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By

Chien Nan Wang

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ABSTRACT

THREE ESSAYS IN INTERNATIONAL FINANCE

AND ECONOMETRICS

By

Chien Nan Wang

(1) An Empirical Analysis of the Choice of Exchange Rate Regimes

The current exchange-rate system is characterized by a wide diversity of exchange-rate arrangements. This diversity is consistent with the "optimum currency area" theory in that the optimum degree of exchange-rate flexibility is based on a cost-benefit consideration of country characteristics. In this essay, a multinomial logit model is established to test the above theory for different regime classifications. Both 1977 and 1980 data are used to see if countries are learning over time. The empirical findings support the optimum currency area theory and thus this empirical model.

(2) Sovereign Risk and Capital Market Equilibrium

This essay presents a theoretical model to describe the effects of default risk on international lending to LDC sovereign borrowers. Walrasian Equilibrium and Credit Rationing Equilibrium are differentiated to provide the

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basis for further theoretical and econometric work. The author establishes a new rationale for credit rationing. The author's work also extends previous works in several respects: (a) it distinguishes the market structure facing borrowers so that Jaffee and Russell's (1976) and Stigliz and Weiss' (1981) Credit Rationing Equilibria become special cases of the model established in this essay; (b) it assumes a risk-averse utility function on the borrower's side to get an interior Walrasian Equilibrium solution; (c) it analyzes different risk taking behaviors of the lender; (d) it considers the portfolio-choice between internal and external investment on the borrower's side; and (e) it incorporates expropriation risk in tandem with default risk to explain the capital-flight phenomenon.

(3) <u>An Econometric Framework for Studying the International Credit-Rationing Problem</u>

An econometric framework capturing the central feature of the theory devleoped in essay 2 is established in this essay to study the international credit-rationing problem. This econometric model is exhaustive in considering all possible types of supply-demand interactions, and it considers both the linear and the non-linear demand curves. The likelihood function can be derived analytically in the linear demand case, but Monte Carlo Integration and Importance Sampling are needed to evaluate the likelihood function in the non-linear demand case.

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As I reach the end of this research journey, I am glad to acknowledge the unique set of individuals who have helped me through difficult stages along the way.

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CHAPTER ONE

INTRODUCTION

A. AN OVERVIEW OF THE CURRENT EXCHANGE RATE SYSTEM

The current exchange rate system is composed of a variety of exchange rate arrangements among countries. The peggers far outnumber the floaters, but two-thirds to four-fifths of world trade and finance are conducted among floaters. Therefore, in trade-weighted terms, the current system is much better classified as a floating-rate system. The fact that countries have chosen to adopt such a wide variety of exchange-rate arrangements suggests that the optimal degree of exchange-rate flexibility may differ across countries, owing probably to their different economic structures.

Let us investigate several characteristics of the current exchange-rate system. First, a stable system of exchange rates is now seen to be based not only on the exchange-rate regime, but also on stable macroeconomic policies at the national level. Therefore, IMF's surveillance incorporates member countries' exchange rate policies and other macroeconomic policies.

The importance of macroeconomic policies to the stability of the current system originates not only with the direct impact of macro policies on current exchange rates, but also with the "expectation" effect. While the former is a familiar subject in international finance, the latter comes from the triple properties of a floating system: (1) current exchange ra

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rates are heavily influenced by expected future exchange rates; (2) expected future exchange rates are heavily influenced by expected future macroeconomic policies; (3) these expected future policies are heavily influenced by past policies. Therefore, exchange-rate policies can not be divorced from basic macroeconomic policies under a floating rate than they can under a fixed rate.

Second, exchange-rate variability has been much greater during the floating-rate period than it was during the last decade of the adjustable-peg system. The greater variability is compatible with the asset-market view of the exchange rate (see for example, Frenkel [1981]). That is, the exchange rate fluctuates in response to new information that is continually being received by the market. And because goods and labor prices adjust much more slowly than the exchange rate in the short run; the latter, in the short run, takes the sole responsibility of adjustment to disturbances and may "overshoot" its equilibrim position (see Dornbusch [1976]).

Third, most countries continue to regard exchange rates, at least in part, as a policy target. Official intervention and the accompanying demand for reserves, have been substantial under the current exchange-rate system--they have not been greater than that under the fixed-rate system. The exchange market intervention has not only aimed at countering disorder, but also at resisting depreciation due to the concern of its inflationary consequences, and resisting appreciation in order to maintain competitiveness.

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As I mentioned earlier, the current system is better classified as a floating-rate system in trade-weighted terms. Thus it is interesting to examine whether the current system sheds lights on the age-old debate about the merits and demerits of flexible rate. More than a decade's floating rate experience shows that floating rates do not provide complete insulation against external disturbances. They have not provided rapid and automatic external balance adjustment; and they have not significantly reduced the demand for international reserves. But neither have floating rates led to a collapse in international trade and investment. They have not destroyed the discipline necesssary to fight inflation; and they have not produced continuous ratchet effects and repeated vicious circles. Moreover, disciplined and internationally coordinated macroeconomic policies--which are usually paired with fixed rates--are showing their importance under floating rates in a world with highly mobile assets and commodities across countries.

During the recent floating rate period, major industrial countries' economic performances have been far worse than they were during the last decade of the adjustable-peg system. However, we cannot place the sole blame for this on the current exchange-rate system itself, because there were also significant environmental changes. The environmental factors include not only external disturbances, but also long-term structural and institutional changes. The former includes, among other

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factors, two major oil-price increases, and the monetary and fiscal policies adopted in their wake; the latter includes, among other factors, the indexation of wages and salaries, the fall in the profitability of firms, and the contemporaneous slowdown of investment growth (see Goldstein [1984]).

Given the disruptive events of the past 15 years, it is easy to be impressed by the resiliency of the current exchange-rate system. Besides some factors mentioned above, the disruptive events also include large changes in current account positions; a number of important bank failures; several serious regional conflicts; and the sometimes large intercountry differences in inflation rates, in monetary policies, and in policy mixes. All of these events have been accommodated (with the exception of LDCs) without either suspending the operation of the exchange market or implementing wide-scale restrictions on trade and capital flows. A weakness of the current system is that the highly variable real exchange rate may impose more resource-allocation costs, but it is compensated by its having smaller average size and average persistence of payment inbalances than those under the adjustable-peg system.

The key to the high adaptability of the current system lies in the present IMF codes of conduct (i.e., the Article of Agreement) that permit Fund members a wide choice of exchange-rate arrangments. A country opts for the fixed rate if it sees that the benefits exceed the costs. The same criterion applies to a floating-rate country, a snake country, and a crawler. The w

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market-based, decentralized, exchange-rate-regime decision provides safety valves when the assignment of adjustment responsibilities and the effort of exchange-rate alignment are not successful. Moreover, the current system is not subject to severe speculative attack as the stringent adjustable-peg system was.

The facts that the current system is characterized by a wide diversity of exchange-rate arrangements, and by pronounced variations in the management of exchange rates across countries, do not imply that it is a non-system or that it lacks a logical foundation. Quite the contrary. This diversity is consistent with the proposition that the optimal degree of exchange-rate flexibility is based on a cost-benefit consideration owing to country characteristics. The "optimum currency area" literature provides the relevent cost-benefit criteria for regime choice. An empirical model based on this theory may provide a useful policy recommendation for the exchange-rate-regime choice. The within-sample prediction may be useful for criticizing the current IMF exchange-rate-regime classifications.

In the first essay (Chapter Two), a multinomial logit empirical model is established, based on the "optimum currency area" theory. While the previous studies on exchange-rate-regime choice are mostly based on a binary regime option or a continuous measure of exchange-rate flexibility, my model tests the "optimum currency area" theory for finer regime classifications with higher statistical efficiency. Previous works are mostly based on 1977 data, while I employ both 1977 and 1980 data to see if countries are learning over time about the choice of the optimal exchange-rate regime.

B. AN OVERVIEW OF THE SOVEREIGN DEBT DEFAULT PROBLEM

In August 1982, Mexico announced that it was unable to service its external debt of approximately $80 billion. Because Mexico's debt default would wipe out many bank lenders' capital positions and cause a chain reaction of bankruptcies, panic quickly spread across the international financial community. Fortunately, through a joint effort of international organizations, such as IMF and World Bank, along with central banks, and commercial banks, and Mexico and other debtor countries, there was effective intervention in the crisis and the breakdown of the international financial system was prevented. However, the root of the problem is still there. That is, many developing countries accumulated a huge amount of debt, which currently totals more than $900 billion. A pessimistic scenario is that LDCs cannot repay; they can only roll the debt over by rescheduling or refinancing until one day they quit the debt repayment effort and default. Then the international financial system will be in a severe crisis again.

Sovereign default risk is the risk that a sovereign government may default on its debt or debt guarantee obligations. A country usually has a sovereign government. A sovereign country, such as Mexico, may refuse to fulfill its debt obligation and cause default. Sovereign default risk exists when there is a non-negative probability that default may occur. Generally speaking, the risk applies to

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any sovereign country. However, the LDC (Less Developed Country) debt problem is not only a historical concern but also an important international economic issue in the 1980s and the foreseeable future. Therefore, I will focus on the LDCs. Most loans to LDCs are loans to a government or guaranteed by the government of the debtor country. Because of the prevalent cross-default clause in the international community, the default on individual loans has a nationwide impact. Therefore, the main concern of the LDC debt problem is sovereign borrowing, which includes government borrowing or borrowing guaranteed by government.

We can view the LDC debt problem from the external and internal aspects of LDCs. The external environment has recently been characterized by sluggish growth, high real interest rates, and deteriorating terms of trade. External shocks caused a huge current-account deficit and resulted in a high level of foreign borrowing. International lending was excessive before the 1982 debt crisis, but overly restrained after 1982. The internal LDC policy management worsens the debt situation by leading to a large budget deficit due to tax collection difficulties, excessive expenditures, a large money supply due to accommodation and inflationary finance, and overvaluation of the currency due to an overly low pace of devaluation. The mismanagement of LDC internal policies, combined with their structural rigidities, worsens the stabilization and adjustment problems in a changing international environment. These in turn create further debt problems.

Economists frequently assume that a sovereign borrower makes the default choice based on a cost-benefit consideration. The benefit of default is that the country escapes its debt-service obligations. The cost comes from foreign retaliation, which can be the prohibition of future borrowing or trade, or seizure of the borrower's foreign assets. Modern trade is based on a complicated trade credit system, so there is another cost when the trade credit is eliminated. Debt repayment will be on schedule if the cost of default is larger than the benefit; debt default will occur if the cost of default is smaller than the benefit. Therefore, a sovereign borrower may be able to repay the debt but choose not to do so. Because of sovereign immunity from foreign interference, a sovereign debtor can choose to default and will not be forced to repay the debt.

The larger the outstanding debt, the higher the benefit of default will be; therefore, the default risk will be higher. Lenders thus constrain their offering of credit to control default behavior. The lender's offer of credit interacts with the borrower's demand for credit to determine the actual loan in the market. It is possible that interest-rate movements are insufficient to eliminate an excess demand for credit. In this case, credit rationing occurs.

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There are similarities and differences between sovereign default and corporate default. Like the sovereign default decision, the corporate default decision is based on a cost-benefit consideration. But here the cost is attached to the equity holders of the firm, and the cost is the firm's future profitability or the future income stream which is lost under default. A firm chooses to default when its net worth is negative. A corporation, like a government, constantly chooses policies that make a future default less likely, thus increasing its creditworthiness. However, for a sovereign government, there is nothing like domestic corporate covenants or bankruptcy provisions; there is no uniform commercial code governing the design and interpretation of a sovereign-loan contract, and no effective international institution to enforce the payment of sovereign debt. It is the lack of such provisions and the inability to seize assets in default that are likely to make credit rationing more prevalent in the international capital market.

International lending was important both before 1930 and after 1970. In the earlier period, default was a recurring phenomenon, across countries and over time. Default was typically settled in negotiation with private bondholder committees, and terms rarely preserved a small portion of the original assets. After this partial repayment, the debtor country could resume borrowing.

subject to a high-risk premium. The widespread international defaults in 1931 and 1932, during the Great Depression, caused the collapse of international borrowing for the succeeding forty years. Large-scale, private-bank lending emerged during the late 1960s. After that, the private lenders strongly resisted the substitution of debt relief for debt rescheduling. Rescheduling is a serious effort to preserve the capital value of outstanding debt. Interest and principal are almost never reduced. Rescheduling usually accompanies a stabilization program supervised by IMF. The program usually includes restrictions on government budget deficit, money supply growth, and commodity price support. It frequently lowers the current account deficit, but the debtor country incurs heavy political and economic costs. Among the successful examples are Chile and Peru; both achieved high economic growth and declining external indebtedness relative to the GNP. However, some countries, such as Zaire and Sudan, lowered their debts, but experienced extreme hardship. Certain debt relief measures should be seriously considered for these troubled countries.

A prospective theoretical development is to consider the strategic aspect of international borrowing. First, while pre-1930 borrowing was characterized by a non-cooperative game, in which there was no formal mechanism enabling a debtor country to commit itself to particular behavior in return for a loan agreement; the post-1970 borrowing was characterized by a cooperative game in which creditor clubs and bank representatives have repeatedly negotiated with debtor countries, and IMF has played the role as an arbiter (see Sachs [1982]). Second, in the negotiation process, how much the borrower pays and how much the lender gives up depend on their bargaining power and are appropriately analyzed by bargaining theory. Third, for the unenforceable, imperfectly competitive, and medium-term or long-term international loan contract, a long-term, dynamic, game theoretic analysis (e.g. "reputation" theory) is of crucial importance. This provides a general model to explain the existence of credit rationing, of rescheduling, of increasingly short-term international credits and of the limited access of poor countries to commercial loan markets (see Crawford [1984]). By interpreting these phenomena as part of the expected outcome from a game played under given conditions, it is possible to assess the impact of changes in the rules of the game.

Now the global environment is not as supportive as it could be. Financial flows to the troubled LDCs are insufficient; and the debtor countries have been lagging in making internal adjustments and opening their economies. Therefore, we need to inquire about how to manage LDC debt effectively, thus decreasing the sovereign-default risk. As suggested in <u>World Debt Tables</u> (1985, 1986) and <u>World</u>

Financial Markets (September/October 1985), the first priority is to boost OECD (Organization for Economic Cooperation and Development) economic growth. For Europe and Japan, expansionary demand policies are recommended; while for the U.S., further reduction of interest rates is necessary. An international joint effort to lower trade barriers is needed to curb the protectionist clamor. International organizations, such as IMF and the World Bank, should consider more flexible financing for LDCs in a broader context. Commercial banks should explore innovative approaches to LDC financing, such as lending in home currency or multiyear, new-money facilities. Debtor countries should curb their inflation, cut down their public sector and price-control categories, and adopt an export-oriented policy. Increased flow of foreign credit should be linked to policy reforms and structural adjustment, and to the increase of industrial-country exports to LDCs. In all, a wide-ranging international joint effort is the key to managing the LDC debt-default problem.

As has been explained, the existence of sovereign-default risk sometimes induces credit rationing in the international capital market. The other possible market result is Walrasian equilibrium, in which the market clears. A study of the credit supply, credit demand, and market equilibria helps us to define the main characteristics of the market. We can thus predict and affect the resulting equilibrium in the international capital market. The accompanying study of creditworthiness, which is a study of default-choice behavior, helps us to evaluate a country's debt-servicing capacity and set up a guideline for debt relief and new maturities in the renegotiation process.

Practical concerns aside, the existing literature on credit rationing has numerous defects. Disequilibrium models do not have a sound theoretical basis; and incentive (adverse selection and moral hazard) models complicate the theory unnecessarily. Moreover, a close link between the theoretical and empirical models in credit-rationing literature is rare.

In the second essay (Chapter Three), I establish a simple, yet useful theoretical model to study the capital market equilibria under the impact of sovereign-default risk. A basic consumption-loan model is established first, and then the model is extended to incorporate both internal and external investment. Both market equilibria and default behavior are studied. There are several extensions from previous works, and the simultaneous inflow and outflow of capital to LDCs is rationalized.

In the third essay (Chapter Four), I establish an econometric model based on the theoretical framework established in the second essay. The econometric model captures the theoretical features in the second essay and differs in specification from previous limited dependent variable econometric models.

In the future I plan to do an empirical study based on the framework of essay two and three. This study will provide insight into the international capital market structure. The model can also be applied to study domestic default behavior in tandem with its impact on the domestic capital market.

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CHAPTER TWO

(ESSAY 1)

AN EMPIRICAL ANALYSIS OF THE CHOICE OF EXCHANGE RATE REGIMES

A. INTRODUCTION

Since the breakdown of the Bretton Woods System, a system of "generalized managed floats" has emerged. It is composed of managed float, joint float, and pegged exchange rate arrangements. The related theoretical development in "optimum currency area" literature analyzes the choice of a country's exchange-rate regime based on a set of country characteristics. It is interesting to see whether the empirical evidence provides support for these theories and whether the actual exchange rate regimes are compatible with the predictions deduced from the optimum currency area theory variables.

A currency area is the domain of one or two or more currencies linked closely together so that they are equivalent to a single currency. The literature of "optimal currency areas" weighs the arguments for having only a few large currency areas--at the extreme, a single currency for the whole world--against the arguments for a great many independent currencies, each circulating in a small area. The weight given to each argument depends on the currency area's economic characteristics (see Yeager [1976]).

Most of the related empirical models, including the one adopted here, are based on a cost-benefit analysis. It is assumed that the sampled nations chose their exchange regime to minimize the disturbances in their balance of trade, adjustment costs, and misallocation of resources. Because the benefit can be viewed as the foregone opportunity cost, all the explanatory variables are cost-related. The explanatory variables are the important factors in deciding cost.

