Debt maturity structure with pre-emptive creditors

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Abstract

Recent experience with financial crises has led to scepticism about the efficacy of crisis management measures that target short-term debt, such as the voluntary/concerted rollovers of interbank lines. Such measures, it is suggested, heighten financial fragility by encouraging creditors to pre-empt each other by lending at ever shorter maturities. We model such pre-emptive behaviour explicitly and explore the implications for the maturity profile of debt. We find that crisis management instruments designed to improve the recovery process for claimholders do not necessarily skew the maturity structure towards the shorter term.

Key words: Debt maturity; international financial architecture; creditor pre-emption.

JEL classification: F33, F34.

Summary

Short-term liabilities play a central role in sovereign debt restructuring. Typically, the creditors of a debtor in distress must decide whether to extend further lines of short-term credit, or whether to cut their losses and refuse to lend. The greater the funding need that creditors must meet, the less likely it is that they will be persuaded to roll over their credit lines. This is because uncertainty about the assessments and actions of other creditors acts as a disincentive for an individual lender to extend credit. Thus, the greater the amount of short-term (immediate) debt outstanding, the more problematic the problem of coordinating creditors becomes.

In dealing with sovereign debt crises, policy-makers have proposed measures such as stays on creditor litigation, temporary payments suspensions, and concerted rollovers of credit lines, in an effort to target short-term debt. But following the use of concerted rollovers in Korea, creditors reacted pre-emptively to the crisis in Brazil – shortening maturities at the onset of crisis and cutting interbank lines sooner than might otherwise have been the case. This experience has led some to question the viability of rollovers and payments standstills as tools for crisis management. By encouraging creditors to 'rush for the exits', it is argued, such measures merely bring forward financial vulnerabilities by pushing debt maturities towards the shorter term.

This paper argues that such logic is not necessarily general. We model the 'rush for 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. First, there is the 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.

The analysis explores the effects of an orderly payments suspension on the creditor's choice of maturity and, hence, on the term structure of debt. We show that if such measures can boost recovery values in the event of crisis, then creditors may not seek short-lived claims. This is

because there is a direct effect in increasing incentives to holding longer-term claims since the returns to holding these are now higher. And there is an indirect and reinforcing ‘strategic’ effect, as higher recovery rates brought about by such policy measures reduce the desire to engage in pre-emption in the first place.

Comparative static results suggest that the overall implications for the term structure of debt depend on the effectiveness of the crisis management framework as well as the length of time that the restructuring is expected to take. If payments suspensions are short-lived and have a positive effect on recovery values, they are unlikely to generate a move towards shorter maturity debt. Longer-lived debt workouts can push maturities towards the shorter term, however. Indeed, for suitably lengthy workouts, it is even possible that there can be a hollowing out of middle maturities as creditors move to either end of the maturity spectrum. It is not typically possible therefore to draw firm conclusions, *a priori*, about the shape of debt maturity profiles when measures such as payments standstills and concerted rollovers are used as part of crisis management.

1 Introduction

Short-term liabilities play a central role in instances of corporate and sovereign debt restructuring. A typical situation is one in which the creditors of a debtor in distress must decide whether to extend further lines of credit, or to cut their losses and refuse to lend. Conventional wisdom among market participants holds that the greater the funding need the lenders must meet, the greater the difficulty of persuading them to roll over their credit lines. This is because the strategic uncertainty concerning the assessments and actions of other creditors in the rollover acts as a disincentive for an individual lender to extend a lifeline. So the greater the amount of short-term debt outstanding and the greater the funding gap, the less likely it is that the collective action problem of short-term claimholders can be solved efficiently.

