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Recurrent financial crisis in LDCs

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RECURRENT FINANCIAL CRISIS IN LDCs

by

ANDRES ZAMUDIO

A THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE
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ABSTRACT

When estimating probabilities of repayment problems in Less Developed Countries (LDCs), the standard approach has been the application of logit models. Since there are few cases of LDCs, panel data has been used to increase the number of observations. The problem with this method is that when there exists state dependence the observations are not independent. In this case the logit models have to be adapted to deal with serial correlation and, possibly, with heterogeneity.

Serial correlation is present because when a rescheduling occurs creditors will probably restrict credit in the future to the country having repayment difficulties. If the borrowing country has been using new loans to service the old debt the restriction of credit will probably create financial difficulties. Heterogeneity is a problem because different country-specific or time-specific covariates are unobserved.
In this dissertation we use duration models to estimate probabilities of repayment problems, in particular probabilities of rescheduling. We consider a rescheduling as exit from the state of financial "health". Since a country can face more than one rescheduling, we have the case of multiple-spells multiple-states models. When using duration models to estimate probabilities of rescheduling we take into account the past. In this case, to estimate the probability of repayment problems at some particular period of time, we need to know the number of previous repayments problems and the number of periods the borrowing country has been "healthy".

The importance of indentifying state dependence is that we can differentiate the first rescheduling from recurrent reschedulings. This differentiation helps to characterize the current debt crisis, when most of the debtor countries have been facing debt restructuring for the second or third time, and where there is a general withdrawal of creditors from the financial market for LDCs. In this case the probability of occurrence of financial problems will be different because these problems are recurrent. Economic policy has to differentiate simple from recurrent financial problems because they behave in a different way.
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Finally, I dedicate this work to my parents.
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CHAPTER I

INTRODUCTION

Since the so called "debt-crisis" of 1982 many less developed countries (LDCs) have faced an increasing number of debt problems. These debt problems usually consist of rescheduling\(^1\) or restructuring of debt, but also can include arrears in interest or principal, different kinds of debt relief or higher-tranche IMF arrangement. Prior to 1982 there were cases of countries having to reschedule their foreign debt (in 1980 and 1981 the number of countries having to restructure the debt were very high). However, since 1982 the debt problem has taken on the look of a debt crisis, not just a series of temporary financial setbacks.

In this dissertation we are interested in the foreign debt, the debt contracted by developing countries with foreign creditors. By debt problems we mean repayment difficulties that are associated with the foreign debt. This is not to suggest that the internal debt (the debt that the public sector has with the private sector of the same country) is not important, but that its study is not covered here. By the same token although we focus on the debt problem of LDCs, this does not suggest that developed countries (DCs) have no debt problems. For example, the U. S. A. is a heavy borrower.

Repayment problems can be the result of diverse factors. For example, they can be caused by shocks that affect the capacity of payment of the borrowing country in the short run (like a drop in prices of exports, sudden capital flights, etc). They can also be the

\(^1\) We are going to use R to denote rescheduling.
result of internal political difficulties. In this case the borrowing country might not be willing to service the debt because this could create internal political problems. Repayment problems can also be simply the consequence of the accumulation of diverse factors over time, for example the accumulation of debt. Its level can reach a point that makes debt servicing very difficult. These problems also can be caused by the withdrawal of creditors from the capital market for LDC which could cause repayment difficulties when the borrowing countries have been using foreign debt to service old debt. For example when there is a constant need to roll-over the short term debt because it has been used to finance long term projects, which don't mature until after several periods of time.

One fact that appears clear is that countries with financial difficulties will experience debt problems again with high probability. This could mean that the usual remedy to cure debt problems, for example restructuring of debt or some kinds of debt reliefs, only work in the short run, and are thus only temporary remedies. The reason for this could be that the structural problems of the LDCs that gave rise to the financial difficulties, are not changed by debt relief or repayment restructuring. For example, it can be the case that the amount of debt is so high that the borrowing countries have reached a point that makes them unable to service the debt (insolvency?). In this case repayment problems will probably occur again, and it is likely that a radical approach to the debt problem will be the only solution. Another reason could be that once a country has financial problems and must reschedule the foreign debt, the facility to get new money will drop. In this case the country will have to service the debt out of the surplus on current account, something that is not easy to do in the short run, especially when the LDC has been experiencing deficits in the current account over several years.
In this dissertation an optimal borrowing model for a typical LDC is presented. We show through the use of a stylized model how reschedulings (Rs) can result from economic agents making rational decisions, and how the realization of a R in the present will increase the probability of R in the future. Rs are considered to be the result of a disequilibrium between supply and demand for loans. Borrowing countries demand loans to either finance current expenditure or service the old debt. The reason why loans are used to service old debt is that borrowing countries use short term debt (the only type of debt instrument available in the model) to finance long term projects. In this case the project is accumulation of capital (there is an incentive to accumulate capital because of the differential in the productivities of capital in DCs and LDCs). Thus, because the maturity of the project is longer than the maturity of the debt, there is need to constantly roll-over the short term debt. We assume that when the LDC is not able to get the financial resources needed to roll-over the debt, financial problems, or R, result.

Using the results of the optimal borrowing model and previous studies on probabilities of repayment problems, we select the exogenous variables to be included in the estimation of probabilities of Rs. Identification of the variables causing Rs is important for economic policy.

Repayment problems imply dynamics. The reason is that probabilities of R today will not be independent of past realizations of R. In this case one needs to take account of the past when estimating these probabilities. For example, it is important to know how long the borrowing country has gone without repayment problems, or how many Rs the LDC has faced recently. For this reason the application of logit models to panel data is not straightforward, due to the existence of serial correlation.
Probabilities of Rs are estimated using duration models. The reason for using duration models is very simple. R occur after the borrowing country has experienced a spell of some length of no-R (financial "health"). Thus R represents the exit from that state. Rs are not independent of previous realizations of R and for this reason its estimation requires the estimation of the spell of no-R and the exit from that state\(^1\). Duration models estimate probabilities of exit from some state given permanence of some length in that state. Since R can happen more than once we are interested in investigating the determinants of the recurrence of Rs: after one financial problem has happened, for how long is the country going to be out of difficulties? Since Rs can occur more than once we have the case of multiple-spells models, not the common case of single spell, since it is necessary to estimate the occurrence of the first, second, etc. R.

To estimate probabilities of R we use continuous time survivor (duration or failure time) models. We use continuous time models, instead of the discrete version, because continuous time models are independent of the time unit used, and, because they can deal more easily with the problems of state dependence and heterogeneity. To estimate the parameters of the hazard function, that is the main point of duration models, we use the package CTM\(^2\) (Continuous Time Models), which contains an efficient algorithm to deal with multiple-spells and multiple-states models. It can also take account of heterogeneity and allows for time dependent covariates.

The structure of this dissertation is as follows. In chapter two a discussion of the development of the debt problem and the loans market (loans for third world countries) is presented. In this chapter

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\(^1\) It is not possible to estimate probabilities of R considering each year-country as one observation, as has been done when applying logit models to panel data. The basic reason is that the observations, in this case, are not independent.

we discuss how the increasing participation of private banks in lending to LDCs have created some kind of instability. It created easy borrowing by LDCs. The private loans are not tied to some specific project; unlike the official ones, they are all purposes loans. It created another source of instability because the future supply of private loans is more insecure that the official one, and if borrowing countries depend heavily on private loans they are vulnerable to cuts in the supply. It is mentioned that the debt build-up can be explained, at least for most of the Latin-American countries, by the coincidence of bad economic shocks (like the oil shock of 1973, or the recession in DCs) and easy lending by private banks. Finally it is mentioned that the debt crisis of 1982 was precipitated by the withdrawal of the creditors from the financial market once they felt that their LDC portfolio was unsound. In this chapter it is also indicated that the main form of repayment problem is rescheduling. It is also considered to be the most severe form because repudiation of debt is not considered in this paper; we assume, in contrast with studies of repudiation risk, that LDCs will always try to service the debt when it is possible.

In the third chapter an optimal borrowing model is presented. It shows how Rs can be the outcome of optimal decisions by the borrowers. We show that R will occur when a LDC needs to roll-over the short term debt, because it is financing a long term project (the build-up of capital) with short term loans, and is unable to find the resources to do it. The conclusion of this chapter is that R is not only caused by financial or economic shocks or by overborrowing, they can also be caused by cut-offs of credits. We also discuss that Rs can be correlated over time, the reason being that creditors might restrict credits in the future when a R occurs, but if credits are restricted then the probability of R increases.

In chapter four a discussion of the data used is presented. We explain how the data was collected. In this chapter some descriptive
statistics are included, and some preliminaries statistics (the Kaplan-Meier statistics) are computed.

In chapter five a discussion of the method used is presented. We explain the duration models and how they can be used to estimate probabilities of $R$. The chapter also includes a brief review of the literature.

In chapter six, the results of the estimation are presented. Results are included for four different specifications of the hazard function. We also carry out some simulations for selected countries. These simulations consist in calculating per-period hazard and survivor functions for the countries selected under four different scenarios. The hazard function indicates the probability of rescheduling at some particular point in time. The survivor indicates the probability of no rescheduling until the period of time considered.

Chapter seven concludes.
CHAPTER II

THE DEBT PROBLEM

1. The capital market for LDCs.

The financial instruments available in the international capital market for Less Developed Countries (LDCs) are varied. There are bonds, official lending (loans offered by international institutions like the World Bank), short and medium term private bank loans and different kinds of special loans (like government to government loans, or loans offered by some special agencies). Currently the most important type of financial instrument is the private bank loan. However the relative importance of this instrument has been changing. In the past bonds and official lending were more important. Starting in the 1960s private bank loans took over and became the most important financial instrument to finance LDCs. After the "debt crisis" of 1982 this instrument entered a period of crisis, and now it seems that the importance of official lending is increasing.

In the past the most common, and almost unique, instrument available to finance LDCs governments was the bond. It is strange if we compare what is happening today when very few LDCs have been able to place bonds in the international capital market. Bonds suffered as a result of the recession of the 1930s and the suspension of payments this produced on LDCs. As a result of this financial crisis most of the bondholders took losses in the value of their bonds and private participation in loans to LDCs governments was negligible for several years¹.

¹ See for example Lindert and Morton (1988) and Eichengreen (1988).
After the Second World War, and especially after the reorganization of the international trade, monetary and financial system, a new era in financial assistance to LDCs began. For some period of time (1950-1970), "official" lending became more important than private lending. Private sources increased their importance in the 1970s and 1980s.

As a result of World War II an international institution, the International Bank for Reconstruction and Development was created. It was designed to finance the reconstruction of Europe. By the early 1950s, when European recovery was well under way, this bank (now the World Bank) started to lend to the LDCs in projects directed at the development of these countries. To this institution we have to add different regional agencies, like the Interamerican Bank (IAB), the AID, or simply governments of DCs, who were also active in lending to developing countries. The credit given by these institutions, usually referred to as official credit, was basically project specific (sometimes the credits were given for political reasons, this was specially the case of the AID or the government to government loans). It was not an all-purpose credit (like the current medium term private loans), it was a credit directed to the development of some specific plan, like roads, electrification, drinking water, etc.

Official lending is quite different from modern medium term private bank loans. First, the loans are directed only to specific projects. For this reason, if a country wants to apply for this type of loan, it has to present a detailed description of the project to be developed, the estimated future revenues, how it is going to pay back, etc. This contrasts with the medium term private loans of the 1970s and 1980s that were basically all-purposes loans. Second, the loans are usually for very long terms. This was different from the type of loans offered by the private banks during that period, which
were for very short terms, basically supplier's credit. Third, the interest rate was usually lower than the market interest rate, so it was a concessional loan. Fourth, the loans were given to countries for whom access to the private credit market was restricted. This was not the case in the 1950s and 1960s when almost any LDC had access to official credit, possibly because the private banks were not yet heavily involved in lending abroad. The situation changed in the 1970s when private banks decided to increase their participation in lending to LDCs. Once private credit was available, the official institutions restricted access to their credit lines to more developed LDCs. So, in the 1970s and part of the 1980s official lending was mainly directed to very poor countries, those for whom access to the private capital market was difficult.1

As we said, private bank participation in lending to LDCs was quite modest in the 1950s and early 1960s. This participation consisted mainly in supplier's credit. This participation increased substantially in the late 1960s and early 1970s. Not only did the amount of lending increase, but the composition of the loans changed as well. The new element was the introduction of medium term private loans, which were made possible by a financial "innovation", the "floating" interest rate applied to these loans.2

The new participation of private banks created, as can be expected since the loans are not in concessional terms, more expensive money for LDCs, a shorter maturity in the loans, but, at the same time, easier access, at least for some countries (the more developed LDCs), to credit lines. Easier loans because the private bank loans are not tied to some specific project and could be used to

1 Since private loans were given to countries considered as creditworthy, which depend on the economic prospects of the country, credit to very poor countries was difficult to obtain.
2 See for example Lindert and Morton (1989) for a discussion on how a financial "innovation" in the 1920s allowed heavy lending to LDCs.
finance an investment project or simply to finance consumption. A necessary condition was that the lender considered the borrowing country creditworthy, which depended on the banks own opinion of the economic prospects of the LDC. As we will see, the participation of private banks created easy borrowing for countries with access to this market. The easy borrowing created one source of instability, weak financial discipline by governments of LDCs since it was now possible to borrow money to finance permanent deficits. The participation of private banks also created another source of instability, a random supply of credit in the future.

Financial discipline on some LDCs was weak because it was possible to get money for different purposes. For consumption (for example to finance the public deficit, as was the case of Mexico in the 1970s an early 1980s), for investment, or even to implement unrealistic economic policies (like keeping a fixed exchange rate when the currency is overvalued). This is very important because when a LDC faces economic problems, the normal solution would be to adjust to the new situation, which could imply restrictive economic policies. However, when easy borrowing is available, it is tempting to borrow, postpone the adjustment to the future, and avoid the restrictive policies that could be politically painful. This was the case in several LDCs following the oil "shock" of 1973 and the subsequent economic depression in DCs. During this period several countries faced higher prices of oil and, at the same time, a restricted market for their exports. The solution was not to reduce expenditure and allow for market adjustment\(^1\), but to borrow and avoid political problems.

The second source of instability is related to the possible cutoff of loans in the future. This is the case because private banks are

\(^1\) When a country faces shocks such as this, problems may be only temporary. In this case borrowing would be the optimal decision. But if the problems are permanent, however, adjustment would be the right policy.
hypersensitive with respect to their loans, so at the first sign of problems they could withdraw from the market (lending to LDCs), creating, by this action, financial problems for LDCs. The result of the easy borrowing was that LDCs were more dependent on loans to service the old debt, therefore they were more vulnerable to external shocks.

The massive participation of private banks in lending to LDCs has been explained by the development of the Eurobanks or offshore banks. Given the fast development of these banks in the late 1960s and in the 1970s, an increasing amount of money was available for lending. However, since these banks were not regulated as much as the banks in their own countries, they were able to offer cheaper money. To this we have to add, as we mentioned before, the addition of a new financial instrument, medium term loans (which were made possible by the application of the "floating" interest rate), and the introduction, somewhat later, of syndicated loans.

But just the availability of resources doesn't explain by itself the huge borrowing of LDCs in the 1970s. To the supply of credit we must add demand. The demand for capital from LDCs was more or less stable (growing smoothly) in the 1950s and 1960s, but a shift occurred at the oil crisis of 1973. When this crisis came some LDCs experienced very large deficits in their current account, although the increased oil prices were not the only cause; exports of these countries fell too. But the LDCs, or most of them did not adjust to the new situation. Instead they continued with the same expansionary policies and to finance the deficits they decided to use the money offered by the Eurobanks. The combination of easy money and

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1 See McFadden et al (1985).
2 They were vulnerable to increases in the interest rate, when the loans were written under the "floating interest rate" terms. And they were vulnerable to supply cut-offs.
governments willing to borrow was one of the causes of increased participation of private banks in the 1970s.

For the banks, lending to the LDCs was a good alternative at that time, because the LDCs were willing to pay a premium on the loans and because it appeared that business with the LDCs would remain profitable since the rate of growth of their economies was almost double the rate of growth of the DCs\(^1\).

It is important at this point to identify the kind of loans private banks, and specially off-shore banks, offered in the past. The primary difference from private loans in the 1960s is that they were primarily medium term and not short term as had been their custom (for example supplier's credits). This change has been explained by the emergence of floating interest rates and the creation of syndicated loans. Floating interest rates mean that the interest rate applied to some medium term loan is defined as the market interest rate, usually the LIBOR\(^2\) or the prime rate, plus some fixed spread (and several fees). Since the first varies constantly, the cost of the loan could vary constantly. In order to avoid capital losses to the bank, given that the bank is borrowing short and lending long, adjustment in the interest rate was needed. This adjustment was usually done every six months (based primarily on the six-months LIBOR). With floating interest rates the risk of a change in the interest rate is transferred from the lender to the borrower. This allowed the Eurobanks to make a transformation of maturity, i.e. allow then to borrow short and lend medium or long.