The concept of "flexibility" needs to be clarified. Different exchange regimes are classified according to different degrees of flexibility. Flexibility is different from variability in that the former is an *ex ante* concept which conveys the policy content, while the latter is the *ex post* actual variation over a period of time.

The optimum currency area literature traditionally seeks to explain the choice between flexible rate and fixed rate. But if we make more detailed and finer classifications (e.g., Float, Wide Margin Peg, and Narrow Margin Peg), we suspect that this choice can be analyzed in terms of the same variables. This is an empirical question and will be closely examined.

The choice between pegging with a single currency and a basket of currencies depends mainly on trade with major partners. In the Bretton Woods tradition, the peg is appropriately chosen to maintain internal balance. Here a relevent concept is effective exchange rate, which is defined as a trade-weighted average of the bilateral exchange rates with a country's trading partners. Williamson (1982) argues that stabilizing the nominal effective exchange rate is the best way to reach internal balance. Therefore, the criterion for choosing between a single currency and a basket of currencies is the stabilization of nominal effective exchange rate. The empirical work will follow this criterion.

The optimum currency area theory has been tested previously by Dreyer (1976), Heller (1977, 1978), P. Holden, Holden, M. and Suss (1979), and Weil (1981). Dreyer employed probit analysis to examine the exchange rate policies of developing countries. His main concern is "prediction." Heller used discriminant analysis in his studies to ascertain whether the suggested optimum currency area variables functioned to distinguish nations in different groups and to test whether the exchange rate policies were appropriate. Holden & Suss constructed a proxy for exchange-rate flexibility and tested the theory using OLS. Weil employed OLS and binary logit techniques on a general classification of floating and pegging countries.

While many of the previous studies reach the same conclusions as those in this paper, this paper differs from them in the following respects:

(1) Heller's discriminant analysis provides appropriate predictions, but it is a non-parametric method, which provides no appropriate interpretations

for the parameter estimates. Probit and logit analyses do not have these weaknesses.

(2) Dreyer's multinomial probit analysis (three alternatives) is quite similar to the multinomial logit analysis in my model. Probit analysis assumes normal distribution of the disturbance, while logit analysis assumes logit distribution. They are similar except for the tail. Only a large sample can reveal the differences. However, the logit model is preferable in the sense that we can get closed form representation of its density and cummulated distribution functions. Dreyer's main concern is prediction. Neither hypothesis tests nor the potentials of different-dimension probit models are studied.

(3) Weil's binomial logit analysis provides the foundation for this paper, but his model has statistical package problems and is deficient in statistical efficiency.

(4) Dickman's multinomial logit model (three alternatives) was an inspiration for this paper, but Dickman obtains a pessimistic result that is distinct from the optimistic result in this paper. His different result is perhaps due to sample selection bias (he omits nations with crawling pegs from the sample). In addition, some of Dickman's

variables are defined differently from mine, and he combines some data that are not consistent.

(5) Holden's and Suss' continuous measure of flexibility is appropriate in studying the optimum currency area theory, and it may set up the criteria for intervention for each country. However, it does not really answer the institutional arrangement question about how to select among discrete exchange rate regimes. It is interesting to note that for the problem of current exchange-rate policy selection, a country actually makes two choices: the kind of regime and the variation of exchange-rate within a regime. While my logit model provides the basis for regime selection, Holden's model provides criteria for intervention within the constraint of a certain exchange regime. Holden's measure of flexibility is the ratio of actual change of exchange rate over the change of reserve, so it can be used as a guide to how much reserve change is compatible with a given exchange-rate variation.

This paper extends Weil's work by employing multinomial logit techniques and more recent data. Some efficiency is gained because of the seemingly unrelated regression nature of the multinomial logit model. We shall investigate the exchange rate regime (dependent variables) in section B. The op

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optimum currency area theory (represented by the independent variables) will be discussed in section C. Then we shall outline the econometric methodology in section D. The econometric results are fully explored in section E, and the conclusion and the future plan are discussed in section F.

B. THE EXCHANGE RATE REGIME (DEPENDENT VARIABLE)

I would like to reiterate the distinction between flexibility and variability. The former is an ex ante concept which conveys policy intent, while the latter is an ex post concept which shows actual variation. Flexibility is our main concern. A discrete qualitative measure is used in this paper. It is compatible with IMF classification and provides a tool for studying the institutional aspect of IMF arrangement. The potential and usefulness of the multinomial logit model are also studied in this context. Data from 1977 and 1980 are employed in this study. The former are employed so that they can be compared with several major studies which employ 1977 data; data from 91 countries are used. 1980 data are employed so that we can compare a country's exchange regime choice behavior over time; data from 88 countries are used.

The dependent variable is defined according to IMF classification of the exchange rate practices of member countries contained in their Annual Report of 1977, i.e.:

(a) Narrow Margin Peg (NMP)

(b) Wider Margin Peg (WMP)

(c) Crawler (C)

(d) Group Float (GF)

(e) Independent Float (IF).

where: (a) Maintains exchange rates within a margin less than 2.25% of the central rates.

(b) Maintains a margin greater than 2.25% of the central rates.

(c) Changes rates discretely according to a set of predetermined indicators.

(d) Snake countries, which maintain within group rate up to 2.25% margin and between group rates without margin.

(e) Does not maintain exchange rates within specific margin.

(a) and (b) can be subsumed under "Peg"; (c), (d) and (e) can be subsumed under "Float."

The dependent variable can be viewed as the revealed preference of the authorities regarding the exchange rate flexibility adopted. It is supposed to reflect the cost-benefit calculations more accurately as experience with the new era accumulates.

In the above classification, different degrees of managing a floating rate are ignored, because it is difficult to make appropriate rankings and place floating rate countries in different managed-float categories. We also do not differentiate between single-currency and basket-currency pegging practices in the general classification (although we single out this option in a later section to study different pegging behavior). The justification for this procedure lies in our desire to derive as unambiguous a ranking as possible between these regimes on the basis of exchange-rate flexibility. Also, we claim that the single currency/basket peg distinction involves less difference in its degree of overall exchange-rate flexibility than the narrow margin/wider margin peg distinction.

The crawler is ranked with higher flexibility than the wide margin pegger, and it is classified as a floater. The reason is that a crawler provides long-run flexibility with short-run fixity, while a wider-margin pegger provides the opposite. In the long run, therefore, a crawler provides more flexibility, while in the very short run a wide margin pegger provides more flexibility. Since the break-up of the Bretton Woods system, it appears that the choice of the regime remains at least a medium-run decision. In this period the above ranking of flexibility is reasonable.

Our ranking of a group floater above a crawler in terms of flexibility is based primarily on an appeal to non-group transactions. It is clear that for these transactions the group float provides more flexibility. Further, even for tran

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transactions within a group, a wider margin is observed for group-floating than for crawling countries.

Since 1978, IMF has not classified member countries in terms of narrow margin/wider margin peg practices. Therefore, the 1980 data are used mainly in distinguishing between peggers and floaters and for studying the single-currency/ basket-currency peg choice behavior.

C. THE OPTIMUM CURRENCY AREA THEORY (EXPLANATORY VARIABLES)

The explanatory variables represent the factors thought to be important in determining the size of the costs of adopting any one of the alternative regimes. They are the important variables suggested by optimum currency area theory:

X_1 (Size): "Size" is a proxy for market power. Nations with little market power will have difficulty influencing their terms of trade; therefore, exchange rate adjustment will have little appeal to them. Thus, we would expect to find large nations more prone to adopting a floating rate. As in Heller (1977, 1978) and other studies, the dollar value of each country's GNP is used as a measure of size. The data are taken from World Bank Atlas (1979) (1982). The 1977 and 1980 data are used.

X_2 (Openness): High exchange-rate adjustment cost is positively correlated with "Openness" in an economy. The major reason is that with increasing levels of openness, exchange rate adjustment is expected to be more inflationary or deflationary and therefore less effective. Ratchet effect arguments, the Mundell-Laffer hypothesis, and the absence of exchange rate illusion all hold most forcefully in very open economies. Thus, one expects that more open economies will tend to adopt exchange rate regimes which entail less flexibility than those adopted by less open economies. The concern here about openness relates to foreign trade. I use the ratio of (Export + Import) over GNP as the measure. GNP is taken from World Bank Atlas (1979) (1982). Export and import are taken from IMF Direction of Trade (1982). The 1977 and 1980 data are used.

X_3 (RM): "Resource mobility" directly influences the efficiency with which resources can be transferred between sectors subsequent to an exchange-rate change. High resource mobility is expected to have low resource reallocation costs if a flexible exchange rate is adopted.

The percentage of domestic output originating in manufacturing can serve as a proxy for the degree of resource mobility. A higher value for this ratio is presumed to be associated with more developed markets and more resource mobility. This measure was suggested by Hawkins and Rangarajan (1970) and Hippel (1979). The 1977 and 1980 data are taken from U.N. Yearbook of National Accounts Statistics (1980), (1983).

X_4 (CM): A proxy of "capital mobility" is sought from measures of financial integration. With high degrees of financial integration, the need for exchange-rate changes would be eliminated, because only fractional changes in interest rate would evoke sufficient equilibrating capital movement across national frontiers. This conventional view is questioned on the grounds that (1) capital flows may be stabilizing or destabilizing; and (2) capital flow for financing purposes may not suit the purpose of adjustment. High capital mobility under a fixed rate will frustrate monetary policy and may eliminate its effect altogether. If there is high capital mobility under a flexible rate, then the trade account must offset capital flows. Therefore, domestic resource allocation costs may occur. There is, therefore, no clear theory of how capital mobility may affect the choice of an exchange rate regime.

The measure of capital mobility (financial integration) is proxied by the ratio of commercial bank holdings of foreign assets to central bank holdings of foreign assets in 1977 and 1980. An increase in this ratio is presumed to indicate increasing depth in the foreign exchange market. Central Bank holding of foreign assets is a scale factor to standardize the CM measure. This measure was adopted by Weil (1981). The data are taken from <u>International Financial Statistics</u> (June, 1981), (June, 1984).

X_5 (RIR): When the inflation rate within an economy differs substantially from the rates of its trading partners, the nation has a greater need to adjust its exchange rate more frequently. This is especially true in the case of nations which experience hyperinflation.

The "relative inflation rate" (RIR) is calculated as the square deviation of a nation's inflation rate from the world rate in the 1976-1977 and 1979-1980 period. The world rate is a proxy for the nation's trading partners' inflation rate. The data are taken from IFS (June, 1979), (June, 1982). The 1977 and 1980 data are used.

X_6 (CC): Kenen argues that a low degree of product diversification is a good reason for a country to form an independent currency area. He argues the following: (1) a well-diversified economy where each industry is subject to an external shock provides only a fraction of total employment, and hence the effect becomes less, and an exchange rate adjustment is not necessary; and (2) substantial exchange rate variation would not be very frequently necessary in a diversified economy because of the averaging of external shocks. The competing view is indicated; that is, since the undiversified economy is also likely to be small and open, competing considerations lead us to conclude that we expect more, rather than less, diversified countries to adopt a flexible rate. If a country has a low level of export diversification, that is also small and open, a flexible rate will cause more exchange rate change and higher resource reallocation costs.

The measure of "commodity concentration" (CC, the inverse measure of diversification) is the ratio of the largest trade category to total trade from 1977, 1980 SITC one digit data. It is derived from U.N. Yearbook of International Trade Statistics (1979, 1983, vol. I: Trade by Nation).

X_7 (GC1)

X_8 (GC2): When a country finds that a large share of its exports are sold in only one, or very few markets, a strong case can be made for maintaining its exchange rate pegged to a single country's currency. A relatively geographically undiversified economy could expect to suffer more exchange rate instability than a more diversified economy, so a fixed rate is preferred.

The "geographic concentration 1" (GC1) is the portion in total export to the largest trading partner. GC2 is the portion to the second largest partner. GC2 will not be added until we consider the choice between the single currency peg and the basket peg. The 1977, 1980 data are derived from U.N. Yearbook of International Trade Statistics (1979, 1983, vol. 1, Trade by Nation).

D. LOGIT MODEL

I shall outline the econometric models used in this essay. They are binomial and multinomial logit models. I will start with the binomial logit model.

(1) Binomial Logit

Assuming there is an underlying response variable y_i^* defined by the regression relationship

$$y_i^* = \beta' x_i + \mu_i \tag{1.1}$$

in practice y_i^* is unobservable. What we observe is a dummy variable y_i defined by

$$\begin{aligned} y_i &= 1 \quad \text{if} \quad y_i^* > 0 \\ y_i &= 0 \quad \text{otherwise} \end{aligned} \tag{1.2}$$

from (1.1) and (1.2) we get

$$\begin{aligned} \text{Prob}\ (y_i = 1) &= \text{Prob}\ (\mu_i > -\beta' x_i) \\ &= 1-F\ (-\beta'\ x_i) \end{aligned} \tag{1.3}$$

where F is the cumulative distribution function for μ_i.

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In this case the observed values of y are just realizations of a binomial process with probability given by (1.3). The likelihood function is

$$L = \prod_{Y_i=0} F(-\beta' x_i) \prod_{Y_i=1} \{1-F(-\beta' x_i)\} \tag{1.4}$$

Normal distribution is the most common assumption for the disturbance term. However, logit distribution can be represented in closed form, and thus can be easily analyzed. Therefore, we assume the disturbance term to have a logit distribution.

If the cumulative distribution of u_i is logistic, we have

$$\begin{aligned} F(-\beta' x_i) &= \frac{1}{1 + \exp\,(\beta' x_i)} \\ 1-F(-\beta' x_i) &= \frac{\exp(\beta' x_i)}{1 + \exp\,(\beta' x_i)} \end{aligned} \tag{1.5}$$

Then we can maximize L w.r.t. β to get MLE $\hat{\beta}$.

Note that

$$\begin{aligned} \ln\left(\frac{\Pr(Y_i=1)}{\Pr(Y_i=0)}\right) &= \ln\left(\frac{1-F(-\beta' x_i)}{F(-\beta' x_i)}\right) = \beta' x_i \\ &= E(Y_i^{*}|x_i) \end{aligned} \tag{1.6}$$

So the relative odds of the case $(y_i = 1)$ w.r.t. the case $(y_i = 0)$ can be estimated according to (1.4), (1.5) and (1.6).

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(2) <u>Multinomial Logit</u>

Assuming m categories, $Y_t = 1,2,\ldots,m$; and $P_1, P_2, \ldots, P_m$ are the probabilities associated with these categories. Expressing them in binary form where F is the distribution function of the disturbance term which is logistic:

$$\frac{P_1}{P_1+P_m} = F(x\beta_1)$$

$$\frac{P_2}{P_2+P_m} = F(x\beta_2)$$

$$\vdots$$

$$\frac{P_{m-1}}{P_{m-1}+P_m} = F(x\beta_{m-1}).$$

These imply:

$$\frac{P_j}{P_m} = \frac{F(x\beta_j)}{1-F(x\beta_j)} = \exp\ (x\beta_j)$$

where we use the normalized rule: $\beta_m=0$ (2.1)

Because $\sum_{j=1}^{m-1} \frac{P_j}{P_m} = \frac{1}{P_m} - 1$ this implies

$$P_m = \{1 + \sum_{j=1}^{m-1} \exp(x\beta_j)\}^{-1} \quad \text{then we have} \qquad (2.2)$$

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$$P_j = \frac{\exp(x\beta_j)}{1+\sum_{j=1}^{m-1}\exp(x\beta_j)} \qquad (2.3)$$

This implies the relative odds to be:

$$\ln \frac{P_j}{P_m} = x_t\beta_j \qquad (2.4)$$

Note if we substitute x_t with $\ln x_t$, β_j can be interpreted as the elasticities of the relative odds with respect to x_t, where β_j can be estimated by maximizing the likelihood function with respect to β_js. And

$$L = \prod_{i=1}^{n} P_{i1}^{Y_{i1}} \; P_{i2}^{Y_{i2}} \; P_{i3}^{Y_{i3}} \ldots\ldots \; P_{im}^{Y_{im}} \qquad (2.5)$$

where P_{ij}: probability for ith individual falls into jth category

$Y_{ij} = 1$ if the ith individual falls into the jth category

$= 0$ otherwise

i.e., relative odds in (2.4) can be estimated from likelihood function (2.5).

Since we use McFadden's conditional logit package, we need to be aware of the equivalence between a conditional logit model and a conventional logit model. A transformation is needed to get multinomial logit results from the cond

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conditional logit results. The transformation is described in the appendix.

E. Econometric Results (Early Data)

The econometric results of the tests and predictions are reported here in four parts. The first three parts employ 1977 data. The first part examines the exchange rate regime selection problem with three alternatives: Narrow Margin Peg, Wider Margin Peg and Float. The second part reclassifies the countries involved into two categories: Peg and Float. The third part considers the choice between the Single Currency Peg and the Basket Currency Peg. The fourth part applies recent data (1980) to compare the exchange rate regime choice behavior over time.

(1) The Choice Among A Narrow Margin Peg, Wider Margin Peg And Float.

A Narrow Margin Peg is the kind of exchange rate pegging with a margin narrower than 2.25%. A Wider Margin Peg is the pegging regime with a margin greater than 2.25%. Both regimes peg a rate either composed of a single currency or a basket of currencies. The Float countries are composed of crawlers, group floaters, indpendent floaters and other managed floaters.