In the international context, policy-makers have proposed measures such as stays on creditor litigation, and concerted rollovers of interbank lines, in an effort to target short-term debt during the management of financial crises. But following the use of concerted rollovers in Korea, creditors shortened maturities pre-emptively and cut interbank lines much more quickly upon the onset of a subsequent crisis in Brazil. The experience has led to scepticism about the efficacy of rollovers and payment standstills as tools for dealing with creditor co-ordination problems.(1) By encouraging creditors to 'rush for the exits', ie lend at shorter and shorter maturities to ensure that they get their money out before others, it is argued that such measures merely bring forward financial crises. For example, Mathieson *et al* (2000, page 136) observe that pre-emptive creditor behaviour makes crisis management policy difficult to finesse as

> '.. emerging market borrowers needing financing will, while moving towards a crisis situation, increasingly have to finance themselves through shorter maturities and at potentially increasing interest rates. This is counter-productive from an external vulnerability point of view...and would stretch the capability of the official community to put together a rescue package before all 'footloose capital' has flown out.'

(1) Data describing the rollover experience in recent financial crises are unavailable in the public domain. The most comprehensive account is offered by Mathieson *et al* (2000). Eichengreen (2000) also catalogues the scepticism to such policy measures. He suggests that other proposals which may lead to pre-emptive creditor behaviour include officially sanctioned standstills and the UDrop proposal of Buiter and Sibert (1999).

The possibility of such creditor behaviour raises some important questions for the design of contemporary crisis management policy. How does the tendency for creditors to be pre-emptive influence the equilibrium maturity profile and, hence, the default rate of sovereign debt? Do measures that focus on short-term debt, such as rollovers, necessarily result in a shortening of debt maturities? And how does the length of time that such measures are in place influence the maturity profile? For example, does it matter if a stay on payments is temporary or long-lived?

Debt maturity structure cannot be considered in isolation from the issue of the pricing of risky debt. 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 finance literature has focused on asset pricing issues, taking the maturity profile as given. In reduced form credit models (eg 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 assumptions on the recovery of payment after a default, provides enough structure to determine bond prices. 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.

Existing models of debt maturity choice have not focused on the implications of creditor behaviour for the equilibrium capital structure. The finance literature typically stresses either the agency costs of debt (Myers (1977)), or emphasises the credit quality of the debtor (eg Diamond (1991, 1993)). Other models tend to highlight the role played by short-term debt in disciplining borrower behaviour. Dooley (2000) argues, for instance, that the output costs generated by a creditor run helps enforce sovereign debt repayment. And, in similar vein, Calomiris and Kahn (1991) suggest that the threat of withdrawal of demand deposits can help discipline bank managers. But these models do not analyse how the failure rate of a project implied by a run influences the maturity structure of debt and, hence, the default profile.

In this paper, we develop a theoretical framework to explore the effects of strategic creditor behaviour on the maturity profile of debt. Creditors face an *ex ante* decision of how to invest in a risky project, and can choose to be either long or short-term claimholders. To highlight the role of investor runs, we stress the role of short-term claimholders as active decision-makers. The greater influence of short-term creditors in forcing the hand of the debtor means that the probability of the project failing before maturity depends on the incidence of short-term debt. Longer maturity claims do better the longer the project survives. In such an environment, and with a given pricing structure, creditors have an incentive to pre-empt each other – ie to choose a maturity that is just shorter than those chosen by other claimholders. The equilibrium capital structure is one that equalises the expected payoff to each type of claimholder *ex ante*, and in which all types of claim are used in equilibrium.

Central to our analysis is the feature that the amount of short-term debt outstanding has a material impact on the survival of the project. The larger the amount of short-term debt due, the greater the probability that the project will fail that period. The empirical literature on the pricing of defaultable debt offers some support for this hypothesis. 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, Galai and Mark (2001, page 373)). In Merton's (1974) original model, the firm defaults when its asset value falls below its total liabilities. In KMV's modification, motivated by historical experience, the default point is not total liabilities, but rather, the sum of short-term liabilities plus half of long-term liabilities. So the greater the proportion of short-term liabilities relative to long-term liabilities, the higher the default hurdle for the firm.

Although cast as a model of investment in a single risky project in which the debtor is passive, our analysis sheds some light on recent debates on the international financial architecture. Specifically, we examine how improvements in the recovery process for bondholders affect the maturity structure. Higher recovery rates are shown to influence creditor behaviour in two ways. First, there is a *direct* effect. Any increase in the recovery rate increases the amount that a bondholder can recover in the event of a default. Second, there is a *strategic* effect – an increase in the recovery rate lowers the payoff to pre-empting relative to the payoff from maintaining a longer maturity instrument. The dampening influence of the strategic effect on pre-emptive behaviour means that policy measures which promote higher recovery rates need not result in a shortening of maturities.