"Floating interest rates did not arise by chance, but as a mechanism that was required for the Euromarket, that huge network of banks, situated outside the U.S.A., that held

\(^{1}\) See Morgan (1984).
\(^{2}\) London Interbank Offered Rate.
growing dollar deposits as a result of the postwar growth in trade. By passing on to the borrower the cost of any increase in the interest rate, floating interest rates allowed the banks to break one of the sacred rules of banking and make long term loans with the backing of short term deposits"1.

Syndicated loans are those financed by the participation of several banks. In this syndicate there is leader, who is usually a large bank that receives a commission for its role as syndicate leader.

"The 'price' of a syndicated medium-term Euro-credit comprises several elements: the floating interest rate, LIBOR, the spread, and a range of fees. Loans, for example, usually carry a commitment fee payable on undrawn funds, a front-end fee payable to lead and co-managers of the loan, and participation fees. In addition, the effective cost of the loan may also vary with its maturity, with a longer maturity, at a given level of spreads, indicating easier borrowing conditions"2.

Syndicated loans created a source of instability because small and medium banks participated in the loans with little consideration of the soundness of the loan. Rather it was done because a large bank, with better information and more experience in international lending, was leading the syndicate.

Participation in loans was carried out, in the early seventies, by large banks. Later they were followed by medium and small banks a situation that was facilitated by the creation of the syndicated

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1 Brandford and Kucinski (1988).
2 Johnston (1982).
loans. Although the participation of medium and small banks was modest at the beginning, they increased their exposure in the late 1970s and early 1980s. Participation of the small and medium banks created a transformation in the average maturity of the LDC debt, because they participated basically in short term loans which were used by the LCDs when the terms of the medium or long term loans became hard, which occurred in the 1980s. This preference of small banks for short term debt can be explained by the fact that they did not have the same information or the experience that large banks had, so they used short term loans because it was much easier to withdraw from the lending market when problems occurred\(^1\).

In the seventies two factors coincided, the economic problems in the World (the recession in the DCs and the oil shock) and the easy lending practices from the private banks. The result was that some LDCs, specially the Latin-Americans, instead of following restrictive economic policies to face the increase in oil prices and later (1974) the increase in price of the DCs products and the decrease in their exports, decided to borrow from the financial market and postpone the necessary austerity policies. The problem with this was that if a country borrowed today it had to repay tomorrow, and thus it had to generate enough savings in the future to be able to repay, suggesting that even tougher austerity policies in the future will be needed. Continuous borrowing to finance permanent deficits in the current account can't go on forever, unless the lenders are willing to keep lending forever and at increasing rates. The collapse of this situation occurred when the DCs governments decided to implement restrictive monetary policies (late 70s early 1980s). The result was an increase in the international interest rate which created an increase in the cost of the loans written on floating interest rates (these types of loans were very important among the more

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\(^1\) For a discussion on the participation of medium and small banks in international lending see Johnson, mimeo.
developed LDCs). Also at that time there was a general concern, among the bankers, about the security of LDC loans, so new loans were restricted. In 1982 the financial crisis came just after the Falklands/Malvinas war. Bankers restricted loans to LDCs, and when the financial problems of Mexico, (an oil rich country) occurred, the bankers almost stopped giving new loans. This general restriction of credit produced immediate financial collapse in several LDCs, since most of these countries were using new loans to service old debt.

Since then the financial market for LDCs has been in a deep crisis. Creditors, in particular the private banks, have been trying to get out of the problem by restricting credit to LDCs (some of them by selling debt titles in the secondary market, at least this has been true for some small banks). In general there exist doubts, among creditors, that they will ever recover the full amount of their loans.

At present, the restriction of credits seems appropriate from the point of view of an individual creditor. But what is good for some particular bank or creditor is not good for creditors as a whole. If they all restrict loans to LDCs the result will be a suspension of payments since the borrowing countries can not, in the short term, run a surplus in the current account large enough to finance debt servicing (interest plus principal payments). In this case, and in order to ensure debt servicing, creditors had to reschedule the old debt, which meant more credits to LDCs, to avoid suspension of payments. This is what some authors have called "forced" loans.

Meanwhile LDCs, in order to service the debt from their own resources and not out of new loans as they had been doing, have tried to generate a surplus in the public budget. This is because most of the debt has been public, which means their governments have been trying to reduce public expenditure and/or increase taxes. The consequence of reducing public expenditure has been a reduction in investment, which means lower growth and less possibilities to pay
in the future, and political and social problems in these countries since the reduction in expenditure means less jobs and/or lower wages for public employees.

Since 1982 the number of multilateral reschedulings has been increasing and it seems that rescheduling, something considered before to be a rare event, has become institutionalized. In this period of "forced" loans and reschedulings (Rs) the amount of new loans made available to borrowing countries has often been just enough to cover debt service due. When the amount of new loans does not cover interest payments and only cover part of the principal due the result is a decrease in the nominal value of the outstanding debt. Figure-1 plots net transfers, from official and private sources, on public and publicly guaranteed debt for the period 1980-1989. Note: net transfers are defined as new loans less interest and principal payments.

Figure-1 shows that official creditors have been active in lending to LDCs, probably to avoid a general suspension of payments, while private creditors have been restricting credit as much as they can (most of the time the new loans are part of the rescheduling agreements). Although net transfers are negative for private sources since 1983, the amount of nominal debt has been increasing given that net flows are still positive (net flows are new loans less interest payments). This is shown in Figure-2.

The different behavior of private versus official creditors has been reflected in the composition of the LDC outstanding debt. Since private sources have been restricting credit their relative importance has been decreasing. This situation is shown in Figure-3, where we plot the public and publicly guaranteed debt.

When the debt crisis started in 1982, the general idea was to make no concessions to borrowing countries. It was thought that the
financial difficulties the LDCs were having were just short run liquidity problems. In this case the remedy was to reschedule the debt without any kind of forgiveness, and was the reason why Mexico and Brazil signed their rescheduling agreements of 1983 under rather hard conditions\(^1\).

Several years after the debt crisis of 1982 a change in the approach to the debt problem occurred. Servicing the debt created a number of economic and political problems for the LDCs and, since the remedy of occasionally rescheduling the debt was not working because rescheduling had become chronic, it was thought that the problems were not just liquidity problems, but more severe, i.e. long run or solvency problems.

As a result of this new viewpoint some private banks created "loan loss reserves". These reserves were intended to be used as a reserve in case of a suspension of a payments. In 1985-86 came the so-called Baker-plan. It consisted of extending more loans to LDCs considered as severely indebted and reschedule their debt under better conditions (for example the rescheduling fee was very low). For some poor African countries part of the debt was forgiven, but what is more important is that it represents the first attempt to reduce the level of the debt.

\(^1\) A rescheduling fee above 2\%. 
Source: The World Bank

The Baker-plan did not consist of an explicit forgiveness of part of the debt of the middle income LDCs, but in allowing LDCs to reduce the burden of the debt. The plan consisted in debt-equity swaps. The idea was to let a private citizen, from one of the LDCs, buy the debt with some discount. This individual could trade, with the government of his country, the debt title for either money, shares, tax exemptions, etc. and in this way the final result was a reduction
Figure-2

Flows on public debt

Source: The World Bank

of the debt\(^1\). It is important to note that, by accepting this debt-equity swap plan private creditors were willing to accept losses on their loans.

This debt-equity swap plan did not work well in practice. The reason was that it created inflationary problems because the governments of LDCs were swapping the debt for local money and because with the swaps there was some possibility of roundtripping.

\(^1\) But it also implies a loss for the creditor, usually a private bank, since the debt was sold with a discount.
In 1989 came the Bradley-plan. This plan represented a more serious attempt in forgiving at least part of the debt. The Bradley-plan is new and is still being developed. This new plan has only been applied to Mexico, Costa Rica and The Philippines. The reason for this small participation can be found in the plan itself. The idea is that only countries taking "serious adjustment programs" can benefit from this plan. The new approach is case-by-case and can only be described when applied to a particular country. For example,
in the case of Mexico it consisted basically in debt exchange. The debt is exchanged for another type of debt with a lower contractual value or interest rate. For creditors to accept this swap the new debt title has to be more secure than the previous one and for this reason the new debt must be backed by some collateral. The collateral is normally supplied, or was supposed to be supplied, by some international institution like the World Bank or the International Monetary Fund.

It would appear that the new approach to the debt problem is to forgive part of the debt, meaning there is a general opinion that LDCs have a solvency not liquidity problem\(^1\). Mechanisms for this forgiveness are still not clear. For example in the case of debt exchange (case of Mexico) some international institution or government of some country must supply the collateral to support the debt exchange, since without the collateral the new debt title will lack credibility among bankers (this lack of enough collateral seems to be the reason why the result of the debt exchange for Mexico was a bit disappointing).

2. Repayment problems.

The debt problems of borrowing countries are not new. There is a long list of countries with debt service difficulties. For example, some states in the U.S.A. had debt problems in the last century, which led to defaults\(^2\). Latin-America is also not new to these kind of problems. In the last century there have been several cases of countries experiencing financial difficulties which led to suspension of payments. For example, we have the case of Mexico, when she

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\(^1\) In this case it does not mean that a borrowing country does not have the resources to service the debt, what it means is that LDCs do not have the possibility to service the debt given the political and social constraints.

suffered the French intervention after suspending payments on her foreign debt in the middle of last century. We also have the cases of massive suspension of payments that followed the recession of 1929-1933. The problems in the 1930s were caused when the foreign markets for LDCs products (basically raw materials) contracted as a consequence of the recession of 1929, and without resources to service the debt several countries, especially the Latin-Americans, had no choice but to suspend payments\(^1\). As a consequence of this debt crisis private lending to LDCs was quite modest for the next 20 or 30 years and participation was almost entirely in short term loans (supplier's credit). The situation was reversed, as we already mentioned, in the 1960s and 1970s.

Debt problems were very rare in the 1950s and 1960s. In the 1970s the number of cases increased, but debt problems were still a rare event\(^2\). It was not until the late 1970s and early 1980s, as a result of the easy lending of the seventies, that debt problems, especially reschedulings (R) became more common. After the debt crisis of 1982 Rs became an institution.

We have been talking in general terms about financial or debt problems but in reality there are a number of different types of repayment problems. That is, there are different ways in which financial problems manifest themselves. Repayment problems can include arrears on interest or capital, rescheduling, IMF negotiations, or simply repudiation of debt.

\(^1\) The "solution" to the debt problems of the 1930s was to help borrowing countries buy back loans since their market value was reflecting a huge discount.

\(^2\) Debt problems were not very important in the 1950s and 1960s because lending was not large. If we compare the debt crisis of the 1930s with the debt crisis of the 1980s we can see that both were preceded by a lending boom.
Probably the most common form of debt problems are arrears. Arrears do not necessarily represent a big financial problem. It can just be a short term liquidity problem. Only when arrears are accumulated over several periods do creditors and debtors opt for a more radical approach to the problem such as rescheduling¹.

IMF negotiations represent a financial problem somewhat more severe than arrears and can be dealt with by adjusting fiscal and monetary policy without need for major changes in the payments schedule.

Rescheduling debt payments (R) is considered a serious problem. The fact that a borrowing country needs to change the schedule of payments implies something about the "soundness" of the loan. Creditors usually charge a rescheduling fee when there is a R. It is also a serious event for borrowing countries since it indicates a low creditworthiness, which in turn means more restricted access to loans in the future. Moreover, the borrowing country has to pay a rescheduling fee. When the debt crisis broke in 1982-3, all the reschedulings were done in such a way that no reductions in the debt were made. In fact the debt increased as a consequence of large rescheduling fees. This approach was modified over time until, as at present, almost no fees are charged for each R.

Another course of action is repudiation of the debt. Repudiation of the debt has not been very common. Recently we have only the cases of Cuba and North Korea who repudiated their debt, but this repudiation had much more to do with political than economical problems. However, the possibility still exists that some country will use this option.

¹ McFadden et al (1985) found that arrears are a good one year predictor of rescheduling.
The first two types of financial problems usually represent the first symptom of the disease. Most of the time they precede a more severe form of problem, rescheduling. Rs result when arrears are accumulated over different periods, so that a new schedule of payments is needed, or when the economic policy adjustment usually implied in IMF negotiations does not go far enough to meet the current schedule of payments. R does not necessarily mean that the present value of the debt will be lower. In reality the debt will go up as a consequence of the application of rescheduling fees. Rs only mean a different structure of payments and usually includes a period of grace and the reschedule of the debt on a medium term basis. Finally we have the most severe form of debt crisis, the repudiation. As we have said this situation has been practically nonexistent recently and involves a strong political decision. Although repudiation has been a real alternative for borrowing countries it has only been used as a weapon (threat of repudiation) to get concessions from creditors when negotiating. Considering that the LDCs economies are very interdependent with the rest of the world, and thus their need to export raw materials in exchange for consumer and capital goods, the idea of "breaking" with the rest of the world seems unrealistic. It is much better for LCDs to negotiate, reschedule the debt, try to get some kind of "discounts" on the debt, or even to condition servicing the debt on the realization of some event (high prices of LDCs exports, or more access to DCs markets, etc.), than to repudiate the debt. With respect to this point it is interesting to see the results of Cooper and Sachs (1985), where they conclude that it is "better" for both parts, creditors and debtors, to reschedule the debt instead of letting the borrowing country repudiate the debt.

There is an extensive list of papers that address the issue of optimal borrowing strategy when default, which most of the time
means repudiation, is possible\textsuperscript{1}. The basic idea is that every borrowing country is assumed to be dishonest, so that it will repudiate the debt if it is optimal to do so. The benefits that repudiation can bring to the borrowing country are all the income that can be saved by not servicing the debt. The costs are the penalties that creditors could impose on the borrowing country, like exclusion from the capital market, seizure of assets, disruption of trade, etc. The basic result of these models is that, since repudiation is possible, credit is constrained. The debt of any borrowing country can not go beyond a point that makes the decision of defaulting optimal for the borrowing country.

In this paper we take a different approach. We consider that borrowing countries always try to service the debt when it is possible, so repudiation is not an issue. When it is difficult to service the debt the borrowing country will try to reschedule the debt or negotiate to get some discount on the debt, but it will never try to repudiate. For these reasons the only type of financial problem considered here is the rescheduling of the debt.

CHAPTER III

AN OPTIMAL BORROWING MODEL WITH RESCHEDULING

The reason why debt problems occur is simple. They occur when a borrowing country has to service an external debt but does not have or is not able to acquire the necessary resources to do it. If the borrowing country has enough savings to service the debt there should not be any repayment problems. If for some reason the LDC has to look for financial resources in the international capital market to service the debt then there may be repayment problems.

We can expect that LDCs demand loans to smooth consumption, finance investment projects, etc., but the question is, why do borrowing countries demand resources to service the debt? Does the fact that a LDC demands loans to service the old debt mean that this country is insolvent? Can this kind of borrowing be rational?

This demand for loans (to cover debt servicing) can result from a multitude of causes. For example, if the debtor plans to service the current debt out of savings but as a consequence of an unexpected shock (like a reduction of income from exports, higher prices for imports, or general productivity shocks that reduce the productive capacity of the country) the capacity of payment is reduced, then the LDC might choose, in order to keep the level of consumption and investment more or less constant, to service part of the debt with its own resources and borrow the rest. Or it may be that the LDC plans to service part of the debt with its own resources and roll-over the rest because it is optimal.

Borrowing to roll-over the debt is justified when short term debt is used to finance long term projects. For example suppose a
LDC is using short-term debt to finance projects like railroads, electricity, etc. Since the return on these projects is extended over a long period of time, the principal cannot be paid off in the short run, hence the need to constantly roll-over the short term debt until the project matures. In the first section of this chapter we present a model that illustrates the need to constantly roll-over the debt when there are no external shocks that affect the capacity of payment of the country and there is no uncertainty about the supply of loans. The model presented is a standard model of optimal borrowing strategy where foreign borrowing is used to finance consumption and capital accumulation. Here the LDC borrows in the first period to increase the capital stock, but once the capital stock has reached an optimal level the LDC borrows again only to roll-over the principal. The debt is never paid off but it is always serviced and the principal is always rolled-over.