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The relative odds* of "Float with respect to Narrow Margin Peg" and "Wider Margin Peg with respect to Narrow Margin Peg" are presented in their MLE (maximum likelihood estimation) results as in Table 5.1-(1), (2), and (3).

(1) Relative odds of Float w.r.t. Narrow Margin Peg

Table 5.1-(1)

Independent Variable	Coefficient	Standard Error	T-Statistics
X_1(SIZE)	0.8126	0.2257	3.6010
X_2(OPEN)	0.1287	0.2760	0.4661
X_3(RM)	-0.3296	0.6993	-0.4713
X_4(CM)	-0.3598	0.2102	-1.7120
X_5(RIR)	0.2941	0.1090	2.6980
X_6(CC)	-0.3925	0.4200	-0.9346
X_7(GC1)	0.3263	0.4107	0.7946
Constant	-6.9290	5.8510	-1.1840

*Relative odds of Float with respect to Narrow Margin Peg is defined as the log value of Prob(Float)/Prob(Narrow Margin Peg). Note here we take the log values of the original independent variables as the independent variables in estimation. Therefore, the estimated coefficients can be interpreted as the elasticities of the relative odds with respect to the independent variables.

(2) Relative odds of Wider Margin Peg w.rt. Narrow Margin Peg

Table 5.1-(2)

Independent Variable	Coefficient	Standard Error	T-Statistics
X_1(SIZE)	-0.1987	0.1629	-1.220
X_2(OPEN)	-0.3647	0.2112	-1.727
X_3(RM)	-0.5400	0.5179	-1.039
X_4(CM)	0.2557	0.1617	1.582
X_5(RIR)	-0.1736	0.0845	-2.055
X_6(CC)	0.0349	0.3685	0.095
X_7(GC1)	-0.9184	0.3204	-2.867
Constant	7.1200	4.5220	1.575

(3) Relative odds of Float w.r.t. Wider Margin Peg

Since $\log(P_1/P_2) = \log(P_1/P_3) - \log(P_2/P_3)$

where P_1: Probability of choosing Float

P_2: Probability of choosing Wider Margin Peg

P_3: Probability of choosing Narrow Margin Peg

We can derive Table 5.1-(3) from 5.1-(1) and 5.1-(2):

Table 5.1-(3)

Independent Variable	Coefficient
X_1(SIZE)	1.0113
X_2(OPEN)	0.4934
X_3(RM)	0.2104
X_4(CM)	-0.6155
X_5(RIR)	0.4677
X_6(CC)	-0.4274

X_7(GC1)	1.2447
Constant	-14.0490

Overall, Likelihood ratio index = 0.4293

Likelihood ratio statistics = 85.84

From Table 5.1-(1), the significant independent variables affecting the relative odds of selecting a Float regime as compared to a Narrow Margin Peg regime are SIZE, CM and RIR. The conventional view of the impacts of SIZE, CM and RIR on exchange regime selection is confirmed.

From Table 5.1-(2), the significant variables affecting the relative odds of selecting the Wider Margin Peg as compared to the Narrow Margin Peg are OPEN, CM, RIR, and GC1. While the conventional views on OPEN and GC1 are confirmed here, the perverse coefficient sign on CM warrants the criticism of conventional theory of CM on the exchange rate regime. The perverse sign of RIR may suggest requiring a better measure of RIR.

From Table 5.1-(3), the sign of CM and RIR (they are significant in both Table 5.1-(1) and 5.1-(2)) are compatible with conventional views.

The likelihood ratio index is analogous to the multiple correlation coeffient, R^2. It is:

$$1- \frac{\text{log likelihood at convergence}^{*}}{\text{log likelihood at zero}} = 0.4293$$

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*Convergence means that the parameter estimate approaches a certain value in an iterative process.

This is quite good among cross-sectional data results.

The likelihood ratio statistic is a goodness-of-fit statistics that is asymptotically distributed as a chi-square with 16 degrees of freedom (# of parameters to be estimated). It is:

2(log likelihood at convergence - log likelihood at zero) = 85.84

which is significant at 1% levels.

Tables 5.2 is the "Success Table" which tells us the prediction success rate of the model, e.g., "1" in the table is the number of cases when the actual practice is Narrow Margin Peg and the prediction from the model is Float regime.

Table 5.2 (Success)

Predictions

(66 correct out of 91 countries, i.e., 72.53%)

A		Float	WMP	NMP
C	Float	12	3	3
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U	Wide Margin Peg	3	10	10
A				
L	Narrow Margin Peg	1	5	44

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		Predictions	
A		% Correct	% Incorrect
C	Float	66.67	33.33
T			
U	Wide Margin Peg	43.48	56.52
A			
L	Narrow Margin Peg	88.00	12.00

It is not surprising that the middle-flexibility regime WMP has the lowest predictability. Due to its intermediate nature, its characters are not sharply contrasted with its neighbors--Float and NWP. The predictability of Float group and NMP group is good. An overall prediction rate is 72.53%.

By looking at the individual inaccurate prediction within each category, I find that 2 out of 4 discrepancies in "Float" come from the intermediate countries (Snake or Crawler), while 4 out of 13 discrepancies in "NMP" come from intermediate category countries. Dropping these incorrect predictions from the intermediate category may sharpen the predictions in Float and NMP. But the re-estimated results do not show any significant improvement. Therefore, dropping data may not be a good strategy.

We may also confirm the view that the snake is composed of Germany floating and others pegging to the Deutsche Mark. The reason is that our prediction for Germany is a floater, while the other snake countries are predicted as NMP. It suggests that the snake itself is a pegging system narrowly defined.

(2) The Choice Between Float And Peg

Here we use a cruder classification where "narrow margin pegger" and "wider margin pegger" are subsumed under "Peg" and "crawlers" and "snake countries" and "independent floater" are subsumed under "Float". The binomial logit model results are:

$$(5.1)\quad \log \frac{P(Y=\text{Float})}{P(Y=\text{Peg})} = \underset{(3.694)}{1.425} \log(\text{SIZE}) \underset{(0.8376)}{+0.3892} \log(\text{OPEN}) \underset{(0.2237)}{+0.2084} \log(\text{RM}) \underset{(-0.857)}{-0.2736} \log(\text{CM}) \underset{(2.247)}{+0.2982} \log(\text{RIR}) \underset{(-1.389)}{-0.7905} \log(\text{CC}) \underset{(1.185)}{+0.6177} \log(\text{GC1}) \underset{(-2.817)}{-\ 15.58}\ \text{CONSTANT}$$

where the numbers in the bracket are the t-statistics.

The likelihood ratio index = 0.5960, which is quite high.

The likelihood ratio statistic = 75.19, which is significant at 1% levels.

The significant coefficients (at 10% significance level) SIZE, RIR and CC, all have the signs compatible with conventional theory. The hypothesis testing performs better in this "2 alternatives" model than in the "3 alternatives" model of the last section. This result is not surprising, because the optimum currency area theory was originally designed to distinguish the choice between the Float and Peg regimes.

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The prediction is successful, as we can see in Table 5.3. Examining the predictions for individual countries, I find four out of a total of nine incorrect predictions are from the borderline countries (snake, crawlers). Only five discrepancies are of serious concern. I also reclassify "snake countries" into "Peg" with the exception of Germany. After rearrangement, the resulting significant variables are OPEN and RIR with correct signs. The overall prediction is the same (this is interesting, although this may be just a coincidence); the individual regime predictions and t-ratios are changed, though.

Comparing Table 5.2 and Table 5.3, we get a lower prediction rate in the "3 alternatives" model (72.53%) than the "2 alternatives" model (89.01%). The reason may be that, with a finer and more detailed classification, it is more difficult to make a clear-cut choice. As for prediction within each regime, an interesting observation is that the success rate is the highest in the group (where each member adopt the same regime) with the largest sample size.

Table 5.3 (Success)
Predictions (81 out of 91, i.e., 89.01%)

		Float	Peg
ACTUAL	Float	18	6
	Peg	4	63

		Predictions	
		% Correct	% Incorrect
ACTUAL	Float	75.00	25.00
	Peg	94.03	5.97

(3) <u>The Choice Between Basket Currency Peg And Single Currency Peg</u>

In Bretton Woods tradition, the choice of the unit to which a country pegs its currency should be guided principally by the pursuit of internal balance, and this requires pegging either to a single or a basket of currencies reflecting the direction and (in principle) the elasticity of total trade (see Williamson, 1982).

Therefore, the distinction between a single currency pegger and a basket currency pegger probably lies in the trade volume. Thus, another independent variable is added to the right hand side, that is, the geographic concentration measure of the second largest trading partner (GC2). The coefficients of both GCs are expected to be positive for the relative odds in selecting a Single Currency Peg as compared to a Basket Peg. The reason is that Basket Peg involves several currencies. If the first two largest trading partners' trade volume is larger, the probability of selecting a Basket Peg becomes less. A binomial logit model is fitted. The prediction result is shown in Table 5.5. The significant coefficients in Table 5.4 are those of OPEN and RM, which are di

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different from the significant coefficients in section (1) and (2). The results here show that the more open a country's economy is and the more resource mobility it enjoys, the higher will be the probability of its choosing a Basket Peg as compared to a Single Currency Peg, while higher geographic concentration produces the opposite result.

From optimum currency area theory, a positive coefficient of RM demonstrates that "Basket Peg" reveals more flexibility than "Single Currency Peg," while a positive coefficient of OPEN demonstrates the reverse result. The theoretical controversy about whether "Basket Peg" or "Single Currency Peg" provides more flexibility in exchange-rate policy remains unsolved. This is also an indication that section (III) and section (I)-(II) are considering different questions. The latter can be answered by optimum currency area theories, while the former needs to be explained by different criteria.

Table 5.4
(Relative odds of Basket Peg vs.Single Currency Peg)

Independent Variables	Coefficient	Standard Error	T-Statistics
X_1(SIZE)	0.3225	0.4114	0.7839
X_2(OPEN)	1.8260	1.1070	1.6500
X_3(RM)	1.8030	1.0840	-0.4862
X_4(CM)	-0.1312	0.2699	-0.4862
X_5(RIR)	0.2102	0.1721	1.2210
X_6(CC)	0.2928E-02	0.7473	0.3918E-02

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X_7(GC1)	-1.0090	1.1070	-0.9113
X_8(GC2)	-1.1410	1.1180	-1.0210
Constant	-9.3900	9.3710	-1.0020

Likelihood ratio index = 0.3423

Likelihood ratio statistics = 23.73

Table 5.5 (Success)

Predictions (38 out of 50, i.e., 76%)

ACTUAL		Peg-S	Peg-B
	Peg-S	29	5
	Peg-B	7	9

Predictions

ACTUAL		% Correct	% Incorrect
	Peg-S	85.29	14.71
	Peg-B	56.25	33.75

(F) ECONOMETRIC RESULTS (RECENT DATA)

Since the current monetary system emerged only after the breakdown of the Bretton Woods System, as time passes and experiences accumulate, countries are supposed to be more shrewd in selecting their regime according to cost-benefit considerations. The actual exchange-rate-regime arrangements change steadily over time, while countries' relative positions

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do not change very greatly. This is perhaps evidence that countries are learning from their experiences about regime-selection behavior. Since optimum-currency-area theory is widely accepted and provides empirically supported economic cost-benefit criteria, I expect that more recent data will better reveal its validity. Another reason that the more recent data might fit the model better is that different countries' exchange rate regimes are interdependent. With more time, it becomes clearer how the other countries behave. There may be a process of convergence to an overall exchange-rate system in which each country's choice preserves an equilibrium, given the choice made by others (see Lane, [1987]). In this paper, I used 1977 data because I want to compare my work with other studies (many of which have used the 1977 data, as the most up-to-date material available). My next plan is to use the more recent data, which is likely to improve my results.

Therefore, I employ 1980 data to re-estimate the above models. I use a careful method in collecting data. If two sources of data can complement each other, but the differences in their overlapped parts do not show a consistent pattern; then I limit myself to a small but safe set of data. After selection and collection, the 1980 data includes 88 countries. As compared to the 1977 data, the 1980 data delete nine countries and add six countries. Since IMF did not differentiate between Wider Margin Peg and Narrow Margin Peg after 1978, my report is on "Float vs. Peg" and "Basket Peg vs. Single Currency Peg" only.

(1) <u>The Choice Between Float And Peg</u>

Following the previous classification of countries into these 2 cells, one for Float and one for Peg, we get the following binomial logit model results:

$$
(5.2)\quad \log \frac{P(Y=\text{Float})}{P(Y=\text{Peg})} = \begin{array}{ll}
0.9653 \log(\text{SIZE}) & -0.8161 \log(\text{OPEN}) \\
(3.355) & (-1.246) \\
+0.4633 \log(\text{RM}) & -0.3829 \log(\text{CM}) \\
(0.6095) & (-1.360) \\
+0.2439 \log(\text{RIR}) & -2.084 \log(\text{CC}) \\
(1.316) & (-1.827) \\
+0.0780 \log(\text{GC}) & +0.0564\ \text{Constant} \\
(0.1068) & (0.0080)
\end{array}
$$

where the number in the bracket is the t-statistics.

The likelihood ratio index = 0.5221.

The likelihood ratio statistics = 63.69

The significant coefficients (at 10% significance level) are those of SIZE, RIR, CC and CM, and all have signs compatible with conventional theory. The prediction result is shown in Table 5.6.

Table 5.6 (Success)

Predictions (73 out of 88, i.e. 82.95%)

		Float	Peg
ACTUAL	Float	21	8
	Peg	7	52

		Predictions	
		%Correct	%Incorrect
ACTUAL	Float	72.41	27.59
	Peg	88.14	11.86

Comparing Table 5.3 and Table 5.6, we get a lower prediction rate from 1980 data (82.95%) than from 1977 data (89.01%). This contradicts the statement elaborated in the beginning of this section. Several probable explanations will be given later.

(2) <u>The Choice Between Basket Currency Peg And Single Currency Peg</u>

Employing 1980 data for pegging countries, we get the binomial logit model result in Table 5.7:

Table 5.7
(Relative Odds of Basket Peg vs. Single Currency Peg)

Independent Variable	Coefficient	Standard Error	T-Statistics
X_1(SIZE)	0.2872	0.2725	1.054
X_2(OPEN)	2.803	1.104	2.339
X_3(RM)	-0.0102	0.6587	-0.0155
X_4(CM)	-0.1286	0.2391	-0.5378
X_5(RIR)	-0.0391	0.2176	0.1795
X_6(CC)	-1.983	1.136	-1.745

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X_7(GC1)	-0.5551	0.7539	-0.7363
X_8(GC2)	-1.814	1.190	-1.525
Constant	0.557	7.054	0.0790

Likelihood ratio index = 0.2676

Likelihood ratio statistics = 21.89.

The significant coefficients are OPEN, CC, and GC 2. The negative coefficient of GC2 is expected. From optimum currency area theory, the negative coefficient of CC reveals that "Basket Peg" is more flexible than "Single Currency Peg," while the reverse is true for the positive coefficient of OPEN. While we can not tell whether "Basket Peg" or "Single Currency Peg" provides more flexibility, this result also suggests that the choice between "Basket Peg" and Single Currency Peg" cannot be answered by optimum currency area theories.

Table 5.8 presents the prediction results by employing 1980 data:

Table 5.8 (Success)
Predictions (44 out of 59, i.e., 74.58%)

ACTUAL		Peg-S	Peg-B
	Peg-S	20	7
	Peg-B	8	24

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		Predictions	
		% Correct	% Incorrect
A	Peg-S	74.07	25.93
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L	Peg-B	75.00	25.00

Comparing Table 5.5 and Table 5.8, we get a lower prediction rate using 1980 data (74.58%) than 1977 data (76%). This is incompatible with the hypothesis elaborated in the beginning of this section.

There are several explanations for this perverse result (also the perverse result on the choice between "Float" and "Peg"). First, we have the data availability problem. Nine countries are dropped in the 1980 samples because of the data insufficiency problem, while six countries are added to restore some degrees of freedom. These changes may affect the results. Second, a country may not learn from previous experience or may not have perfect information about the current international economic variables. A country may also have different regime-choice behaviors during different stages of the business cycle (e.g. while the world was in a slow growth phase in 1977, 1980 was characterized by a mild recession) and different international economic environments (e.g., in 1980, the U.S. adopted new monetary operating procedures, and the second oil crisis had just occurred; the transition may have been bumpy). Finally, we should know that the

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the group characteristics are determined solely on the countries which really adopted the regime. If the countries involved made inappropriate choices (e.g., due to political factors), there is no way to see their policy bias from our statistical procedure. Therefore, the perverse resutls may be due to some countries' erratic choices.

G. CONCLUSION

In this paper, we ask the same question that Heller (1977) did:

> Is the current international monetary system really a system, or is it a haphazard colelction of ad hoc arrangements resulting from decisions by individual countries?

Before we go into summarizing the empirical results, we should be aware that the countries involved may make inappropriate choices which are unobservable from our statistical procedures. Thus, even if the optimum currency area theory is supported from the empirical evidence, this theory may still not be an appropriate guide for the regime-choice behavior. With this caution in mind, we can begin summarizing the results.

The empirical study in this paper shows that there is some inherent order in exchange regime selection, and the op

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optimum currency area theory provides acceptable criteria for that choice. The empirical support comes from two sources:

(A) all the overall predictions based on the logit model with optimum currency area variables have prediction rates above 74%, and some of them are much higher. All the individual regime predictions are above 56%, (except for one in the "3 alternative" model, which is 44.5%. Note, however, when there are more than two alternatives, 44.5% is much better than average.); and some of them are much higher; and

(B) hypothesis tests on the signs of the significant coefficient are mostly compatible with optimum currency area theory.