The comparative static results of the model suggest that the equilibrium maturity profile also depends on whether these measures are temporary or long-lived. Different assumptions about the duration of rollovers generate different maturity profiles for debt. We find that measures which permanently improve the recovery rate do not necessarily skew the maturity profile towards the shorter term. Similar results obtain if the reorganisation process is a short-lived one that culminates in permanently higher recovery rates in the future. In more intermediate cases the results are ambiguous, however. If a rollover or similar measure is moderately lengthy, creditors are faced with weighing up the relative benefits of staying or pre-empting. In such circumstances, there can even be a tendency for the maturity profile to be 'double peaked' as creditors either opt for very long or very short maturities.

The paper proceeds as follows. Section 2 describes the basic two-period model and shows how the probability of project failure depends on the incidence of short-term debt. Section 3 extends the model to a multi-period framework and characterises the equilibrium capital structure of the debtor. Section 4 discusses some comparative static results and explores the effects of changes in the recovery rate, drawing implications for crisis management. A final section concludes.

2 Two-period model

A project is to be financed by two classes of debt – short term and long term. Short-term debt affords the creditor the opportunity to terminate involvement in the project at an interim date, while long-term debt locks in the creditor until termination of the project. At termination, a creditor receives the promised amount if the project succeeds, but nothing if it fails. Because of the possibility of default, both types of debt trade at a discount to the face value, and the discount for the long-term debt will be larger to reflect the absence of recourse to foreclosure at the interim stage.

There are three dates, *initial*, *interim* and *final* labelled as period 0, 1 and 2 respectively. And there is a continuum of risk-neutral creditors, each endowed with one unit of the consumption good and identical additive utility functions

$$u(c_1, c_2) = c_1 + c_2,$$

where c_t is consumption in period t. Creditors have access to a *storage technology* that preserves their unit endowment of the consumption good for as long as they choose, but does not yield any additional return. This acts as an outside option that allows them to consume the endowment at any time if they do not invest in the project.

By entering into a *long-term loan*, a creditor enters into a contract in which he invests his unit endowment into the project in return for a promise of repayment by the debtor of

$$1 + q \quad \textbf{(1)}$$

units of the consumption good at the final date if the project succeeds. If the project fails, he receives nothing.

By entering into a *short-term loan* at date 0, a creditor has an option to 'wait and see'. At date 1, each creditor is repaid a contracted amount, without any risk of default. At the same time, each creditor observes a signal concerning the prospects of the project, and decides whether to re-lend to the firm or not. If the creditor re-lends, we say that the loan is *rolled over*. If the creditor does not re-lend, we say that the creditor *forecloses*. If the creditor decides to roll over the loan to the final date and the project succeeds, then he receives the amount

$$1 + r \quad \textbf{(2)}$$

for every unit lent. But if the project fails he loses everything. By foreclosing, a creditor receives only the contracted amount for the loan at date 1. We denote this contracted amount as

$$\theta(1 + r) \quad \textbf{(3)}$$

where $0 < \theta < 1$. So for the short-term creditor, the notional forward rate from date 0 to date 1 is given by $\theta(1 + r)$, while the notional forward rate from date 1 to date 2 is given by $1/\theta$. While the creditor faces no risk of default between date 0 and date 1, he does face such risk between date 1 and date 2.

At date 1, there must be enough working capital in order for the project to proceed to the final period. If the capital in place from long-term debt or from any equity is insufficient to meet this amount, there is a *funding gap*. If such a gap exists, then it must be filled by short-term creditors who roll over their loans to the final period. Denote by F the funding gap, by z the amount of short-term debt coming due in period 1, and by ℓ the proportion of short-term creditor who foreclose at date 1. Then the project proceeds to date 2 if, and only if,

$$F \leq (1 - \ell)\, z \quad \textbf{(4)}$$

In other words, the amount of short-term debt that is rolled over, given by $(1 - \ell)\, z$, is enough to plug the funding gap. If this inequality is not satisfied, then the project fails.

