country (with α' and $\Delta\alpha'$ insignificant). But, across the whole period, the interaction coefficients of fundamentals with the systemic index (β_k') are jointly significant, suggesting that there is a difference in incentives related to the systemic nature of economies.

The results in Table 10.6 suggest that the first element to the moral hazard test is satisfied—the coefficients $\Delta\beta_k'$ are jointly significant—there is a change in incentives post-policy proportional to the systemic nature of the country. There is also support for the second element of the hypothesis. The *a priori* direction of the relationship between fundamentals and participation is reversed for both reserve coverage and the real effective exchange rate coefficient. Post-SRF, the more systemic the country, the more reserve coverage becomes positively related to IMF programme participation, that is, the opposite of the *a priori* relationship.[81] The marginal REER coefficient is also opposite to the *a priori* assumption—smaller misalignments of the real exchange rate make participation in IMF programmes by systemic countries more likely. The coefficients on the ratings residuals have a more ambiguous interpretation and do not indicate a significant change in incentives in the post-SRF period. The estimates suggest that, for reserve coverage in particular, resource usage by more systemic countries is in the opposite direction to the general trend.[82]

An alternative candidate for a policy event is the Russian crisis (1998 Q3). Dell'Ariccia *et al.* (2002) suggest that the IMF's decision not to intervene reduced expectations of future bailouts, casting doubts over the 'international financial safety net'. Estimating the model using this event does not alter the findings. There is a general upward shift in the probability of entering a programme in the period from 1998 Q3, and systemically important countries appear to have acted as if a financial safety net was present. In other words, the Russian non-bailout did not lower the propensity for systemic countries to use official

[81] This might reflect the rise in reserve coverage in Asia post-crisis which was concurrent with the presence of a number of more systemic Asian countries being in an IMF programme. But estimating the model excluding the Asian crisis economic (Indonesia, Korea, Malaysia, Philippines, and Thailand) produced the same results.

[82] This effect appears to be of significant relative magnitude (as calculated by the marginal effect at the means). Post-SRF, for a given reserve cover, the marginal effect at the mean suggests that a country with a systemic index of 0.25 would be 30% more likely to be in a programme than a country with a systemic index of zero. This effect compares to general fall in the probability of programme participation post-SRF, for given reserve cover, of around 40%.

sector resources. But the lack of sensitivity of the results to changes in events could reflect the proximity of the two events. It could also reflect limitations in the policy equation, which depends only on the degree of systemic importance.

Interpretation

Changes in programme participation could reflect changes in the supply-side incentives for the IMF to lend, changes in the demand-side incentives of potential borrowers, or a combination of the two. Only changes in demand-side incentives could be related to potential debtor moral hazard. Given this identification problem, one would ideally estimate a structural model of both the demand- and supply-side of IMF programme participation. If we are to follow such an approach, which variables should be incorporated in the supply-side of the model?

Some guidance is provided by an IMF study of the empirical importance of different existing access criteria (see IMF, 2001). These criteria included a perceived need for Fund resources (the demand-side) and various supply-side variables, for example, the borrower's capacity to repay, its track record in previous programmes and its stock of outstanding IMF credit relative to its quota. A number of financial and 'strength of programme' variables were used as indicators of the capacity to repay. The significant supply-side variables were the level of outstanding IMF credit at the beginning of the arrangement relative to exports (viewed as a financial indicator of the capacity to repay), the projected current account adjustment (a 'strength of programme' indicator of the capacity to repay) and the presence of a poor track record in previous programmes. Incorporating these variables into the regressions is problematic because they are not amenable to the time-series dimension in the dataset. So the use of a structural model presents a tradeoff between analytical rigour and empirical tractability. Reflecting this tradeoff, the reduced form approach has been preferred in the literature on the economic determinants of IMF programmes.

The fundamental variables in the final reduced form model—reserve coverage, real exchange rate appreciation and a residual indicator of creditworthiness (the ratings residual variable)—are all indicators of a debtor's potential need for IMF resources. Furthermore, they are consistent with those variables identified in previous studies (e.g. IMF, 2001) as indicators of the demand for Fund resources.

Thus, the results may, indeed, be picking up the sorts of changes in demand-side incentives that are required to validate the hypothesis of moral hazard.[83]

[83] Indeed the IMF study (IMF, 2001, p. 25) concludes that the relatively small explanatory power of indicators of existing access criteria and the importance of the constant term 'suggests the existence of an implicit norm for access'. This could be viewed as adding weight to the interpretation of our reduced-form model as picking up primarily changes in demand-side incentives.

11

The 'Original Sin' Problem

11.1 REPUTATION AND THE CURRENCY COMPOSITION OF DEBT

An important insight from the models so far is that the main sovereign bankruptcy reform proposals are ambiguous in terms of their effect on overall welfare, and in terms of their ability to harness private sector involvement. An alternative method of bringing the private creditors into the picture may be to directly improve national balance sheet mismatches by creating an environment in which emerging market countries can borrow abroad, and long-term, in their own currency. As Table 8.2 in Chapter 8 showed, emerging market countries are typically unable to borrow abroad in local currency terms—a phenomenon referred to as *'original sin'*.[84] The precise reasons for original sin are unclear, though one factor inhibiting domestic debt markets is the perceived weakness of the monetary institutions in emerging market countries. Opportunistic management of the exchange rate by policymakers may explain creditors' unwillingness to lend in a unit that the borrower to manipulate. Countries may, therefore, need to build a reputation for a sound monetary framework, or develop a long track record of keeping the exchange rate fixed, before they can convince lenders of their creditworthiness.[85]

We now develop a variant of the Obstfeld (1996) model developed in Chapter 3 to examine this issue. The model is based on Gai and Tan (2004). Each time creditors extend loans to a country, they assign a probability to the policymaker being disciplined (as opposed to opportunistic) about maintaining the value of the exchange rate and, based on these beliefs, choose the currency composition of the debt.

[84] See Eichengreen and Hausmann (1999).

[85] Existing research (e.g. Hausmann *et al.*, 2001; Eichengreen *et al.* 2002) has not considered the forces that determine country reputations and their influence on the currency composition of debt. Jeanne (2002) is an exception. He considers the effects of monetary credibility on original sin, but does not focus on reputation formation.

Creditors then receive repayments, but are unable to distinguish whether payments arise from good fortune or good economic management. Following payment, they properly observe the nature of the macroeconomic shock and update their beliefs about the type of policymaker with whom they are dealing. But since policymaker types can change over time in ways that are not transparent to lenders, there is a possibility that subsequent lending may involve a different kind of policymaker. Creditors, thus, constantly update their beliefs about the type of policymaker they face. Updating causes reputations to have value, with the premium from having a good record determined by creditors' perceptions of the proportion of disciplined types in the population.[86]

The themes of coordination and strategic complementarities reemerge in such a setting. Specifically, the complementarity between past and present behaviour means that there may be up to three steady state *Markov perfect* equilibria depending on parameter values.[87] In the first, disciplined policymakers always maintain a fixed exchange rate regardless of their records. In the second, disciplined policymakers always act opportunistically, despite their track records. And in the third, policymakers fix only if they have a good record to maintain. The analysis suggests that original sin—the track record of one's predecessors—generates a persistence in creditors' willingness to lend in foreign currency terms. Past behaviour, by shaping the way that achievements are interpreted, influences current reputational incentives. The hysterisis generated by collective reputations means that the length of time on a fixed exchange rate needed to build a reputation high enough to issue domestic currency debt may be substantial.[88]

[86] See Tirole (1996), Mailath and Samuelson (2001), and Tadelis (1999) for game-theoretic analyses of reputation building.

[87] See Fudenberg and Tirole (1991) for a detailed discussion of the Markov perfect equilibrium concept.

[88] Our approach has parallels in the literature on reputation in sovereign debt. Grossman and van Huyck (1993) analyse a model in which sovereign debt in local currency serves to shift the risk associated with the unpredictability of tax revenues from the debtor to its creditors. They also show how reputation can support a 'risk shifting' equilibrium, in which local currency debt is issued. In the reputational equilibrium, the amount of local currency debt is such that the short-run gains from repudiation via unexpected devaluation are smaller than the long-run costs from the loss of a trustworthy reputation. But their model lacks sufficient structure to pin down the inflation rate and does not explain how reputations are built—the analysis assumes that the length of time over which lenders remember a repudiation is an exogenous, random, variable. See also Cole *et al*. (1995), Ball (1995), and Sibert (2003).

Time is discrete and has an infinite horizon. The economy is run by a group of policymakers of unit mass who are matched, at each interval $t = 0, 1, 2, \ldots, \infty$, with a corresponding mass of atomistic creditors. Policy-makers differ in their behavioural preferences and belong to two indistinguishable types—disciplined or *D-types* in proportion Δ, and opportunistic or *O-types* in proportion $1 - \Delta$. *D-types* face a lower cost of maintaining fixed exchange rates than *O-types*, but incur higher costs if they renege on their commitment to the peg. This reflects different attitudes to the presence of currency mismatches in the economy. The distribution of types is assumed to be constant over time.

The tenure of a policymaker follows an exponential distribution. In other words, a policymaker alive at time t remains in office up to at least $t + 1$ with an exogenous probability $1 - \lambda \in (0, 1)$. If a policymaker loses office, he is replaced by a successor so that only a single generation is in control during any one period. Creditors cannot observe the exit or replacement of the policymaker and, at the start of each date, are unsure whether a policymaker has been 'reincarnated' as another type. The idea is that while a change in government is usually observable, shifts in internal politics and lobbying activity are less so. For example, a government may replace the central bank governor or a finance minister without any outward signs of a shift in policy. But creditors know that such replacements are possible and take this into account when forming expectations and making decisions.