We can list the details of some observations or findings in this paper:

(1) The prediction results are fairly good in general. When I examine the individual incorrect predictions, many of them are from the intermediary category, so they are not serious mispredictions.

(2) Usually the prediction results on extreme regimes are better than on the intermediate regimes. The reason may be that intermediary characters are not easily distinguished from neighboring regime

characters. Throwing away intermediary observations like crawlers and/or snake countries may not necessarily improve the results on predictions.

(3) In Float-Peg or Narrow Margin Peg-Wider Margin Peg-Float choices, the relative odds of selecting a more flexible regime with respect to a less flexible one increases as the size of the country and resource mobility increase, but falls as openness, commodity concentration, and geographic concentration increase. When the degree of financial integration and the divergence of national inflation rate from world average rate increase, the impact on the relative odds of exchange rate regime choice is ambiguous. While the ambiguous impact of capital mobility is expected from the theory, the ambiguous result of relative inflation rate suggest the need for a better measure of it. However, in general, the optimum currency area theory is supported in both Float-Peg classifications and finer regime classifications and in different years. The "2 alternatives" choice model usually outperforms the "3 alternatives" choice model because the optimum currency area theory was originally designed to explain the choice between Float and Peg.

(4) Significant variables when selection is between extreme regimes (e.g., Float vs. NMP) and when selections are between closed regimes (e.g., WMP vs. NMP) are different. This shows that the relevant variables in making choices are conditional on the alternative regimes considered. When we change the number of alternative regimes, or we shift observations among alternatives, the significant variables change, i.e., we are testing the relevance of different variables.

(5) In Basket Peg vs. Single Currency Peg choice, the relative odds of selecting Basket Peg with respect to Single Currency Peg increase when openness and resource mobility increase, but falls when commodity concentration and geographic concentration increase. These results make it difficult to rank the degree of flexibility between Basket Peg and Single Currency Peg and suggest that the choices between these two regimes depend on criteria that are not taken into account by the theory of optimum currency areas.

(6) The disappointing result that 1980 data is outperformed by 1977 data may be due to the following:

   (i) We do not have exactly the same countries in our 1977 and 1980 samples.

(ii) A country may not learn from experience and may not have perfect information, and the structure relevant to the choice behavior may shift over time.

(iii) Some countries may make inappropriate choices which are not observable from our statistical procedure.

Finally, I would like to mention some possible future research. First, several independent variables may be replaced with improved measures:

(I) We can use a better measure of inflation rate, e.g., the trade-weighted inflation differential devised by Holden:

$$RIR = \Delta P_1 - \sum_{j=1}^{n} a_{ij} \qquad j \neq 1$$

where P_i is the inflation rate of country i; a_{ij} is the proportion of country i's total trade that occurs with country j.

(II) Two alternative measures of commodity concentration can be used:

(a) the ratio of a country's exports of a particular good to world import of that good; this is related to the "market power" explanation for the importance of a country's size;

(b) Hirschman-Gini coefficient of concentration:

$$cc_j = (\Sigma_i (X_{ij}/X_j)^2)^{1/2}$$

where cc_j is the commodity concentration of country j

X_j is the value of exports from country j

X_{ij} is the value of exports in SITC 1-digit category i of country j.

(III) Most GNP series are exchange rate (R) adjusted. However, it is more appropriate to use purchasing power parity (PPP) adjusted data. The reason for this is the Belassa effect. PPP and R are not moving together because of productivity bias. A developed country has higher P_N/P_T ratio as compared to a developing country (P_N is the price of non-traded goods; P_T is the price of traded goods).

Second, we may synchronize the data for 1977 and 1980. That is, we may drop the same nine countries in 1977 samples as those dropped from 1980 samples; we may also drop the six extra country samples in 1980 data.

Third, by using better measures and synchronous data, we would expect to use the optimum currency area theory as a criterion to classify exchange rate regimes. We can then judge whether the IMF classification is appropriate by the way the multinomial logit model performs in terms of hypothesis tests and predictions. And the analysis of regime choice in this paper complements the work of Holden, et.al. (1979), who use a continuous measure of the dependent variable, which is the degree of intervention divided by the degree of exchange rate variability. While my model supplies the recommended regime choice, their model supplies the recommended intervention within a particular regime.

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APPENDIX*

The multinomial logit model makes the choice probability dependent on individual characteristics only. The McFadden conditional logit model considers the effects of choice characteristics on the determinants of choice probability as well.

Algebraically, though, the multinomial logit model and conditional logit model are totally equivalent. Start from the MNL model $P_i/P_1 = \exp\{(\beta_i - \beta_1)X\}$ and assume $X = (Z_1 Z_2 \ldots, Z_n)$ and $\beta_1 = (0 \ldots \alpha \ldots 0)$ to get the conditional logit form $P_i/P_1 = \exp\{\alpha(Z_i - Z_1)\}$. Alternatively, start from the conditional logit form $P_i/P_1 = \exp\{\alpha(Z_i - Z_1)\}$ and assume $\alpha = (\beta_1, \beta_2, \ldots, \beta_m)$ and $Z_i = (0, \ldots X, \ldots 0)$ to get the MNL form $P_i/P_1 = \exp\{(\beta_i - \beta_1)X\}$.

This transformation is needed when using McFadden's conditional logit package to get MNL results.

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*Taken from sections of Maddala's book, Limited-Dependent and Qualitative Variables in Econometrics, 1984.

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CHAPTER THREE

(ESSAY 2)

SOVEREIGN RISK AND THE CAPITAL MARKET EQUILIBUIUM

A. INTRODUCTION

In the 1970s and 1980s, Less Developed Countries (LDCs) accumulated huge foreign debts due to external factors, which included oil price increases and a world recession, as well as internal factors, which included huge budget deficits and hyperinflation. Two main forms of international lending to the LDCs prevail: official and private bank lending. While the former may be significantly affected by political factors, the latter is more probably based on economic rationale and is the concern of this paper. As elaborated in Chapter One, the main concern in the LDC debt problem is sovereign borrowing (see also Eaton and Gersovitz [1981b]), which includes government borrowing or borrowing guaranteed by government.

International capital mobility is supposed to provide LDC with sufficient funding, but the capital availability problem is serious for LDC. One probable reason is the higher sovereign risk (repudiation risk) which characterizes the third world financial environment as compared to the financial environment in the first world. Repudiation of debt is a sovereign choice when the country can repay the debt but choose not to repay based on a cost-benefit consideration.

As opposed to domestic borrowing, sovereign borrowing is characterized by non-enforceability due to sovereign immunity from foreign interference. Unlike in domestic corporate covenants or bankruptcy provisions, there is no common commercial code and there are no international enforcing institutions. Moreover, time inconsistency problems arise when a borrower's statement on the amount of new borrowing or future spending is violated after the borrowing takes place (see Hellwig [1977]). This problem highlights the importance of precommitment in terms of future expenditure programs (e.g. under IMF conditionality) to attract large loans at lower rates (see Sachs and Cohen [1985]). The existence of international lending while debt repayment is unenforceable is curious. It is the endogenous cost of default which provides grounds for international lending. The cost comes from the prohibition of future borrowing or trade (e.g. through elimination of trade credit), and seizure of the borrower's foreign assets. Repayment will be on schedule if the cost of default is larger than the benefit (the latter is the waiver of the debt service obligation). Though creditors may have a problem making credible the threat that they will actually impose the cost, there are two reasons why they may still impose the sanctions (see Krugman [1985]). The first is that creditors may view themselves as playing a "repeated game" in which reputation is important. The second is that creditors may not perfectly agree on renegotiating the terms of a loan, and there are thus individual interests in seizing the assets of a defaulting country.

As will become clear later, the loan offer curve becomes upward sloping and then backward bending when default is a real possibility. This enhances the possibility of credit rationing. A review of the rationale of credit rationing from previous works is in order.

Jaffee and Modigliani (1969) attribute credit rationing to institutional factors, such as usury laws, good will, and the fact that banks can not openly collude. They claim that banks subject to these institutional constraints can best exploit their market power by classifying customers into a rather small number of classes, within each of which a uniform rate is charged. In each class, the uniform rate may be less than the market clearing rates of some borrowers. This explains why credit rationing of some borrowers may be profitable. The weakness of this approach is that it begs the question of what basic forces lead to loan market institutions.

Jaffee and Russell (1976) attribute credit rationing to asymmetric information; that is, lenders cannot distinguish _ex ante_ between "honest" and "dishonest" borrowers. Therefore, lenders grant that a representative borrower has non-zero probability of default. This implies a backward-bending or an upward-sloping zero-profit loan offer curve. The offer curve intersects with the demand curve at the no-rationing equilibrium. This equilibrium can be dominated by the credit rationing equilibrium where the borrower's iso-utility curve is tangent to the offer curve. The rationing equilibrium is preferred to the no-rationing equilibrium by the honest borrower because fewer individuals default at the smaller loan size, and under competition these gains are passed on to the honest borrowers. The risk-neutral lender is indifferent about whether to use the rationing contract or the no-rationing contract because the offer curve is an iso-profit curve. Dishonest borrowers will also choose the rationing contract, or their self-selection will reveal their identity and they will get no loan at all. Therefore, a competitive market reaches an equilibrium in which all borrowers are rationed. There is a redundancy in this approach; that is, asymmetric information is not necessary for credit rationing in the pooling equilibrium, where both honest and dishonest borrowers select the same loan package. But overall, this is a useful approach; it is similar to the monopsony case in my model.

Eaton and Gersovitz (1981) attribute credit rationing to price rigidity in credit markets, because the borrower will not pay the price if he defaults. The more he has borrowed, the higher will be the price, and the more likely that the borrower will default. Because price does not exist under default, it becomes more unlikely that higher prices will be available as price rises. In other words, price rigidity rises as price increases. The amount that a country actually borrows is the minimum of two quantities: the amount it wishes to borrow and the amount it can borrow. Credit rationing occurs when there is excess demand; this is similar to the familiar "Disequilibrium Approach". The weakness of Eaton and Gersovitz's approach is the same as that of all disequilibrium models--the rationale is insufficient to explain why the price will not move.

Stiglitz and Weiss (1981) attribute credit rationing to the sorting (adverse selection) and incentive (moral hazard) effects of interest rates. Increasing interest rates could increase the riskiness of the bank's loan portfolio, either by discouraging safer investors, or by inducing borrowers to invest in riskier projects, and therefore could decrease the bank's profit. Thus the expected return curve is non-monotonic because the interest rates affect borrowers' actions. Credit is rationed if there is excess demand at the interest rate where the loan offer curve peaks (corresponding to the peak point of the expected return curve). The lender will not increase the interest rate because then his expected return will be decreased. Stiglitz and Weiss provide an interesting model to explain credit rationing. But the asymmetric information assumption (adverse selection and moral hazard) is not necessary for the existence of credit rationing. My model uses much less restrictive assumptions to provide a rationale for credit rationing.

In my model, credit rationing occurs simply because of the backward bending shape of the loan offer curve and the competitive force. Information is symmetric between lenders and borrowers, and all borrowers are potentially dishonest. The competitive force renders the upper half of the loan offer curve inefficient. If the demand curve intersects the lower half of the loan offer curve, we have a Walrasian Equilibrium. If the demand curve does not intersect the efficient part of the loan offer curve, we have a Credit Rationing Equilibrium* at the interest rate level corresponding to the reflection point on the offer curve. The interest rate will not be pushed up at the credit rationing point simply because competition among lenders renders a higher interest rate inefficient, and therefore not available. The market ends up with either the Credit

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*The credit rationing point here is not deliberately chosen by the lenders and/or the borrowers via the first principle; it is a competitive market result where there is no inherent price rigidity. This is a difference in spirit from the mainstream disequilibrium models. For convenience, the credit rationing point in my model is termed credit rationing equilibrium.

Rationing Equilibrium (C.E.), or the Walrasian Equilibrium (W.E.). We say that the market switches between the two equilibria. The differentiation of the two equilibria is the main thesis of this essay.

Having selectively reviewed previous rationale for credit rationing and compared them with my own rationale, let us now turn to market structure and its impact on LDC borrowing. Most LDC borrowing is made by governments or are backed by LDC government guarantees. On the one hand, the LDC government can employ its monopsony* power, which is defined as the capability to exploit the trade-off along the loan offer curve to increase the social welfare (see Sachs and Cohen, 1985); on the other hand, LDC governments may provide the domestic firm or individuals with borrowed funds at a fixed interest rate (see World Development Report, 1985). A domestic firm or individual or even government agent can also borrow without government guarantee in the international financial market; if the lenders observe the country's risk characteristics but not those of the individual, the individual then faces a given interest rate. Both the government provision and the individual international borrowing belong to the perfect competition case, in contrast to the monopsony case. These two alternative market structures need to be carefully considered in tandem with the theoretical development.

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*This is actually quasi-monopsony, since the borrower's demand for external debt does not increase the interest rate paid by other borrowers, but only its own interest cost.

The interaction between sovereign risk and the existence of capital market equilibrium is a central phenomenon in the international capital market. The analysis of it provides a theoretical framework in which to study the LDC debt default problem, and also provides the groundwork for an econometric study. In this essay, a general theoretical framework is established in which the LDC loan market and debt default problem can be studied. Further theoretical and institutional details can be added later.

In Section B, we present the basic model. It is developed in terms of a simple yet representative two-period model. This model is an extension of Sachs and Cohen (1985), Heffernan (1985), and Kahn and Haque (1985). The main attempt is to put them into a coherent framework to study the endogenous default decision and capital market equilibrium. The basic model is developed first; then it is extended in two directions:

(1) It appears that the probability of default was low before the 1982 debt crisis*, so a lender's risk taking behavior was not of much concern. After the 1982 debt crisis the probability of default tends to be high. Whether the lender is risk neutral or risk averse is

*In August 1982, Mexico announced that it was unable to service its external debt of approximately $80 billion. While Mexico was seeking to reschedule $20 billion, the estimates put Latin American total outstanding debt at $300 billion.

important. In fact, some people suggested that up to the end of 1982, risk neutrality best described the behavior of the banks in their decision to make sovereign loans, but from this date, risk aversion would be a better description (see e.g. Povey 1983). While I assume risk neutrality in the basic model, risk aversion, which incorporates the lender's portfolio choice behavior, is modelled in the extended version. Different risk-taking behavior induces different capital-market equilibrium.

(2) Domestic and external investment are incorporated as two more sources of absorption besides consumption. Expropriation risk is also incorporated to explain the phenomenon of simultaneous inflow and outflow of capital as the result of rational borrowers' portfolio choices. LDC precommitment (e.g. adopting an IMF austerity program) and the impact of expropriation risk are studied in this context.

In Sections B to D, the above theoretical model is developed under the alternative assumptions of perfect competition and monoposony on the borrower's side. In Section E an econometric model is outlined to capture the main feature of the theoretical model. Section F summarizes the main results and provides the conclusion.

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B. THE BASIC MODEL

(1) Sovereign Risk And The Supply Of Sovereign Loans

The international economy is divided into a first world and a third world*. The first world is composed of a group of developed countries with excess supply of capital. The third world is composed of a group of LDC with excess demand for capital. Arbitrage leads the first world to supply the third world with capital until expected rates of return are equalized. International lending is assumed to be competitive. The representative third world country is assumed to be a small open economy in the international financial market. In a world with certainty, it faces a loan offer with fixed terms. For the convenience of later development, I assume the country's output is used for export only (e.g., it is a natural resource exporting country).

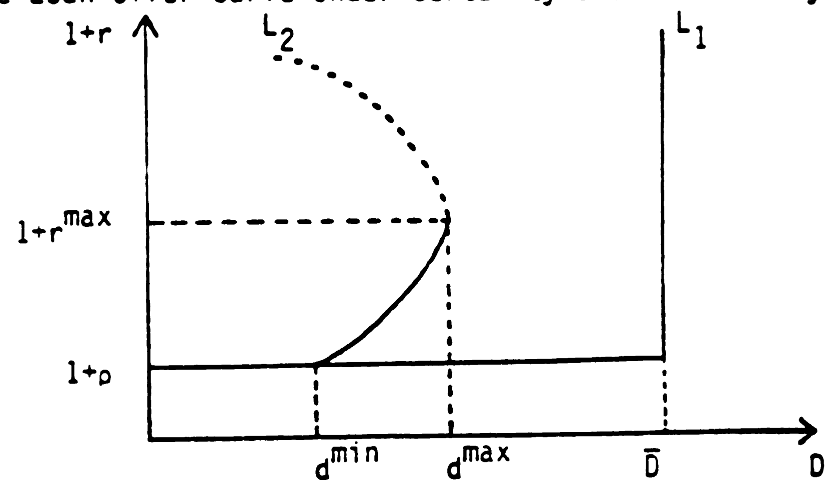
In the context of international lending, debt repayment is not enforceable. If default is taken to be any failure to respect the terms of a loan agreement, the unenforceable nature of international lending gives rise to a kind of default which is not due to the infeasibility of debt repayment but due to the debtor's unwillingness to repay the debt. Eaton and Gersovitz (1981a) use the term "debt repudiation" to denote this kind of default. A

*The model developed in this essay can be applied to any sovereign loan, including the U.S. debt, not limited to an LDC loan.

borrower repudiates his debt when the benefit from default is larger than the cost of default (from now on, I will use the term "default" to refer to "repudiation"). The benefit of default is the retained debt service payment. The cost of default may arise from several sources: exclusion from future borrowing, trade disruption (e.g.,through elimination of trade credit), seizure of foreign assets, etc. These penalties are summarized by a fraction λ of national output; it is assumed that borrowing, trade and foreign assets are in proportion to a country's size.