The funding gap F can be thought of as the underlying fundamentals of the project. If F were negative, then the project would succeed irrespective of the actions of the short-term creditors.

Define

$$y \equiv z - F$$

So **(4)** holds if and only if $z\ell \leq y$. In other words, y represents the underlying strength of the project. If y is high, the project succeeds with only a small amount of additional rollover of short-term debt. But if y is small, then a large number of short-term creditors must roll over in order for the project to succeed. We suppose that y is a random variable, distributed uniformly over the unit interval [0, 1], which is to say that the funding gap is distributed uniformly on the interval $[z - 1, z]$.

At the interim date, all creditors have access to imperfect information concerning the realisation of y. Creditor i observes the realisation of the signal

$$x_i = y + s_i \qquad \textbf{(5)}$$

where the noise terms $\{s_i\}$ are i.i.d., and have uniform density over the interval $[-\varepsilon, \varepsilon]$, where ε is a small positive constant. Although all investors receive a signal, only short-term creditors can utilise the information, as it is only they who have a choice at the interim date.

2.1 The probability of project failure

Following Morris and Shin (1998) we solve for an equilibrium in terms of 'switching strategies' – ie strategies where a creditor has a critical realisation of the signal, x^*, below which he will foreclose and above which he will roll over.(2) This, in turn, implies that there is a critical value of the state y^* above which the project succeeds. We solve for the critical signal x^* and the critical state y^* simultaneously.

If the short-term loan is rolled over, the payoff at the final date depends on the state y and is given by

$$\begin{cases} 1 + r & \text{if} \quad z\ell\left(y\right) \leq y^* \\ 0 & \text{if} \quad z\ell\left(y\right) > y^* \end{cases} \qquad \textbf{(6)}$$

The critical level of cashflows, y^*, is defined as the state y at which $y^* = z\ell\left(y^*\right)$. If short-term creditors switch at the point x^*, the incidence of foreclosure is given by the mass of short-term

(2) A *strategy* for a short-term investor i is a rule of action that maps each realisation of his signal x_i to an action - rollover or foreclosure.

creditors whose signal x_i lies to the left of the critical value x^*. Since $\{x_i\}$ are i.i.d. conditional on y and uniformly distributed over $\left[y-\varepsilon, y+\varepsilon\right]$, we have

$$\ell(y) = \frac{x^* - (y-\varepsilon)}{2\varepsilon}$$

So at the critical state y^*,

$$\frac{y^*}{z} = \frac{x^* - (y^* - \varepsilon)}{2\varepsilon} \tag{7}$$

This gives us one equation in two unknowns, y^* and x^*. A second equation in these two unknowns can be obtained by noting that short-term creditors maximise their expected payoffs, given the strategies of the other lenders. Conditional on signal x, the state y is distributed uniformly over the interval $[x-\varepsilon, x+\varepsilon]$. So the expected payoff from rolling over, conditional on signal x is

$$0 \cdot \frac{y^* - (x-\varepsilon)}{2\varepsilon} + (1+r) \cdot \frac{x+\varepsilon-y^*}{2\varepsilon}$$

while the payoff to foreclosure is non-random and given by $\theta(1+r)$. At the switching point, x^*, the short-term creditor is indifferent between rolling over and foreclosing. Hence at x^*,

$$(1+r) \cdot \frac{x^* + \varepsilon - y^*}{2\varepsilon} = \theta(1+r)$$

or

$$x^* - y^* = \varepsilon(2\theta - 1) \tag{8}$$

From equations **(7)** and **(8)** we have

$$y^* = \theta z \tag{9}$$

In other words, the critical value of fundamentals at which the project succeeds or fails is proportional to the amount of short-term debt, z. The switching point x^* can also be solved in terms of the fundamentals using **(8)**.