The policymaker minimises a loss function of the form

$$W_t = -\hat{y}_t + \frac{1}{2}\pi_t^2 + C(\pi_t), \tag{11.1}$$

where $\hat{y}_t$ is the real net output after adjusting for deviations from natural output, π_t is the rate of inflation, and $C(\pi_t)$ reflects the fixed costs of maintaining (or abandoning) a commitment to a fixed exchange rate regime. Following Backus and Driffill (1985), we make the simplifying assumption that the loss function is linear in output. If PPP holds, and with suitable normalisation of the foreign price level, the inflation rate corresponds to the realised rate of currency depreciation so that $\pi_t = 0$ for a fixed exchange rate regime. The function $C(\pi_t)$ is of the form:

$$C(\pi_t) = \begin{cases} (1 - \theta_i)\bar{c}, & \text{if } \pi_t > 0, \\ \theta_i, & \text{if } \pi_t = 0, \\ (1 - \theta_i)\underline{c}, & \text{if } \pi_t < 0, \end{cases} \tag{11.2}$$

where $i = D, O$. In what follows $0 < \theta_D < 1, \theta_O = 1, \bar{c} > 0$, and $\underline{c} = 0$. The assumption that $\underline{c} = 0$ is made for analytical tractability and does not entail any loss of generality.

The per-period output of the economy is influenced by the amount of the loan, L_t, that the policymaker is able to borrow from his creditors. To highlight the role of reputation, we consider only short-term debt and exclude the possibility that output can be stored or invested. So a country borrows for a project, the loan becomes due, and then further borrowing is needed for subsequent output. We therefore suppose

$$y_t = L_t - \varepsilon_t, \tag{11.3}$$

where ε_t is a conditional i.i.d. supply shock with zero mean that cannot be observed by creditors until the end of the period.[89]

When extending loans to the country, creditors must decide whether to lend in domestic currency or foreign currency terms. Under the Fisher identity of uncovered interest parity and normalising the nominal foreign interest rate ($i_t^* = 0$), we can express the real burden of debt as:[90]

$$L_t[m(1 + \pi_t) + (1 - m)(1 - (\pi_t - \pi_t^e))], \tag{11.4}$$

where m is an indicator function such that

$$m = \begin{cases} 1, & \text{if foreign currency debt,} \\ 0, & \text{if local currency debt.} \end{cases} \tag{11.5}$$

Notice that an unexpected depreciation lowers the real burden of domestic currency debt, whereas an anticipated depreciation has no effect. By contrast, depreciation (whether unanticipated or anticipated) raises the real burden of foreign currency debt. Clearly if the policymaker was committed to maintaining a fixed exchange rate regime, $\pi_t = \pi_t^e = 0$, and the real burden of the debt would be L_t regardless of the currency composition. Thus, by lending in foreign currency the creditor is less exposed to policymaker opportunism—he receives L_t if the *D-type* commits to the peg, compared with $L_t(1 + \pi_t)$ if the *D-type* floats. By choosing to lend in domestic currency, the creditor receives

[89] We abstract from competitiveness effects on output in order to simplify the algebra and focus attention on reputational forces.

[90] To see this, note that we can express the real burden of debt as $L_t[m(1 + r_t^*)E_t P_t^* / P_t + (1 - m)(1 + r_t)]$, which, in turn, can be written as $L_t[m(1 - \pi_t + \dot{e}_t) + (1 - m)(1 - \pi_t + \pi_t^e - \pi_t^{*e})]$. Imposing a short-term link between inflation and the exchange rate to allow for incomplete pass-through, so that $\pi_t = \dot{e}/2$, and if foreign inflation is zero on average, yields the desired expression.

$L_t - L_t(\pi_t - \pi_t^e)$ if the *D-type* reneges on his commitment to fix the exchange rate.

Net output in each period is therefore

$$\hat{y} = L_t - L_t[m(1+\pi_t) + (1-m)(1-\pi_t+\pi_t^e)] - \varepsilon_t. \tag{11.6}$$

In order to service debt at the end of period t, output must be sufficient to meet the real debt burden, so

$$\varepsilon_t^* = L_t[1 - m(1+\pi_t) - (1-m)(1-\pi_t+\pi_t^e)] \tag{11.7}$$

is the realisation of the supply shock that exhausts the debtor's surplus. Side-stepping the problem of a sovereign's willingness to pay, assume that creditors are able to make the country pay all it can. Debt is repaid in full if $\varepsilon_t \leq \varepsilon_t^*$, whereas partial payments are made if $\varepsilon_t > \varepsilon_t^*$. Accordingly, the critical value of L_t associated with ε_t^* is

$$L_t^* = \frac{\varepsilon_t^*}{[1 - m(1+\pi_t) - (1-m)(1-\pi_t+\pi_t^e)]}. \tag{11.8}$$

If ε_t is uniformly distributed with sufficiently wide support, $\varepsilon_t \sim U[-Z, Z]$, then the probability of a good payments outcome for the creditor is $\Pr[G] = \Pr[\varepsilon_t \leq \varepsilon_t^*] = [Z + \varepsilon_t^*]/2Z$ and, conversely, the probability of a *bad* payments outcome is $\Pr[B] = \Pr[\varepsilon_t > \varepsilon_t^*] = [Z - \varepsilon_t^*]/2Z$. Let $h \in \{G, B\}$ denote the payments track record of the policymaker.

If we ignore the fixed cost term $C(\pi_t)$, the first-order condition to the minimisation problem implied by equations (11.1) and (11.6) balances the net output gain from unexpected inflation against the cost of an extra unit of inflation at the margin. So the policymaker chooses

$$\pi_t = (1-2m)L_t, \tag{11.9}$$

allowing the *ex post* policy losses under the flexible and fixed exchange rate regimes to be characterised as

$$\begin{aligned} W_{t,\text{flex}} = {} & -L_t + L_t[m(1+(1-2m)L_t) \\ & + (1-m)(1-(1-2m)L_t+\pi_t^e)] + \varepsilon_t + \frac{1}{2}L_t^2(1-2m)^2 \end{aligned} \tag{11.10}$$

and

$$W_{t,\text{fix}} = -L_t + L_t[m + (1-m)(1+\pi_t^e)] + \varepsilon_t. \tag{11.11}$$

A policymaker will choose to devalue if

$$W_{t,\text{fix}} - W_{t,\text{flex}} > (1 - \theta_i)\bar{c}. \tag{11.12}$$

Since $W_{t,\text{fix}} > W_{t,\text{flex}}$ for the *O-type*, he always prefers to opportunistically manipulate the currency. In contrast, *D-types* face a choice between rules and discretion. The *D-type* prefers to maintain a fixed exchange rate regime if the size of the debt (and hence the output shock, ε_t) is not too large. In particular, the peg is maintained if $L_t \in [0, \bar{L}]$, where

$$\bar{L} = \sqrt{\frac{2(1 - \theta_D)\bar{c}}{(2m - 1)^2}}. \tag{11.13}$$

Notice that $\bar{L} = \sqrt{2(1 - \theta_D)\bar{c}}$ when $m = 0$ and also when $m = 1$, that is, the threshold point at which the *D-type* devalues is the same *regardless* of the currency composition of the debt.

Creditors are thus faced with both adverse selection and moral hazard. As they cannot observe the replacement of policymakers, they cannot recognise the *type* they are dealing with. And since creditors cannot see the supply shock, they are unsure if their repayments reflect a poor outturn of nature or wilful devaluation by the policymaker. Moreover, since there is a continuum of myopic creditors, no single creditor is able to individually affect the play of the policymaker or the future play of the game. The only concern for the creditor is the probability he assigns to the policymaker delivering a *good* payments outcome in each period. So whenever a creditor is matched with a policymaker, he forms a conjecture about the composition of the policymaking group and their past and present behaviour based on the observed track record of debt repayment.

Events in each period unfold as follows. At the beginning of period t, creditors are matched with policymakers and extend loans. They assign a probability, ϕ_t, to the policymaker being disciplined and, based on these beliefs, choose the currency composition of the debt, $m(\phi_t)$. The output shock is observed by policymakers, who make their exchange rate choices. Creditors then receive their repayments from the output that is produced. At this stage, they are able to observe the realised value of the output shock and update their beliefs about the type of policymaker they are facing. At the end of the period, with probability λ, the policymaker leaves office and is replaced by a successor. The sequence of events is illustrated in Figure 11.1.

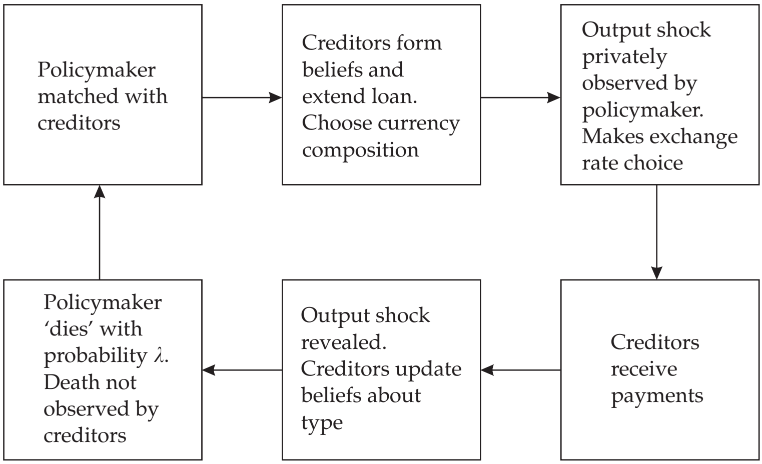


Figure 11.1. *Time-line of events in each period*

11.2 THE VALUE OF REPUTATION

Since the *O-type* always sets exchange rate policy opportunistically, our attention is on the value to the *D-type* from reputation building. A key feature of the framework is the possibility that a *D-type* may always be replaced by an *O-type* at the end of each period. This provides the *D-type* with incentives to fix the exchange rate so as to separate himself from *O-types*. In so doing, the *D-type* gradually builds and develops a reputation for creditworthiness and a commitment to low inflation.