Consider a two period horizon. Borrowing takes place in period one. Debt repayment is scheduled for period two. Default will occur if the penalty is less than the debt service. If there is no uncertainty, the threat of repudiation risk generates a credit ceiling $\bar{D}$ which is shown in Figure 1 as the ceiling for the loan offer curve L_1. In Figure 1, r is the risk adjusted interest rate,

Figure 1
The Loan Offer Curve Under Certainty and Uncertainty



ρ is the safe interest rate, and D is the amount of borrowing. $\bar{D}$ is the amount of borrowing where the cost of default is equal to the penalty of default. Therefore, we have $\lambda P_2 Q_2 = (1+r)\bar{D}$ where P_2 is the second-period terms of trade (TOT), Q_2 is second-period real output, and λ is the proportion of output corresponding to the penalty of default. Taking the import goods price as numeriare, the l.h.s. (left hand side) represents the cost of default while the r.h.s. represents the benefit of default. As long as the amount of borrowing D is less than or equal to $\bar{D}$, the cost of default is larger than the benefit of default, and the borrower will choose to repay. The loan will be safe, and the interest rate will be equal to the safe rate of interest ρ. Therefore, $\bar{D} = \frac{\lambda P_2 Q_2}{1 + \rho}$. If D exceeds $\bar{D}$, the country will default for any interest rate greater than or equal to ρ. No risk premium can compensate for the certainty of default. All lending is cut off at point $\bar{D}$. The loan schedule is kinked and shown as L_1 in Figure 1.

Now we assume a world with uncertainty. Lenders are assumed to be risk neutral. They face the competitive market and get nothing back when an LDC loan is defaulted (we can also assume that lenders renegotiate to get something back, but it will not affect the qualitative results). There are two assets for the lenders to choose. One is the risky asset, which is the sovereign loan with return r; the other is the first-world safe asset with zero probability of default and return ρ. The uncertainty can be reflected in output, default penalty, interest rate or TOT (Terms of Trade), etc. For convenience, and for capturing the stylized fact that oil price change is a major reason for LDC debt repayment uncertainty, we assume TOT uncertainty. This uncertainty is represented by a random variable v which is distributed uniformly and symmetrically on $[v_0 \; v_1]$, with mean 0. Using the same notation as in the case of certainty (except here P_2 represents the "mean" value of the TOT), we can determine that the probability of default* is:

$$(1) \quad \pi = \Pr[\lambda P_2(1+v)Q_2 < (1+r)D] = \frac{(1+r)D-(1+v_0)\lambda P_2 Q_2}{\lambda P_2 Q_2(v_1-v_0)}$$

the first equality represents that a country defaults if the penalty is less than the benefit. Since v is uniform on $[v_0 \; v_1]$, so $\Pr[v < c] = \frac{c-v_0}{v_1-v_0}$, where c is a constant. This explains how we get the second equality. Since lenders are risk neutral and get nothing under default, their portfolio choice behavior and competitive force (assuming free entry) will give us:

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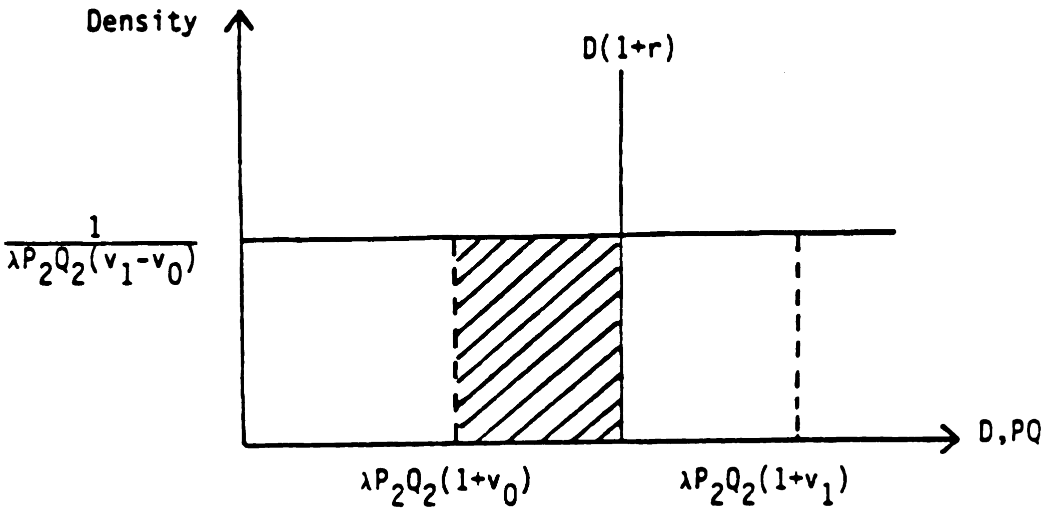
* Equation (1) can incorporate total indebtedness $\bar{D}_2$ to reveal the impact of the amount of debt overhang. A model incorporating total indebtedness, income growth rate and domestic investment, is outlined in Appendix C.

$$(2) \quad 1 + \rho = (1+r)(1-\pi) + (0)\cdot\pi = (1+r)(1-\pi)$$

where the equality points out the equalization of expected return on the safe asset and the risky asset. There is unrestricted entry of new lenders; for this reason, a risk-neutral lender's offer curve is a zero iso-profit curve. Lenders are assumed to know all relevant characteristics of individual borrowers. Information is assumed to be symmetric between lenders and borrowers.

The lender's loan offer curve has an upward sloping portion under uncertainty. The reason is that as the amount of borrowing goes up, π will go up, so r will go up due to higher risk premium. The reason that π will go up can be seen from Figure 2 where $\lambda P_2Q_2(1+v_0)$ and $\lambda P_2Q_2(1+v_1)$ are the lower bound and upper bound of the penalty of default. As D increases, $D(1+r)$ increases and the shadowed portion increases accordingly. The shadowed portion represents the case where the penalty of default is less than the debt service. The larger is the shadowed portion, the higher is the probability of default (π). The offer curve in Figure 1 bends backward above a certain level of interest rate. The reason is that when the interest rate reaches a high level, the probability of default becomes so high (because the benefit of default becomes high) that zero profits require that the loan quantity be smaller in order to decrease the default rate.

Figure 2
The density of the uniform distribution and the probability of default



Similar to Sachs and Cohen (1985), we derive the lender's offer curve under uncertainty (it is the aggregate market curve, and each lender provides a horizontal loan offer curve given aggregate D and ρ). My approach to the offer curve is similar to Sachs and Cohen in all respects, except that I assume TOT uncertainty to capture the main character of the LDC debt problem.

The loan-offer curve* is composed of two parts:

*It can be shown that a large class of the distribution (refers to the source of uncertainty in the model) yields a supply of credit of the type in my model. Refer to Aizenman (1986). Whether the loan offer curve is backward bending or not hinges on the elasticity of the probability of repayment, which in turn hinges on the distribution of the random variable. Aizenman claims that a large class of distributions, including normal distribution, yield the offer curve of the type as in my model.

$$(\bar{3})\quad 1 + r = 1 + \rho \qquad 0 < D < d^{min} = \frac{\lambda(1+v_0)P_2Q_2}{1+\rho}$$

The above formula is the horizontal portion of the loan offer curve.

$$(3)\quad 1 + r = F(D) \qquad d^{min} \leq D \leq d^{max} = \frac{\lambda P_2Q_2(1 + v_1)^2}{4(1 + \rho)(v_1 - v_0)}$$

The above formula is the upward sloping portion of the loan offer curve, where

$$F(D) = \frac{\lambda P_2Q_2(1 + v_1) - \sqrt{4(1 + \rho)(v_1 - v_0)\lambda P_2Q_2(d^{max} - D)}}{2D}$$

We can thus determine r^{max} at the inflection point:

$$1 + r^{max} = F(d^{max}) = \frac{2(1 + \rho)(v_1 - v_0)}{1 + v_1} - 1 .$$

As shown in Figure 1, d^{min} is at the end of the horizontal portion (the horizontal portion corresponds to the points where $\pi = 0$) of the loan offer curve L_2. L_2 is upward sloping between d^{min} and d^{max}. This segment corresponds to F(D), which is the smaller square root of the quadratic equation derived from (1) and (2). The backward bending portion corresponds to the larger root of the same quadratic equation. Competition among the first world lenders invalidates the backward bending portion.

because borrowers always prefer the low interest rate loan package to the high interest rate package. So we represent the backward bending portion by a dotted line. Note that we get d^{min} by taking the maximum D where $\pi = 0$, and we get d^{max} by taking the D where $\frac{\partial r}{\partial D} \to \infty$.

Now we want to establish that F(D) is upward sloping:

Proof. We need to show:

$$\frac{\partial F}{\partial D} = -\frac{P_2Q_2(1 + v_1)}{2D^2} + \frac{4(1 + \rho)P_2Q_2D(v_1 - v_0) + 2X}{2D^2X^{1/2}} > 0$$

where

$$X = [\lambda P_2Q_2(1 + v_1)]^2 - 4(1 + \rho)\lambda P_2Q_2D(v_1 - v_0)$$

Accordingly, $\frac{\partial F}{\partial D} > 0 \longleftrightarrow 16(1+\rho)^2\lambda^2P_2^2Q_2^2D^2(v_1-v_0)^2+4\lambda^2P_2^2Q_2^2(1+v_1)^2X$

$$> \lambda^2P_2^2Q_2^2(1 + v_1)^2X$$

which is always the case. Q.E.D.

We can get the other comparative static properties of the lender's offer curve by using the implicit function theorem:

Let $G=1+r-F(D)=1+r-\frac{\lambda P_2Q_2(1+v_1)-\sqrt{4(1+\rho)(v_1-v_0)\lambda P_2Q_2(d^{max}-D)}}{2D}$

then $\frac{\partial D}{\partial \lambda} = - \frac{\partial G/\partial \lambda}{\partial G/\partial D}$

where $\frac{\partial G}{\partial D} = - \frac{1}{2D^2} \frac{\lambda P_2 Q_2 (1+v_1)}{\sqrt{1-4(1+\rho)(v_1-v_0)\lambda P_2 Q_2 D/\lambda^2 P_2^2 Q_2^2 (1+v_1)^2}}$

$$+ \frac{\lambda P_2 Q_2 (1+v_1)}{2D^2}$$

$$< 0$$

and $\frac{\partial G}{\partial \lambda} = \frac{1}{2D} \frac{\lambda P_2^2 Q_2^2 (1+v_1)^2 - 2(1+\rho)(v_1-v_0)P_2 Q_2 D}{[\lambda^2 P_2^2 Q_2^2 (1+v_1)^2 - 4\lambda(1+\rho)(v_1-v_0)P_2 Q^2 D]^{-1/2}}$

$$- \frac{P_2 Q_2 (1+v_1)}{2D} > 0$$

$$\rightarrow \frac{\partial D}{\partial \lambda} > 0.$$

Increasing λ increases the penalty of default which decreases the probability of default. Therefore the amount of lending increases.

Similarly, we can prove

$\frac{\partial G}{\partial Q_2} > 0$, $\frac{\partial G}{\partial P_2} > 0$, therefore

$$\frac{\partial D}{\partial Q_2} = - \frac{\partial G/\partial Q_2}{\partial G/\partial D} > 0$$

$$\frac{\partial D}{\partial P_2} = - \frac{\partial G/\partial P_2}{\partial G/\partial D} > 0.$$

i.e. The higher is the second period output or terms of trade, the larger is the amount of lending. The reason is that the resulting higher penalty of default enables a larger amount of lending to be consistent with a given probability of default.

The sign of the partial derivative of D with respect to the range parameter of the probability distribution for TOT is determined as follows:

$$\frac{\partial G}{\partial (v_1 - v_0)} = \frac{1}{4D} \{4(1+\rho)(v_1-v_0)\lambda P_2 Q_2 [\frac{\lambda P_2 (1+v_1)^2}{4(1+\rho)(v_1-v_0)} - D]\}^{-1/2}$$

$$\cdot [-4(1+\rho)\lambda P_2 Q_2 D] - \frac{\lambda P_2 Q_2}{4D} < 0$$

$$\rightarrow \frac{\partial D}{\partial (v_1 - v_0)} = - \frac{\partial G/\partial (v_1 - v_0)}{\partial G/\partial D} < 0.$$

That is, a higher degree of uncertainty increases the probability of low income, and thus increases the probability of default, and a higher probability of default causes the contraction of lending. Therefore, a higher degree of uncertainty causes the contraction of lending.

The sign of the derivative of D with respect to the safe rate of interest is derived as follows:

$$\frac{\partial G}{\partial \rho} = \frac{1}{2D} \{4(1+\rho)(v_1-v_0)\lambda P_2 Q_2 [\frac{\lambda P_2 (1+v_1)^2}{4(1+\rho)(v_1-v_0)} - D]\}^{-1/2}$$

$$\cdot \ [-4(v_1-v_0)\lambda P_2Q_2D] \ < 0$$

$$\rightarrow \frac{\partial D}{\partial \rho} = - \frac{\partial G/\partial \rho}{\partial G/\partial D} < 0$$

A higher safe rate of interest, as it constitutes a higher opportunity cost for lenders, lowers the volume of lending offered.

(2) Sovereign Risk And The Demand Of Sovereign Loans

Let us consider the optimal borrowing strategy of a country. I assume each individual borrower within a country shares a perfect competitive market, and they are inherently dishonest* in that they will default if it is to their advantage. I also assume a nonlinear (risk averse) quasi-homothetic utility function so the individual demand replicates the market demand. Utility is a function only of consumption, and is weakly intertemporally separable.** Sachs and Cohen [1985]

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*This is compatible with Eaton and Gersovitz (1981). I think this is the right approach and coexistence of indistinguishable honest and dishonest borrowers assumed in Jaffee and Russell (1976) is redundant. Honest borrowers are basically irrational and omitting them will not change the Jaffee and Russell model in any significant way. Therefore, the indistinguishability of honest and dishonest borrowers by lenders should no longer be a source of asymmetric information between borrowers and lenders.

**An alternative way to reach the same result is to assume that relative price is fixed over time. For the details of the separation problem, refer to Deaton and Muellbauer (1980).

assume a linear (risk neutral) utility function. Let δ be the social discount rate (discount rate on the national level). Then if $1+r \neq 1+\delta$, it implies a corner solution of D. This defeats the purpose of our paper, which is the differentiation between two borrowing equilibria. It is necessary to assume a diminishing intertemporal marginal rate of substitution to get an interior solution of D (where we can incorporate risk neutrality as a special case). My theory can be viewed as an improvement over Sachs and Cohen's work in terms of providing a more general theoretical framework which permits either a corner solution or an interior solution for D.

The expected utility $[EU = EU(C_1) + (1+\delta)^{-1}EU(C_2)]$ is formulated as follows:

$$(4)\quad EU = U(C_1)+(1+\delta)^{-1}\int_{v_0}^{v_0+\pi(v_1-v_0)} U[(1-\lambda)P_2(1+v)Q_2]h(v)dv$$

$$+ (1+\delta)^{-1}\int_{v_0+\pi(v_1-v_0)}^{v_1} U[P_2(1+v)Q_2-(1+r)D]h(v)dv$$

The first integral represents the expected utility under default. The second is the expected utility under repayment.

EU is maximized with respect to C_1, C_2 and D, subject to*:

(5) (a) $C_1 = P_1Q_1 + D$

(b) $C_2 = \text{Max}\ (C_2^D\ C_2^N)$

(c) $C_2^D = (1 - \lambda)P_2(1 + v)Q_2$

(d) $C_2^N = P_2(1 + v)Q_2 - (1 + r)D$

(e) v is uniform on $[v_0\ v_1]$ with mean 0

(f) $\pi = p_r[\lambda P_2(1 + v)Q_2 < (1 + r)D]$

where C_i is the consumption for period i. C_2^D is the second period consumption in the case of default; C_2^N is the second period consumption in the case of repayment. The second period consumption is chosen to be the maximum between C_2^D and C_2^N to maximize the expected utility function. Before we go further into the borrower's problem, we need to consider the impact of different market structures on our results. In previous literature, Jaffee and Modigliani (1969), Stiglitz and Weiss (1981), and Eaton and Gersovitz (1981a) all assume that the borrower's market

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*Q_1 in (a) can be substituted by Q_2/g, where g is the growth rate of real income. A model incorporating income growth rate, total indebtedness and domestic investment is outlined in Appendix C.

is perfectly competitive. Sachs and Cohen (1985) assume the borrower has monopsony power, which is defined as the ability to exploit the trade-off along the offer curve. While they either make these assumptions implicitly or explicitly, they do not explore thoroughly the impact of the borrower's market structure on the capital market equilibrium. This paper uses a general framework to incorporate different market structures on the borrower's side and their impacts on the capital market equilibrium. If the borrower is a government, it is likely that this country has monopsony power over the loan (see Sachs and Cohen [1985]). On the other hand, a government can borrow and provide the individuals with funds at a certain rate (see World Development Report [1985]). Individuals can also borrow in the international financial market without government guarantee (such borrowing constitutes about 20% of total outstanding debt); if the lenders observe the country's risk characteristics, but not those of the individual, the individual then faces a given interest rate. The government provision and the individual unguaranteed borrowing belong to the perfect competition case. In the case of monopsony, the equilibrium occurs at the tangency between the borrower's indifference curve and the lender's offer curve. Then there is no well defined demand curve. To have a well- defined sovereign loan demand curve, we need to have perfect competition on the borrower's side, but then we need to consider the aggregation problem. Basically, we assume that the individual in the country does the borrowing. The borrower takes the interest rate as given; as established either by the government or by the international capital market. The representative individual has his own demand curve. To use this individual demand to replicate the market demand, the individual demand needs to be exactly aggregatable into the market demand. Therefore we assume a quasi-homothetic utility function (i.e., we have a linear Engle curve, but it need not go through the origin) in order to aggregate individual demand. These assumptions have already been made earlier.