There are two notable features to this solution. First, since y is distributed uniformly over the unit interval, the probability that the project fails is given by $y^* = \theta z$. The probability of project failure increases linearly in the proportion of investors z who choose to become short-term lenders. The increased probability of failure as z increases reflects the greater degree of fragility of the project to early liquidation. Second, as can be seen from **(9)**, the critical state y^* does not depend on the size of the noise term, ε. In the limiting case where creditors are perfectly informed of the true state, ie $\varepsilon \to 0$, the switching point x^* coincides exactly with the critical state y^*(see **(8)**). So with negligible noise, the short-term creditor's equilibrium payoff can be written as a function of y alone.

Confining attention to the limiting case where $\varepsilon \to 0$, the project succeeds if and only if y is larger than the critical state y^*. In these circumstances, the payoff is $1 + r$. If the state y falls short of y^*, the creditor will have chosen to foreclose and collect the payoff $\theta\,(1 + r)$. Since y has a uniform distribution over the unit interval [0, 1], the *ex ante* expected payoff in equilibrium of the short-term creditor is

$$\theta\,(1 + r) \cdot y^* + (1 + r) \cdot (1 - y^*)$$

Since $y^* = z\theta$ this can be written as

$$\theta^2 z\,(1 + r) + (1 - z\theta)\,(1 + r) \qquad \textbf{(10)}$$

At date 0, the expected payoff from the short-term loan can be no higher or lower than the expected payoff from the long-term loan. The long-term creditors receive $1 + q$ if the project succeeds. Since the probability of success is $1 - \theta z$, the expected payoff of the long-term creditors is

$$(1 - \theta z)\,(1 + q) \qquad \textbf{(11)}$$

At the *ex ante* stage, short and long-term debt must have the same expected payoff which, in turn, must be equal to the return on the storage technology (which is 1). Hence,

$$\begin{cases} \theta^2 z\,(1 + r) + (1 - z\theta)\,(1 + r) = 1 & \text{(short-term)} \\ (1 - \theta z)\,(1 + q) = 1 & \text{(long-term)} \end{cases} \qquad \textbf{(12)}$$

These equations define a relationship between the incidence of short-term debt z, and short and long interest rates, r and q. The short-term rate is given by

$$r = \frac{\theta z\,(1 - \theta)}{1 - \theta z\,(1 - \theta)} \qquad \textbf{(13)}$$

while the long-term rate is

$$q = \frac{\theta z}{1 - \theta z} \tag{14}$$

The slope of the notional yield curve (as measured by the ratio $\frac{1+q}{1+r}$) is

$$\frac{1+q}{1+r} = 1 + \frac{\theta^2 z}{1 - \theta z} \tag{15}$$

Both short and long-term interest rates are increasing in the incidence of short-term debt, z. The slope of the yield curve is also increasing in z. This is because as z increases, the probability of default rises, implying that debtholders of both categories must be compensated for the expected loss. And as the default probability rises, the advantage of short-term debt over long-term debt becomes more pronounced since, in the event of a bad outcome, the short-term debtholders can exercise their option not to roll over the loan. The value of this option is increasing in the incidence of short-term claimholders.

3 A multi-period model

In the two-period model sketched above, the incidence of short-term debt has a direct and very simple relationship to the probability of failure. The probability that the project will proceed to the next period is a linear function of the amount of short-term debt coming due. This result rests on the assumption that only the short-term claimholders are active decision-makers, while holders of long-term claims are passive. Although this is clearly a caricature of reality, the greater influence of short-term creditors in forcing the hand of the borrower, and in influencing the direction of the outcome, seems uncontroversial.

We examine a multi-period analogue of the two-period model, maintaining the assumption that the survival of the project to the next period is determined by the shortest maturity lenders. The payoff structure of the game departs from the two-period model in certain respects, but the focus remains on determining the capital structure of the project equilibrium – that is, in characterising the maturity profile of debt, and in determining the debt to equity ratio.

Investors can choose to be equityholders or lend to the entrepreneur of a risky project. 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, we suppose that 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.

The assumption that the notional forward rate is constant is rather strong, but it is a convenient way to tie down the pricing relationship in order to focus on the determination of the failure rate (hazard rate) in our model. In conventional pricing models of debt (eg Duffie and Singleton (1999)), 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. In our model, 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.