When there is a need for financial resources to service any debt and these resources cannot be obtained in the market, repayment problems occur. We saw in the previous chapter that when there exist repayment problems, arrears come first, so part of the debt service is postponed. When repayment difficulties continue rescheduling is likely to occur. Repayment difficulties can also occur when the LDC decides, for political reasons, not to service the debt even when it has the resources to do so. As we had mentioned earlier we neglect the possibility of repudiation. However there are situations when the borrowing country may have enough resources but it is still very difficult to service the debt. This happens for example when the government (if it is the debtor) has problems generating enough savings. For example, sometimes it is difficult to reduce expenditure and/or increase taxes. If the private sector is the debtor and there exist foreign exchange restrictions, debtors might find it difficult to service the debt.
Insufficient savings does not imply repayment problems because credit can be used to service the debt. This was the case for most Latin-American countries in the late 1970s, when they used external aid to service old debts. The essential points are the existence of a positive demand for loans to service the debt coupled with the difficulty of getting money. In general, new loans are used not only to service the old debt but also to help finance current expenditure. This demand for loans does not necessarily imply the existence of an outstanding debt to be serviced. We can assume that if a borrowing country has an outstanding debt and there is a positive demand for new loans, any restrictions on financial resources will result in repayment problems. For example, when a LDC with an outstanding debt cannot get all the financial resources needed, the money still available will be used to cover basic needs. Only when current consumption and investment expenditures are covered will the resources left over be used to service the debt. In this case repayment problems occur when the demand for loans is greater than the supply.

Demand for loans will consist of the resources necessary to cover debt service and current expenditures, like consumption, investment, etc. The reasons for borrowing to cover current expenditure are not very different from the reasons for the debt buildup\(^1\). Some of these are:

a) To smooth consumption.
b) For investment. This means that the expected rate of return on the new projects must be greater than the interest rate applied to foreign loans.
c) For adjustment purposes. If there is a structural change in the economy and adjustment is necessary (for example the jump in oil

\(^1\) See McFadden et al (1985).
prices in 1973), in this case foreign borrowing can smooth the transition.

d) For transaction motives. Most of international trade is based on credit so there is need to use supplier's credit.

e) As a precautionary motive. When the foreign market is erratic some reserve build-up is needed especially when a country needs to service a debt and there exist the risk of fluctuations in the prices of exports.

f) To support some economic policies. For example ambitious liberalization programs (cases of Chile and Argentina), which usually resulted is heavy borrowing by the private banks. Maintaining a fixed exchange rate when the currency is overvalued, this usually led to deficit in the current account and capital flights (this was very much the case of Mexico and Venezuela in the early 1980s).

The supply of loans is determined, as we saw in the first chapter, by different variables. Some elements are general to every LDC and others are country specific. Among the general variables we have the situation of the capital market in DCs, the economic situation in the world, the situation of the financial market for LDCs (when debt problems exist in several LDCs it is probable that credit can be restricted to every LDC). Country specific variables are those considered by the banks in their assessment of a country's risk: These include the economic prospects of the country, exchange controls, etc. Independently of the economic performance of a particular country, credit is conditional on the realization of some exogenous (to the borrowing country) variables. For this reason we are going to consider, for the purposes of modelling optimal borrowing, the supply of loans as a random variable. In this case when there is a disequilibrium between supply and demand, in particular when demand is greater than supply, financial problems (R) is the result.
For the purposes of modelling repayment problems (Section 3.2) we assume that the only source of uncertainty comes from the supply of loans. In this case the borrowing country does not face external shocks that affect its exports revenues or its productivity, it only faces possible cut-offs of loans. This randomness of the supply of loans can create financial difficulties because there is always an incentive for the LDC to borrow money from the capital market and take advantage of the higher marginal productivity of capital in LDCs than in the rest of the world. But since the debt is a short-term instrument (in this case it only last one period) and accumulation of capital is a long-term project, there is constant need to roll-over the principal. However this need of resources to service the debt makes the borrowing country vulnerable to supply cut-offs with the consequence of repayment difficulties.

This way of modelling repayment problems differs from other studies in several ways\textsuperscript{2}. The principal difference is that the uncertainty comes from the creditors not from the debtors. In this case borrowing countries will always try to service the debt when it is possible, so there is no uncertainty about the "willingness" of LDCs to service the debt. The uncertainty comes from the possibility of supply cut-offs which can result in financial difficulties. This approach contrasts with other models of risk of default where it is assumed that there exists uncertainty about the willingness and ability of borrowing countries to service the debt. The second difference is that the model presented here is not a general equilibrium model. For this reason we assume that the interest rate applied to LDC loans is fixed and does not adjust to possible disequilibrium between supply and demand, so the interest rate is not a market clearing mechanism. It is not a market clearing

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mechanism because, as it has been argued\(^3\), when there exists risk of repudiation, or risk that part of the cost of repayment problems are transferred to creditors, the result is credit constraint, not movements in the interest rate.

The typical models of repudiation risk\(^4\) assume that a borrowing country will repudiate its debt if it is optimal for it to do so. The benefit of repudiating the debt is the debt service that the LDC will save while the cost is the penalties that creditors would impose on defaulting countries. If the debt is large enough it is possible that repudiating the debt is a rational decision for the LDC. For this reason creditors will never allow the level of the debt to reach a point that makes repudiation optimal. The result is that credit is constrained and defaults (repudiations) never occur. Grossman and Van Huyck (1988) and Bulow and Rogoff (1989) represent studies on repudiation risk where partial defaults or reschedulings are possible. Although in the last cases repudiation or rescheduling is possible, the idea is that borrowing countries face the choice between defaulting or not and so keeping good reputation with creditors.

In the present chapter we present two models of optimal borrowing strategy. The first one is a standard optimal borrowing model when there is no uncertainty\(^5\). It is the base model. The second model is an optimal borrowing strategy model where uncertainty is introduced on the supply side to allow for the possibility of Rs. In this model we just try to explain, in a very simple way, why Rs can result when agents are making optimal decisions. For this reason the only source of uncertainty present in the model is related to the supply of loans. Repayment difficulties

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\(^3\) See for example Eaton and Gersovitz (1981), or Stiglitz and Weiss (1981).


\(^5\) The model is taken from Cooper and Sachs (1985).
can be the consequence of other factors besides fluctuations in the supply of credit and for this reason the present model should be viewed only as a simple illustration of how Rs can occur when there are optimal decisions by the economic agents.

1. Base model.

Consider a small developing country. In this country there is a social planner (for example the government) who wants to find the way to achieve the best growth path such that the utility derived from the consumption of the goods consumed is maximized and the path satisfies some constraints. To achieve his goals this social planner picks the amount of investment, consumption and level of borrowing. Investment will decrease the amount of resources available for consumption today but will increase the production tomorrow (via an increased stock of capital). The social planner can use international credit when expenditure is greater than output. Borrowing from the financial markets allows the country to have a higher level of consumption and investment today but since the money has to be repaid, the economy has to generate, in the future, enough resources to service the debt. In this simple model we assume that there is no uncertainty. The production function, the law of motion of the capital stock and the debt are known, the interest rate associated with the debt is fixed, and there is no uncertainty regarding the supply of loans. This is important; since the economy is small it can borrow all the money it wishes without affecting the interest rate. The financial resources are always there and the probability that there will be a cut-off of loans in the future is zero. This is so because creditors know that the economy will satisfy some boundary constraints, for example the limit of the present value of the debt is zero.
Suppose we are dealing with only one good or an aggregation of goods. Utility is obtained from the consumption of that good. We are going to consider all the income variables per capita, and assume that there is no growth in the population. In this way we do not bother with labor. The utility is going to be a function of the entire path of consumption (infinite horizon). To simplify the analysis we are going to constrain this function to be a time separable utility function, i.e.,

\[ U(C_0, C_1, \ldots, C_t, \ldots) = \sum_{t=0}^{\infty} \beta^t u(c_t) \]  

where the parameter \( \beta \) measures the discount on future consumption, small values of this parameter implies a strong preference for present consumption. The current utility function is assumed to have the regular properties, i.e., \( u' > 0 \) and \( u'' < 0 \), where \( u' \) represents the first order derivative, and \( u'' \) the second order derivative.

We assume that there is a production function which has capital per capita as its only argument. The output of this production function can be used for consumption, investment or to service the debt. Let's assume that either there is no government or that government expenditure is included in the consumption and investment variables. In which case we have,

\[ F(K_t) = C_t + I_t + N_t, \]  

where \( "N_t" \) denotes the payments made to service the debt at "t". \( C_t \) and \( I_t \) are the consumption and the gross investment. Let us assume that the production function is a positive function of the capital stock and that the marginal productivity is decreasing.

The capital stock (capital per capita in this case) has a depreciation rate of \( 'd' \) per period. This stock can only be increased
via gross investment, $I_t$, so, the motion of the capital stock is the following,

$$K_{t+1} = K_t(1-d) + I_t.$$  ......................................................... (3)

To simplify the analysis we assume that there exist only one type of financial instrument: one period loans. This assumption implies that all the debt plus the interest payments associated with it have to be fully paid every period. Since we are considering a small developing economy, this country can borrow all the amount of money it wants without affecting the interest rate. The fact that the country has to pay the full amount of the loan plus the interest every period does not mean that the country cannot roll-over part or the complete debt. If the country wants to repay only part of the debt now and defer the rest of the payment to the future, it can do so by borrowing the amount it wants to roll-over. In this case there is no problem for the small country to roll-over the debt\(^6\). We assume that there are two types of markets in this economy, the financial and the goods market. The goods market opens first, so all the decisions about consumption and investment have to be made first. After the goods market has closed the financial market opens and then all the payments and new borrowings can be made. Let us denote by $D_t$ the outstanding debt at the end of period \(t-1\), so it is the debt that has to be fully paid at \(t\) (plus the interest payments). Since $N_t$ represents the financial payments made at \(t\), we can define the demand for new loans as,

$$y_t = (1+r)D_t - N_t,$$

So the demand for loans at period $t$ is equal to the debt service due less the payments made. In the present case, since we are assuming

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\(^6\) When there is no uncertainty about the supply of loans the difference between short and long term loans is misleading.
no uncertainty, the country will always find the resources needed, so, demand will always be equal to supply. If we use (2), the motion of the stock of debt is the following,

$$D_{t+1} = (1+r)D_t + (I_t + C_t) - F(K_t), \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (4)$$

where 'r' is the interest rate applied to the debt. Notice that (4) implies that new borrowing can be used either for consumption or for investment\(^7\). The payments are equal to the income minus investment and consumption\(^8\). To avoid unbounded solutions, for example unbounded borrowing to support unbounded consumption we make the assumption that the limit of the present value of the debt be equal to zero,

$$\lim_{t \to \infty} D_t(1+r)^{-t} = 0 \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (5)$$

The initial conditions consist of a positive stock of capital and some amount of outstanding debt. Since we are studying the case of a small developing country, let us assume that the stock of capital per capita is small with respect to the rest of the world, which in turns implies that the marginal productivity of capital is big compared to world standards. In the same manner we can assume that the initial level of debt is positive (or zero), but not negative.

Putting together all the elements above mentioned we can write the problem as,

\(^7\) This is not the case of the model of Bade (1972), where loans can only be used to finance investment.

\(^8\) In an economy without government we have that, \(Y=C+I+X-M\), so \(Y-I-C = X-M\): the surplus in the current account is used to service the debt.
Max \[ \sum_{t=0}^{\infty} \beta^t u[C_t] \] s. t.,

a) \( F(K_t) = C_t + I_t + N_t \),

b) \( K_{t+1} = K_t(1-d) + I_t \).

c) \( D_{t+1} = (1+r)D_t + (I_t + C_t) - F(K_t) \),

d) \( \lim_{t \to \infty} D_t(1+r)^{-t} = 0 \),

e) \( D_0 \) and \( K_0 \) given.

This is dynamic programming problem which can be solved by standard methods. First let us define the following,

\[ x_t = K_t(1+r) + I_t \] and \[ y_t = (1+r)D_t - N_t \],

in this case the problem can be written as,

Max \[ \sum_{t=0}^{\infty} \beta^t u[y_t-(1+r)D_t+F(K_t)+K_t(1-d)-x_t] \] s. t.,

a) \( D_{t+1} = y_t \),

b) \( K_{t+1} = x_t \),

c) \( \lim_{t \to \infty} D_t(1+r)^{-t} = 0 \),

d) \( D_0 \) and \( K_0 \) given.
The "states" of this problem are the stocks of debt and capital and the "controls" are the new variables $x_t$ and $y_t$. Note that the current "states" are not arguments in the transition equations. This redefinition makes the analytical solution a lot simpler.

Bellman's equation becomes,

$$V(D_t, K_t) = \text{Max} \left\{ u(y_t - (1+r)D_t + F(K_t) + K_t(1-d) - x_t) + \beta V(D_{t+1}, K_{t+1}) \right\}$$

s. t. $K_{t+1} = x_t$ and $D_{t+1} = y_t$.

The first order conditions are:

$$x_t:$$

$$-u'(C_t) + \beta \frac{\partial V(K_{t+1}, D_{t+1})}{\partial K_{t+1}} \frac{dK_{t+1}}{dx_t} = 0$$

where $u'(C_t)$ means the marginal utility of consumption evaluated at "t". Since the current state is not part of the transition equation we have,

$$\frac{\partial V(K_{t+1}, D_{t+1})}{\partial K_{t+1}} = [F(K_{t+1}) + (1-d)]u'(C_{t+1}),$$

so this first order condition can be expressed as,

$$u'(C_t) = \beta [F'(K_{t+1}) + (1-d)]u'(C_{t+1}) \quad \text{................................. (6)}$$

$$y_t:$$

$$u'(C_t) + \beta \frac{\partial V(K_{t+1}, D_{t+1})}{\partial D_{t+1}} \frac{dD_{t+1}}{dy_t} = 0$$

but again the state ($D_t$) is not part of the transition equation,
\[
\frac{\partial V(K_{t+1}, D_{t+1})}{\partial D_{t+1}} = -(1+r)u'(C_{t+1}),
\]

and this implies,

\[
u'(C_t) = \beta (1+r)u'(C_{t+1}) \tag{7}
\]

Using both conditions we get,

\[
F'(K_{t+1}) = r + d \tag{8}
\]

So the optimal path implies that the marginal productivity of capital is equal to the sum of the depreciation and the interest rate.

For the present case we have that the steady state is reached after one period. Suppose we are at \(t=0\). The capital and the debt stock are given, so condition (8) can only be satisfied next period. Since we are considering the case of a small developing economy let us also assume the following: At time 0 the capital stock is such that the marginal productivity of capital is bigger than the interest plus the depreciation rate (i.e. the capital per capita is small compared to the rest of the world). Since we are going to consider the case of a borrowing country let us assume that the initial level of debt is not negative (the country considered is not a creditor), let us assume that the initial level is zero. These assumptions are,

\[F'(K_0) > r + d, \text{ and } D_0 = 0.\]

In order to satisfy (8) investment at \(t=0\) has to be such that the growth of capital allows (8) be satisfied in period one. Let us denote \(G()\) as the inverse function of the marginal productivity of capital. Investment, at period zero, has to satisfy,
I_0 = G(r+d) - K_0 (1-d),

this guarantees that the marginal productivity of capital in the next period (period one) is equal to 'r+d'. The level of output reaches the steady state once the capital stock reaches its steady state level. This is because the production function is only a function of the capital stock. The investment, starting from period one, will be equal to the amount needed to replace the depreciated capital stock, so

I_t = dK^*, \quad \text{for } t=1,2,\ldots ,

where K^* = G(r+d). If we look at condition (7), we see that the optimal path implies a smooth consumption path; this path is increasing or decreasing depending on the particular values of the parameters. Now we can see that one of the reasons for borrowing is to smooth consumption as well as to increase the stock of capital. For simplicity let us assume that the subjective discount of the future is equal to the financial discount, i.e., 1/(1+r) = \beta. The result is that the consumption is constant along the path. Putting together all the results we have the steady state flows as,

Y^* = F(K^*) = I^* + C^* + N^*. \quad \text{......................... (9)}

Where the value for the steady state consumption and financial payments has to be determined. Using the transition equation for the debt and the boundary condition (the limit of the present value of the debt be equal to zero), we get,

N^* = rD_1 = r(-N_0) = r[I_0 + C^* - F(K_0)] \quad \text{......................... (10)}

Using (9) and (10) we get the expression for the steady state consumption,

C = [(F(K^*) - I^*) + r[F(K_0) - I_0])/(1+r) \quad \text{......................... (11)}
The outstanding debt will always be equal to the first period debt (equals to minus $N_0$) although the limit of the present value is zero.

The result of this model is that there is a jump in the capital stock from period zero to period one, and from there the stock does not move. The investment at $t=0$ has to be big enough to allow this jump in the capital stock, but once it reaches the steady state the investment is only used to replace the depreciation of the steady state capital (net investment is zero). The consumption immediately reaches the steady state. For this reason the country has to borrow the difference between the product and the investment plus consumption at $t=0$. The nominal debt will be constant as it will never be fully repaid but will always be serviced. This is possible because there is no problem to roll-over the debt.

2. Model with Rescheduling.

In this section we consider an economy very similar to the one described in the above section. Most of the parameters of the economy are the same except the ones that refer to the supply of loans. We still have a small developing country, with a stock of capital per capita which is small compared to world standards, with or without any outstanding debt at the beginning of the analysis. There is a social planner who wants to maximize some utility function over the entire consumption path of the country. The rest of the parameters of this economy are the same with a separable utility function, production function and law of motion of the capital stock.