Now we have two benchmark cases; one is monopsony, the other is perfect competition. Since government inherently has monopsony power to exploit the offer curve, monopsony is more likely to be the case in the LDC debt problem. However, there are also cases for perfect competition and it is a necessary assumption for studying the loan demand function; it has also been employed in many important works in credit rationing and gets empirical support. Therefore, we shall inquire into both cases with an emphasis on the perfect competition case. Whether or not the latter is a reasonable abstraction can be examined by empirical tests.

From (5), we get the first order condition in maximizing the expected utility function with respect to the amount of borrowing:

$$(6) \qquad \frac{\partial EU}{\partial D} = 0 \rightarrow (1 - \pi)\ \frac{d(1 + r)D}{dD} = \frac{U_{C_1}}{E(U_{C_2}|ND)}$$

where ND means "No Default"

i.e., intertemporal marginal cost = intertemporal marginal rate of substitution, where

$$E(U_{C_2}|ND) = (1 + \delta)^{-1}(1 - \pi)^{-1} \int_{v_0+\pi(v_1-v_0)}^{v_1} U'[P_2(1+v)Q_2$$

$$- (1 + r)D]h(v)dv$$

$$1 - \pi = \int_{v_0+\pi(v_1-v_0)}^{v_1} h(v)dv$$

To get a specific analytical form of the demand curve, we employ a constant relative risk aversion utility function:

$$(6)' \quad U(C) = \frac{C^{1-\alpha}}{1-\alpha}$$

where α: relative risk aversion coefficient, $0 \lesssim \alpha \lesssim 1$.

Under perfect competition, the interest rate is treated as a given parameter by the borrower, i.e., $\frac{\partial r}{\partial D} = 0$. Then from (6) and (6)' we have:

$$(1 + r)(A^{1-\alpha}-B^{1-\alpha})C_1^{\alpha} = (1 + \delta)(v_1 - v_0)(1 - \alpha)P_2Q_2$$

where $A = P_2(1 + v_1)Q_2 - (1 + r)D$

$$B = \frac{1 - \lambda}{\lambda}(1 + r)D$$

Taking the special case $\alpha = 1$, and using L'Hôpital's rule, we get:

$$(7) \quad (1 + r)(\ln A - \ln B)C_1 = (1 + \delta)(v_1 - v_0)P_2Q_2$$

Differentiating both sides of (7) with respect to r, we get the slope of the demand curve:

$$(8) \quad \frac{\partial D}{\partial r} = \left[-(1 + r)^2 \frac{1}{A} C_1 - (1 + r)^2 \frac{1}{B} \frac{1 - \lambda}{\lambda} C_1 + (1 + r)(\ln A - \ln B)\right]^{-1} \cdot \left[(\ln B - \ln A)C_1 + (1 + r)\frac{1}{A} DC_1 + (1 + r)\frac{1}{B}\frac{1 - \lambda}{\lambda} DC_1\right]$$

$\partial D/\partial r$ is not always negative here. It is easy to prove that if π is given, then $\partial D/\partial r < 0$. The sign becomes ambiguous because π is endogenous here as in equation (1). The reason is:

$$r \text{ increases } \left\langle \begin{array}{l} D \text{ decreases (with fixed } \pi) \\ \pi \text{ increases, therefore, } D \text{ increases} \end{array} \right\rangle .$$

makes the sign unclear.

whereas π is endogenous, we can see from Figure 2 that higher r will induce higher π, and the increase of π induces a larger amount of borrowing due to higher expectation of future default.

By assuming π to be endogenous, we can find conditions under which $\partial D/\partial r < 0$. We adopt the following sufficient but not necessary condition:

$$(*) \qquad \ln A - \ln B > (1 + r)C_1 \frac{1}{A} + (1 + r) \frac{C_1}{B} \frac{1 - \lambda}{\lambda}$$

The rationale for this condition is as follows:

$$(*) \qquad \rightarrow P_2Q_2 > \{B \exp[(1 + r)C_1 \frac{1}{A} + (1 + r) \frac{C_1}{B} \frac{1 - \lambda}{\lambda}]$$

$$+ D(1 + r)\} (1 - v_1)^{-1} > 0$$

i.e., mean output needs to be larger than a certain positive value. The rationale for the output constraint is that when output is low, the penalty on default is low. When r is above a threshold value, the borrower will borrow more in the first period and default in the second period. The demand curve becomes upward sloping. Taking condition (*) as given, we have a well-behaved, downward-sloping demand curve.

We can get the other comparative static properties of the borrower's demand curve by using the implicit function theorem:

From (7),

$$(1+r)C_1\{\ln[P_2(1+\frac{v_1-v_0}{2})Q_2-(1+r)D]-\ln[\frac{1-\lambda}{\lambda}(1+r)D]\}-$$

$$(1+\delta)(v_1-v_0)P_2Q_2=0$$

We denote the l.h.s. as H. Then we have

$$\frac{\partial D}{\partial \lambda} = -\frac{\partial H/\partial \lambda}{\partial H/\partial D}$$

where $$\frac{\partial H}{\partial D} = (1+r)C_1[\frac{-(1+r)}{P_2(1+\frac{v_1-v_0}{2})Q_2-(1+r)D} - \frac{\frac{1-\lambda}{\lambda}(1+r)}{\frac{1-\lambda}{\lambda}(1+r)D}] < 0$$

$$\frac{\partial H}{\partial \lambda} = (1+r)C_1\ [\frac{-(1+r)D}{\frac{1-\lambda}{\lambda}(1+r)D} \cdot \frac{-1}{\lambda^2}] > 0$$

$$\rightarrow \frac{\partial D}{\partial \lambda} > 0.$$

A higher penalty of default decreases the probability of default. It also decreases the second period consumption under default, but the second period consumption under repayment is not changed. The probability of repayment increases. In other words, for the expected utility function, the weight of utility under repayment increases while the weight of utility under default decreases. But the newly incorporated repayment portion has the consumption level, which is lower than the excluded portion under default. Thus the expected second period utility is decreased. Therefore, the borrower's optimal intertemporal consumption choice will shift toward the first period. This increases the optimal amount of borrowing.

As for the derivative of D with respect to Q_2, we have:

$$\frac{\partial H}{\partial Q_2} = (1+r)C_1 \cdot \frac{P_2(1+v_1)}{P_2(1+v_1)Q_2-(1+r)D} - (1+\delta)(v_1-v_0)$$

the sign is ambiguous.

$$\rightarrow \frac{\partial D}{\partial Q_2} = - \frac{\partial H/\partial Q_2}{\partial H/\partial D} \text{ has an ambiguous sign.}$$

The reason for the ambiguity is that higher Q_2 not only increases the second period consumption under default but also the second period consumption under repayment. While the probability of default becomes less, the net effect on the expected second period utility is unclear. Therefore, there is no clear implication with respect to the intertemporal consumption choice or the amount of borrowing.

Similarly, we can use the same rationale to explain why $\frac{\partial D}{\partial P_2}$ has an ambiguous sign.

As for the sign of $\frac{\partial D}{\partial(v_1 - v_0)}$, it is explored as follows:

$$\frac{\partial H}{\partial(v_1 - v_0)} = \frac{(1+r)C_1P_2Q_2}{2[P_2(1+v_1)Q_2-(1+r)D]} - (1+\delta)P_2Q_2$$

which is ambiguous in sign.

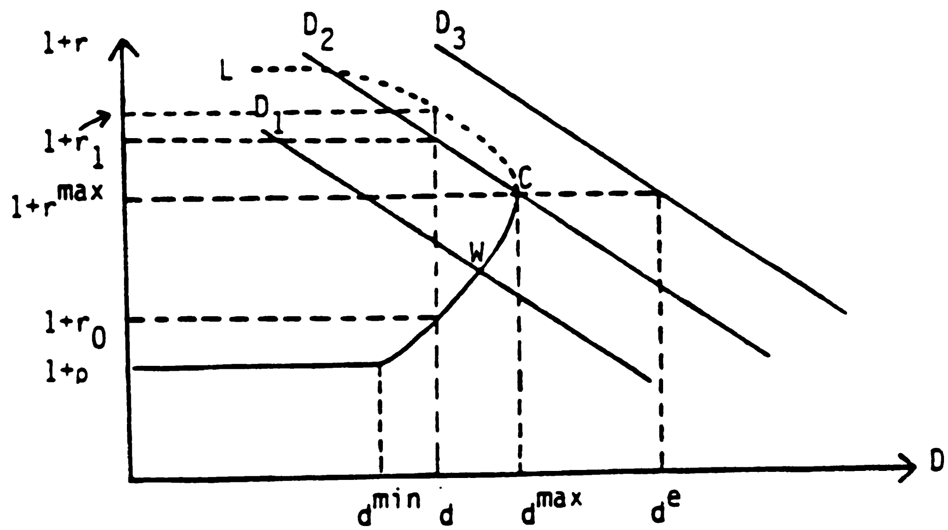
Therefore $\frac{\partial D}{\partial(v_1 - v_0)}$ has an ambiguous sign. The reason is that higher degree of uncertainty increases the probability of lower income which will increase the probability of default, while both consumption under default and repayment are changed. It is unclear how this change of probability of default will shift the intertemporal consumption choice.

Since the borrower faces a given risky asset interest rate r, the safe rate of interest ρ is in no way to affect the borrower's consumption and borrowing choice.

(3) <u>Sovereign Risk And The Market Equilibrium</u>

I am now going to develop the market equilibrium. It is innovative and in some sense midway between the disequilibrium approach and the optimization approach to the credit rationing problem. We have two benchmark cases, perfect competition and monopsony. We can differentiate the Walrasian Equilibrium (W.E.) from the Credit Rationing Equilibrium (C.E.) in the perfect competition case, but not in the monopsony case. The reason is that under perfect competition, we can have a well-defined demand curve. It is the particular shape of the loan offer curve and its interaction with the demand curve which gives us two equilibria. This can be seen more clearly from Figure 3.

Figure 3
Walrasian Equilibrium vs. Credit Rationing Equilibrium



As shown in the previous section, the loan offer curve L is upward sloping and then backward bending due to the existence of default risk. D_1, D_2, D_3 are downward sloping demand curves. Competition among lenders renders the backward bending part of the loan offer curve invalid. The reason is that any loan package (r_1, d) on the backward bending part is dominated by (r_0, d) on the lower part of lower part of the loan offer curve. The reason for this is that the loan offer curve is an iso-profit curve, so the risk-neutral lender is indifferent among any points on the offer curve. Lower interest cost is certainly preferred by the borrower to higher interest cost (given the same amount of loan). Thus competition among lenders will render the upper portion of the loan offer curve invalid. Therefore the backward bending part is represented by a dotted line.

If demand curve is to the right of D_2 (e.g., D_3), then there is excess demand at any level of interest rate. For the interest rate above $1 + r^{max}$ there is no valid loan package; for the interest rate below $1 + r^{max}$ excess demand will push the interest rate upward. At point C, there is excess demand, but the interest rate will not move because a higher efficient interest rate is not available. We view point C as an equilibrium credit rationing point because the price persistently stays at a level with excess demand and is consistent with rational lender and borrower behavior.

If demand curve is to the left of D_2 (e.g., D_1), then demand intersects supply at W. This is the Walrasian Equilibrium point where market clears. C.E. and W.E. are differentiated based on the relative position of the demand and offer curve. The particular shape of the loan offer curve here makes credit rationing possible.

We will establish the equilibrium properties under perfect competition and monopsony in the following sections.

(a) Perfect Competition

(i) Walrasian Equilibrium (W.E.)

The market clears at W.E., i.e. supply of loan = demand of loan. Totally differentiate (3) and (7) (in (3) we differentiate the upward sloping portion of the loan offer curve), then solve the simultaneous equations. Here r and D are endogenous, and their values are the same for the loan offer and loan demand equation to clear the market. Taking into account the definition of π, we get the comparative static properties for the W.E.:

$$(9) \quad \dot{r} = a_1\dot{\lambda} + a_2\dot{Q}_2 + a_3\dot{P}_2 + a_4(v_1 \dot{-} v_0) + a_5 \dot{\rho}$$

$$\dot{D} = b_1\dot{\lambda} + b_2\dot{Q}_2 + b_3\dot{P}_2 + b_4(v_1 \dot{-} v_0) + b_5 \dot{\rho}$$

$$\dot{\pi} = c_1\dot{\lambda} + c_2\dot{Q}_2 + c_3\dot{P}_2 + c_4(v_1 \dot{-} v_0) + c_5\dot{\rho}$$

"." means differential. The coefficients are derived in Appendix A*. Unfortunately, the signs are all ambiguous. In Figure 3, W.E. is shown as W.

*It has been suggested that the "Correspondence Principle" could be used to pin down further sign properties of W.E.. I have tried it, but it is not helpful for this model. The result is reported in Appendix B.

(ii) Credit Rationing Equilibrium (C.E.)

In Figure 3, C.E. occurs at C. Competition will force equilibrium out of the backward bending portion of the loan offer curve, while the lower part of the offer curve corresponds to the W.E.. At C, we have:

$$(10) \qquad r = r^{max} = \frac{2(1 + \rho)(v_1 - v_0)}{1 + v_1} - 1$$

$$D = d^{max} = \frac{\lambda P_2 Q_2 (1 + v_1)^2}{4(1 + \rho)(v_1 - v_0)}$$

$$\pi = \frac{(1 + r^{max})d^{max} - (1 + v_0)\lambda P_2 Q_2}{\lambda P_2 Q_2 (v_1 - v_0)} = \frac{3}{4} - \frac{1}{2(v_1 - v_0)}$$

Totally differentiating (10), we get the comparative static properties for the Credit Rationing Equilibrium:

$$(11) \qquad \dot{r} = d_1\dot{\lambda} + d_2\dot{Q}_2 + d_3\dot{P}_2 + d_4(v_1 \dot{-} v_0) + d_5\dot{\rho}$$

$$\dot{D} = e_1\dot{\lambda} + e_2\dot{Q}_2 + e_3\dot{P}_2 + e_4(v_1 \dot{-} v_0) + e_5\dot{\rho}$$

$$\dot{\pi} = f_1\dot{\lambda} + f_2\dot{Q}_2 + f_3\dot{P}_2 + f_4(v_1 \dot{-} v_0) + f_5\dot{\rho}$$

Looking into the coefficient, we have:

$$d_1 = 0.$$

As can be seen from (1), the increase of λ increases the penalty of default, so the risk premium goes down. On the other hand, the increase of λ induces a higher credit limit, which will increase the risk premium. These two effects counterbalance each other.

$$d_2 = 0.$$

The impact of Q_2 on r^{max} is the same as λ on r^{max} as can be seen from (1).

$$d_3 = 0.$$

The impact of P_2 on r^{max} is the same as λ and Q_2 on r^{max}.

$$d_4 = \frac{2(v_1 - v_0)}{1 + v_1} > 0.$$

Higher uncertainty increases the probability of lower income. This increases the probability of default; therefore the risk premium and r^{max} goes up.

$$d_5 = \frac{2(1 + \rho)}{1 + v_1} > 0.$$

When ρ increases, lenders will adjust their portfolio toward the safe asset. The demand for the risky asset goes down, so the price of the risky asset goes down and the return on the risky asset r goes up.

$$e_1 = \frac{P_2 Q_2 (1 + v_1)^2}{4(1 + \rho)(v_1 - v_0)} > 0.$$

Higher penalty on default strengthens the lender's confidence of debt repayment; therefore, the lender raises the credit limit.

$$e_2 = \frac{P_2 (1 + v_1)^2}{4(1 + \rho)(v_1 - v_0)} > 0.$$

The impact of Q_2 on d^{max} is the same as λ on d^{max}, because both increase the penalty of default.

$$e_3 = \frac{Q_2 (1 + v_1)^2}{4(1 + \rho)(v_1 - v_0)} > 0.$$

The increase of P_2 also increases the penalty of default, and therefore will raise the credit limit.

$$e_4 = \frac{\lambda P_2 Q_2 (1 + \frac{v_1 - v_0}{2})}{4(1 + \rho)(v_1 - v_0)^2} \left(\frac{v_1 - v_0}{2} - 1\right)$$

If $v_1 - v_0 > 2$, this implies $e_4 > 0$.

$v_1 - v_0 < 2$, this implies $e_4 < 0$

i.e. when the degree of uncertainty is low, increasing uncertainty has a more significant effect in increasing the probability of low income, so the credit ceiling is lowered. When the degree of uncertainty is high, increasing uncertainty has a more significant effect in increasing the penalty of exclusion from future borrowing, so the credit ceiling is raised.

$$e_5 = \frac{-\lambda P_2 Q_2 (1 + v_1)^2}{4(1 + \rho)(v_1 - v_0)} < 0$$

When ρ increases, lenders adjust their portfolios toward safe assets; therefore the risky asset portfolio decreases.

$$f_1 = 0.$$

Higher λ raises the penalty of default, but also raises the limits of borrowing so that the benefit of default also increases.

$$f_2 = f_3 = 0.$$

The impact of Q_2 and P_2 on π is the same as λ, as can be seen from (1).

$$f_4 = \frac{1}{2(v_1 + v_0)^2} > 0.$$

Higher uncertainty increases the probability of lower income, which decreases the penalty of default and increases π.

$$f_5 = 0.$$

When ρ increases, r will increase, and D will decrease. So r and D counterbalance each other, and the benefit of default $(1 + r)D$ remains the same while the penalty of default is not changed.