3.1 Creditor payoffs

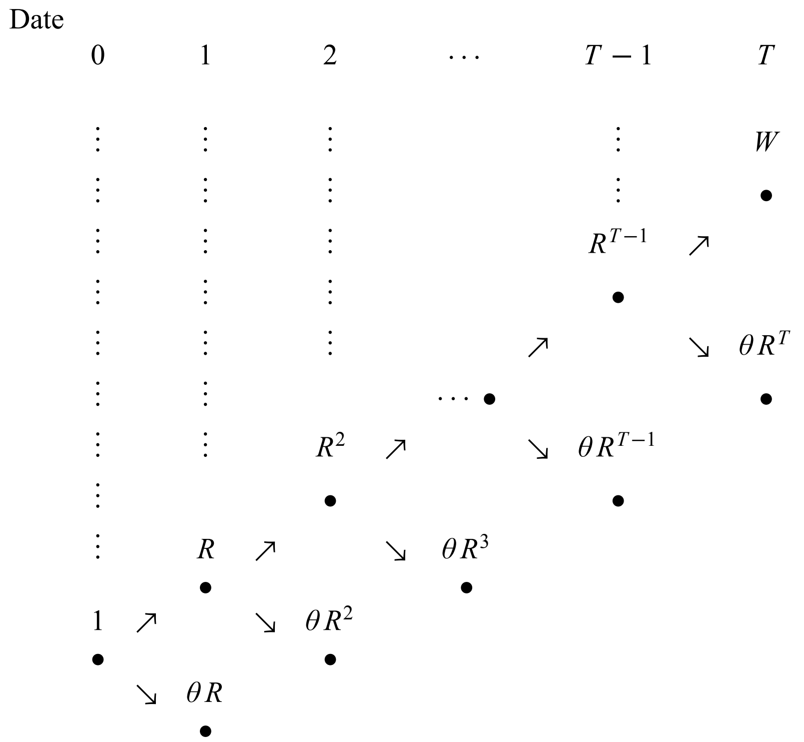
The key feature that drove the results in the two-period model was the fact that the probability of failure was increasing in the incidence of short-term debt. Indeed, in our simple setting, the probability of failure was *proportional* to the incidence of short-term debt, reflecting the fragility of the project to the creditor runs of the shortest maturity lenders. In what follows, we take it as an assumption that 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:

$$\gamma(t) \equiv \frac{p(t)}{p(T+1)+\sum_{s=t}^{T} p(s)} \qquad \textbf{(16)}$$

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.

Our most significant departure from the two-period model is the fact that the value of the project

Table A: The value of the project



increases over time. Thus, 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 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

$$W - R^T \tag{17}$$

and all debtholders are paid in full. Table A illustrates the evolution of the value of the project.

The payoffs of all 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
	1	θR	R	R	R	R	$\cdots$	R	R
		θR	θR^2	R^2	R^2	R^2	$\cdots$	R^2	R^2
Debt	3	θR	θR^2	θR^3	R^3	R^3	$\cdots$	R^3	R^3
maturing	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	R^T
Equity		0	0	0	0	0	$\cdots$	0	$W - R^T$

The action set of the individual can be denoted by $\{1, 2, \cdots, T, T+1\}$, 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

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

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

$$\begin{aligned} &[1-p(1)]\left[1-\frac{p(2)}{\sum_{s=2}^{T+1} p(s)}\right] \ldots \left[1-\frac{p(t-1)}{\sum_{s=t-1}^{T+1} p(s)}\right] \frac{p(t)}{\sum_{s=t}^{T+1} p(s)} \\ &= \sum_{s=2}^{T+1} p(s) \cdot \frac{\sum_{s=3}^{T+1} p(s)}{\sum_{s=2}^{T+1} p(s)} \cdots \frac{\sum_{s=t}^{T+1} p(s)}{\sum_{s=t-1}^{T+1} p(s)} \cdot \frac{p(t)}{\sum_{s=t}^{T+1} p(s)} = p(t) \end{aligned} \tag{18}$$

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

$$V(T+1) = p(T+1) \cdot (W - R^T) \tag{19}$$

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

$$V(t) = \sum_{s=1}^{t} p(s) R^{s-2} + R^t \sum_{s=t+1}^{T+1} p(s) \tag{20}$$

3.2 The equilibrium capital structure

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. To find the incidence of the different types of claims, we seek the fixed point of the mapping from capital structure to payoffs to capital structure.