Let $\phi_{t,h} \equiv \Pr[D|h]$ be the probability that the creditor assigns to the policymaker being disciplined, given that he observes payments record, h. Upon observing a good record, the creditor's expectation of inflation is

$$\pi^e_{t,G} = \phi_{t,G} L_t (1 - 2m). \tag{11.14}$$

Substituting $\pi^e_{t,G}$ and the expression for π_t into the loss function yields

$$W_t = L_t \pi^e_{t,G}(1 - m) - \frac{1}{2} L_t^2 (2m - 1)^2 + \varepsilon_t, \tag{11.15}$$

and taking expectations gives

$$E_{t-1}(W_t) = L_t \pi^e_{t,G}(1 - m) - \frac{1}{2} L_t^2 (2m - 1)^2.$$

So the present discounted value of losses under discretion is

$$V(\phi_{t,G}) = L_t\pi^e_{t,G}(1-m) - \frac{1}{2}L_t^2(2m-1)^2 - \varepsilon_t + (1-\theta_D)\bar{c} + \frac{\delta}{1-\delta}\left[L_t\pi^e_{t,G}(1-m) - \frac{1}{2}L_t^2(2m-1)^2\right], \tag{11.16}$$

which simplifies to

$$V_G = \frac{1}{1-\delta}\left[-\frac{1}{2}L_t^2(2m-1)^2 + L_t\pi^e_{t,G}(1-m)\right] + \varepsilon_t + (1-\theta_D)\bar{c}. \tag{11.17}$$

A similar expression can be obtained for V_B. It follows that the gain from a good record at time t is

$$V_G - V_B = \frac{L_t(1-m)}{1-\delta}[\pi^e_{t,G} - \pi^e_{t,B}]. \tag{11.18}$$

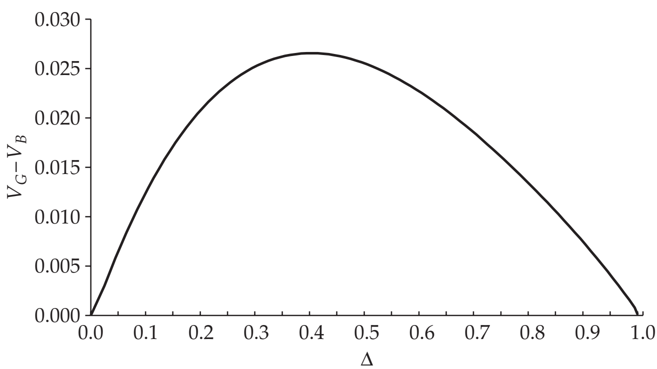
If $m = 1$, the *ex post* value of losses is the same, regardless of track record. Under these circumstances there are no long-term benefits to having a good track record—if creditors lend in foreign currency, the only value to a *D-type* from maintaining the peg is from the short-run gain from doing so.

To find $\pi^e_{t,h}$, we make use of Bayes' rule to identify the conditional probabilities. In particular,

$$\phi_{t,G} \equiv \Pr[D|G] = \lambda\Delta + (1-\lambda)\frac{\Delta\Pr[G|\text{fix}]}{\Delta\Pr[G|\text{fix}] + (1-\Delta)\Pr[G|\text{flex}]},$$
$$\phi_{t,B} \equiv \Pr[D|B] = \lambda\Delta + (1-\lambda)\frac{\Delta\Pr[B|\text{fix}]}{\Delta\Pr[B|\text{fix}] + (1-\Delta)\Pr[B|\text{flex}]}. \tag{11.19}$$

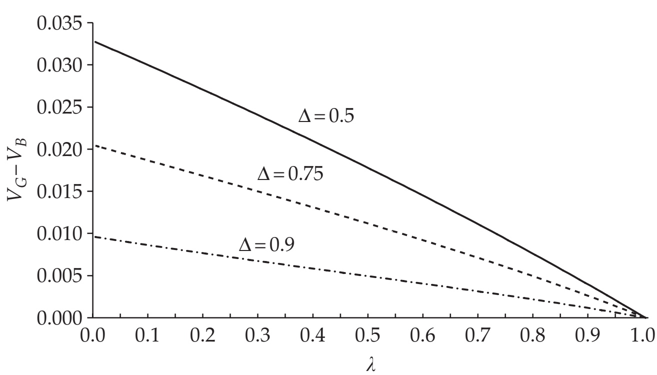
The numerator of the fraction in the second part of (11.19) represents the mass of fixing *D-types* with a good record, and the denominator the total mass of policymakers with good records. The term captures the creditors' perception of the proportion of disciplined 'fixers' among the population, if policymakers are known to stay in office with probability $1-\lambda$. Better past behaviour by one's peers (reflected in a higher $\Pr[G|\text{fix}]$) raises present incentives for good behaviour. Other things equal, it raises $\pi^e_{t,G}$ and lowers $\pi^e_{t,B}$. There is thus a complementarity between past and present behaviour—when policymakers have behaved well in the past, creditors are more willing to attribute causality to past actions. A policymaker's record becomes a more informative signal of his type.

Gai and Tan (2004) derive $\pi^e_{t,G}, \pi^e_{t,B}$ in terms of the exogenous parameters of the model. Figures 11.2 and 11.3 highlight the relationship between reputational incentives and peer group characteristics. Group composition, Δ, influences the value of a good reputation through its effects on beliefs. Figure 11.2 shows that $V_G - V_B$ is concave and single-peaked as a function of Δ, reflecting the nature of the updating rules with exogenous replacements. Note $V_G - V_B = 0$ when $\Delta = 0$



Parameters: $\theta_D = 0.5$, $\bar{c} = 0.25$ and $\lambda = 0.25$.

Figure 11.2. *Group composition and the value of a good reputation*



Parameters: $\theta_D = 0.5$ and $\bar{c} = 0.25$.

Figure 11.3. *The effect of changes in replacement rates on reputation value*

and $\Delta = 1$. Intuitively, if a group becomes too homogenous then the incentives to build a reputation disappear.[91]

Changes in the likelihood of replacement, λ, have an unambiguous effect on reputational incentives (Figure 11.3). If replacement is certain, $\lambda = 1$, a *D-type* has no incentive to cultivate a reputation and chooses exchange rate policy in accordance with the rule specified in (11.12). If there are no replacements, $\lambda = 0$, policymaker type is permanent but not observable by lenders, bringing the model in line with the conventional treatment of reputation in Backus and Driffill (1985). If a *D-type* were to ever devalue, it would be regarded as an *O-type* forever. So long as the policymaker is not too impatient (i.e. fixing the exchange rate is preferred to the one-shot gain from devaluation), reputation has value and the *D-type* chooses to fix the exchange rate.

11.3 BUILDING TRUST

We now consider the role played by reputation in supporting the exchange rate choice of the *D-type* policymaker and the currency composition of debt issued by the creditors. Since the creditor's posterior probability that the policymaker is a *D-type*—the state variable, ϕ_t—completely summarises the direct effect of the past on the current environment, we focus attention on *Markov* strategies. In a Markov perfect equilibrium, policymakers minimise their loss functions, creditors' expectations are correct, and creditors use Bayes' rule to update posteriors. The posterior probability, ϕ_t, is given by

$$\begin{aligned}\phi_t &= \Pr[D|G] \times \Pr(G) + \Pr[D|B] \times \Pr(B)\\ &= \left[\lambda\Delta + (1-\lambda)\frac{\Delta \Pr[G|\text{fix}]}{\Delta \Pr[G|\text{fix}] + (1-\Delta)\Pr[G|\text{flex}]}\right] \times \frac{Z+\varepsilon_t^*}{2Z}\\ &\quad + \left[\lambda\Delta + (1-\lambda)\frac{\Delta \Pr[B|\text{fix}]}{\Delta \Pr[B|\text{fix}] + (1-\Delta)\Pr[B|\text{flex}]}\right] \times \frac{Z-\varepsilon_t^*}{2Z},\end{aligned} \tag{11.20}$$

and creditors' expectation of inflation is therefore

$$\pi_t^e = \phi_t L_t (1-2m). \tag{11.21}$$

[91] The point that the persistent possibility of a type change can sustain first-best incentives was first noted by Holmstrom (1999) in the context of the market for managerial talent.

The complementarity between past and present behaviour, coupled with the fact that π_t^e influences the probability of good and bad states via its effects on ε_t^*, suggests the possibility of multiple equilibrium expected inflation rates in the model. Specifically, depending on parameter values, there may be up to three steady state Markov perfect equilibria:[92]

- a steady state where the *D-type* always adopts a fixed exchange rate;
- a steady state where the *D-type* always adopts a floating exchange rate;
- an intermediate steady state where the *D-type* fixes if he has a good record, but floats if he does not.

Deriving π_t^e in terms of the parameters of the model and substituting it along with the expression for π_t in (11.9) into the policymaker's loss function yields the realised *ex post* loss at time t when the policymaker has the option of changing the exchange rate. Denote this by $W_{t,\text{flex}}(\phi_t)$. Under a fixed exchange rate, $\pi_t = 0$, so the relevant loss function is $W_{t,\text{fix}}(\phi_t)$. The *D-type* always fixes when

$$V_D(\phi_t) - V_D(\phi_t; \text{flex}) \leq 0; \quad \forall \phi_t, \tag{11.22}$$

where

$$\begin{aligned} V_D(\phi_t) &= W_{t,\text{fix}}(\phi_t) + \theta_D \\ &\quad + \frac{\delta}{1-\delta}(1-\lambda)[Pr[G|\text{fix}]V_D(\phi_{t,G}) + \Pr[B|\text{fix}]V_D(\phi_{t,B})], \end{aligned}$$

and

$$\begin{aligned} V_D(\phi_t; \text{flex}) &= W_{t,\text{flex}}(\phi_t) + (1-\theta_\text{D})\bar{c} \\ &\quad + \frac{\delta}{1-\delta}(1-\lambda)[\Pr[G|\text{flex}]V_D(\phi_{t,G}) + \Pr[B|\text{flex}]V_D(\phi_{t,B})]. \end{aligned}$$

Equation (11.22) compares the present discounted value of present and future payoffs when the *D-type* always fixes with the payoffs that arise when a *D-type* opts to devalue, initially and in the future. In other words, it establishes the circumstances under which the primitive parameters governing group reputation support the choice of a fixed exchange rate regime by a *D-type*.

[92] Analysis of a unique equilibrium to the coordination problem in models of collective reputation is beyond the scope of this chapter. The interested reader is referred to Levin (2001) who uses equilibrium selection arguments similar in spirit to those of Morris and Shin (2003*b*).