What is different in this model is the behavior of the supply of loans. We assume that loans can be cut-off in the future. We still
consider that there is only one type of debt, one-period debt, where the principal and the interest have to be fully repaid every period. The country can still roll-over the debt or even borrow more (if it is optimal) but that will be possible only if there are financial resources available to do that. It is only in this context that the separation of markets (financial and goods markets) makes sense. At period 't' the planner has to decide the amount of consumption, investment and financial payments to be made without knowing if there will be funds available. If the demand for loans is positive and loans are restricted it will not be possible to roll-over the debt or to borrow more. In reality, when the normal sources of funds like official borrowing or medium-term private loans are not available, the country has to look for more expensive or risky loans, for example short term loans. When these sources are closed the country might either stop servicing part of the debt (arrears) or look to reschedule the debt. When this happens the country will probably have to pay rescheduling fees (that is normal). In any event, when the supply of loans is restricted there is a high probability that the country will have to pay higher costs for the debt because of the rescheduling fee or the more expensive loans. For the purposes of the model we are going to assume that there is a non zero probability that a penalty be imposed on the demand for loans conditional on the situation of the financial market. In this model uncertainty comes from the possible higher cost of the debt.

Since there exists the possibility that the debt cannot be rolled-over it becomes important to match the maturity of the debt with the maturity of the project financed by the loan. It is not enough for the project to have a better return than the interest rate as the structure of the project has to be such that generates the resources needed to pay off the principal when its repayment is due\textsuperscript{9}. In the case of the present model, investment is used to increase the stock of

\textsuperscript{9} See for example McFadden et al (1985).
capital when the capital is used to produce goods via a production function. The "project" investment seems to be "profitable" when the marginal productivity of capital is greater than the interest rate plus the depreciation rate. However the project does not generate the resources to pay off the principal (remember in the first section the debt is never paid, but it is always serviced), it only increases the product enough to pay the interest applied to the debt. For this reason the interest rate originally applied to the debt is not the real cost of the debt as it has to take into account the possibility of an increased cost due to the rescheduling penalties.

We are going to assume that the borrowing country faces a random supply of capital. This supply of capital can take any value between zero and some upper bound say "A". The supply of capital is a random variable conditional on the realization of some exogenous variables like the economic and financial situation of the DCs, financial problems of other countries, etc. Let us denote by \( g(S_t) \) and \( G(S_t) \) the density and the cumulative distribution functions respectively of the supply. Since both are conditional on some exogenous variable we can write them as \( g(S_t \mid Z_t) \) and \( G(S_t \mid Z_t) \). We assume that financial problems occur when the supply of loans is insufficient to cover the demand. Let \( R_t \) be the random variable denoting rescheduling, or financial problems, at period 't'. This is a binary random variable that takes the value one when a rescheduling occurs and zero otherwise. The probability of financial problems can be expressed as,

\[
P(R_t = 1) = P(y_t > S_t) = G(y_t \mid Z_t),
\]

where \( y_t \) denotes the demand for loans. When financial problems occur, a penalty is applied to the whole demand for loans (not only to the portion of the demand not covered by the supply). Let us denote by \( \epsilon_t \) the random variable rescheduling fee. This variable takes the value "a" with probability "P" when there are financial
problems and the value zero otherwise (with probability $1 - P$). Given the discussion about the supply and demand for loans it is clear that the probability of penalties is a function of the demand for loans (it is the upper bound of the cumulative distribution function) as well as a function of a set of exogenous variables. In particular, we have that,

$$ P(y_t, Z_t) = G(y_t | Z_t) = \int_{0}^{y_t} g(S_t) dS_t, $$

Using Leibnitz's rule we have,

$$ \frac{\partial P(y_t, Z_t)}{\partial y_t} = g(y_t | Z_t) > 0, $$

The motion of the debt in this case is as follows,

$$ D_{t+1} = (\epsilon_{t+1}) y_t \quad \quad \quad \quad \quad \quad \quad \quad (1) $$

where "$\epsilon_{t+1}$" is the random variable representing the penalty applied to debt not paid, and $y_t$ is (as before) the demand for loans.

With this new assumption, we can write the social planner's problem as,

$$ \text{Max} \ E_0 \sum_{t=0}^{\infty} \beta^t u[y_t - (1+r)D_t + F(K_t) + K_t(1-d) - x_t] \quad \text{s. t.,} $$

a) $K_{t+1} = x_t$,
b) \( D_{t+1} = (1 + \varepsilon_{t+1}) y_t \)

c) \( D_0, K_0 \) and \( \varepsilon_0 \) given,

where the expectation operator is taken with respect to the random variable "\( \varepsilon_{t+1} \)" given information at "0". We assume that when the decisions about consumption and investment are made at 't', "\( \varepsilon_t \)" is known but not "\( \varepsilon_{t+1} \)". As before we defined,

\[
x_t = K_t(1-d) + I_t, \quad \text{and} \quad y_t = (1+r)D_t - N_t.
\]

Note that in the present case there is no need to include the boundary constraint (the expected present value of the debt equals zero) as there is an upper bound on the supply of loans. Besides, we also assume that the rescheduling fee is big enough to discourage the borrowing country from extending borrowing. The problem is as before a dynamic programming model, the difference being that it is stochastic. For this case Bellman's equation becomes,

\[
V(D_t, K_t) = \max \{ u[y_t - (1+r)D_t + F(K_t) + K_t(1-d) - x_t] + \beta E \{ V(D_{t+1}, K_{t+1}) \} \}
\]

s.t.,

\[
K_{t+1} = x_t \quad \text{and} \quad D_{t+1} = (1 + \varepsilon_{t+1}) y_t
\]

The first order conditions are:

\[
x_t:
-u'(C_t) + \beta E_t \frac{\partial V(K_{t+1}, D_{t+1})}{\partial K_{t+1}} \frac{dK_{t+1}}{x_t} = 0
\]
but since the current "state" is not an argument in the transition equations we have,

\[
\frac{\partial V(K_{t+1},D_{t+1})}{\partial K_{t+1}} = \frac{\partial U(C_{t+1})}{\partial K_{t+1}} = [F'(K_{t+1}) + 1 - d]U'(C_{t+1})
\]

which implies,

\[u'(C_t) = \beta[F'(K_{t+1}) + (1-d)]E_t[u'(C_{t+1})] \quad \cdots \cdots \ \ (2)\]

This is the case because "\(\beta\)" and "\(d\)" are fixed parameters and the marginal productivity of capital at "\(t+1\)" does not depend on the realization of the random variable "\(\epsilon_{t+1}\)". Investment at time \(t\), and, therefore, the capital stock at 't+1' are independent of the realization of the random variable "\(\epsilon_{t+1}\)". The other first order condition is,

\(y_t:\)

\[u'(C_t) + \beta \frac{\partial E_t[V(K_{t+1},D_{t+1})]}{\partial y_t} = 0\]

We have, by the definition of the random variable, \(\epsilon_{t+1}\), the following expression for the expected value of the maximizing function (we use the definition of the transition equations and the definition of the density function of the rescheduling fee),

\[E_tV(K_{t+1},D_{t+1}) = E_tV(x_t,(1+\epsilon_{t+1})y_t)\]

\[= [1-P(y_t)]V(x_t,y_t) + P(y_t)V(x_t,(1+a)y_t)\]

in this case we have,

\[\frac{\partial E_tV(K_{t+1},D_{t+1})}{\partial y_t} = E_t\frac{\partial V(K_{t+1},D_{t+1})}{\partial y_t} + g(y_t)[V(x_t,(1+a)y_t) - V(x_t,y_t)]\]
but,

$$\frac{\partial V(K_{t+1}, D_{t+1})}{\partial y_t} = -(1+r)(1+\epsilon_{t+1})U'(C_{t+1}),$$

putting together the above expressions the second order condition implies,

$$u'(C_t) = \beta [(1+r) \{E[(1+\epsilon_{t+1})u'(C_{t+1})]\} + M(x_t, y_t) \quad \text{......... (3)}$$

where,

$$M(x_t, y_t) = g(y_t)[V(x_t, y_t) - V(x_t, (1+a)y_t)],$$

which is a positive number since the density function is positive and the difference in the maximizing function is positive since this function is decreasing with respect to the level of debt\(^{10}\).

Both conditions, (2) and (3), imply,

$$\gamma = \frac{F'(K_{t+1}) - d - r}{1 + r} > 0 \quad \text{.................................................. (4)}$$

where,

$$\gamma = \frac{E[\epsilon_{t+1}u'(t+1)]}{E[u'(t+1)]} + \frac{M(x_t, y_t)}{(1+r)E_t[U'(C_{t+1})]} > 0$$

So \(F'(K_{t+1}) > d + r\), because the real cost of borrowing is not 'r' but an increasing function of the probability of rescheduling (which is a

\(^{10}\) \(\frac{\partial V(K_{t+1}, D_{t+1})}{\partial D_{t+1}} = -(1+r)U'(C_{t+1})\)
function of the demand for loans and the factors affecting the supply) and the parameters of the model.

From (2) we can see, if we still assume $\beta = 1/(1+r)$, that the current marginal utility of consumption has to be greater than the expected utility next period. We know from (4),

$$\frac{F'(K_{t+1}) - d - r}{1 + r} > 0 \Rightarrow F'(K_{t+1}) + 1 - d > 1 + r \Rightarrow \beta[F'(K_{t+1}) + 1 - d] > 1,$$

so,

$$U'(C_t) > E_t[U'(C_{t+1})].$$

With respect to the capital stock we can see that the level will be lower than the level reached when the supply of loans was not random. The reason is that now the marginal productivity of capital has to be big enough to compensate for a possible increase in the cost of borrowing as consequence of rescheduling fees.

If the initial conditions are $D_0 = 0$ and $F'(K_0) > d + r$, there will be borrowing in the first period to increase the capital stock. The reason is as follows. When borrowing is close to zero, the expected marginal cost is very close to the interest rate (when demand for loans is close to zero the probability that the supply is greater than the demand will be very small which results in the probability of rescheduling fees being very small). So, there is an incentive to borrow something and increase the capital stock. However, borrowing can not go beyond some point where the demand for loans makes the expected cost too high (remember that the expected cost of the debt is an increasing function of its level). There will be a strong incentive to borrow more if the initial stock of capital is very small, indicating a high marginal productivity of capital. We would therefore expect that the demand for loans be a decreasing function of the stock capital. On the other hand, a high level of debt will
discourage investment financed by borrowing because resources will be needed to service the debt, so more borrowing to support investment would make the expected cost too high.

Finally, the demand for loans will be an increasing function of the stock of debt as the bigger the stock of debt the more the resources that will be needed to service the debt. High levels of debt will discourage consumption and investment.

The solution to the model implies that there will be a positive demand for loans. For example, if the initial stock of capital is small by world standards and the initial level of debt is not too big, the solution indicates that there will be investment financed by external borrowing directed to increasing the stock of capital and take advantage of the difference in marginal productivity. If the initial stock of debt were large there will be a constant need to service the debt. Doing this could consume a lot of resources. Then the question arises is it worthwhile for the borrowing country to pay-off the debt immediately to avoid the risk of rescheduling fees? Paying-off the debt implies lower levels of current consumption and investment. If the borrowing country pays off the debt immediately the result is a low level of current consumption and the possibility of higher consumption in the future (because there will not be any debt to be serviced). Low consumption in one period to allow for higher consumption later is not a rational decision. The solution to the optimization problem implies a smooth consumption path as shown by condition (2). Consumption in the current period cannot be too low in relation to the future consumption because the current marginal utility will be too high and will create an incentive to borrow and consume more now, lowering the current marginal utility, and getting lower expected consumption tomorrow (due to the increased risk of getting a rescheduling fee). In this case the LDC will service part of the debt and roll-over the rest.
The optimal solution indicates that R is possible. The borrowing country take the risk of having R as being equal to the probability of higher costs for the debt only. So, in this simple model, optimal decisions and reschedulings are possible. However, as we said earlier, R is a serious event, it is not good for the creditors and we could expect credit to be more restricted in the future if there is an R now. In the above model we assumed that the supply of loans will be only conditional on the realization of some exogenous variables. However, this supply of loans can be conditional on past reschedulings as well. For example let us assume for simplicity that the supply of loans (the ex-ante supply) is correlated with past realizations of itself. In this case when a LDC borrows money it has to take into account the fact that restricted supply of loans today can increase the probability of restricted supply tomorrow (if the correlation is positive). The solution to the model is similar. The expressions for first order conditions remain the same, the only difference is the dynamic solution to those first order conditions where the supply of loans is correlated over time (in the new setting past realizations of the supply are part of the "states").

The model presented is a simple one. The motivation for including it was to illustrate how R can result from optimal decisions by economic agents. In this simple form the model explores how repayment problems can result when a developing country tries to finance a long-term project like capital build-up using a short-term debt. Here as the penalty for R consists only of a rescheduling fee, the LDC will find it optimal to use foreign borrowing to invest and build-up the capital stock (in order to take advantage of the difference in the marginal productivity of capital). The model considered does not take into account other factors that determine the demand for new loans and therefore the probability of R. These factors were mentioned at the beginning of this chapter and consisted mainly of the different shocks that affect either the capacity or the willingness of the LDC to service the debt (for
example decrease in the price of exports, capital flights, etc.). These factors make the LDC look for financial resources or demand new loans to service the old debt and result in the LDC having a positive demand for loans. We mention them as they should be included (even if they were not included in the optimal borrowing model) in any estimation of the probabilities of R.

The model concludes that the probability of R will be a function of the determinants of demand which in this case are the states of the system like the stock of capital and debt, the determinants of supply, and variables like variation of exports, growth of GNP, etc. that although not considered in the model are also important in explaining R. In short, we call these terms covariates or explanatory variables and denote them by \( X_t \). The probability of R can be written as, assuming that \( R_t=1 \) means rescheduling at period "t" as,

\[
P(R_t=1 \mid X_t) = P(y_t > S_t \mid X_t)
\]

We assumed that the supply of loans is correlated over time. This assumption was made to model the possibility of state dependency. When the supply of loans is restricted in some period it is possible that R will be the result. If the supply of loans presents positive correlation over time then the result will be a restricted supply of loans in the future meaning a high probability of R. In general we can expect that R today will not be independent of R yesterday, the reason being if a country has financial difficulties today credits might be restricted in the future as the country is less creditworthy implying restricted credit in the future for this country. In this case the probability of R can be written as,

\[
P(R_t=1 \mid R_{t-1}, \ldots, R_{t-k}, X_t) = P(y_t > S_t \mid R_{t-1}, \ldots, R_{t-k}, X_t) \quad (5)
\]
In general we can expect that the probability of $R$ at time $t$ will be conditional on the complete history of repayment problems of the LDC and the covariates that explain current Rs.
CHAPTER IV

THE DATA

To estimate the probabilities of R data on debt, debt service, GNP, exports, imports, reserves, etc. was needed. The information on the debt variables were taken from the World Bank publication "The World Debt Tables", while data on exports, imports, etc. was taken from the IMF publication "International Financial Statistics".

For the estimation the largest possible sample had to be obtained, but as reliable information on the relevant variables were not always available for most of the LDCs very simple economic variables were used in the estimation: variables like exports, imports and reserves which are easily available for most of the LDCs. The result was a sample of 68 LDCs taken from six different regions\(^1\). These regions were Latin-America, Africa south of Sahara, East Asia, South Asia, North Africa and Middle East and some less developed Mediterranean countries. It can be seen that the regions represent countries of similar culture and income level. The distribution of the countries (in our sample) by region is shown in figure-1\(^2\).

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\(^1\) The classification of countries by regions was taken from the one given in "World Debt Tables".

\(^2\) 21 countries from Latin America, 24 from Africa south of Sahara, 7 from East Asia, 7 from North Africa and Middle East, 4 from South Asia and 5 from the Mediterranean.
The sample used covered the period 1970-1988. There were 19 observations for each one of the 68 countries. During this period different countries had to reschedule their debts and some of them had to reschedule it several times. This situation (as we mentioned the previous chapter) can be explained by the withdrawal of the creditors from the capital market once a R occurs. Figure 2 shows the distribution of countries (again the distribution of countries in our sample) by the number of Rs faced in the period 1970-1988.
Twenty seven countries did not reschedule their debt in the period considered. These countries (no-rescheduling) are from very different regions, but in general we can say that countries from East Asia, North Africa and the Middle East did not experience many repayment problems during the period considered (the exceptions are The Philippines and Morocco). One interesting point in the above figure is that the number of countries with only one R is small relative to the countries with 2, 3, 4 or 5 Rs, indicating that a LDC either does not reschedule its debt or does it several times.
The above Rs did not occur evenly over the period considered. Rs were a rare event in the 1960s or 1970s but the situation changed in the 1980s, and especially after the so-called Debt Crisis of 1982. The evolution of R can be seen in Figure-3.