Our focus is on the equilibrium capital structure that equalises the expected payoff to each type of claimholder, and in which all types of claims are used in equilibrium.(3) This involves finding the capital structure for which

$$V(1) = V(2) = \cdots = V(T) = V(T+1) \tag{21}$$

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

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

(3) 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.

The expected payoff to the claimholder of maturity t is given by the t-th 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

$$p = M^{-1}k \qquad \textbf{(22)}$$

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

4 Comparative static results

We now explore the effects of changes in the recovery rate for the equilibrium debt maturity profile. As the general solution to **(22)** is rather cumbersome and uninformative, we highlight our findings with specific numerical examples. Changes in the recovery rate are particularly relevant to the debate on the role of crisis management measures.

4.1 Increasing the recovery rate

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 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 **(22)**. 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, ie,

$$V(T+1) = p(T+1)(W - R^T) = f(\theta) \quad \textbf{(23)}$$

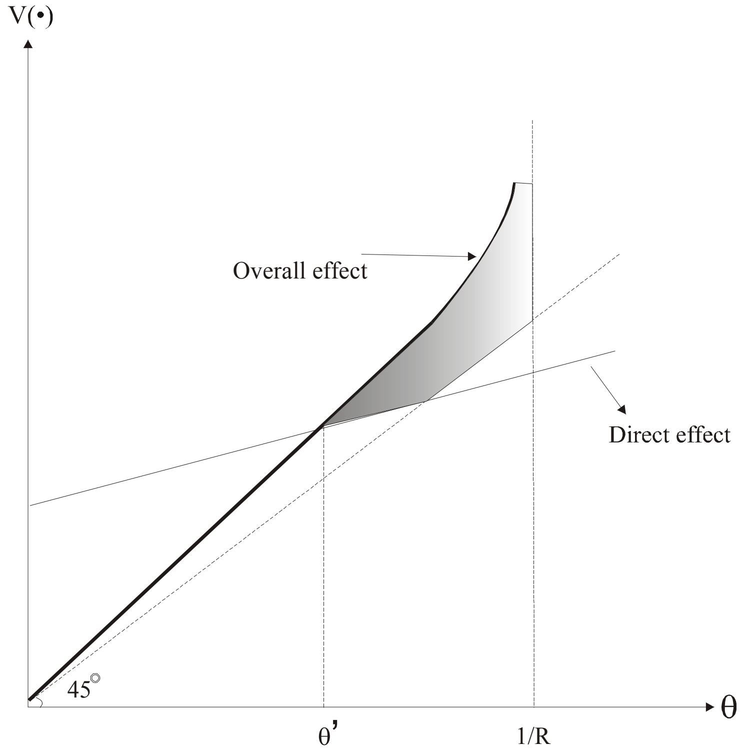
Chart 1 shows how the equilibrium expected payoff varies with the recovery rate for the assumed numerical values. As can be seen, the expected equilibrium payoff is increasing in θ and lies above the 45 degree line in the relevant range, $0 < \theta < \frac{1}{R}$. In other words, marginal improvements 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 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. Chart 1 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.

4.2 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. These might include concerted rollovers, stays on creditor litigation, and orderly debt workouts. An in-depth analysis of the factors that influence the recovery rate from the debtor-side is beyond the scope of this paper. The improved recovery process for claimholders could, for instance, reflect greater adjustment effort on the part of the debtor following third-party intervention. In the international context, the ability of the official sector to facilitate this (eg through well-focused IMF programmes) is a matter of some debate. For