The non-linear nature of π_t^e suggests the possibility of a third, intermediate, equilibrium in addition to the two steady states of always fixing and always floating. Here the D-*type* fixes only when he has a good record to maintain. Gai and Tan (2004) show that a necessary condition for an intermediate steady state is

$$\Pr[G|\text{fix}] < \frac{1}{\Delta}\left[1 - \frac{\frac{1}{2Z}L_t^3\Delta^2(S - L_t)(1-\lambda)}{L_tS\Delta - \frac{1}{2}L_t^3S/Z\cdot\Delta(1-\lambda)}\right] \tag{11.23}$$

where $S = \sqrt{2(1-\theta_D)\bar{c}}$. Thus a policymaker's decision to fix depends on how good past behaviour has been, that is, on the size of $\Pr[G|\text{fix}]$. The importance of a good track record for a present policymaker, that is the complementarity between past and present behaviour, diminishes the more costly is an opportunistic devaluation $(1-\theta_D)\bar{c}$, and is strengthened the greater the proportion of *D-types* in the population (Δ). Equation (11.23) also suggests that the supply of loans is an important constraint on the policymaker's choice. The larger the quantum of lending, L_t, the greater the importance of a good track record for current behaviour.

It remains to determine when creditors will choose to issue debt in domestic currency to a *D-type*, that is, the circumstances under which $m(\phi_t) = 0$. Creditors will lend in domestic currency terms if the expected return from local currency debt is greater than the expected return from foreign currency debt, given a good record. So $m(\phi_t) = 0$ if:

$$\begin{aligned}\Pr[D|G].L_t &+ [1 - \Pr[D|G]].[L_t - L_t(\pi_t - \pi_t^e)] \\ &\geq \Pr[D|G].L_t + [1 - \Pr[D|G]].[L_t(1+\pi_t)].\end{aligned} \tag{11.24}$$

In other words, the investor's choice of the currency composition of debt depends on the inflation risk premium. In particular, $m(\phi_t) = 0$ when

$$L_t[1 - (\pi_t - \pi_t^e)] \geq L_t(1+\pi_t),$$

or

$$\pi_t^e(\phi) - 2\pi_t \geq 0. \tag{11.25}$$

How long must a *D-type* maintain a fixed exchange rate before creditors are willing to lend in domestic currency? Let T be the number of periods of exchange rate fixing which makes a policymaker just indifferent between the *ex post* losses from a fixed and floating exchange rate regime. Thus at T

$$\begin{aligned} W_{t,\mathrm{fix}}(\phi_t) + \theta_D + \frac{\delta^T}{1-\delta}&(1-\lambda)[\Pr[G|\mathrm{fix}]V_D(\phi_{t,G}) \\ &+ \Pr[B|\mathrm{fix}]V_D(\phi_{t,B})] - W_{t,\mathrm{flex}}(\phi_t) - (1-\theta_D)\bar{c} \\ &- \frac{\delta^T}{1-\delta}(1-\lambda)[\Pr[G|\mathrm{flex}]V_D(\phi_{t,G}) \\ &+ \Pr[B|\mathrm{flex}]V_D(\phi_{t,B})] = 0. \end{aligned} \tag{11.26}$$

Substituting for equation (11.17), and rearranging we obtain

$$\begin{aligned} T = \frac{1}{\ln\delta}\Bigg[&\ln\left(-\frac{1}{2}L_t^2 - \theta_D + (1-\theta_D)\bar{c}\right) + 2\ln(1-\delta) \\ &- \ln L_t - \ln(1-\lambda) - \ln\Bigg(\pi_G^e\bigg(\frac{-Z}{2Z-(L_t-\pi_t^e)S} \\ &+ \frac{L_t}{S}\bigg) + \pi_B^e\bigg(\frac{Z-(L_t-\pi_t^e)S}{2Z-(L_t-\pi_t^e)S} + \frac{S-L_t}{S}\bigg)\Bigg]. \end{aligned} \tag{11.27}$$

Taken together, equations (11.27) and (11.25) allow us to identify $\hat{T}$, the minimum number of periods of successful pegging that must

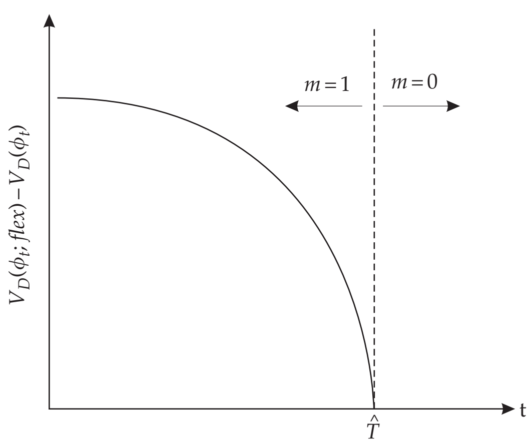


Figure 11.4. *Time needed to build a reputation for monetary stability*

elapse before creditors are indifferent between the currency composition of debt. Figure 11.4 illustrates this situation by plotting the net payoffs of the *D-type* over time. To the left of $\hat{T}$, the *D-type* prefers to fix the exchange rate and creditors lend in foreign currency terms. $\hat{T}$ is increasing in λ and decreasing in Δ. Intuitively, as *D-types* are more likely to be replaced, creditors require the policymaker to demonstrate his commitment to the peg for much longer. As fewer periods on an exchange rate peg are needed, the greater the proportion of *D-types* in the population. Clearly, the minimum number of periods of successful pegging required to build a reputation sufficient to be able to borrow in domestic currency can be substantial. Good reputations are hard to build.

The inability of countries at the periphery of the international monetary system to borrow in domestic currency, or to hedge exchange rate risk, exposes these economies to large-scale currency mismatches that exacerbate financial instability. As we have seen, a possible explanation is that a history of high inflation and opportunistic management of the exchange rate makes creditors unwilling to lend in a currency that the borrower can manipulate.[93] A policymaker's current incentives to manage the exchange rate are affected by his past behaviour and, because his track record is imperfectly observed by other agents in the economy, by the behaviour of his predecessors as well. This generates incentives for policymakers to try to fix the exchange rate to build a reputation for financial probity and to distinguish themselves from those who would try to opportunistically manipulate the exchange rate. Countries may, therefore, try to limit exchange rate movements, notwithstanding the costs of fixing. The complementarity between past and present behaviour means that there is hysterisis in the updating behaviour of creditors, which leads them to be wary about extending credit in domestic currency.

Reputation is not the only factor influencing the currency composition of debt. Market microstructure and barriers to financial innovation are also likely to be key influences on the ability of a country to issue domestic currency debt. Eichengreen and Hausmann (2002) argue that the optimal portfolio for the typical investor has a limited number of currencies. Each additional currency adds costs and risks, while bringing opportunities for diversification. It means that investors are likely

[93] For an alternative view that emphasises the financial constraints of the private sector rather than the time inconsistency of policy, see Caballero and Krishnamurthy (2003).

to have a declining appetite for exotic currencies. So if a country is able to convince investors to hold its currency in their portfolios, it makes it harder for other countries to do likewise. They advocate international initiatives to help develop liquid debt markets and erode perceptions of exotic currency debt.

A number of countries in the Asia-Pacific have moved in this direction by recently establishing an Asian Bond Fund (ABF). The ABF is managed by the Bank for International Settlements and backed by the capital of high credit-rated countries such as Australia, Japan, and New Zealand. The aim is to buy sovereign US$-denominated debt issued by Asian governments on international capital markets, to help promote local debt markets. At a later stage, the scheme is expected to extend to include local currency debt. Currency mismatches are effectively eliminated, since the countries backing the fund are able to hedge their exposure to the local currencies. In the medium-long term, the intention of such a fund is to encourage private sector involvement in local bond markets, increasing liquidity and improving the lending terms for governments in the region. While the measure is unlikely to resolve the problem of original sin on its own, it may be a useful supplement to the development of transparent, credible, institutions and policy frameworks.

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12

Next Steps in the Debate

Our intention in writing this monograph has been to bring together and critically assess the analytical basis of the modern debate on the international financial architecture. By delving into the micro-foundations of crisis, we have sought to clarify the crucial role played by creditor coordination in the origin and management of financial crises. A broad lesson that emerges is that handling financial crises is a subtle affair with few clear-cut choices. Potential financial architects would do well to temper the hubris of their proposals.

Figure 12.1 summarises the main elements of the debate. The pragmatic approach taken to crisis resolution by policymakers in the most recent emerging market crises lies in between the two extremes of pure liquidity and solvency crises. Regardless of location on this spectrum, however, crisis management relies on the coordination of creditors for a critical part of its success. The three main proposals put forward to facilitate this process each have pros and cons. Despite the insights of theory, there is much that is still to be agreed upon.

Recent policy debate has seen the emergence of another proposal—a voluntary *code of conduct*—that strives to set out a best practice for private sector involvement in crisis resolution.[94] A central part of these codes are disclosure principles for debtors, which require the borrower to publicly account for its debts and the cash flows to be allocated to debt servicing. On the creditor side, codes seek to encourage the formation of coherent creditor groupings to constructively engage with the debt reorganisation process. The implications of such proposals are unclear, however. The effects of increased transparency on creditor coordination and financial stability are poorly understood. And the role of creditor groups must be flexible enough to adapt to the ever-changing structure of private capital flows.

[94] See, for example, "Toward a code of good conduct for sovereign debt re-negotiation", Banque de France, 2003.