To gain insight as to how a R occurs, we estimated the Kaplan-Meier statistics for the occurrence or no-occurrence of a R. Since any LDC can face several Rs the Kaplan-Meier statistics (KMS) have to be calculated for every transition or R, i.e., the KMS for the first transition or R, the KMS for the second R, etc. In our sample we have a maximum of 9 Rs in the period considered (Zaire), but since there were not enough cases for transitions higher than 4 or 5, we only estimated the KMS for the first three transitions. The KMS were then plotted against time (0-19) as the sample consisted in 19 years or periods. The KMS indicates the probability that a country has not faced a R or failure until time "t", so it is an estimate of the survivor function\(^3\). A drop in the KMS would indicate a higher probability of "failure" at time "t". Three additional cases were also included besides the first three transitions. In one case the KMS was calculated for the occurrence of any R, it could be the first, second, third, etc. (in the graphic it is referred as "1 or more" Rs); every R was considered as equal. Another case is related to the occurrence of the second, third, etc. R ("2 or more" Rs) where every R other than the first was considered equally. Finally the KMS was calculated for the occurrence of the fourth, fifth, etc. R ("4 or more" Rs).

\(^3\) We will talk about the survivor function in the next chapter.
Figure-3

Number of Rs over time
In Figure-4 the KMS differs a lot depending on the order of the R. The importance of the order of the R can be seen if we compare, in Figure-4, the KMS for the first R with the statistic for the second, third, etc. R (2 or more). In this case, the probability of no-R drops quickly for the second case indicating an early occurrence of the third, fourth, etc. R. Once a R occurs, it is not only likely that another R will occur but is likely to occur soon.

![Figure-4](image)

Kaplan-Meier statistics

In Figure-5 the KMS for the rest of the cases are included. In this case we plotted the statistic using the whole period (19 years) but in reality we did not have cases of countries spending 18 or 19
years with only 2 or 3 Rs, so the statistic should hence be interpreted only until period 5 or 6. The KMS differs a lot when referring to the first or the rest of the transitions.

**Figure-5**

Kaplan-Meier statistics

The above statistics were calculated only using information on time of rescheduling. However, for the actual estimation of probabilities of R a set of covariates was used to show their relative importance in explaining these Rs.
From the optimal borrowing model of Chapter III we know that the probability of R will be a function of the stock of capital and debt and the situation of the international capital market. As we said before the optimal borrowing model was a simple one and did not include some other factors that could cause an increase in the demand for loans. For this reason we decided to include some of the variables that have been used before in other studies of country risk analysis. The following is a summary of some of these covariates:

a) Debt service ratio: This is the ratio of debt service due to export earnings. This variable has been considered to be a most important indicator of R as it measures the burden (in the short run) of the debt service relative to the income generated by exports.
b) Ratio of debt to GNP: This variable has been included as another measure of the burden of the debt in the long-run. It is divided by the GNP to scale the debt by the size of the economy.
c) Average Rate of growth of exports or GNP: This variable would indicate how dynamic the LDC is, as the more dynamic the LDC the lower the probability that it will face Rs. This is an example of a structural variable, i.e. it is a variable that is more or less constant from period to period.
d) Variance of exports: Fluctuation in exports is important since the larger the variance the more likely the LDC will be short of cash at some point and therefore suffer repayment difficulties.
e) Imports to GNP ratio: This variable has been included to measure how dependent the LDC is on foreign goods. If the LDC is highly dependent on imports then any fluctuations in revenues will result in either new borrowing to cover necessary imports or financial problems.
f) Reserves to import ratio: Smaller reserves means that the LDC is more vulnerable to export fluctuations.
g) Amortization rate or the inverse of the average maturity: This variable would indicate how hard the terms of the loans are and
hence this variable is more related to the situation of the financial market than to the economic situation of the LDC.

h) GNP per capita and/or regional dummies: The idea behind their inclusion is to take care of the difference between countries with respect to their income levels.

i) Structural variables like the share of the agricultural product in the GNP, foreign trade regime, distribution of income, etc. These structural variables help to identify the type of country that reschedule the debt, not the timing of the R.

The debt service ratio has been considered to be the most important indicator of country risk. In the optimal borrowing model presented in chapter II the probability of R was a function of the stock of capital, debt and the determinants of the supply of loans. In that model we considered only one-period debt where the full amount of the debt plus the interest payments had to be paid in the next period. In this case the only difference between the stock of debt and the service due was the interest payments. In the case where the interest rate is given, the demand for loans can be written as a function of either the stock of capital or the interest due (it only needs a redefinition of the states in the borrowing model). For the purposes of determining an explanatory variable for the model any of them can work as well. When there is a long term debt, there will be a difference. Then the stock of debt will indicate the burden of the debt in the long or medium run, and the debt service due will indicate the burden in the short run. In this situation the debt service (due at time t) will be determined by the debt contracted at time t-1, t-2, ..., t-k, and the terms of the loans (the structure of payments). In terms of the model of chapter III the "states" of the system will not be the outstanding debt at time t, but the debt signed at time t-1, t-2, ..., t-k (assuming the terms of the loans are constant). To get information for each of the countries as to when

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4 These structural variables were included in Berg and Sachs (1988).
the debt was signed, and the terms of the loans is very difficult. For this reason we have to rely on the information given by the debt service due and the level of the outstanding debt at time t. A large stock of debt does not necessarily imply a large debt service due because it is possible that most of the payments have to be made in the future.

Besides the debt service ratio and the stock of debt another important covariate is the ratio of reserves to imports. We said in Chapter III that one of the first symptoms of financial problems was arrears on interest or capital. We can expect a LDC, when faced with debt service problems, to try to use part of the reserves and when it is not enough the LDC might decide to postpone debt servicing (arrears). We can expect low levels of reserves to be an indicator of arrears or mild repayment problems, which in turn are good indicators of more severe form of problems. As a consequence of diverse economic problems like capital flights, overvalued currency, etc. when the LDC faces a reduction in reserves, the probability of repayment problems will be greater since low levels of reserves will make the LDC vulnerable to fluctuations in prices of exports, etc., whereby any shortage of currency will be reflected in arrears or in general repayment problems.

The stock of capital is another important variable that explains the demand for loans and therefore the probability of repayment problems. Information on the stock of capital is not available for many LDCs (most of them), so, it is necessary to include another measure for the productive capacity of the country.

As we mentioned earlier the covariates included in the estimation were chosen considering the type of variables needed for the estimation and the need to use very simple variables in order to include the biggest number of LDCs possible. For example reliable information on exports and imports (of both goods and services) is
not available for most of the LDCs. In this case only data on exports and imports of goods were considered; we can assume that the trade of goods is a good proxy for the trade of goods and services. Information on private debt and short term debt was only available for few countries and for a small period, basically the 1980s. In order to prevent a reduction in the size of the sample, we decided to work only with medium and long term public and publicly guaranteed debt. Another variable we had problems with was the GNP in dollar terms. Again, in order not to decrease the sample we decided to omit it and use some other variable as a proxy, for example instead of the debt-GNP we used debt-imports ratio. We needed to divide the stock of debt by some variable in order to get a measure of the scale of the debt, the obvious choice was the GNP. Since we could not include it we decided to pick a variable that could be a good indicator of the variations, and the level, of the GNP. We selected imports. The reason for choosing imports is that imports fluctuate in the same direction as income. Because imports for LDCs consist usually of raw materials and capital goods and they are needed in a more or less constant proportion relative to income, the ratio of GNP to imports does not change a lot. One problem with using imports as a proxy for GNP occurs when comparing countries with a different trade regime since imports are more important for export oriented countries.

The explanatory variables we used in the estimation were the debt service ratio, debt-imports ratio, estimated exports over real exports, reserve-imports ratio, LIBOR, inflation in the U.S.A, regional dummies and an index of previous rescheduling in the previous five years. The first variable was calculated by dividing the debt service due by the estimated exports; the last variable was obtained by adjusting OLS to series of exports and time (eight observations were used, the current and the previous seven ones). The ratio of estimated to real exports was included as an index of export fluctuations. It was calculated using the estimated exports as
explained above. Reserves-imports ratio was calculated using data on reserves and imports of goods. Regional dummies were included to differentiate countries from the six different regions that we are considering. Each region should represent countries of similar culture and income level\(^5\). Finally we included variables that indicate the situation of the financial market and the world economy. The first one is an index of the real six-months LIBOR interest rate. We calculated this index by dividing the nominal series by the U.S. inflation rate. This variable represents a proxy of the situation of the financial market because high levels of the real interest rate implies more restricted financial markets\(^6\). The second variable is the inflation rate in the U.S. High level of this variables means more expensive imports for LDCs.

To give an idea of the magnitude of the debt, in particular its relation with some variables like exports, imports, etc. we plotted in Figures 6-17 aggregate data on debt, debt-service, imports, exports and reserves, for each one of the six regions defined previously. Notice that the plots reflect the aggregate data only for the countries considered in the sample (68 LDCs) not in general for countries that correspond to these regions.

From figures 6-17 it is can be seen that, except for the region East Asia, in the 1980s the gap between debt and imports increases. This is important because one of the covariates to be used in the estimation of the hazard functions is the debt-to-imports ratio. To see the how the behavior of debt and imports differs from two types of countries we aggregate the information in two different groups,

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\(^5\) Feder, Just and Ross (1981) found that regional dummies and income per-capita work the same way, one can be used instead of the other.

\(^6\) Since the loans for middle income LDCs are written in variable interest rate (see chapter I), we can say that high LIBOR means higher costs to LDCs, this is true, but the increase in cost is already captured by the variable debt service ratio, so a high level of LIBOR will only indicate, in this particular case, that loans are more difficult to obtain.
rescheduling and no-rescheduling countries. The first ones are the countries that had at least a R in the period considered, the second ones are the 27 LDCs that did not reschedule their debt in this period. Figures 18-21 plots the data for these two groups. Here it is clear the difference between rescheduling and no-rescheduling countries with respect to the behavior of imports and debt. For the firsts the gap increases in the 1980s while for the seconds it stays more or less constant.

Finally, since the real LIBOR and the inflation rate of the U.S. is included in the estimation, we plotted, in Figure-22, the LIBOR, real LIBOR and the inflation rate (this is the percent wholesale price increase for the U.S.A., which was used to calculate the real LIBOR).
Figure-6

Africa South of Sahara

Source: IMF
Figure-7

Africa South of Sahara

Source: IMF
Figure-8

East Asia

Source: IMF
Figure-9

East Asia

Source: IMF
Figure-10

Latin America

Source: IMF
Figure-11

Latin America

Source: IMF
Figure-12

Mediterranean

![Graph showing the growth of reserves, imports, and debt from 1969 to 1989.]

Source: IMF
Figure-13

Mediterranean

Source: IMF
Figure-14

North Africa and Middle East

Source: IMF
Figure-15

North Africa and Middle East

Source: IMF
Figure-16

South Asia

Source: IMF
Figure-17

South Asia

Source: IMF
Figure-18

No-Rescheduling Countries

Source: IMF
No-Rescheduling Countries

Source: IMF
Rescheduling Countries

Source: IMF
Figure-21

Rescheduling Countries

Source: IMF
Figure-22

Prices and Libor over time

Source: IMF
CHAPTER V

STATISTICAL METHODOLOGY

We saw in Chapter III that the probability of $R$ at time $t$ will be conditional on a set of exogenous variables and past realizations of the dependent variable $R$.

Repayment problems can in general be considered as a process rather than an event. We saw in the first chapter that the first symptom of problems are arrears and only when arrears are accumulated over several periods a rescheduling of payments is the likely outcome. In this case we can say that repayments difficulties last several periods, therefore the concept of a process rather than an event seems to be more appropriate. When we consider repayment difficulties in this broader sense (almost any kind of repayment problem) then we should talk about the spell or process of repayment problems and not the event rescheduling. However, as we said in the first chapter the only type of repayment problem considered in this paper is the "severe" form of problems: $R^1$. When we are considering only the severe form of repayment problems it does not matter if the LDC has been experiencing "minor" financial difficulties for the problem to be considered as severe (meaning rescheduling). In this case it does not matter if the LDC has been in a process of experiencing minor financial difficulties, it is only when the problem has become severe enough when a $R$ is the result. Although the negotiations to complete a rescheduling agreement can last several months the decision to reschedule is not something that takes several periods.

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1 Remember that we are not considering the possibility of repudiation.
Since we are estimating probabilities of occurrence of an event, we are dealing with a dependent variable that takes only discrete values (it is one when a R occurs and zero otherwise). For this reason a possible way to carry out the estimation could be applying logit or probit models. This method has been used before to assess country risk. However since R presents correlation over time (existence of state dependence) logit models have to be extended to take this into account. In this case the observations based on panel data are not independent. Since there exists the possibility of heterogeneity due to unobservables, the method used has to be also extended to deal with these problems.

The method we use to estimate probabilities of R and spells of no-R, or financial "health", is continuous time survivor or duration models. With this method we can estimate directly the probability of Rs and the time elapsed between two Rs (or the spell of financial "health"). The first probabilities are called in the survivor models literature the hazard rate. It indicates the probability that an event fail (in the present case the probability that a R occurs) given that it has not failed until period t. The second probability is called the survivor function. It indicates the probability that an event does not fail in some number of periods (in the present case the survivor function will indicate the probability that the spell of no-R be greater than certain number of periods).

Probabilities of Rs and spells of no-Rs can be estimated with some adjustment by binary dependent variable models like logit and probit (although the problem of state dependence and heterogeneity has still to be solved). We choose to use continuous time models (in short we call them survivor models, SM) because they are invariant

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2 We talk about these studies later.
3 See for example Feder, Just and Ross (1981), where they talk about conditional logit and the way to estimate spells of no-R.
to the time unit used and because at this point it is much easier to deal with state dependence and heterogeneity using continuous rather than discrete time models. To estimate the parameters of the hazard function we used the algorithm CTM which can handle multiple-states and heterogeneity in a very general way. We will talk about this algorithm later, now let us review briefly other studies on the probability of repayment problems.

1. Previous studies.

The idea of estimating repayment problems is not new. There are several studies that address the issue of country risk. These studies, usually called country risk analysis, estimate the probability of default or repayment problems using a set of explanatory variables. Estimating repayment problems is important for the creditors if they want to know how risky lending to some particular country would be. Country risk indicators are important to assess country creditworthiness. To estimate the probability of repayment problems it has been common to use some country specific variables in order to determine their importance in causing R. The variables normally used have been debt and economic variables (although some authors used political variables). Examples of the first ones are the debt service ratio (the debt service to exports ratio), the debt to income ratio, etc. Examples of the seconds are reserves to imports ratio, income per-capita, etc.

The first attempts at estimating country risk using explanatory variables consisted in simple indexes. These indexes were calculated

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4 See for example Flinn and Heckman (1982), or Kiefer (1988).
6 Most of the time default and repayment problems are used as if the meant the same.
using a weighted average of different debt and economic variables. This method was used mainly by the banks in the 1960s and early 1970s. An obvious problem with this method was how to obtain the right "weights".

Later, discriminant analysis were used as a way to obtain statistically the "weights" for the explanatory variables. This method was used by Frank and Cline (1971). Discriminant analysis calculates the "weights" by separating, using the explanatory variables, two different populations: countries with and without repayment problems. Sargen (1977), is another study of country risk analysis that uses discriminant analysis.

Since the dependent variable is binary it has been an ideal candidate for logit models. These models have been specifically developed to deal with binary dependent variables. Feder and Just (1977) represent the first paper that applied logit models to estimate country risk. The use of the logit model was basically the only difference with respect to the previous papers because the dependent variable was the same and the explanatory variables were more or less the same. Feder, Just and Ross (1981) and Cline (1984), represent other attempt at using logit models to assess country risk. Berg and Sachs (1988) used probit models to estimate probabilities of repayment problems. Lately Snider (1990) applied logit models to predict any kind of suspension of payments (like arrears). The novel element in this paper is the incorporation of political variables. For example the ability of the governments to collect taxes, capital flights (which means lack of confidence in the government by the private agents), etc.

McFadden et al (1985) represents a more general approach to estimate repayment problems. They used a disequilibrium model with the possibilities of arrears or mild financial problems and reschedulings. They worked with demand and supply for loans
(which was not the case in the previous studies where reduced forms were used) obtaining repayment problems as a result of a disequilibrium, in particular when demand is greater than supply.

Most of the above mentioned estimation was done pooling time series and cross sectional data (panel data) as a way to increase the size of the sample. When panel data is used there exists the possibility of serial correlation\(^7\). As we saw in Chapter III, the occurrence of R will not be independent over time. R today will in general be correlated with R yesterday. For this reason logit models or the density function for the disequilibrium models have to be extended to take into account the existence of serial correlation. McFadden et al (1985) used lagged observations of the dependent variable as a way to test the existence of state dependence, they found the coefficient positive and significant.