(b). <u>Monopsony</u>

If the borrower is a monopsonist in the loan market, that means the LDC governments takes the lender's offer curve as given and exploits this information to increase social welfare. Then (6) becomes:

$$(12) \quad D \frac{\partial r}{\partial D} = \frac{(1 + \delta)(v_1 - v_0)Q_2P_2}{(\ln A - \ln B)C_1} - 1 - r \quad \text{as} \quad \alpha \to 1$$

$\frac{\partial r}{\partial D}$ comes from (3) which is the slope of loan offer curve.

$$\frac{\partial r}{\partial D} = -\frac{\lambda P_2Q_2(1 + v_1)}{2D^2} + \frac{4(1 + \rho)P_2Q_2D(v_1 - v_0) + 2X}{2D^2X^{1/2}}$$

where

$$X = [\lambda P_2Q_2(1 + v_1)]^2 - 4(1 + \rho)\lambda P_2Q_2D(v_1 - v_0).$$

After substitution, we get

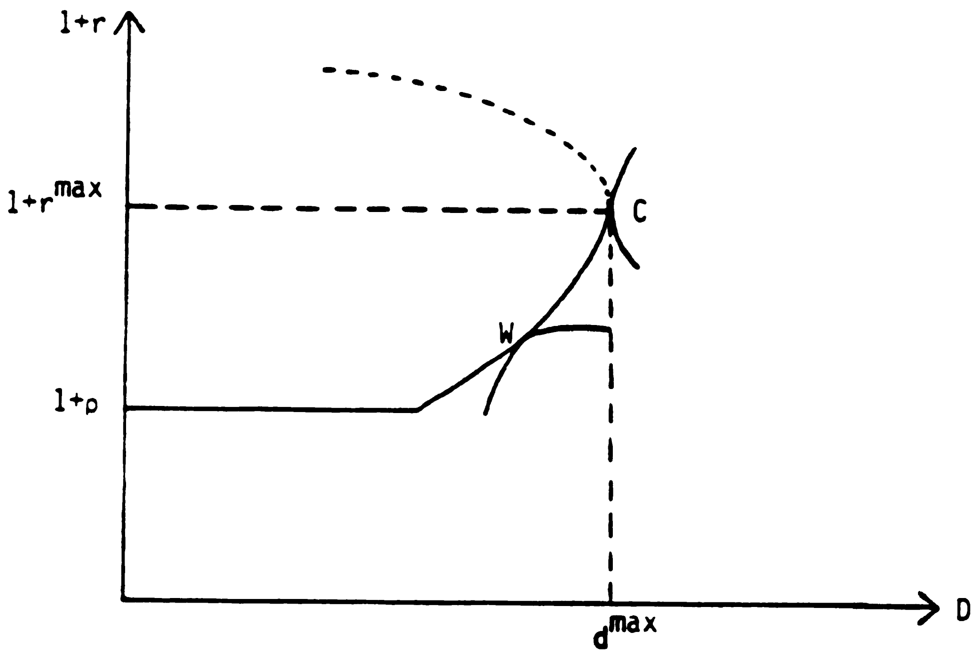
$$(13) \quad -\frac{\lambda P_2Q_2(1 + v_1)}{2D} + \frac{4(1 + \rho)\lambda P_2Q_2D(v_1 - v_0) + 2X}{2DX^{1/2}}$$

$$= \frac{(1 + \delta)(v_1 - v_0)Q_2P_2}{(\ln A - \ln B)C_1} - 1 - r.$$

Totally differentiating (3) and (13), then solving them simultaneously, we get the comparative static properties for equilibrium r, D, π. The signs of the coeffients are ambiguous. But they are easy to estimate econometrically in the context of a simultaneous equation system.

Now let us examine Figure 4. The monopsony equilibrium occurs at the tangency between the borrower's indifference curve and the loan offer curve. For example, the tangency can occur at W or C. (This is compatible with Jaffee and Russel (1976)). In the competitive case, W can be the W.E., and C can be the C.E., and they can be differentiated. In the monopsony case, both W and C are attached to the same model structure and cannot be identified separately.

Figure 4
The Equilibria Under Monopsony



C. RISK AVERSE LENDER

The probability of default appears to be higher in the post-1982 period than in the pre-1982 period both because of the huge debt service burden and world-wide recession. The lender's risk-taking behavior becomes a concern now. That is, theoretically, risk-taking behavior corresponds to the curvature of the utility curve, where the utility is a function of income. Taking an extreme view, with low probability of default, as in the pre-1982 period, income was nearly certain, so the curvature and the risk-taking behavior was not of much concern. But in the post-1982 period, probability of default is high; income is thus varying greatly, and the risk-taking behavior is important. Whether the lender is risk neutral or risk averse will have an impact on the capital market (see Povey, 1983). I will attempt here to re-establish the market equilibrium under the assumption that lenders are risk averse.

In the case of risk-averse lenders when free entry is permitted, the appropriate offer curve is the iso-expected-utility curve. We need to equate the expected utility of the return to the safe loan and the risky loan:

$$(14) \quad U[(1+\rho)D] = EU[(1-\pi)(1+r)D+\pi \cdot (0)] = EU[(1-\pi)(1+r)D]$$

To get a manageable solution, I will try two forms of risk averse utility functions. One is a log utility function, the other is a constant-relative-risk-aversion utility function. Let us start by substituting a log utility function into equation (14)::

$$(15) \qquad \log(1+\rho)D = \frac{1}{v_1-v_0} \int_{v_0+\pi(v_1-v_0)}^{v_1} \log(1+r)D \;\; dv$$

$$= (1-\pi) \log (1+r)D$$

where v is the random variable corresponding to TOT uncertainty as we defined it in Section II.

Solving (15) for D, we get:

$$(16) \qquad D = (1+r)^{-1} \lambda P_2 Q_2 [1+v_1-(v_1-v_0) \log (\tfrac{1+\rho}{1+r})]$$

where $\frac{\partial D}{\partial r} = \frac{1}{(1+r)^2} \cdot \lambda P_2 Q_2 (v_1-v_0) + \frac{1}{(1+r)^2} \cdot \lambda P_2 Q_2 (v_1-v_0) \log(\frac{1+\rho}{1+r})$

$$- \frac{1}{(1+r)^2} \cdot \lambda P_2 Q_2 (1 + v_1) < 0.$$

Here we use the property that $v_0 \geq -1$ (since TOT cannot be negative). This portion of the loan offer curve is downward sloping. The other (horizontal) portion of the loan offer curve is:

$$(17) \qquad 1 + r = 1 + \rho \qquad 0 < D < \bar{D} = \frac{\lambda(1+v_0)P_2Q_2}{1 + \rho} .$$

Here $\bar{D}$ is the credit ceiling. The comparative statics are:

$$\frac{\partial \bar{D}}{\partial \lambda} > 0, \ \frac{\partial \bar{D}}{\partial P_2} > 0, \ \frac{\partial \bar{D}}{\partial Q_2} > 0 .$$

Higher λ, P_2, Q_2 raise the credit ceiling because they increase the penalty of default. Lenders are thus willing to raise the credit ceiling.

$$\frac{\partial \bar{D}}{\partial (v_1 - v_0)} < 0.$$

Higher uncertainty of TOT lowers the credit ceiling by increasing the probability of low nominal income.

$$\frac{\partial \bar{D}}{\partial \rho} < 0 .$$

Higher ρ increases the benefit of default, and lenders lower the credit ceiling to prevent default.

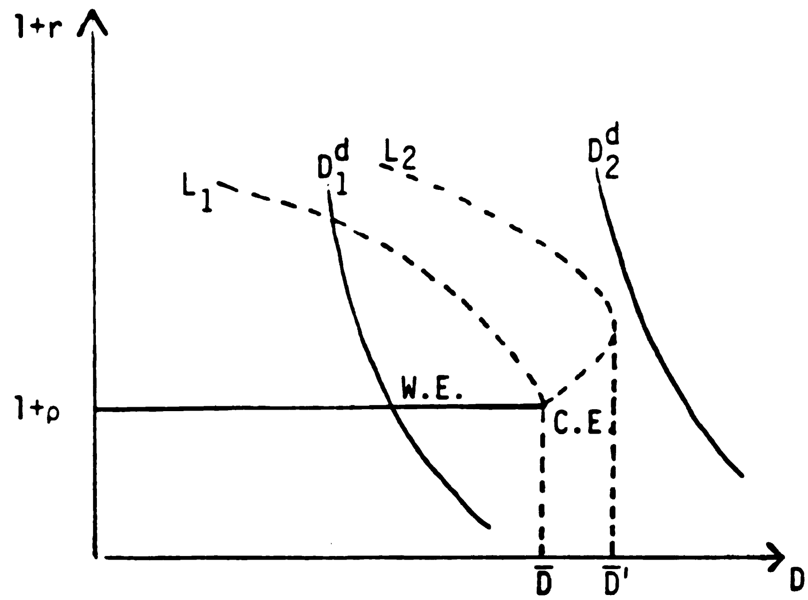
The loan offer curve, loan demand curve, and market equilibrium are shown in Figure 5.

Market competition renders the upper portion of the offer curve inoperative. If demand curve intersects the horizontal portion of the offer curve, such as D_1^d, we have

Walrasian Equilibrium (W.E.). If demand curve does not intersect the horizontal portion of the offer curve, such as D_2^d, we have Credit Rationing Equilibrium (C.E.).

Figure 5

The equilibria when lenders have a risk averse utility function.



Now let us try the constant relative risk aversion utility function:

$$U(C) = \frac{C^{1-\alpha}}{1-\alpha} \quad 0 \leq \alpha \leq 1.$$

Then we get the condition:

$$(18) \quad \frac{[(1+\rho)D]^{1-\alpha}}{1-\alpha} = \frac{1}{v_1-v_0} \int_{v_0+\pi(v_1-v_0)}^{v_1} \frac{[(1+r)D]^{1-\alpha}}{1-\alpha} \, dv$$

$$= (1-\alpha)^{-1} \, (1-\pi)[(1+r)D]^{1-\alpha}$$

$$\text{Let} \quad H = \frac{[(1+\rho)D]^{1-\alpha}}{1-\alpha} - (1-\alpha)^{-1} \frac{\lambda P_2 Q_2(1+v_1)-(1+r)D}{\lambda P_2 Q_2(v_1-v_0)} \cdot [(1+r)D]^{1-\alpha}$$

$$\rightarrow \frac{\partial D}{\partial r} = - \frac{\partial H/\partial r}{\partial H/\partial D}$$

Since $\frac{\partial H}{\partial r}$, $\frac{\partial H}{\partial D}$ are both ambiguous in sign, so is $\frac{\partial D}{\partial r}$.

This implies a credit ceiling larger than $\bar{D}$. For example, loan offer curve and credit ceiling can be L_2 and $\bar{D}'$ respectively (see Figure 5).

Since the log-utility function has the same first and second order derivatives as the constant relative risk aversion function with risk averse coefficient to be equal to 1, so the log utility function has relative risk averse coefficient to be 1 too. Therefore, it is likely that a higher degree of risk aversion decreases the credit ceiling.

To get the market equilibrium, we simply substitute the risk neutral loan offer curve in ($\bar{3}$) and (3) by (16) and (17). The demand curve is the same as in the basic model. Then we can get W.E. and C.E. by following a procedure similar to that in Section II.

In summary, log utility function, which is a risk averse function is shown to imply a backward-bending offer curve. Therefore, Walrasian equilibrium occurs along the horizontal portion of the offer curve, while credit rationing equilibrium occurs at the corner. Higher degree of risk aversion is shown to constrain the credit. Equilibrium properties can be developed conformably.

D. A MODEL WITH INTERNAL AND EXTERNAL INVESTMENT

The previous model assumes that borrowing is for consumption smoothing purposes (importing oil is an example). While this captures some stylized facts in the 1970s, it neglects the prevalent project lending which supplements domestic savings. Another interesting phenomenon is the simultaneous capital inflow and outflow (capital flight) in the LDC, which has caused serious difficulties. There is strong evidence of its recent occurrence, as provided by Cuddington (1985) and others, especially in Argentina, Mexico, and Venezuela.

To incorporate internal investment into the model, we need to specify the production function with an eye on the aggregation problem; we need to specify the appropriate source of uncertainty. The precommitment strategy is also of concern because precommitting to an investment program could induce more credit. To explain the simultaneous external borrowing and external and domestic investment without a distinction being made between the government and private individuals, we need to assume that the domestic and external environments are characterized by different sources of uncertainty. As compared to the well-established political systems and smoothly functioning economies of most developed countries, the LDCs are characterized by having the expropriation risk when considering domestic investment. The expropriation risk includes dramatic changes in political and economic regimes, overvalued real exchange rate, high and variable inflation rates, general financial instability, and so forth. In other words, the domestic resident faces the possibility that his assets may be expropriated by the domestic government, whereas the risk on similar assets held abroad is assumed to be negligible. The key assumption in this concept of expropriation risk is that the individual loses both assets and liabilities. Any event that satisfies this definition would be covered by the analysis.

I will specify a model to incorporate consumption, internal and external investment, repudiation and expropriation risk. My approach is similar to Khan and Hague (1985). The main difference is that I have the endogenous default choice in my model. I start with a standard model with external borrowing and investment, and explain the difficulty in modelling the simultaneous inflow and outflow of capital. Then I specify a model with an expropriation risk to overcome the above difficulty. Then I develop the market equilibrium in a way that follows my basic model in Part B of this essay for both theoretical and econometric interest.

(1) A Standard Model

This model differs from the basic model in several aspects:

(a) The income of the borrower country comes from two sources. One is external investment, the other is domestic investment. The income resulting from repatriation of external investment is represented by Q_1, where uncertainty enters. This uncertainty summarizes the interest rate uncertainty in the international capital market, the exchange rate uncertainty, and OECD income uncertainty (which affects the profitability of external investment). The domestic production function is linear in terms of capital input ($F = (1 + u)K$, where F is the production function, u is the marginal product of capital). Domestic investment is the only capital available and capital stays for only one period ($I^d = K$). The linear assumption allows exact aggregation in investment function. The same argument applies to external investment.

(b) Assume that costs involved in investing abroad increase with the size of the investment. This is due to conditions such as geographical distance and consequent difficulties in monitoring. If $\psi(I^e)$ represents the total transfer of resources to foreign countries required for investment I^e, we have a rising marginal cost:

$$\psi'(0) = 1, \ \psi'(I^e) > 1, \ \psi''(I^e) > 0, \text{ where } I^e > 0.$$

(c) Assume that the LDC borrowing in the first period is for financing domestic investment only. External investment is excluded based on the hypothesis that borrowing is not for financing capital flight. Consumption is excluded in order to focus the investment; the inclusion of consumption will not affect the following results. I^d is total domestic capital formation financed by domestic saving I^i and foreign borrowing D.

(d) The borrower has a risk-averse utility function and nonsatiation. The individual in the borrowing country chooses his level of consumption, investment, and borrowing. To maximize the expected return from the investment in the second period, the individual in the borrowing country must decide how to divide his investment between the domestic market, I^i, and the external market, I^e.

(e) Repudiation risk is assumed where a country defaults if the benefit of default is larger than the penalty.

I am going to show that the standard model is not appropriate in explaining the simultaneous inflow and outflow of capital. The problem facing the domestic resident is

$$\max_{C_1, C_2, I^i, I^e, D} \quad EU$$

$$(19)\quad EU = U(C_1)$$

$$+(1+\delta)^{-1} \int_{v_0}^{v_0+\pi(v_1-v_0)} U\{(1-\lambda)[(1+v)Q_2+(1+u)I^d]\}h(v)dv$$

$$+(1+\delta)^{-1} \int_{v_0+\pi(v_1-v_0)}^{v_1} U\{[(1+v)Q_2+(1+u)I^d]+(I^e-D)(1+r)\}h(v)dv$$

subject to

$$(20)\quad (a)\quad C_1 = Q_1 - I^i - \psi(I^e)$$

$$(b)\quad I^d = I^i + D$$

$$(c)\quad C_2 = \text{Max}\,(C_2^D,\ C_2^N)$$

(d) $C_2^D = (1 - \lambda)[(1 + v)Q_2 + (1 + u)I^d]$

(e) $C_2^N = [(1 + v)Q_2 + (1 + u)I^d] + (I^e - D)(1 + r)$

(f) $C_1 \geq 0,\ C_2 \geq 0,\ I^i \geq 0,\ D \geq 0$

(g) v is uniform on $[v_0\ v_1]$

(h) $\pi = P_r[\lambda((1+v)Q_2 + (1+u)I^d) < (1+r)(D - I^e)]$

$$= \frac{(1 + r)(D - I^e) - \lambda(1 + u)I^d - \lambda Q_2(1 + v_0)}{\lambda Q_2(v_1 - v_0)}$$

Q_2 is the mean income from repatriation of external investment.

C_2^D is the second period consumption with default.

C_2^N is the second period consumption without default.