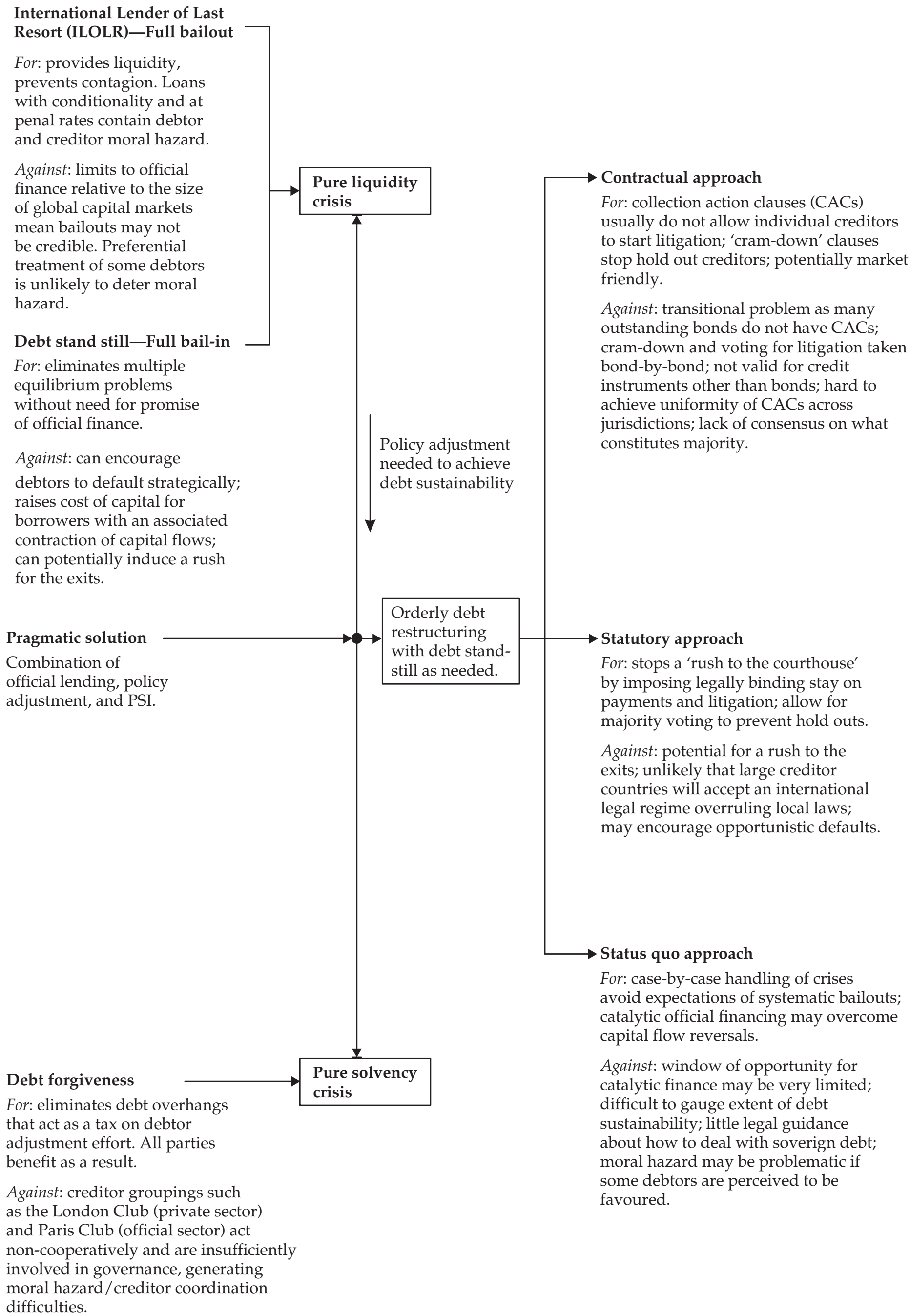

Figure 12.1. *The private-sector-involvement debate*

The experience with international financial crisis management, thus far, invites a degree of pessimism. Creditor coordination problems today are as significant as during the debt crises of the 1930s and 1980s; the incentives of the official sector remain distorted by geo-political considerations; and debtor moral hazard remains rife. As Tirole (2002) observes, this has called into question the role of the IMF as crisis manager. Rightly or wrongly, critics suggest that the IMF's focus has been tangential to the issues central to the immediate handling of crisis. The inadequate representation of many member countries in decision-making has also meant that calls for regional agencies to assume a leadership role have begun to resonate. The design and analysis of supra-national and regional arrangements for financial cooperation represents the next important challenge for future research.

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Appendix A

Solution to the First-Order Differential Equation

This appendix illustrates the mathematical methods needed to solve equation (4.6), a first-order differential equation. Readers are referred to textbooks such as Chiang (1984) for more rigorous treatments.

We first re-arrange (4.6) into:

$$\dot{S}(t) + \frac{1}{\alpha}[M(t) - \beta S(t)] = 0. \tag{A.1}$$

To derive the general solution of (A.1), we first multiply it by an **integrating factor**, I, to make it an **exact equation**.

$$I\dot{S}(t) + \frac{I}{\alpha}[M(t) - \beta S(t)] = 0. \tag{A.2}$$

Consider the following first-order differential equation,

$$\frac{\partial F(s,t)}{\partial s}ds + \frac{\partial F(s,t)}{\partial t}dt = 0, \tag{A.3}$$

which is said to be exact if and only if:

$$\frac{\partial F(s,t)}{\partial s \partial t} = \frac{\partial F(s,t)}{\partial t \partial s}. \tag{A.4}$$

Thus, for (A.2) to be exact,

$$\begin{aligned}\frac{\partial I}{\partial t} &= \frac{1}{\alpha}\frac{\partial I[M(t) - \beta S(t)]}{\partial s}, \\ &= -\frac{I\beta}{\alpha}. \end{aligned} \tag{A.5}$$

On solving, the integrating factor equals:

$$I = e^{\int(-\beta/\alpha)dt}.$$

Now, (A.2) can be written as:

$$e^{\int(-\beta/\alpha)dt}ds + \frac{e^{\int(-\beta/\alpha)dt}}{\alpha}[M(t) - \beta S(t)]\,dt = 0. \tag{A.6}$$

We can find a function $F(s,t)$ by integrating the exponential of the first term of (A.6) with respect to s:

$$\begin{aligned} F(s,t) &= \int e^{\int(-\beta/\alpha)dt}\,ds \\ &= e^{\int(-\beta/\alpha)dt}S(t) + \psi(t), \end{aligned} \tag{A.7}$$

where $\psi(t)$ is a function of t. Notice that the function $F(s,t)$ is a constant as its total differentials equal zero.

Partially differentiating (A.7) with respect to t yields,

$$\frac{\partial F(s,t)}{\partial t} = -e^{\int(-\beta/\alpha)dt}S(t)\left(\frac{\beta}{\alpha}\right) + \psi'(t). \tag{A.8}$$

Comparing (A.8) with the second term of (A.6),

$$\psi'(t) = \frac{M(t)}{\alpha}e^{\int(-\beta/\alpha)dt},$$

or

$$\psi(t) = \int\left[\frac{M(t)}{\alpha}e^{\int(-\beta/\alpha)dt}\right]dt + A_0, \tag{A.9}$$

where A_0 is an arbitrary constant. Substituting (A.9) into (A.7) gives the general solution to (A.1):

$$S(t) = -e^{-\int(-\beta/\alpha)dt}\int\left[\frac{M(t)}{\alpha}e^{\int(-\beta/\alpha)dt}\right]dt + Ae^{\int(-\beta/\alpha)dt}, \tag{A.10}$$

where A is an arbitrary constant.

Recall that $\beta = [a_0P^*(t) - a_1i^*(t)P^*(t)]$ and $\alpha = a_1P^*(t)$. If we assume that all foreign variables are exogenous constants, then (A.10) can be written as

$$S(t) = -e^{(\beta/\alpha)t}\int\left[\frac{M(t)}{\alpha}e^{-(\beta/\alpha)t}\right]dt + Ae^{(\beta/\alpha)t}. \tag{A.11}$$

Notice that the final term is growing exponentially, reflecting some sort of *speculative bubble*. To rule out this kind of behaviour, we set $A = 0$, such that

$$S(t) = -e^{(\beta/\alpha)t} \int \left[\frac{M(t)}{\alpha} e^{-(\beta/\alpha)t} \right] dt. \tag{A.12}$$

We can further simplify the integral in (A.12) using integration by parts, that is,

$$\int u dv = uv - \int v du.$$

Let $v = e^{(-\beta/\alpha)t}(-\alpha/\beta)$, then $dv = e^{(-\beta/\alpha)t}\,dt$. Since $M(t) = D(t) = D(0) + \mu t$, so we can write $u = [D(0) + \mu t]/\alpha$, and $du = \mu/\alpha dt$. Therefore,

$$\begin{aligned} \int \left[\frac{M(t)}{\alpha} e^{-(\beta/\alpha)t} \right] dt &= - \left[\frac{D(0) + \mu t}{\alpha} \right] \frac{\alpha}{\beta} e^{-(\beta/\alpha)t} + \frac{\mu}{\beta} \int e^{-(\beta/\alpha)t} dt \\ &= - \left[\frac{D(0) + \mu t}{\beta} \right] e^{-(\beta/\alpha)t} - \frac{\alpha\mu}{\beta^2} e^{-(\beta/\alpha)t}. \end{aligned} \tag{A.13}$$

Substituting (A.13) into (A.12),

$$\begin{aligned} S(t) &= -e^{(\beta/\alpha)t} \left\{ - \left[\frac{D(0) + \mu t}{\beta} \right] e^{-(\beta/\alpha)t} - \frac{\alpha\mu}{\beta^2} e^{-(\beta/\alpha)t} \right\} \\ &= \left[\frac{[D(0) - \mu t}{\beta} \right] + \frac{\alpha\mu}{\beta^2}. \end{aligned} \tag{A.14}$$

As mentioned in the text, under the no-arbitrage condition, the moment of a successful attack on foreign exchange reserves occurs at the time z when the shadow exchange rate equals the fixed rate, $\bar{S}$. Thus,

$$z = \left[\frac{\beta \bar{S} - D(0)}{\mu} \right] - \frac{\alpha}{\beta}. \tag{A.15}$$

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Appendix B

Conditional Distributions

Let $f(w, y)$ be the joint density function of two normally distributed variables with means μ_w and μ_y, and variances σ_w^2 and σ_y^2 respectively. Then the joint density function is given as

$$f(w, y) = \frac{1}{2\pi\sigma_w\sigma_y\sqrt{1-\rho^2}} \exp\left[-\frac{1}{2(1-\rho^2)}(u^2 - 2\rho uv + v^2)\right], \quad \text{(B.1)}$$

where $u = (w - \mu_w)/\sigma_w$, $v = (y - \mu_y)/\sigma_y$, and $\rho = \text{cov}\,(w, y)/(\sigma_w\sigma_y)$ is the correlation coefficient.