Most of the authors above mentioned were primary interested in identifying the "characteristics of defaulting" countries (countries with repayment problems) rather than estimating the timing of R. It was more important to identify "structural variables" of the economy (variables that do not change very much for several periods) rather than time dependent variables that could be important to determine when repayment problems occur\(^8\). Since the timing of R was not very important for some authors, the next few (two) observations that followed a R from a rescheduling country were eliminated from the analysis, because, it was argued, those years still represent the characteristics of a defaulting countries and since no rescheduling were reported for those years these observations had to be

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\(^7\) "If observations are independent both over individuals and over time, a panel data QR (qualitative response) does not pose any problem. It is just another QR model, possible with more observations than usual. Special problems arise only when observations are assumed to be correlated over time", Amemiya (1985), pag. 348.

\(^8\) This is not the case of the McFadden et al (1985) paper.
eliminated. This is very different from what we are trying to do that is estimating the timing of R and duration of spells of no-Rs.

Finally, the above papers used basically data on Rs and arrears not data on default or repudiation. For this reason the estimation of country risk really means risk of repayment problems not risk of default or repudiation. This is interesting because some of the authors talk about defaulting countries when what is really happening are repayment difficulties not repudiations.

2. Econometric specification.

Estimation of probabilities of financial problems involve using explanatory variables to estimate probability of occurrence of a binary variable. The binary variable R takes the value one when repayment problems occur and zero otherwise. In the previous chapter we saw that repayment problems occur when the demand for new loans is greater than the supply. We assumed that the supply of loans is a function of a set of exogenous variables while the demand is a function of the state variables of the system⁹: the stock of capital and the outstanding debt. In the present case where we are not giving functional forms for the demand and supply, we express the probability of R as function of the determinants of supply and demand knowing that a R will occur when a disequilibrium situation is present (in particular when demand is greater than supply). In any case we are estimating reduced form models. In this case we are not interested in the structural parameters of the supply and demand functions but in identifying the variables that cause R. The problem with only estimating reduced form models is their interpretation. For example if we find that

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⁹ The demand for loans will be a function too of the parameters of the supply of loans, by which I mean the parameters of the density function.
there is a negative correlation between Rs and the level of reserves can we say that this is the case because higher reserves means the LDC is not having problems generating enough savings to service the debt? Or is the reason that higher reserves increases the creditworthiness index of the LDC? In the present case we don't have many variables that can be identified with both the demand and the supply so this ambiguity with the interpretation will not be very important.

The probability of R was written as,

\[ P(R_t=1 \mid R_{t-1}, \ldots, R_{t-k}, X_t) = P(y_t > S_t \mid R_{t-1}, \ldots, R_{t-k}, X_t) \quad \text{..... (1)} \]

where \( X_t \) represents the covariates at time \( t \). If the probability of R at time \( t \) is only a function of the number of previous Rs not a function of when they occurred then (1) can be rewritten in the following way. First let us define the states in this model. When the LDC has not experienced a R we say that it is in state "zero". If the country has experienced only one R then it is in state "one", \( n \) Rs means state "n", etc. Let \( y_{k,t} \) be the variable indicating a typical LDC (we omit the country specific index) is in state \( k \) at time \( t \). The probability of R at time \( t \) assuming \( k-1 \) previous Rs can be expressed as,

\[ P(\text{Rescheduling at } t) = P(y_{k1} \mid X_t, y_{k-1,t-1}) \quad \text{................. (2)} \]

Note that in this form all past information on the number of previous Rs is included in the variable \( y_{k-1,t-1} \) which represents the realization of the dependent variable in the previous period. In this case we have the case of a markov model\(^{10}\). Since the probability of

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\(^{10}\) Amemiya (1985) obtains continuous time survivor models, I mean the hazard function, as the limit when time interval goes to zero of a first order Markov process. The notation in this Chapter is a modification of the notation used by Amemiya.
R at time \( t \) will in general be dependent on time (as the explanatory variables are time dependent) we have the case of a first order semi-Markov process. The way we defined the states implies a model similar to a birth process. This process has the following characteristics: state \( k \) can only be followed by state \( k+1 \) and it can only follows state \( k-1 \). It is not possible to go from state \( k \) to state \( k+j \) (for \( j>1 \)) or from a state \( k \) to a state \( l \) when \( l<k \).

Suppose we want to know the probability of \( R \) at time \( t \) given that the country has not experience a \( R \) yet. This means we are interested in the first occurrence of \( R \). Let us denote by \( T(1) \) the random variable time of first failure or in general \( T(k) \) represents time of the \( k^{th} \) failure. Assuming that the country started at time 0 in state zero we can express the conditional probability of \( R \) at \( t \) given no previous Rs as,

\[
P[T(1)=t \mid T(1)>t-1] = P(y_{1,t} \mid X_t, y_{0,t-1}) \text{ ..................} (3)
\]

This expression represents the hazard function in the duration models literature. It express the conditional probability that an event fail at time \( t \) given duration until time \( t-1 \).

If we want the unconditional probability of \( R \) then (3) has to be multiplied by the probability of no \( R \) until time \( t-1 \) which is \( P(y_{0,t-1}) \). In this way we obtain the density function for \( T(1) \). The probability \( P(y_{0,t-1}) \) (survivor until time \( t-1 \)) will be a function of past realizations of the dependent variable and the corresponding realizations of the covariates. We can write this survivor function as,

\[
P[T(1)>t-1] = P(y_{0,t-1} \mid X_{t-1}, y_{0,t-2}) P(y_{0,t-2}) =
\]

\[
= P(y_{0,t-1} \mid X_{t-1}, y_{0,t-2}) P(y_{0,t-2} \mid X_{t-2}, y_{0,t-3}) P(y_{0,t-3}) = \ldots
\]

\[
= P(y_{0,1} \mid X_1, y_{0,0}) \cdot P(y_{0,2} \mid X_2, y_{0,1}) \ldots P(y_{0,t-1} \mid X_{t-1}, y_{0,t-2}) \text{ . (4)}
\]


where the initial condition is \( P(y_{0,0}) = 1 \). The unconditional probability, \( P[T(1)=t] \), can be written as,

\[
P[T(1)=t] = P(y_{1,t} \mid X_t, y_{0,t-1}) \cdot P[T(1)>t-1] = \\
= P(y_{1,t} \mid X_t, y_{0,t-1}) \cdot P(y_{0,t-1} \mid X_{t-1}, y_{0,t-2}) \cdots P(y_{0,1} \mid X_1, y_{0,0}) \quad \ldots \quad (5)
\]

For the particular case of single spells (once a failure occurs the experiment ends) we can interpret the last factors in (5), i.e. \( P(y_{0,t-1} \mid X_{t-1}, y_{0,t-2}) \), as the probability of no failure given no previous failure, that is, it is equal to unity minus the hazard function for that period. Given this interpretation (5) can rewritten as,

\[
P[T(1)=t] = P[T(1)=t \mid T(1)>t-1] \cdot \{1-P[T(1)=t-1 \mid T(1)>t-2]\} \cdots \\
\ldots \{1-P[T(1)=1 \mid T(1)>0]\}
\]

\[
= h(t) \cdot [1-h(t-1)] \cdot [1-h(t-2)] \cdots [1-h(1)] = h(t) \cdot S(t-1)
\]

where \( h(t) \) is the hazard function at time \( t \) and \( S(t-1) \) the survivor.

For the continuous case model the above functions can be written (assuming for a moment the single spell case) as follows. The hazard function without covariates is,

\[
P(t < T < t + \Delta t \mid T > t) = \lambda(t) = f(t)/S(t) \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (6)
\]

where \( S(t) = P(T>t) \) and \( f(t) = P(T=t) \). \( f(t) \) and \( S(t) \) are the density and the survivor function of the random variable \( T \) (time of
failure). If we denote by $F(t)$ the distribution function of $T$ the above functions satisfy the following conditions$^{11}$,

\begin{equation}
F(t) = 1 - S(t) \tag{7}
\end{equation}

\begin{equation}
S(t) = \exp\{- \int_0^t \lambda(s)ds \} \tag{8}
\end{equation}

\begin{equation}
f(t) = \lambda(t) \exp\{- \int_0^t \lambda(s)ds \} \tag{9}
\end{equation}

Estimation of failure or transition time (equation six) represents the principal point of duration models. Once the hazard is obtained the rest of the functions, especially the survivor function can easily be obtained because of the one-to-one correspondence between them. To carry out the estimation functional forms for the hazard must be given. The specifications to be used will be restricted by the type of hazards allowed in the algorithm we use. In this case only the hazards available in CTM will be considered.

Hazard functions are said to be time dependent when their derivative with respect to time is not zero. The only case of time independent hazard is the exponential family. In the exponential case the hazard is just a constant. When covariates are introduced into the hazard function it can still be time independent as long as time is not part of the arguments and the covariates are time independent too. When there exist time dependent covariates, as is our case, the hazard rate will exhibit time dependence even if we only consider hazards in the exponential family. In this paper we

\footnote{There is a one-to-one correspondence between the hazard, the density, the survivor and the distribution function.}
estimate Weibull type hazards so time is explicitly included in the function.

In our model we know that multiple failures and spells of no-Rs are possible. For this reason we need to consider the case of multiple-states models. In this case we need to estimate several hazards (one for each transition or failure). The expressions for these hazards have to be modified to take into account that they will be in general a function of the time spent in a particular state. To express the hazard and survivor functions for the general case let us define the following. Let $\tau(k)$ represent time when state $k$ starts or time when state or spell $k-1$ ends (in a continuous time model both are the same). $T(k)$ is the random variable denoting time spent in spell $k-1$ or time to exit to state $k$. $t_k$ will be a particular realization of the variable $T(k)$. Given these definitions the following must be true,

$$\tau(k) = \sum_{i=0}^{k} t_i$$

We have been assuming that the beginning of the experiment is when the LDC is in state 0 and it is starting the spell (later on we are going to talk about the initial condition problem). Since we have the case of a birth process the transition from one state to another must follow a particular order. In this case there is no need to specify both the original and final state because if we know the destination we know the origin. For this reason we will only index the hazard function by the final state. The probability of transition from state $k-1$ to state $k$ given that $t_k$ was the time spent in state $k-1$ will in general be a function of durations in previous states. To facilitate the analysis we take the specialization defined in Heckman and Singer (1984) for birth processes: the hazards only depend on the time spent in the last spell and the number of previous spells.
Indexing the hazard with the exiting state will indicate the number of previous failures. The probability that the first R happens after $t_1$ periods is (we are using the assumption that the LDC starts the spell at state 0),

$$P[T(1) > t_1] = \exp\left(- \int_0^{t_1} \lambda_1[u;X(u)] \, du\right) \quad \ldots \ldots \ldots \ldots \quad (10)$$

The probability that a spell of no-R in state k-1 be at least $t_k$ periods is,

$$P[T(k) > t_k] = \exp\left(- \int_0^{t_k} \lambda_k[u;X(u+\tau(k-1))] \, du\right) \quad \ldots \ldots \ldots \ldots \quad (11)$$

Note that in (10) and (11) the hazard function is not conditional on past durations or previous spells because by indexing the hazard the number of previous failures is known. Also note that in (11) only one hazard function is used to obtain the survivor function ($\lambda_k$) and not the sum of all the hazards (except the one representing exit from state k-1) as would be the case in a general multiple-state spell model. This is the case because of the type of process we are considering, state k-1 can only exit to state k. The time dependent covariates are indexed by the normal time period no by the time spent in the spell.

Suppose we have the case of a LDC who stays $t_1$ periods without a R then it has a R at that time and stays $t_2$ periods without a R and then the experiment ends. What is in this case the likelihood function for this LDC? Since the second spell is incomplete we have the case of a censored spell. The only thing we know about it is that the spell was greater than $t_2$. The likelihood for this LDC can be written as,
\[ L = \lambda_1[t_1|X(t_1)] \exp\{- \int_0^{t_1} \lambda_1[u|X(u)] \, du\} \exp\{- \int_0^{t_2} \lambda_2[u|X(u+\tau(1))] \, du\} \]

Note that the likelihood function for an individual has to specify the complete history of events since the beginning of the experiment to the end. The likelihood for the complete sample will be the product of the individual likelihood functions.

Since we are studying developing countries the sample of spells will always be incomplete. This is the case because some spells began before the sampling date or because some other spells did not finish at the end of the sampling date. When we have incomplete spells of the second type we are dealing with right censoring. Right censoring is not a problem, it can be handled by the survivor models easily (we showed how to write the likelihood function when there are right censoring). What represents a more serious problem is when spells begin before the sampling date. This is the case of left censoring. If left censoring is not taken into account when estimating hazard functions the result are inconsistent estimators\(^\text{12}\). As we said before we are assuming that each country begins the spell in state-zero at the beginning of the sampling period. The reason for this assumption is the following. Repayment problems only occur when there is an outstanding debt and there is difficulty in servicing it, so one pre-requisite is the existence of an outstanding debt. The sample we are considering in the present study covers the years 1970-1988 period where external borrowing became very important for LDCs. Late 1960s and early 1970s represent the beginning of the heavy involvement by the private banks in lending to LDCs. We can assume that the level of external debt was not very important before 1970 for the general LDC therefore there is no need to talk about

important repayment problems before 1970. There are some exceptions to this: some countries had some financial difficulties and were involved in some borrowing before 1970. For example Argentina, Brazil and India had to reschedule the debt before 1970. However, besides these cases repayment problems were a rare event in those years. Before 1970 most of the LDCs were involved in some kind of "official" lending (credits mainly from the World Bank). This type of credit was very different from the private one (with respect to the security of future loans) and its amount was modest. For this reason there was no major danger of repayment problems at that point. In this case the assumption that the initial condition is state-zero and that this spell started at the beginning of our sampling date (1970) is not very strong.

When using a sample of developing countries, heterogeneity problems are always present. In the sample considered there are countries from very different regions and cultures. We have countries from Africa, Latin-America or Asia. Some of the differences can be eliminated by the covariates considered. However there are still some unobservable variables (like cultural, historical or political variables) that make every LDC different from the rest. If heterogeneity is not taken into account the results can be biased towards negative duration dependence\(^{13}\). A common way to deal with heterogeneity is by assuming that the unobservables can be represented by a random variable which is assumed to have some particular distribution function. In this case the hazards and survivor functions will be conditional on the realization of the unobservables or in this case the realization of this new random variable. For example the hazard (6) can be expressed as,

\[
P(t < T < t + \Delta t \mid T > t, \theta) = \lambda(t|\theta) = \frac{f(t|\theta)}{S(t|\theta)}
\]

\(^{13}\) See Heckman and Singer (1984).
where \( \theta \) denotes the random variable representing unobservables. To get unconditional functions it is necessary to integrate the hazard or survivor function with respect to the variable \( \theta \). For example, if the density function of \( \theta \) is \( h(\theta) \) (11) can rewritten as,

\[
P[T(k) > t_k] = \int_{\mathcal{A}} \exp\left\{ - \int_0^{t_k} \lambda_k[u|X(u+\tau(k-1),\theta)] \, du \right\} h(\theta) \, d\theta
\]

where \( \mathcal{A} \) is the range of \( \theta \).

In this dissertation the estimation of the hazards was made using the algorithm CTM\(^1\) which estimates a very flexible family of hazard functions. This algorithm is designed to deal with the case of multiple-spell multiple-states models. It allows time dependent covariates. It takes care of heterogeneity by assuming different density functions for the unobservables like standard normal, log-normal, gamma or it can use non-parametric techniques. CTM allows diverse specifications of the hazard function which depend on the particular values assumed by the parameters. The general form of the hazard function allowed in this package is,

\[
\lambda_i[t_i|X(t_i+\tau(i-1)),\theta] = \exp\{ X(t_i+\tau(i-1))'\beta + \sum_{j=1}^{k} \gamma_j[ (t_i^{-\delta_j} - 1)/\delta_j ] + c_i \theta \}
\]

In this specification the hazard function depends in general on the time spent in the spell (although the coefficients of \( t \) can restricted to zero). This is the so-called duration dependence term and its captured by the expression,

\(^1\) See Hotz (1983).
where the index \( j \) can go from one to "k". This expression is the Box-Cox transformation of "t". When \( \delta_j = 0 \), the expression is equal to \( t_1^{\gamma_j} \).

The heterogeneity component is captured by the expression \( C_i \theta \), where \( C_i \) is a state parameter to be estimated and \( \theta \) is the individual-specific heterogeneity component. The parameter \( C_i \) allows the heterogeneity component to play a different role in each state. The random variable \( \theta \) can be specified as we said as standard normal, log-normal or exponential or it can be estimated nonparametrically.

The vector \( \beta \) represents the coefficients of the covariates which can in general include functions of past values. In our case we did not use lagged covariates. The coefficients of the typical hazard can be restricted across transitions. This is very important for our case since given the reduced sample we are using it is not feasible to estimate many hazard functions and therefore many parameters. In this case it is necessary to constrain the parameters for some of the hazards in order to decrease the number of parameters estimated.

The typical CTM hazard can be reduced to some well known hazard functions. For example, if we set \( \delta_j = 0 \) for \( j > 1 \) we get a Weibull specification (the one we used in the estimation). \( \gamma_1 = 1 \) and \( \delta_j = 0 \) for \( j > 1 \) gives a Gompertz hazard. Setting \( \gamma_j = 0 \) for \( j > 0 \) produces an exponential specification.