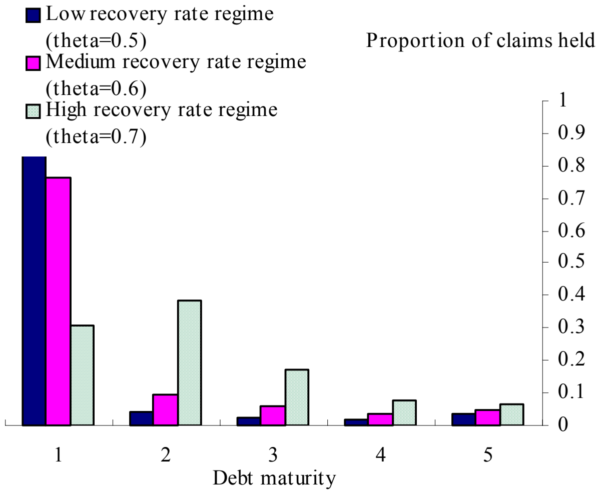
Chart 1: Equilibrium expected payoff



instance, Gai *et al* (2001) argue that official sector intervention to facilitate debt workouts may improve the expected output of the debtor and, hence, the recovery rate, whereas others (eg Dooley (2000)) are more sceptical.

The model outlined above is, nevertheless, flexible enough to accomodate both views. 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 case, 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.

Chart 2: Recovery rate regimes and the maturity profile



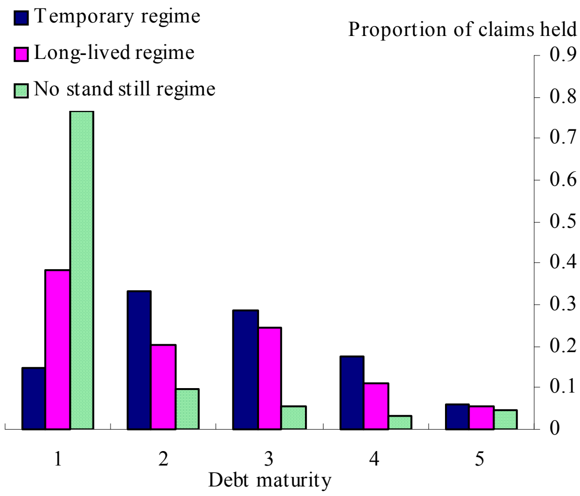
Case 1 (permanent changes in the recovery rate)

Chart 2 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 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:

Chart 3: Crisis management measures and debt maturity



Project failure date

		1	2	3	4	5
	1	θR	R	R	R	R
Asset	2	ϕR	θR^2	R^2	R^2	R^2
maturing	3	ϕR	ϕR^2	θR^3	R^3	R^3
date	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 Chart 3. 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 $\phi = 0.7$. So 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 Chart 3 shows the proportion of debt held is evenly spread across the different maturities. This suggests that 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 the 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	θR^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 effects of such a long-lived workout on the equilibrium maturity profile is also shown in Chart 3. 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. This choice will depend on the relative benefit from pre-empting or staying put, ie 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 become part of the financial architecture and 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. Debt profiles can come in many different shapes.

It should be stressed that our 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.

	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

5 Concluding remarks

This paper offers a framework with which to explore the effects of crisis management measures on the maturity structure of debt. In so doing, it accords an explicit role to pre-emptive creditor behaviour. Although creditors who prefer longer maturity debt can do better if the project progresses to an advanced stage, the fact that the project may fail before the debt matures provides creditors with the incentive to choose a slightly shorter maturity – given the maturity choice of others. Some commentators have suggested that the tendency for creditors to behave in this manner renders crisis management instruments that target short-term debt counter-productive. Citing the experience of Brazil in 1998, they argue that short-term debt rollovers are likely to result in an ever shortening of maturities as creditors 'rush for the exits'.

We show, however, that such logic is not necessarily general. Even allowing for the pre-emptive nature of creditor behaviour, crisis management measures can lead to lengthier debt maturities. This is because instruments that help improve the recovery rate for bondholders can lower the incentives for pre-emption, as well as increasing the payoff to the claimholder in the event of a default. The ultimate implications for the debt maturity profile are likely to depend on whether the measures are perceived to be temporary or long-lived, and on the effectiveness of the recovery process.

We have focused on the implications for the debt maturity profile under conditions where the notional yield is held fixed. This stands in contrast to reduced form credit models that explore the pricing of risky debt. As such, our model is partial equilibrium in nature. Developing a richer model that examines the effects of pre-emptive behaviour on both prices and maturities is an important area for future research.

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