By definition, the conditional density function of y for fixed value of w is

$$f(y|w) = \frac{f(w, y)}{f(w)}, \quad \text{(B.2)}$$

where $f(w)$ is the marginal density function of w, which is given by

$$\begin{aligned} f(w) &= \int_{-\infty}^{\infty} f(w, y)dy \\ &= \int_{-\infty}^{\infty} \left\{ \frac{\exp[-1/(2(1-\rho^2))(u^2 - 2\rho uv + v^2)]}{2\pi\sigma_w\sigma_y\sqrt{1-\rho^2}} \right\} dy \\ &= \frac{1}{2\pi\sigma_w\sqrt{1-\rho^2}} \int_{-\infty}^{\infty} \exp\left[-\frac{1}{2(1-\rho^2)}(u^2 - 2\rho uv + v^2)\right] dv. \end{aligned} \quad \text{(B.3)}$$

Adding and subtracting $\rho^2 u^2$ to the exponent term gives

$$f(w) = \frac{\exp(-u^2/2)}{2\pi\sigma_w\sqrt{1-\rho^2}} \int_{-\infty}^{\infty} \exp\left[-\frac{1}{2(1-\rho^2)}(v - \rho u)^2\right] dv. \quad \text{(B.4)}$$

And let $z = (v - \rho u)/\sqrt{1-\rho^2}$ such that $dv = \sqrt{1-\rho^2}dz$, so (B.4) can be rewritten as

$$\begin{aligned} f(x) &= \frac{\exp(-u^2/2)}{\sqrt{2\pi}\sigma_w} \int_{-\infty}^{\infty} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{z}{2}\right) dz \\ &= \frac{1}{\sqrt{2\pi}\sigma_w} \exp\left(-\frac{u^2}{2}\right). \end{aligned} \tag{B.5}$$

Substituting (B.1) and (B.5) into (B.2), and after a few algebraic manipulations, we can write the conditional density as

$$f(y|w) = \frac{1}{\sqrt{2\pi}\sqrt{1-\rho^2)}\sigma_y} \exp\left\{-\frac{1}{2}\left[\frac{v-\rho u}{\sqrt{1-\rho^2}}\right]^2\right\}. \tag{B.6}$$

The conditional density function in terms of the means and variances of w and y is given by

$$f(y|w) = \frac{1}{\sqrt{2\pi}\sqrt{1-\rho^2}\sigma_y} \exp - \left[\frac{1}{2}\left(\frac{y - [\mu_y + \rho(\sigma_y/\sigma_w)(w-\mu_w)]}{\sqrt{1-\rho^2}\sigma_y}\right)\right]. \tag{B.7}$$

Equation (B.7) shows that the conditional density function of y for fixed value of w is also normally distributed with

$$\text{mean} = \mu_y + \rho\frac{\sigma_y}{\sigma_w}(w - \mu_w), \tag{B.8}$$

$$\text{variance} = (1-\rho^2)\sigma_y^2. \tag{B.9}$$

Note that (B.8) corresponds to a linear regression of y on w, with $\rho\sigma_y/\sigma_w$ being the estimate of the slope parameter.

Suppose that the fundamental θ is normally distributed with mean μ_θ and variance σ_θ^2. Investor i only observes a private signal x_i about θ such that

$$x_i = \theta + \varepsilon_i. \tag{B.10}$$

Since $\varepsilon \sim N(0, \sigma_\varepsilon^2)$ and is independent from θ, the mean and variance of x_i are given by

$$\mathrm{E}(x_i) = \mu_\theta, \qquad \mathrm{var}\,(x_i) = \sigma_\theta^2 + \sigma_\varepsilon^2. \tag{B.11}$$

Notice that the correlation coefficient $\rho = \sigma_\theta^2/\sqrt{\sigma_\theta^2(\sigma_\theta^2 + \sigma_\varepsilon^2)}$. To derive the conditional mean and variance of $f(\theta|x)$, we make use of (B.8) and (B.9) by substituting $\mathrm{E}(x_i)$, $\sqrt{\mathrm{var}(x_i)}$, μ_θ, and σ_θ for μ_w, σ_w, μ_y, and σ_y respectively. After some algebraic manipulations, we get,

$$\begin{aligned} \text{mean } &= \frac{\mu_\theta \sigma_\varepsilon^2 + x\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\varepsilon^2}, \\ \text{variance } &= \frac{\sigma_\theta^2 \sigma_\varepsilon^2}{\sigma_\theta^2 + \sigma_\varepsilon^2}. \end{aligned} \tag{B.12}$$

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Bibliography

Ades, A., Masih, R., and Tenengauzer, D. (1998). *GS-WATCH: a new framework for predicting financial crises in emerging markets*. Economic research, Goldman Sachs.

Agénor, P., Bhandari, J., and Flood, R. (1992). Speculative attacks and models of balance of balance of payments crises. *IMF Staff Papers*, **39**, 357–94.

Allen, F. and Gale, D. (1998). Optimal financial crises. *Journal of Finance*, **53**, 1245–84.

—— —— (2000). Financial contagion. *Journal of Political Economy*, **108**, 1–33.

—— —— (2003). Financial fragility. New York University, Mimeo.

Amemiya, T. (1985). *Advanced Econometrics*. Basil Blackwell, Oxford, UK.

Backus, D. and Driffill, J. (1985). Inflation and reputation. *American Economic Review*, **75**, 530–8.

Baig, T. and Goldfajn, I. (1999). Financial market contagion in the Asian crisis. *IMF Staff Papers*, **46**, 167–95.

Banque de France (2003). Toward a code of good conduct for sovereign debt re-negotiation. Paper prepared for the IIE/IFRI seminar on Sovereign Debt Restructuring held in Paris, 9 March 2003.

Ball, L. (1995). Time consistent inflation policy and persistent changes in inflation. *Journal of Monetary Economics*, **36**, 329–50.

Banerjee, A. (1992). A simple model of herd behaviour. *Quarterly Journal of Economics*, **107**, 797–817.

Barro, R. and Gordon, D. (1983). A positive theory of monetary policy in a natural rate model. *Journal of Political Economy*, **91**, 589–610.

—— and Lee, J. W. (2002). IMF programs: who is chosen and what are the effects? NBER Working Paper No. 8951.

Becker, T., Richards, A., and Thaicharoen, Y. (2003). Bond restructuring and moral hazard: are collective action clauses costly? *Journal of International Economics*, **61**, 127–61.

Ben-Akiva, M. and Lerman, S. (1985). *Discrete Choice Analysis: Theory and Application to Travel Demand*. MIT Press, Cambridge, MA.

Berg, A. and Pattillo, C. (1999*a*). Are currency crises predictable? A test. *IMF Staff Papers*, **46**(2), 107–38.

—— —— (1999*b*). Predicting currency crises: the indicators approach and an alternative. *Journal of International Money and Finance*, **18**, 561–86.

—— Borensztein, E., Milesi-Ferretti, G. M., and Pattillo, C. (1999). Anticipating balance of payments crises: the role of early warning system. Occasional Paper 186, IMF.

Besley, T. and Case, A. (2000). Unnatural experiments? Estimating the incidence of endogenous policies. *Economic Journal*, **110**, F672–94.

Bikchandani, S., Hirshleifer, D., and Welch, I. (1992). A theory of fads, fashion, custom, and cultural change as informational cascades. *Journal of Political Economy*, **100**(5), 992–1026.

Blackburn, K. and Sola, M. (1993). Speculative currency attacks and balance of payments crises. *Journal of Economic Surveys*, **7**, 119–44.

Blundell, R. and MaCurdy, T. (1999). Labour supply: a review of alternative approaches. In O. Ashenfelter and D. Card, editors, *Handbook of Labour Economics, Volume 3A*. North Holland, Amsterdam.

Bolton, P. and Rosenthal, H. (2002). Political intervention in debt contracts: moratoria and bailouts. *Journal of Political Economy*, **110**, 1103–34.

Bordo, M. and Flandreau, M. (2003). Core, periphery, exchange rate regimes, and globalisation. In M. Bordo, A. Taylor, and J. Williamson, editors, *Globalisation in Historical Perspective*. University of Chicago Press, Chicago, IL.

Bryant, J. (1980). A model of reserves, bank runs and deposit insurance. *Journal of Banking and Finance*, **4**, 335–44.

Buiter, W. (1987). Borrowing to defend the exchange rate and the timing and magnitude of speculative attacks. *Journal of International Economics*, **23**, 221–39.

Bulow, J. and Rogoff, K. (1988). Multilateral negotiations for rescheduling developing debt: a bargaining theoretic framework. *IMF Staff Papers*, **35**, 644–57.

——— (1989*a*). A constant recontracting model of sovereign debt. *Journal of Political Economy*, **97**, 155–78.

——— (1989*b*). Sovereign debt: is to forgive to forget? *American Economic Review*, **79**, 43–50.

——— (1990). Cleaning up third world debt without getting taken to the cleaners. *Journal of Economic Perspectives*, **4**, 31–42.

—— Geanakoplos, J., and Klemperer, P. (1985). Multimarket oligopoly: strategic substitutes and complements. *Journal of Political Economy*, **93**, 488–511.

Burnside, C., Eichenbaum, M., and Rebelo, S. (2001). Prospective deficits and the Asian currency crisis. *Journal of Political Economy*, **109**, 1155–97.

Bussiére, M. and Mulder, C. (1999). External vulnerability in emerging market economies: how high liquidity can offset weak fundamentals and the effects of contagion. Working Paper 99/88, IMF.

Caballero, R. and Krishnamurthy, A. (2003). Excessive dollar debt: financial development and underinsurance. *Journal of Finance*, **58**, 867–93.

Calvo, G. (1988). Servicing the public debt: the role of expectations. *American Economic Review*, **78**, 647–61.

—— and Mendoza, E. (1996). Mexico's balance of payments crisis: a chronicle of a death foretold. *Journal of International Economics*, **41**, 235–64.

—— —— (2000). Rational contagion and the globalisation of security markets. *Journal of International Economics*, **51**, 79–113.

Calvo, S. and Reinhart, C. (1996). Capital flows to Latin America: is there evidence of contagion effects. In G. Calvo, M. Goldstein, and E. Hochreiter, editors, *Private Capital Flows to Emerging Markets*. Institute for International Economics, Washington DC.

Caprio, Jr., G. (1998). Banking on crises: Expensive lessons from recent financial crises. mimeo, World Bank.