In the next Chapter we discuss the specification we used in the estimation. We present the results of the estimation and calculate the hazard and survivor function for a set of selected countries under different scenarios.
CHAPTER VI

ESTIMATION AND SIMULATIONS

1. Results

To estimate probabilities of \( R \) we need to define the covariates and a functional form for them (for example they can be lagged, quadratic, log, etc.) and pick a functional form for the hazard function. The covariates included in the estimation as we mentioned in Chapter IV are: debt service to estimated exports ratio, debt-imports ratio, reserves-imports ratio, real to estimated exports ratio (this is an index of exports fluctuations), rate of inflation in the U.S.A. and real LIBOR. For all of them we use the current observation, without any lag or any kind of transformation.

The next step is to pick a functional form for the hazard function. Since we are using the algorithm CTM for the estimation the functional form of the hazards will be restricted by the forms available in this program. The typical CTM hazard has the following form,

\[
\lambda_i(t_i | X(t_i+\tau(i-1)), \theta) = \exp\{ X(t_i+\tau(i-1))'\beta + \sum_{j=1}^{k} \gamma_j[(t_i-1)/\delta_j] + c_i\theta \}
\]

For this expression it is only necessary to specify the type of heterogeneity to be used and the duration dependence parameters. We talked about these parameters in the previous chapter.
In this chapter we estimated four different specifications of the hazard function. In the first model we specified the hazards without any heterogeneity components so it was only necessary to pick the duration dependence parameters. We had convergence problems when attempting to estimate more than one of the Box-Cox transformations or when trying to estimate both parameters (gamma and delta). For this reason we set for all the models estimated, k=1 and $\delta=0$. In this case we ended up estimating Weibull type hazards. This Weibull hazard has the following form,

$$\lambda_i[t_i | X(t_i+\tau(i-1)), \theta] = t_i^{\gamma_j} \exp \{ X(t_i+\tau(i-1))' \beta + c_i \theta \} \quad \ldots \quad (1)$$

In our sample the maximum number of Rs was 9 which means we have a maximum of 10 states (remember that state zero is the state of financial "health" or no-Rs). Estimation of all the parameters for every one of the nine hazards (because there are nine transitions or changes of state given the specification of our model) is unfeasible given the size of the sample and the fact that there are few cases of countries experiencing transition 4-5, 5-6, etc. Since it was not possible to estimate all the parameters for every one of the nine hazards it was necessary to impose some restrictions on the parameters in order to reduce the number of parameters to be estimated. In the first model estimated (the simplest one) there are no heterogeneity components and all the parameters were restricted to be equal across transitions, i.e. the coefficient of $X_i$ in transition 0-1 is equal to the coefficient of $X_i$ in transitions 1-2, 2-3, etc. This implies that all transitions are treated as being equal implying that the probability of R will be the same no matter how many Rs occurred before. In this case only one hazard function is estimated. This is of course a simplification. We saw in Chapter IV that the Kaplan-Meier statistic is very different depending on the order of the R, so the probability of R should be very different when we refer to
the first R rather than to a recurrent R. In Table-1 we present the results of the first model.

**TABLE - 1**

The parameters are restricted to be equal across transitions

<table>
<thead>
<tr>
<th>Name of variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.850</td>
<td>1.166</td>
</tr>
<tr>
<td>Gamma</td>
<td>-0.180</td>
<td>0.085</td>
</tr>
<tr>
<td>Delta</td>
<td>0.0</td>
<td>------</td>
</tr>
<tr>
<td>Debt/imports</td>
<td>0.214</td>
<td>0.035</td>
</tr>
<tr>
<td>Reserves/imports</td>
<td>-1.105</td>
<td>0.390</td>
</tr>
<tr>
<td>Exports/est-X</td>
<td>-2.238</td>
<td>0.823</td>
</tr>
<tr>
<td>Inflation-US</td>
<td>0.885</td>
<td>0.407</td>
</tr>
<tr>
<td>Real-LIBOR</td>
<td>1.409</td>
<td>0.460</td>
</tr>
</tbody>
</table>

Table-1 only reports the results of the typical transition or hazard. All the coefficients of the covariates have the expected sign and the parameters are significant. It is interesting that the parameter gamma is negative indicating negative duration dependence. This result indicates that given some realization of the covariates the longer a country stays without R the less likely it will face it. Since we are omitting some variables (some of them might be unobservables) and restricting the parameters of the different transitions to be equal there must be some specification problems with this model. That is probably the reason why we are getting negative duration dependence parameters. We will see that this negative duration dependence result does not hold for different specifications of the model.
The coefficient of the debt to imports ratio is significant and has the expected sign: the larger the debt with respect to the size of the economy the more likely the LDC will face a R. The real to estimated exports ratio has the right sign and is significant; the bigger real exports (with respect to the estimated) the smaller the probability of R because it means the country gets unexpected income from an increase in volume or price of exports which implies more resources for the country. The parameter of the reserves to imports ratio is significant and has the expected coefficient; the bigger is this ratio the less likely the LDC is having financial difficulties like arrears. Inflation in the U.S. has the right sign; the higher the inflation in the U.S. the more likely the LDC will have economic problems (due to increased prices of imports). Real LIBOR is significant and with the expected sign; the higher the real LIBOR the more restricted the financial market is and therefore the more likely the LDC will have financial problems.

For this first model the sign of the coefficients of the covariates is the expected one (and it is significant). This result shows that the covariates used have been important at explaining Rs. However, if we want to determine how much a particular covariate increases or decreases the probability of R it is necessary to do some simulations. These simulations are carried out in the second section of this chapter where different scenarios for the covariates are included.

The second model is just an extension of the first one. First we included five regional dummy variables (we are working with six regions but one dummy has to be dropped, in this case the dummy representing less developed Mediterranean countries is not included) as a way to deal with heterogeneity. We also included another dummy variable that indicates if the country had a R in the previous five years. The idea to include the last variable is to investigate if state dependence is present. Finally we included the variable most
used to assess country risk: the debt-service ratio. As in model-1 we estimated only one hazard (restricting all the parameters to be equal across transitions) and we set the parameter delta to zero. The results of the second model are reported in Table-2.

TABLE - 2

Parameters are restricted to be equal across transitions

<table>
<thead>
<tr>
<th>Name of variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.463</td>
<td>1.119</td>
</tr>
<tr>
<td>Gamma</td>
<td>0.160</td>
<td>0.118</td>
</tr>
<tr>
<td>Delta</td>
<td>0.0</td>
<td>-------</td>
</tr>
<tr>
<td>Debt-service/est-X</td>
<td>0.279</td>
<td>0.781</td>
</tr>
<tr>
<td>Debt/imports</td>
<td>0.115</td>
<td>0.40</td>
</tr>
<tr>
<td>Reserves/imports</td>
<td>-0.991</td>
<td>0.491</td>
</tr>
<tr>
<td>Exports/est-X</td>
<td>-2.595</td>
<td>0.842</td>
</tr>
<tr>
<td>Inflation-US</td>
<td>0.871</td>
<td>0.369</td>
</tr>
<tr>
<td>Real-LIBOR</td>
<td>1.124</td>
<td>0.427</td>
</tr>
<tr>
<td>Previous-R</td>
<td>1.540</td>
<td>0.252</td>
</tr>
<tr>
<td>Africa-south-of-Sah.</td>
<td>-0.053</td>
<td>0.341</td>
</tr>
<tr>
<td>East-Asia</td>
<td>-1.233</td>
<td>0.511</td>
</tr>
<tr>
<td>Latin-America</td>
<td>-0.161</td>
<td>0.362</td>
</tr>
<tr>
<td>North-Africa</td>
<td>-0.811</td>
<td>0.462</td>
</tr>
<tr>
<td>South-Asia</td>
<td>-0.184</td>
<td>0.574</td>
</tr>
</tbody>
</table>

As expected the coefficient of the debt-service ratio is positive but it is not significant. In another study, Berg and Sachs (1988) found that the debt-service ratio is not important in explaining Rs when the debt service refers to the public debt\(^1\). However there is a

\(^1\) We are using public and publicly guaranteed debt.
difference with other studies where this variable has always been significant\(^2\). In general the inclusion of these variables did not change very much the coefficients of the previous variables or their significance. The only difference is with respect to the duration dependence parameter (\(\gamma\)). In this model this parameter is positive (although it is not significant) implying the longer a country stays without financial problems the more likely it will face them\(^3\). A possible explanation for this change of sign is that model-1 was misspecified so the inclusion of more variables gave the parameter \(\gamma\) the correct sign\(^4\).

With respect to the regional dummies it is interesting to note that only one of them was significant, the dummy corresponding to East Asia. This would indicate that regions are not the source of heterogeneity in this model or that heterogeneity, if existent, is present in other forms. This result is interesting because other authors found that regional dummies are important\(^5\) in explaining Rs.

One result that is very important is that the dummy representing previous Rs was positive and significant indicating that if a country had a R in any of the previous five years it is likely that it will have another R. This result indicates the existence of state dependence since previous realizations of the dependent variable are important to predict current realizations. For this reason the next step was to estimate two hazards or transitions, one for the first occurrence of an R and the second for recurrent R.

\(^2\) It does not matter if we use real exports instead of estimated exports in the debt service ratio, in any case the parameter is not significant.
\(^3\) When the covariates do not change.
\(^4\) In any case it is difficult to say what should be the correct sign for \(\gamma\). Since we are dealing with time dependent covariates the hazard function is not constant over time because the covariates change over time. The hazard function could be an increasing or decreasing function of time depending on the behavior of the covariates.
\(^5\) See for example McFadden et al (1985), or Feder, Just and Ross (1981).
Model-1 is equal to model-2 when the parameters of the seven covariates above mentioned are restricted to be equal to zero. To investigate the importance of this set of restrictions we evaluated the likelihood-ratio-test (the null hypothesis implies that the restrictions hold). The null hypothesis was rejected at 5% and 1% of significance\textsuperscript{6}.

In the third model we estimated two hazard functions one for the first occurrence of R and the second for any other occurrence of Rs besides the first (something similar to what we did when we calculated the Kaplan-Meier statistics in Chapter IV). In this case the parameters of the transition 0-1 are estimated without constraints (except delta equals zero) and the parameters of the transitions 1-2, 2-3, 3-4, etc. are restricted to be the same among them. Since we are estimating two hazards instead of one the number of parameters to be estimated are the double than in the previous case, this means that the estimation could be unfeasible. To estimate the two hazards we decided to reduce the number of parameters estimated by eliminating the variables that were not important in the first two models. In this case we eliminated the regional dummies, the debt service ratio and the dummy representing previous R (we do not need to use it when estimating two hazards which itself takes care of the state dependence issue).

In this case model-3 is similar to model-1, the difference being that the parameters of the second transition for model-1 are restricted to be equal to the parameters of the first transition. The results of the third model are reported in Table-3.

\textsuperscript{6} The calculated statistic is 50.1 which is a chi-square with seven d. of f.
### TABLE-3

Two hazards

<table>
<thead>
<tr>
<th>Name of variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transition 0-1:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>1.359</td>
<td>1.446</td>
</tr>
<tr>
<td>Gamma</td>
<td>0.105</td>
<td>0.452</td>
</tr>
<tr>
<td>Delta</td>
<td>0.0</td>
<td>------</td>
</tr>
<tr>
<td>Debt/imports</td>
<td>0.675</td>
<td>0.134</td>
</tr>
<tr>
<td>Reserves/imports</td>
<td>-1.993</td>
<td>0.833</td>
</tr>
<tr>
<td>Exports/est-X</td>
<td>-4.527</td>
<td>1.483</td>
</tr>
<tr>
<td>Inflation-US</td>
<td>1.553</td>
<td>0.783</td>
</tr>
<tr>
<td>Real-LIBOR</td>
<td>1.471</td>
<td>0.872</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name of variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rest of transitions:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>2.634</td>
<td>1.459</td>
</tr>
<tr>
<td>Gamma</td>
<td>0.177</td>
<td>0.125</td>
</tr>
<tr>
<td>Delta</td>
<td>0.0</td>
<td>------</td>
</tr>
<tr>
<td>Debt/imports</td>
<td>0.061</td>
<td>0.071</td>
</tr>
<tr>
<td>Reserves/imports</td>
<td>-0.482</td>
<td>0.870</td>
</tr>
<tr>
<td>Exports/est-X</td>
<td>-1.704</td>
<td>1.114</td>
</tr>
<tr>
<td>Inflation-US</td>
<td>0.569</td>
<td>0.573</td>
</tr>
<tr>
<td>Real-LIBOR</td>
<td>0.569</td>
<td>0.573</td>
</tr>
</tbody>
</table>

If we compare the results of model-1 with the results of model-3 for the first transition we find that the results are not very different. For example we can see that the intercept and the
coefficient gamma were more or less the same. The parameters for
the rest of the variables changed just a little. The absolute
magnitude increased but the significance of these variables did not
change except for the parameter of LIBOR which is now marginally
not significant (the t-ratio is 1.687). The situation is a lot different
when we consider the second hazard which represents the rest of the
transitions or recurrent R. In this hazard all the coefficients of the
covariates have the right sign but now they become insignificant.
These results would indicate that the model works well for the first
R. However it does not work well for recurrent R. One explanation
for this result could be that the existence of unobserved variables
might be contaminating the results.

To test the importance of estimating two hazards instead of
only one we carried out the likelihood-ratio-test. Remember that
model-1 is equal to model-3 when the seven parameters of the
second transition are restricted to be equal to the parameters of the
first transition, so there are seven restrictions. The null hypothesis
(only one hazard) is rejected at 5% and 1% level of significance7.

Since we are dealing with countries of different culture,
political status or economic regime, we have to be concerned with
heterogeneity problems. To see its importance we ran model-3
assuming that the heterogeneity component has a standard normal
distribution. The results of the estimation are reported in Table-4.

7 The calculated statistic is 105.12.
TABLE-4

Two hazards
Heterogeneity: std-normal.

<table>
<thead>
<tr>
<th>Name of variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition 0-1:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>1.227</td>
<td>1.615</td>
</tr>
<tr>
<td>Gamma</td>
<td>0.127</td>
<td>0.558</td>
</tr>
<tr>
<td>Lambda</td>
<td>0.0</td>
<td>----</td>
</tr>
<tr>
<td>Debt/imports</td>
<td>0.836</td>
<td>0.196</td>
</tr>
<tr>
<td>Reserves/imports</td>
<td>-2.043</td>
<td>0.997</td>
</tr>
<tr>
<td>Exports/est-X</td>
<td>-4.731</td>
<td>1.615</td>
</tr>
<tr>
<td>Inflation-US</td>
<td>1.425</td>
<td>0.790</td>
</tr>
<tr>
<td>Real-LIBOR</td>
<td>1.439</td>
<td>0.879</td>
</tr>
<tr>
<td>Factor-loading</td>
<td>0.740</td>
<td>0.610</td>
</tr>
</tbody>
</table>

Rest of transitions:
| Intercept          | 4.416       | 1.625         |
| Gamma              | 0.733       | 0.219         |
| Lambda             | 0.0         | ----          |
| Debt/imports       | 0.054       | 0.111         |
| Reserves/imports   | -0.047      | 1.368         |
| Exports/est-X      | -2.595      | 1.103         |
| Inflation-US       | 0.778       | 0.628         |
| Real-LIBOR         | 0.104       | 0.751         |
| Factor-loading     | 0.962       | 0.225         |
Table-3 and Table-4 show very similar results, at least for the first transition. The sign of all the parameters is the same, the difference being that the results of table-4 indicate a bit higher absolute magnitude of the parameters. The results are different when we look at the second transition. In this transition the sign of the parameters is still the same although the absolute value of the parameters is a little bit higher in table-4. The major difference is with respect to the intercept, the parameter gamma and the coefficient of the real to estimated exports ratio. When the model is estimated incorporating a heterogeneity component (with standard normal distribution) these parameters for the second transition become significant. This result and the fact that the parameter "Factor-loading" is significant for the second transition indicates the importance of the heterogeneity component. When unobservables are incorporated the results are somewhat (but not very much) different.

With this result we can conclude something similar to McFadden et al (1985)\(^8\): there exist true state dependence and heterogeneity is present in a non-obvious way. With respect to the last point we should notice that the regional dummies were not significant in the first models. In this case we can say that regions are not the source of heterogeneity. The source has to be found in other variables not considered in the model (because it was difficult to find information on them for all the LDCs in our sample), like political variables, trade regime, etc. With respect to state dependence we should say that the results indicate that the model (the covariates we are using) behaves well when we refer to the first occurrence of R, but when we talk about recurrent Rs the model does rather poorly (only one of the covariates was significant).

\(^8\) "... there are both true state dependence and country effects", McFadden et al (1985), pp. 192.
2. Simulations

In this section we present estimates for the hazard and survivor functions for some selected countries.

Evaluating the instantaneous hazard (remember we are working with continuous time duration models) is not complicated. It is only necessary to collect the value for the parameters and covariates and evaluate the expression for the hazard. However, if we are interested in estimating the hazard for an interval of time such as a year, we need to do some calculations.

Suppose time intervals are denoted by \( J \) \((J= 0, 1, 2, \ldots , L)\). These time intervals can be years or months (in our case time intervals are years). The probability that a \( R \) occurs in the interval \( J \) can be expressed as,

\[
P(T = J) = S(J-1) - S(J)^9
\]

(2)

where \( S(k) \) represents survivor until the end of time interval \( k \). This expression represents the density function for the occurrence of a \( R \), not the hazard function which is a conditional probability. Since the survivor function can be expressed as a function of the instantaneous hazard, (2) can be rewritten as,

\[
P(T = J) = \exp\left( - \int_0^{(J-1)\Delta} h(u)du \right) - \exp\left( - \int_0^{J\Delta} h(u)du \right) \ldots \ldots
\]

(3)

where \( h(u) \) represents the instantaneous hazard function and \( \Delta \) is the size of the interval. (3) can be written as,

\[9\] See Flinn and Heckman (1982).
\[ f(J) = S(J-1) \left[ 1 - \exp\left(- \frac{\int h(u) \, du}{(J-1)\Delta} \right) \right] \] .......... \hspace{1cm} (4)

By definition the hazard function is,

\[ \lambda(J) = \frac{f(J)}{S(J-1)}. \]

In this case the hazard for the interval \( J \) becomes,

\[ \lambda(J) = 1 - \exp\left(- \frac{\int h(u) \, du}{(J-1)\Delta} \right) \] .......... \hspace{1cm} (5)

This hazard rate is still a function of time dependent covariates but to simplify notation we did not write them. In the models we estimated we restricted the parameter delta to be zero, therefore, the estimated hazards were Weibulls. For example when heterogeneity is not included this Weibull can be written as,

\[ \lambda[t \mid X(t)] = \gamma_j \, \exp\{ X(t)\beta \} \] .......... \hspace{1cm} (6)

If the covariates were time independent the hazard (2) could be easily evaluated because (3) would in this case be easily integrated. Since this is not the case and the distribution of the covariates is unknown integration of (3) is not straightforward. The method used in the CTM package is to assume that the covariates do not change smoothly over the interval but that the change only occurs at the beginning of the time interval. After the change occurs the covariates remain constant during the rest of the interval. In this case the integration for each time interval is simple. Once we obtain the "interval" hazards we can compute the survivors using the following formulae,
\[ P(T > J) = [1-h(1)] [1-h(2)] \ldots [1-h(J)] \]

(7)

Per period hazards and survivors were computed for eight countries: Argentina, Brazil, Egypt, Korea, Mexico, Turkey, Yugoslavia and Zaire. The three Latin-american countries were selected because they represent the biggest borrowers among LDCs. Egypt was selected because it is a borrower that usually gets government-to-government loans. Korea was selected because it is a heavy borrower and has had some financial difficulties but never has rescheduled the debt. Turkey is included because it had some financial problems in the late 1970s and early 1980s but overcame these problems and has not had a R since 1982. Yugoslavia is interesting because it does not represent a market oriented economy, so we would expect a different behavior from this country. Zaire was selected because it is the country with the biggest number of Rs in the period considered.

We estimated hazards and survivors for the sampling period (1970-1988) and for the next three years. To calculate the rates for the off-sample periods we needed some kind of forecast for the covariates. In the first case presented which we call the base scenario, the off-sample values for the covariates were calculated by applying OLS to each individual series using time as the explanatory variable. In this base scenario the hazards and survivors for the sampling period are obtained by using the actual data being that the estimates for the periods 1989-1991 are based on the "forecast" of the covariates.

The hazards and survivors were calculated not taking into account information on time of rescheduling for the different countries. In this case these rates should be interpreted as the probability of the first occurrence of an R. To calculate the rates we
used the results for the first transition of model-4. Figures 1-8 plot the calculated hazards and survivors for the eight countries considered. They also indicate (straight lines) the time when an actual R occurred.

Figures 1-8 show that the calculated hazards and survivors predict well the occurrence of the first R for Argentina, Brazil, Egypt, Korea and Mexico. The prediction for Turkey, Yugoslavia and Zaire is not that accurate. For Argentina, the value of the calculated hazard in 1985 (year of the first Argentinean R) is practically one. The value of the hazard is very low for the years 1970-1981. In 1982 it jumped to 0.216 and the next year it reached 0.904 (this is the year of massive rescheduling for the LDCs). It can be seen in figure-1 that the probability of "survivor" or no rescheduling for 1985 is zero.

For Brazil the calculated hazards never reached values close to unity except for the off-sample periods\(^\text{10}\). However the first jump in the hazard occurs in the year of the first R, 1983. In this year the value of the hazard is 0.226 which is not high if we compare it with the hazards for Argentina but it represents the first jump in the hazard rate and it occurs in the year of the first R. The estimated survivor for 1989 is basically zero.

The estimated hazards for Egypt are low. However there is a jump in the calculated hazard one year before the first R happened (1986), where it has a level close to 0.4. In this case the model seems to work fairly well considering that Egypt is a special borrower (it got some government-to-government loans and when this country had some financial difficulties some of the loans were forgiven).

\(^{10}\) The hazards are 0.724, 0.843, and 0.930 for the years 1989, 1990 and 1991.
The case of Korea is interesting. In spite of Korea being a heavy borrower and having had some repayment difficulties, it never had to reschedule its debt. The calculated hazards and survivors show this situation: very low probabilities of R for the period 1970-88. For example the survivor for 1988 is 0.773.

The case of Mexico is also interesting. The estimated hazards are very low for the years 1970-1981. In 1982 there occurs a small jump (the hazard is 0.233 for this period) but in 1983, year of the first R, the estimated hazard jumps to 0.983. After 1983 the calculated hazard fluctuates but always having high values. For the off-sample years the hazard stays very high again (close to one). The survivor for 1985 is basically zero (0.001192), meaning the probability of not having had a R in the period 1970-85 is practically zero. The estimated hazards do not explain well the occurrence of Rs for Turkey, Yugoslavia and Zaire. For the second case the estimated hazards are always very low in spite of the fact that Turkey had to reschedule her debt in 1978, 1979, 1980 and 1982. The jump in the hazard occurs in 1979 (year of the second R). The probability of survivor for 1991 is 0.498. Yugoslavia is very interesting. This country had to reschedule its debt 5 times during the period considered, however, the estimated hazards are always low. We expected some different behavior from Yugoslavia since it represents a non-market oriented economy. The estimated hazards for Zaire are very low for the period 1970-1978. In 1979 occurs the first important jump in the hazard rate (it reaches 0.175) however this is the year of the third not the first R. Since then the hazard fluctuates but keeps growing. For example the hazards for 1989,1990 and 1991 are 0.555, 0.640 and 0.724. The survivor for 1989 and 1990 is practically zero (0.012 and 0.005).
Figure-1

Argentina Base

Probabilities

Years

0.0 0.2 0.4 0.6 0.8 1.0

Survivor

Hazard
Figure 2

Brazil
Base

Probabilities

Years

Survivor
Hazard
Figure-3

Egypt
Base

Survivor
Hazard

Probabilities


Years
Figure-5

Mexico
Base

\[ \text{Probabilities} \]

\[ \text{Years} \]

--- Survivor
--- Hazard
Figure-6

Turkey
Base

![Graph showing Turkey Base with years from 1968 to 1993 and probabilities ranging from 0.0 to 1.0. The graph includes lines representing Survivor and Hazard.]
Figure 7

Yugoslavia Base

Survivor Hazard

Probabilities

Years


1.0 0.8 0.6 0.4 0.2 0.0
Figure-8

Zaire Base

Probabilities

Years


Survivor Hazard
As we said the hazards and survivors presented in figures 1-8 are based on the actual values of the covariates for the period 1970-1988, recalling that OLS\textsuperscript{11} was used to get the off-sample value for the covariates. This is the reason why we called it the base scenario. As an alternative to this we calculated hazards and survivors for three different scenarios of the covariates. The idea behind this is to investigate what could have been the result having the covariates being different during the period 1970-1991.

In the first scenario, called Libor, all the covariates are the same as in the base scenario with the exception of the index for real LIBOR and the inflation rate in the U.S.A. We fix the real LIBOR to be 3% over the whole period while the inflation rate is fixed at 4%. We said in Chapter IV that these two variables are used because they indicate the situation of the financial and commodities market so when we fix these two variables at low levels we are trying to investigate what influence better conditions abroad could have had on borrowing countries. Notice that a real LIBOR of 3% does not mean better than the actual conditions for some years. For example the actual real LIBOR was negative for some years in the middle of the 1970s.

The second scenario, called Debt, consists of the same covariates as in the base scenario except for the debt to imports ratio. In this scenario we assume that the rate of growth of the outstanding debt is 70% the actual average growth the period 1970-1988. For this scenario we created another time series for debt by assuming a smooth rate of growth, i.e. we did not incorporate the normal fluctuations that this variable shows so we assumed a smooth path for this variable. Once obtained, the new series for the debt was divided by the actual series of imports to get the new debt to imports ratio. The idea behind including this scenario is to

\textsuperscript{11} Regressing each single series against time.
investigate what difference could have been made a reduced level of debt.

In the last scenario, called Exports, the variable real exports to estimated exports (which is an index of export fluctuations) is set to one for the whole period. The rest of the covariates are equal to their values in the base scenario.

Calculated hazards and survivors for the six countries and the three scenarios are plotted in figures 9-24 (in these figures we use black dots instead of straight lines to show actual time of R). The results show that the scenarios base and exports produce very similar results for all the countries. The scenario Libor also gives similar results to these two scenarios although for some countries like Brazil, Mexico and Zaire there are some differences. The differences consists in some fluctuation of the calculated hazard.

The debt scenario is the only one that really produces different results. The differences can easily be seen for the case of Argentina, Brazil, Mexico and Zaire. For the Argentinean case the difference is impressive showing that a reduced level of debt would have made Argentina a lot less prone to R. The same can be said about Brazil, Mexico and Zaire.

The Korean case is interesting. The results of Figure-12 indicates that the survivor is lower under the export than under the debt and Libor scenarios. Since estimated exports (which are used to evaluate the real estimated exports ratio) are just the trended exports (the result of using OLS on exports and time) and since exports in Korea have been growing very fast the scenario of an actual to estimated exports ratio equal to one implies lower than normal export revenues for Korea under the Export scenario considered. This is why this scenario produces for Korea lower survivors. For Egypt the hazards are slightly lower under the
exports and debt than in the base scenarios, but the differences are not very important. For the Yugoslavian case all the scenarios seem to produce very similar results (the estimated hazards were already very low in the base scenario). The case of Turkey is similar to the Korean. The export scenario produces lower survivors than the other two scenarios (the libor scenario produces just slightly lower survivors than the debt scenario). The reason for this result can be found, as in the Korean case, in the behavior of the Turkish export sector.
Figure-9

Argentina
Estimated hazards

Year Probabilities

--- Libor
- - Debt
--- Exports
Figure 10

Argentina
Estimated survivors

Probabilities

Years


Libor
Debt
Exports
Figure-11

Brazil

Estimated hazards
Figure-12

Brazil

Estimated survivors

Probabilities

Years
Figure 13

Egypt
Estimated hazards

Proportions


Years

Libor
Debt
Exports
Figure 14

Egypt
Estimated survivors

Probabilities


Years

Libor
Debt
Exports
Figure 15

Korea

Estimated hazards

Probabilities

- - - - Libor
- - - - Debt
- - - - Exports

Years

Figure-16

Korea

Estimated survivors

Years


Probabilities

0.0 0.2 0.4 0.6 0.8 1.0

Libor

Debt

Exports
Figure-17

Mexico
Estimated hazards

[Graph showing estimated hazards for Mexico from 1968 to 1993, with lines for Libor, Debt, and Exports, and probability levels indicated on the y-axis.]
Figure-18

Mexico
Estimated survivors

Probabilities

1.0
0.8
0.6
0.4
0.2
0.0

Years

--- Libor
- Debt
--- Exports
Figure-19

Turkey
Estimated hazards

Probabilities

Years


Libor
Debt
Exports
Turkey
Estimated survivors

Figure-20
Figure-21

Yugoslavia
Estimated hazards

Probabilities

0.0  0.2  0.4  0.6  0.8  1.0


Years

- - Libor
- - Debt
--- Exports
Figure-22

Yugoslavia

Estimated survivors

- - - - - Libor
-- -- Debt
--- -- Exports

Years


Probabilities
Figure-23

Zaire
Estimated hazards

Probabilities

Years

Figure-24

Zaire
Estimated survivors

Probabilities

Years


Libor
Debt
Exports
CHAPTER VII

CONCLUSIONS

The main purpose of this dissertation was to estimate probabilities of rescheduling when state dependence and heterogeneity are present. The first problem arises from the possible existence of serial correlation in the dependent variable R. The second problem emerges from the fact that there are many unobserved variables that may be important in explaining repayment problems. These variables are unobserved mainly because there is no reliable information for political and structural variables for most of the LDCs. In this case the unobservables were included in the estimation as a random component with a standard normal distribution.

This dissertation included a discussion of the development of the loan market for LDCs and a discussion of the types of repayment problems that exist; this is covered in chapter two. In chapter three, a simple model of optimal borrowing with possibility of R is included. The model shows in a simple way how rescheduling can be produced when there exists rational behavior by economic agents. In chapter five a brief review of the literature is presented and duration models are discussed.

The results of the estimation are presented in chapter six. These results show that there exists a big difference between the first occurrence of a R and the second, third, etc. These results were anticipated in chapter four when some preliminary estimates were made of the survivor functions (the Kaplan-Meier statistics) and we concluded that it made a difference when we talk about the first occurrence of R or when we talk about recurrent Rs.
In the estimation of the hazards we found that in general the covariates included were significant with the exception of the debt service ratio. We found that there exist state dependence and heterogeneity in the model. We found that the source of heterogeneity is not regional differences. As a result of the existence of state dependence and heterogeneity we estimated two hazards: one for the first occurrence of Rs and the second for the next occurrences of Rs and integrated these hazards with respect to a random variable. The random variable representing the unobservables was assumed to have a standard normal distribution. The results were very different depending on the order of the transition. For the first hazard the model seems to work fine. All the covariates except the debt service ratio are significant, but for the second hazard the covariates do not seem to the explain the occurrence of Rs with the exception of the index of exports fluctuations. This result could have been expected if we look at the Kaplan-Meier statistics, where the second or third failure occurs rather quickly (the Kaplan-Meier statistic drops after one period).

The fact that the covariates did not help to explain second and third occurrences of R implies that there is a problem with the specification of the model. One factor that was not considered in the borrowing model was the fact that after 1982 which is the year of the debt crisis, the creditors almost stopped extending loans without first considering if a particular LDC has been a good borrower\(^1\) or not. This withdrawal from the loan market created general repayment problems among LDCs. Before 1982, few LDCs experienced financial difficulties. After this period (when R were common) some LDCs faced either a second or third R, for this reason the covariates did not

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\(^1\) This situation is not new, Eichengreen (1989) say that after the repayment crisis of the 1930s creditors stopped extending creditors to almost every borrowing country, regardless of whether the borrowing country was, or not, a good debtor.
help to explain the recurrence of R as something else was happening (the withdrawal of creditors from the capital market). Other factors not included in the estimation were data on political variables. As Berg and Sachs (1988) pointed out the trade regime and distribution of income are important variables in determining the type of country that faces repayment difficulties. Another source of problems was the lack of complete data on private and short term debt as well as data in general on short term debt. For this reason we had to restrict the analysis to public and publicly guaranteed debt.

Since the model predicted the first occurrence of R better, we carried out some simulation exercises for the first occurrence of a R. In this exercise we calculated per-period hazards and survivors for eight countries for four different scenarios of the covariates. The results of the simulations show that the scenario that really makes a difference is when we assume a rate of growth for the nominal debt of 70% the actual growth. This result would imply that the major problem of LDCs has not been exports fluctuations, situation of the capital market, amount of the debt service due or the level of reserves but the level of the outstanding debt. We can say that this variable plus previous repayment problems are the major determinants of Rs.

The results of the estimation and simulation seem to indicate that LDCs are having not liquidity problems but a more severe type of problem that could be a solvency problem. In this case the solution to the debt crisis of LDCs should take into account that the main factor of reschedulings is the level of the debt.

As we said in Chapter II new approaches to the debt problems have been tried since 1985. The first being the Baker-plan and lately the Bradley-plan. In both these plans the main idea was to extend credit lines to LDCs and to offer a discount on the debt. The first plan did not work well because the debt-equity swaps were
creating some problems in LDCs economies. The second plan, which is newer, stipulates the need for a debt reduction based on the exchange of debt titles. This debt exchange needs the support of some international institution of government to supply the resources needed as collateral. Without this collateral the private bankers will not accept the new debt titles in exchange for the old ones.
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