Caramazza, F., Ricci, L., and Salgado, R. (2000). Trade and financial contagion in currency crises. IMF Working Paper, 00/55.

Carlsson, H. and van Damme, E. (1993). Global games and economic selection. *Econometrica*, **61**, 989–1018.

Chan, K. and Chiu, Y. (2002). The role of (non-)transparency in a currency crisis model. *European Economic Review*, **46**, 397–416.

Chang, R. and Velasco, A. (2001). A model of financial crises in emerging markets. *Quarterly Journal of Economics*, **116**, 489–517.

Chari, V. and Jagannathan, R. (1988). Banking panics, information, and rational expectations equilibrium. *Journal of Finance*, **43**, 749–60.

Chari, V. V. and Kehoe, P. (2000). Financial crises as herds. Working Paper 600, Federal Reserve Bank of Minneapolis.

Chiang, A. C. (1984). *Fundamental Methods of Mathematical Economics*. McGraw-Hill, New York, third edition.

Chinn, M. (2000). Before the fall: were East Asian currencies overvalued? *Emerging Markets Review*, **1**(2), 101–26.

Chui, M. (2002). Leading indicators of balance-of-payments crises: a partial review. Bank of England Working Paper No. 171.

—— Gai, P., and Haldane, A. (2002). Sovereign liquidity crises: Analytics and implications for public policy. *Journal of Banking and Finance*, **26**, 519–46.

—— Hall, S., and Taylor, A. (2004). Crisis spillovers in emerging market economies: interlinkages, vulnerabilities, and investor behaviour. Bank of England Working Paper No. 212.

Cline, W. (2000). The role of the private sector in resolving financial crises in emerging markets. NBER Conference on Economic and Financial Crises in Emerging Markets, Woodstock, Vermont.

Cole, H. and Kehoe, P. (1995). The role of institutions in reputation models of sovereign debt. *Journal of Monetary Economics*, **35**, 45–64.

—— Dow, J., and English, H. (1995). Default, settlement and signalling—lending resumption in a reputational model of sovereign debt. *International Economic Review*, **36**, 365–85.

Cooper, R. (1999). *Coordination Games: Complementarities and Macroeconomics*. Cambridge University Press, Cambridge, UK.

—— and Ross, T. W. (1998). Bank runs: Liquidity costs and investment distortions. *Journal of Monetary Economics*, **41**, 27–38.

Corden, M. (1989). An international debt facility? In J. Frenkel, M. Dooley, and P. Wickham, editors, *Analytical Issues in Debt*. IMF, Washington DC.

Corsetti, G., Pesenti, P., and Roubini, N. (1999). What caused the Asian currency and financial crisis? *Japan and the World Economy*, **11**, 305–73.

—— Guimaraes, B., and Roubini, N. (2003). International lender of last resort and moral hazard: a model of the IMF's catalytic finance. Yale University, mimeo.

—— Dasgupta, A., Morris, S., and Shin, H. S. (2004). Does one Soros make a difference? A theory of currency crises with large and small traders. *Review of Economic Studies*, **71**, 87–114.

Cramer, J. (1990). *The Logit Model for Economists*. Edward Arnold, Great Britain.

Crouhy, M., Galai, D., and Mark, R. (2001). *Risk Management*. McGraw-Hill, New York.

Dell'Ariccia, G., Schnabel, I., and Zettelmeyer, J. (2002). Moral hazard and international crisis lending: a test. IMF Working Paper, 02/181.

Demirgüç-Kunt, A. and Detragiache, E. (1998). The determinants of banking crises: evidence from developing and developed countries. *IMF Staff Papers*, **45**, 81–109.

Diamond, D. and Dybvig, P. (1983). Bank runs, deposit insurance, and liquidity. *Journal of Political Economy*, **91**, 401–19.

Dooley, M. (2000). Can output losses following international crises be avoided? NBER Working Paper 7531.

Dornbusch, R., Goldfajn, I., and Valdés, R. (1995). Currency crises and collapses. *Brookings Papers on Economic Activity*, **2**, 219–93.

Drazen, A. (1999). Political contagion in currency crisis. NBER Working Paper No. 7211.

Duffie, D. and Singleton, K. (1999). Modelling term structures of defaultable bonds. *Review of Financial Studies*, **12**, 687–720.

Eaton, J. and Fernandez, R. (1995). Sovereign debt. In G. Grossman and K. Rogoff, editors, *Handbook of International Economics, Volume 3*. North Holland, Amsterdam.

—— and Gersovitz, M. (1981). Debt with potential repudiation: theory and estimation. *Review of Economic Studies*, **48**, 289–309.

—— ——, and Stiglitz, J. E. (1986). The pure theory of country risk. *European Economic Review*, **30**, 481–513.

Edison, H. J. (2000). Do indicators of financial crises work? An evaluation of an early warning system. International Finance Discussion Paper 675, Board of Governors of Federal Reserve System.

Edwards, S. (1998). Interest rate volatility, capital controls, and contagion. NBER Working Paper No. 6756.

Eichengreen, B. (2000). Can moral hazard caused by IMF bailouts be reduced? Geneva Report on the World Economy, Special Report No. 1, CEPR.

—— (2002). *Financial Crises and What to do About Them*. Oxford University Press, New York.

—— and Hausmann, R. (1999). Exchange rates and financial fragility. In *New Challenges for Monetary Policy*. Federal Reserve Bank of Kansas City.

—— —— (2002). How to eliminate original financial sin? *Financial Times*, 22 November.

—— and Mody, A. (2000). Would collective action clauses raise borrowing costs? NBER Working Paper No. 7458.

—— and Portes, R. (1995). *Crisis? What Crisis? Orderly Workouts for Sovereign Debtors*. CEPR, London.

—— Rose, A., and Wyplosz, C. (1995). Exchange market mayhem: the antecedents and aftermath of speculative attacks. *Economic Policy*, 251–312.

—— —— —— (1996*a*). Contagious currency crises. NBER Working Paper No. 5681.

—— —— —— (1996*b*). Speculative attacks on pegged exchange rates: an empirical exploration with special reference to the European Monetary System. In M. Canzoneri, W. Ethier, and V. Grilli, editors, *The New Transatlantic Economy*. Cambridge University Press, Cambridge, MA.

—— Hausmann, R., and Panizza, U. (2002). The mystery of original sin. Paper prepared for the IADB conference on Currency and Maturity Matchmaking: Redeeming Debt from Original Sin, Washington DC, November.

Esquivel, G. and Larrain, F. (1998). Explaining currency crises. Harvard Institute for International Development Discussion Paper No. 666.

Fane, G. (2000). *Capital Mobility, Exchange Rates and Economic Crises*. Edward Elgar, Cheltenham, UK.

Finney, D. (1971). *Probit Analysis*. Cambridge University Press, Cambridge, MA.

Fischer, S. (1990). Rules versus discretion in monetary policy. In B. Friedman and F. Hahn, editors, *Handbook of Monetary Economics, Vol. 2*. North Holland, Amsterdam.

Flood, R. and Garber, P. (1984). Collapsing exchange-rate regimes. *Journal of International Economics*, **17**, 1–13.

—— and Marion, N. (1999). Perspectives on the recent currency crisis literature. *International Journal of Finance and Economics*, **4**, 1–26.

Forbes, K. and Rigobon, R. (2001). Measuring contagion: conceptual and empirical issues. In S. Claessens and K. Forbes, editors, *International Financial Contagion*. Kluwer Academic Publishers, UK.

Frankel, J. and Rose, A. (1996). Currency crashes in emerging markets: an empirical treatment. *Journal of International Economics*, **41**, 351–66.

Freixas, X. and Rochet, J. (1997). *Microeconomics of Banking*. MIT Press, Cambridge, MA.

Froot, K., O'Connell, P., and Seasholes, M. (2001). The portfolio flows of international investors. *Journal of Financial Economics*, **59**, 151–93.

Fudenberg, D. and Tirole, J. (1991). *Game Theory*. MIT Press, Cambridge, MA.

Gai, P. (1994). International capital flows to developing countries—a theoretical analysis. D. Ph. Thesis, University of Oxford.

—— and Shin, H. S. (2004). Debt maturity structure with pre-emptive creditors. *Economics Letters*, **85**, 195–200.

Gai, P. and Tan, K. (2004). Good housekeeping? Reputation, fixed exchange rates and the 'original sin' problem. Hong Kong Institute of Monetary Research Working Paper, No. 8.

—— and Taylor, A. (2004). International financial rescues and debtor country moral hazard. International Finance, forthcoming.

—— Hayes, S., and Shin, H. S. (2004). Crisis costs and debtor discipline: the efficacy of public policy in sovereign debt crises. *Journal of International Economics*, **62**, 245–62.

Geithner, T. (2000). Resolving financial crises in emerging markets. Remarks before the Securities Industry Association and Emerging Markets Traders Association, New York, NY, US Treasury, 23 October.

Gerlach, S. and Smets, F. (1995). Contagious speculative attacks. *European Journal of Political Economy*, **11**, 45–63.

Glick, R. and Rose, A. (1999). Contagion and trade: why are currency crises regional? *Journal of International Money and Finance*, **18**, 603–18.

Goldfajn, I. and Valdés, R. (1998). Are currency crises predictable?. *European Economic Review*, **42**, 873–85.

Goldstein, I. and Pauzner, A. (2002). Demand deposit contracts and the probability of bank runs. Duke University, mimeo.

Gorton, G. (1988). Banking panics and business cycles. *Oxford Economic Papers*, **40**, 751–81.

Greene, W. H. (2003). *Econometric Analysis*. Prentice Hall, NJ, fifth edition.

Greenspan, A. (1999). Testimony before the committee on banking and financial services. US House of Representatives, 20 May 1999.

Grossman, H. and van Huyck, J. (1988). Sovereign debt as a contingent claim. *American Economic Review*, **78**, 1088–97.

—— —— (1993). Nominally denominated sovereign debt, risk shifting and reputation. *Journal of Economics and Business*, **45**, 341–52.

Haldane, A. and Kruger, M. (2001). The resolution of international crises: private finance and public funds. *Financial Stability Review, Bank of England*, **11**, 193–202.

—— and Scheibe, J. (2004). IMF lending and creditor moral hazard. Bank of England Working Paper No. 216.

—— Penalver, A., Saporta, V., and Shin, H. S. (2004). Analytics of sovereign debt restructuring. *Journal of International Economics*, forthcoming.

Hausmann, R., Panizza, U., and Stein, E. (2001). Why do countries float the way they float? *Journal of Development Economics*, **66**, 387–414.

Hawkins, J. and Turner, P. (2000). Managing foreign debt and liquidity risks in emerging economies—an overview. Bank for International Settlements Policy Paper No. 8.

Hernandez, L. and Valdés, R. (2001). What drives contagion? Trade, neighbourhood, or financial links. *International Review of Financial Analysis*, **10**, 203–18.

Hoggarth, G., Saporta, V., and Reis, R. (2002). Costs of banking system stability: some empirical evidence. *Journal of Banking and Finance*, **26**, 825–55.

Holmstrom, B. (1999). Managerial incentive problems: a dynamic perspective. *Review of Economic Studies*, **66**, 169–82.

IMF (1998). World economic outlook. Washington DC.

—— (2001). Review of access policy in the credit tranches and under the extended fund facility—background paper. Washington DC.

—— (2002). Selected decisions and selected documents of the IMF. Twenty-seventh issue, Washington DC.

Independent Evaluation Office (2003). The IMF and recent capital account crises: Indonesia, Korea, Brazil. Washington DC.

Jarrow, R. and Turnbull, S. (1995). Pricing derivatives on financial securities subject to credit risk. *Journal of Finance*, **50**, 53–86.

Jeanne, O. (2001). Sovereign debt crises and the international financial architecture. IMF, mimeo.

—— (2002). Why do emerging economies borrow in foreign currency? Paper prepared for the IADB conference on Currency and Maturity Matchmaking: Redeeming Debt from Original Sin, Washington DC, November.

Kamin, S. (2002). Identifying the role of moral hazard in international financial markets. International Finance Discussion Paper 736, Board of Governors of Federal Reserve System.

Kaminsky, G. (1999). Currency and banking crises: The early warnings of distress. IMF Working Paper 99/178.

—— and Reinhart, C. (1999). The twin crises: the causes of banking and balance-of-payments problems. *American Economic Review*, **89**, 473–500.

—— —— (2000). On crises, contagion, and confusion. *Journal of International Economics*, **51**, 145–68.

—— Lizondo, S., and Reinhart, C. (1998). Leading indicators of currency crises. *IMF Staff Papers*, **45**, 1–48.

—— Lyons, R., and Schmukler, S. (2001). Mutual fund investment in emerging markets: an overview. In S. Claessens and K. Forbes, editors, *International Financial Contagion*. Kluwer Academic Publishers, UK.

—— —— —— (2004). Managers, investors, and crises: mutual fund strategies in emerging markets. *Journal of International Economics*, forthcoming.

King, M. (1999). Reforming the international financial system—the middle way. *Financial Stability Review, Bank of England*, **7**, 203–11.

Kletzer, K. (1988). External borrowing by LDCs: a survey of theoretical issues. In G. Ranis and T. Schultz, editors, *The State of Development Economics*. Basil Blackwell, London.

—— (2003). Sovereign bond restructuring: collective action clauses and official crisis intervention. IMF Working Paper No. 03/134.

Kletzer, K. and Wright, B. (2000). Sovereign debt as intertemporal barter. *American Economic Review*, **90**, 621–39.

Klimenko, M. (2002). Trade interdependence, the international financial institutions, and the recent evolution of sovereign-debt renegotiations. *Journal of International Economics*, **58**, 177–209.

Knight, M. and Santaella, J. (1997). Economic determinants of IMF financial arrangements. *Journal of Development Economics*, **54**, 405–36.

Kreps, D. and Wilson, R. (1982). Reputation and imperfect information. *Journal of Economic Theory*, **27**, 280–312.

Krueger, A. (2002*a*). *A new approach to sovereign debt restructuring*. IMF, Washington DC.

—— (2002*b*). New approaches to sovereign debt restructuring: an update on our thinking. Remarks at the Conference 'Sovereign Debt Workouts: Hopes and Hazards?', Institute for International Economics, Washington DC.

Krugman, P. (1979). A model of balance-of-payments crises. *Journal of Money, Credit and Banking*, **11**, 311–25.

Kumar, M., Moorthy, U., and Perraudin, W. (1998). Predicting emerging market currency crises. Birkbeck College, mimeo.

Lane, T. and Phillips, S. (2000). Does IMF financing result in moral hazard? IMF Working Paper, 00/168.

Levin, J. (2001). Career concerns and collective reputation. Stanford University, mimeo.

Lindert, P. and Morton, P. (1989). How sovereign debt has worked. In J. Sachs, editor, *Developing Country Debt and the World Economy*, pp. 225–35. University of Chicago Press, Chicago, IL.

Longin, F. and Slonik, B. (1995). Is the correlation in international equity returns constant: 1960–1990. *Journal of International Money and Finance*, **14**, 3–26.

Loretan, M. and English, W. (2000). Evaluating 'correlation breakdowns' during periods of market volatility. International Finance Discussion Paper 658, Board of Governors of Federal Reserve System.

Mailath, G. and Samuelson, L. (2001). Who wants a good reputation? *Review of Economic Studies*, **68**, 415–41.

Masson, P. (1998). Contagion: monsoonal effects, spillovers, and jumps between multiple equilibria. Working Paper 98/142, IMF.

Mathieson, D., Schinasi, G., and others (2000). International capital markets: developments, prospects, and key policy issues. IMF, Washington DC.

McBrady, M. and Seasholes, M. (2000). Bailing in. Haas School of Management, University of California Berkeley, mimeo.

Miller, M. and Zhang, L. (2000). Sovereign liquidity crisis: the strategic case for payments standstills. *Economic Journal*, **110**, 309–34.

Morgan, J. P. (1998). Event risk indicator handbook. J. P. Morgan Global Foreign Exchange Research, Technical Series.

Morris, S. and Shin, H. S. (1998). Unique equilibrium in a model of self-fulfilling currency attacks. *American Economic Review*, **88**, 587–97.

Morris, S. and Shin, H. S. (2003*a*). Catalytic finance: how does it work? London School of Economics, mimeo.

—— —— (2003*b*). Global games: theory and applications. In M. Dewatripont, L. Hansen, and S. Turnovsky, editors, *Advances in Economics and Econometrics: Theory and Applications, Eighth World Congress, Volume I*. Cambridge University Press, Cambridge, MA.

—— —— (2004). Coordination risk and the price of debt. *European Economic Review*, **48**, 133–53.

Mussa, M. (1999). Reforming the international financial architecture: limiting moral hazard and containing real hazard. Paper presented at the Reserve Bank of Australia Conference on Capital Flows and International Financial System, 9–10 August 1999, Sydney.

Obstfeld, M. (1996). Models of currency crises with self-fulfilling features. *European Economic Review*, **40**, 1037–47.

Osborne, M. and Rubinstein, A. (1990). *Bargaining and Markets*. Academic Press, San Diego, Calif.

Penalver, A. (2004). How can the IMF catalyse private capital flows? A model. Bank of England Working Paper No. 215.

Potter, S. (1995). A non-linear approach to US GNP. *Journal of Applied Econometrics*, **10**, 109–25.

Rodrik, D. and Velasco, A. (1999). Short-term capital flows. NBER Working Paper No. 7364.

Rogoff, K. and Zettelmeyer, J. (2002). Bankruptcy procedures for sovereigns: a history of ideas, 1976–2001. *IMF Staff Papers*, **49**(3), 470–507.

Roubini, N. (2003). Private sector involvement in crisis resolution and mechanisms for dealing with sovereign debt problems. In A. Haldane, editor, *Fixing Financial Crises in the 21st Century*. Routledge, London.

Rubinstein, A. (1982). Perfect equilibrium in a bargaining model. *Econometrica*, **50**, 97–109.

Sachs, J. (1995). Theoretical issues in international borrowing. In G. Bird and P. Snowden, editors, *International Debt*, *Volume I*. Edward Elgar, UK.

—— (2002). Do we need an international lender of last resort? Frank Graham Lecture at Princeton, 1995.

—— Tornell, A., and Velasco, A. (1996*a*). Financial crises in emerging markets: the lessons from 1995. *Brookings Papers on Economic Activity*, **1**, 147–215.

—— —— —— (1996*b*). The Mexican peso crisis: sudden death or death foretold? *Journal of International Economics*, **41**(3–4), 265–83.

Schwarcz, S. (2000). Sovereign debt restructuring: a bankruptcy reorganisation approach. *Cornell Law Review*, **85**, 101–87.

Sibert, A. (2003). Monetary policy committees: individual and collective reputations. *Review of Economic Studies*, **70**, 649–65.

Summers, L. (2000). International financial crises: causes, prevention and cures. *American Economic Review*, **90**(2), 1–16.

Tadelis, S. (1999). What's in a name? *American Economic Review*, **89**, 548–63.

Taylor, J. (2002). Sovereign debt restructuring: A US perspective. Remarks at the Conference 'Sovereign Debt Workouts: Hopes and Hazards?', Institute for International Economics, Washington DC.

Tirole, J. (1996). A theory of collective reputations (with applications to the persistent of corruption and to firm quality). *Review of Economic Studies*, **63**, 1–22.

—— (2002). *Financial Crises, Liquidity, and the International Monetary System*. Princeton University Press, NJ.

Van Rijckeghem, C. and Weder, B. (2001). Sources of contagion: finance or trade? *Journal of International Economics*, **54**(2), 293–308.

Velasco, A. (1996). Fixed exchange rates: credibility, flexibility, and multiplicity. *European Economic Review*, **40**, 1023–35.

Wells, R. (1993). Tolerances of arrearages: how IMF loan policy can affect debt reduction. *American Economic Review*, **83**, 621–33.

White, M. (2002). Sovereigns in distress: do they need bankruptcy? *Brookings Papers on Economic Activity*, **1**, 287–319.

Zhang, X. (1999). Testing for 'moral hazard' in emerging markets lending. Institute of International Finance Research Paper, No. 99-1.

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