The first order necessary (Kuhn-Tucker) conditions are:

(21) $$\frac{\partial EU}{\partial I^i} = - U'(C_1) - (1 + \delta)^{-1}(1 + \mu)Q_2^{-1} h(v)U(A)$$

$$+ (1 + \delta)^{-1}(1 + u)Q_2^{-1} h(v)U(B)$$

$$< 0 \text{ if } I^i = 0$$

$$= 0 \text{ if } I^i > 0.$$

$$(22)\quad \frac{\partial EU}{\partial I^e} = - U'(C_1)\psi'(I^e) + (1 + \delta)^{-1}(1 + r)h(v)Q_2^{-1} \cdot [U(B) - U(C)]$$

$$< 0 \quad \text{if} \quad I^e = 0$$

$$= 0 \quad \text{if} \quad I^e > 0.$$

$$(23)\quad \frac{\partial EU}{\partial D} = - (1 + \delta)^{-1}(1 + u)Q_2^{-1}\ h(v)U(A)$$

$$+ (1 + \delta)^{-1}(1 + u)Q_2^{-1}\ h(v)U(B)$$

$$- (1 + \delta)^{-1}(1 + r)h(v)Q_2^{-1}[U(B) - U(C)]$$

$$< 0 \quad \text{if} \quad D = 0$$

$$= 0 \quad \text{if} \quad D > 0$$

where

$$A = (1 - \lambda)(1 + v_0)Q_2 + (1 + u)I^d$$

$$B = [(1 + v_1)Q_2 + (1 + u)I^d] + (I^e - D)(1 + r)$$

$$C = \frac{1 - \lambda}{\lambda}(1 + r)(D - I^e)$$

When $\psi(I^e) = I^e$, and if $D > 0$, they imply that (21) and (22) are identical. Then agents will be indifferent when choosing between domestic and foreign investment. There is an indeterminacy such that it is always possible to increase or decrease D and I^e by the same amount and stay at the same utility level (because the cost of borrowing and the return from foreign investment are the same).

Borrowing abroad (i.e., $D > 0$) will be rational only if the domestic rate of return is higher than external investment; then I^e is equal to 0. Note that in (21), the marginal cost due to I^i is $U'(C_1)$; the marginal benefit is the rest of (21), which we call E. In (22) the marginal cost is $U'(C_1)\psi'(I^e)$. The marginal benefit is the rest of (22), which we call F. If $\psi'(I^e) > 1$, we only need to define the relevant rate of return as the net of the costs of making such investment, then (a) $F/\psi' = E$ implies indifference about domestic or external investment. Since $F > E$ implies that $\partial EU/\partial D < 0 \rightarrow D = 0$, i.e., no borrowing. (b) $F/\psi' > E$ implies that the domestic resident invests only abroad and the second period capital formation consists only of debt.

The above indeterminacies and corner solutions make the model inappropriate for explaining simultaneous capital inflow and outflow. This motivates a model with expropriation risk.

(2) A Model With Expropriation Risk

There is a probability ϕ (expropriation risk)* that the firm in the borrowing country, together with its debt obligations, will be taken over by the government (with no compensation). Then the second period consumption of the resident relies solely on earnings from external investment. Let superscript s denote the state without nationalization, and n denote nationalization. The problem facing the domestic resident is

$$\max_{C_1, C_2, I^i, I^e, D} EU$$

where $EU = U(C_1) + (1 + \delta)^{-1}[(1 - \phi)EU(C_2^s) + \phi EU(C_2^n)]$

Subject to:

(24) (a) $C_1 = Q_1 - I^i - \psi(I^e)$

(b) $I^d = I^i + D$

(c) $C_2^s = \text{Max}(C_2^{sD}, C_2^{sN})$

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*This risk applies to the country without exchange control, e.g., Hong Kong. For countries with exchange control (e.g., Mexico), and if the control is violated, there is a different cost attached to capital flight. It involves a penalty if the smuggling of currencies is discovered; the benefit is due to higher expected return from foreign investment.

(d) $C_2^{sD} = (1 - \lambda)[(1 + v)Q_2 + (1 + u)I^d]$

(e) $C_2^{sN} = [(1 + v)Q_2 + (1 + u)I^d] + (I^e - D)(1 + r)$

(f) $C_2^n = \mathrm{Max}(C_2^{nD}, C_2^{nN})$

(g) $C_2^{nD} = 0$

(h) $C_2^{nN} = (1 + r)I^e$

(i) $\pi = P_r\{\lambda[(1+v)Q_2 + (1 + u)I^d] < (1 + r)(D - I^e)\}$
Note that default risk is not affected by the expropriation risk because government takes over the debt burden of the expropriated assets.

(j) $C_1 \geq 0,\ C_2 \geq 0,\ I^i \geq 0,\ I^e \geq 0,\ D \geq 0$

C_2^s is the second period consumption without expropriation (safe).

C_2^{sD} is the second period consumption without expropriation and with default.

C_2^{sN} is the second period consumption without expropriation and without default.

C_2^n is the second period consumption with expropriation (nationalization).

C_2^{nD} is the second period consumption with expropriation and with default.

C_2^{nN} is the second period consumption with expropriation and without default.

These imply:

$$(25)\quad EU = U(C_1) + (1 + \delta)^{-1}(1 - \phi) \int_{v_0}^{v_0+\pi(v_1-v_0)} U[((1 + v)Q_2$$

$$+ (1 + u)I^d)(1 - \lambda)]h(v)dv$$

$$+ (1 + \delta)^{-1}(1 - \phi) \int_{v_0+\pi(v_1-v_0)}^{v_1} U[(1+v)Q_2+(1+u)I^d$$

$$+ (I^e - D)(1 + r)]h(v)dv$$

$$+ (1 + \delta)^{-1}\phi \int_{v_0+\pi(v_1-v_0)}^{v_1} U[(1 + r)I^e]h(v)dv$$

the expected utility is composed of the parts with or without expropriation, and the parts with or without default. Default risk is endogenous, while expropriation risk is exogenous.

The Kuhn-Tucker conditions are:

$$(26)\quad \frac{\partial EU}{\partial_I i} = - U'(C_1) - (1 + \delta)^{-1}(1 - \phi)(1 + u)h(v)Q_2^{-1}U(A)$$

$$+ (1 + \delta)^{-1}(1 - \phi)h(v)(1 + u)Q_2^{-1}U(B)$$

$$+ (1+\delta)^{-1}\phi U[(1+r)I^{e}] \frac{1+u}{Q_2(v_1 - v_0)} h(v)$$

$$< 0 \quad \text{if} \quad I^{i} = 0$$

$$= 0 \quad \text{if} \quad I^{i} > 0.$$

(27) $$\frac{\partial EU}{\partial I^{e}} = -\psi'(I^{e})U'(C_1)+(1+\delta)^{-1}(1-\phi)(1+r)h(v)Q_2^{-1}[U(B)-U(C)]$$

$$+(1+\delta)^{-1}\phi U[(1+r)I^{e}](1+r)h(v)(\lambda Q_2)^{-1}(v_1 - v_0)^{-1}$$

$$< 0 \quad \text{if} \quad I^{e} = 0$$

$$= 0 \quad \text{if} \quad I^{e} > 0.$$

(28) $$\frac{\partial EU}{\partial D} = (1+\delta)^{-1}(1-\phi)(1+u)Q_2^{-1}h(v)U(A)$$

$$+ (1+\delta)^{-1}(1-\phi)(1+u)Q_2^{-1}h(v)U(B)$$

$$- (1+\delta)^{-1}(1-\phi)(1+r)h(v)Q_2^{-1}[U(B) - U(C)]$$

$$- (1+\delta)^{-1}\phi U[(1+r)I^{e}]$$

$$\cdot[1 + r - \lambda(1+u)](\lambda Q_2)^{-1}(v_1 - v_0)^{-1}h(v)$$

$$< 0 \quad \text{if} \quad D = 0$$

$= 0$ if $D > 0$.

With positive D, equations (26) and (27) remain independent (i.e. not identical), so we can have an interior solution $I^i > 0$, $I^e > 0$, and $D > 0$.

If D and I^i are positive, foreign investment will be made such that:

$$\frac{\psi'(I^e) - 1}{1 + r} = \frac{\phi(1 - \pi)U'[(1 + r)I^e](1 + \delta)^{-1}}{U'(C_1)}$$

i.e., marginal cost ratio = intertemporal marginal rate of substitution.

i.e., $\frac{J}{K} = \frac{L}{M}$

J = Extra marginal cost due to investment abroad.

K = Marginal cost of domestic investment.

L = Discounted marginal utility under nationalization and no default.

M = Current marginal utility.

We can see that an increase in the probability of expropriation and probability of repayment shift the portfolio in the direction of foreign investment. That is, lower π and/or higher ϕ implies higher $\psi'(I^e)$, which in turn implies higher I^e.

What we have done is introduce a wedge between the internal and external rate of return to prevent corner solutions. This wedge is provided by the expropriation risk.

If the risk of expropriation is endogenized, then results similar to that above can be obtained. Here we assume that the government policy rule is known to the public, similar to the Rational Expectation approach. Then we want to see the impact on the above result. Define the endogenized probability of expropriation as:

$$\phi = P_r \{[(1 + v)Q_2 + (1 + u)I^d]$$

$$- \text{Min } [(1 + r)(D - I^e), \lambda((1 + v)Q_2 + (1 + u)I^d)] > w\}$$

where w is the cost of expropriation. It is a random variable distributed on $[0, \hat{w}]$ uniformly. The probability of expropriation is defined as the probability that the benefit of expropriation is larger than the cost of expropriation. The former is the national output minus the minimum between the debt service and the penalty of default, which are the outlay corresponding to the choice of repayment or default. Then we can set up the expected utility function:

$$(29)\quad EU = U(C_1)$$

$$+(1+\delta)^{-1} \int_{v_0}^{v_0+\pi(v_1-v_0)} \int_{(1-\lambda)[(1+v)Q_2+(1+u)I^d]}^{\hat{w}} U[((1+v)Q_2+(1+u)I^d)(1-\lambda)]f(w.v)dwdv$$

$$+(1+\delta)^{-1}\int_{v_0+\pi(v_1-v_0)}^{v_1} \int_{(1+v)Q_2+(1+u)I^d-(1+r)(D-I^e)}^{\hat{w}} U[((1+v)Q_2+(1+u)I^d-(D-I^e)(1+r)]f(w.v)\,dwdv$$

$$+(1+\delta)^{-1} \int_{v_0+\pi(v_1-v_0)}^{v_1} \int_0^{(1+v)Q_2+(1+u)I^d-(1+r)(D-I^e)} U[(1+r)I^e]f(w,v)dwdv.$$

This is the expected utility function which incorporates both the endogenous default risk and endogenous expropriation risk considerations.

As a possible simplification, one might assume that w and v are independent. Then we can express the joint density of w and v as:

$$f(w,v) = \frac{1}{\hat{w}} \frac{1}{v_1 - v_0}$$

It can be shown that we get results similar to those we got earlier. That is, expropriation risk provides a wedge between the internal and external investment returns. So we can rationalize the simultaneous inflow and outflow of capital in LDCs.

(3) Capital Market Equilibrium

Let us assume that the ϕ (probability of expropriation) is exogenous, i.e., not derived from a government decision rule, but ϕ is known to the public. We can derive various kinds of market equilibria as follows:

(a) Perfect Competition

(i) Walrasian Equilibrium (W.E.)

Let us establish the shape of the demand curve first. Take the partial derivative of (28) with respect to r to get $\partial D/\partial r$. It turns out to be negative if λ is not too small. The explanation is that when λ is very small, default becomes virtually certain. The borrower would borrow more in the first period and default in the second period. The demand curve may then be upward sloping.

Following the same procedure as in previous models, we get the lender's offer curve.

(30) $1 + r = 1 + \rho$

where $0 < D < d^{min} = \dfrac{\lambda[(1 + v_0)Q_2 + (1 + u)I^d]}{1 + r} + I^e$

$1 + r = F(D)$

where $d^{min} \leq D \leq d^{max} = \dfrac{\lambda[Q_2(1 + v_1) + (1 + u)I^d]^2}{4(1 + \rho)Q_2(v_1 - v_0)} + I^e$

and $F(D) =$

$$\frac{\lambda Q_2(1+ v_1) + \lambda(1 + u)I^d - \sqrt{4\lambda(1 + \rho)Q_2(v_1 - v_0)(d^{max} - D)}}{2(D - I^e)}$$

It can be proved that $\partial F/\partial D > 0$.

To get the W.E., we totally differentiate the three first order conditions (26), (27), (28), and the lender's offer curve (30). Then we solve this simultaneous equation system to get the reduced form. Note that we have the endogenous variables r, D, I^d, and I^e, and exogenous variables λ, Q_2, P_2, ρ, and $v_1 - v_0$.

(ii) Credit Rationing Equilibrium (C.E.)

From (30), we get

(31) $$d^{max} = \frac{\lambda[Q_2(1 + v_1) + (1 + u)I^d]^2}{4(1 + \rho)Q_2(v_1 - v_0)} + I^e$$

(32) $$r^{max} = F(d^{max}) - 1 = \frac{2(1 + \rho)Q_2(v_1 - v_0)}{Q_2(1 + v_1) + (1 + u)I^d} - 1.$$

The borrower's demand equation (28) is not binding in C.E. (because there is excess demand), but (26) and (27) are, so we solve the equation system (26), (27), (31), and (32) and get the reduced form solution for C.E.

The problem is that all the signs are ambiguous. Since my model is basically an extension of Sachs' model, the sign failure here provides us with a natural question:

> Is Sachs' model useful when we incorporate more realistic considerations, e.g., non-linear utility function, non-trivial investment function, etc.?

One way to get determinate sign properties is to take I^{d^*}, I^e as predetermined. If the investment plan is made before period one, then investment in period one still needs to be financed, though the investment decision is not made endogenously. That is, we can separate the finance decision from the investment decision. This will help us to get determinate signs without changing the model specification.

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* There are further justifications in LDCs about why I^d can be taken as exogenous. First, rationing may fall on borrowing for consumption rather than on borrowing for investment, which is consistent with the observed developing country characteristic of maintaining investment program even under financial austerity. Second, aggregate investment decisions in developing countries are likely to be based on domestic interest rates, which are mostly subject to institutional ceilings and not moving together with foreign interest rates. A model incorporating domestic investment, total indebtedness and income growth rate is outlined in Appendix C.

(iii) <u>Further Considerations</u>

<u>Precommitment</u>

If a country precommits itself to an investment program, this will have an impact on interest rates and credit ceilings. In the Walrasian Equilibrium

$$\frac{\partial r}{\partial I^d} = \frac{\partial F}{\partial I^d}$$

$$= \frac{1}{2(D - I^e)} \{\lambda(1+u) - \tfrac{1}{2}X^{-1/2} 2[\lambda Q^2(1+v_1) + \lambda(1+u)I^d \lambda(1+u)]\}$$

$$< 0.$$

From the lenders perspective, this is the risk premium they would like to adjust according to the LDC precommitment in domestic investment.

The reason is that when I^d goes up output will go up; then penalty of default goes up; thus π goes down and risk premium goes down. Therefore, r goes down.

Similarly, in Credit Rationing Equilibrium

$$\frac{\partial D^{max}}{\partial I^d} = 2\lambda[Q_2(1+v_1)+(1+u)I^d](1+u)/4(1+\rho)Q_2(v_1-v_0) > 0.$$

Precommitment to ensure that foreign loan proceeds are used for domestic investment can improve the creditworthiness of an individual or a country. Therefore risk premium or debt ceiling varies directly with the level of domestic investment undertaken in these two equilibria.

Thus private lending tends to be given to those countries which are allowed for IMF high tranche drawings. IMF allows further drawing of a member country only if that country can take a certain investment program and can limit domestic consumption--the so called austerity program.

More About Expropriation Risks

From the previous result, we know $\partial I^e/\partial\phi > 0$. From (26), using the implicit function theorem, we get

$$\frac{\partial I^i}{\partial\phi} = [(1+\delta)^{-1}(1-\phi)(1+u)^2h(v)Q^{-1}(\frac{1-\lambda}{A} - \frac{1}{B})-U''(C_1)]^{-1}$$

$$\cdot\ [(1+\delta)^{-1}(1+u)h(v)Q_2^{-1}(\ln A - \ln B)$$

$$+ (1 + \delta)^{-1}U[(1 + r)I^e]\cdot \frac{1 + u}{Q_2(v_1 - v_0)}]$$

$\frac{\partial I^i}{\partial\phi} < 0$ if $U''(C_1)$ is not too large.

$$\frac{d(d^{max})}{d\phi} = \frac{\partial d^{max}}{\partial I^i}\ \frac{\partial I^i}{\partial\phi} + \frac{\partial I^i}{\partial\phi}$$

$$= \frac{2\lambda(1 + u)[Q_2(1 + v_1) + (1 + u)I^d]}{4(1 + \rho)Q_2(v_1 - v_0)} \cdot \frac{\partial I^i}{\partial\phi} + \frac{\partial I^e}{\partial\phi}.$$

The sign depends on the relative size of $\partial I^i/\partial\phi$ and $\partial I^e/\partial\phi$. Therefore a country with a higher expropriation risk does not necessarily have a smaller credit limit.

(b) Monopsony

Now in the first order condition, $\partial r/\partial D \neq 0$, $\partial r/\partial I^d \neq 0$, $\partial r/\partial I^e \neq 0$ and these partials come from the lender's offer curve. What I will do is get the first order conditon under monopsony. Then a unique equilibrium can be derived by totally differentiating and solving them.

$$(26)' \quad \frac{\partial EU}{\partial I^i} = -U'(C_1) - (1+\delta)^{-1}(1-\phi)(1+u)h(v)Q_2^{-1}U(A)$$

$$+ (1+\delta)^{-1}(1-\phi)h(v)(1+u)Q_2^{-1}U(B)$$

$$+ (1+\delta)^{-1}(1-\phi)h(v)(I^e - D)Q_2^{-1}U(B)\frac{\partial r}{\partial I^i}$$

$$+ (1+\delta)^{-1}\phi U'[(1+r)I^e]\partial(1-\pi)/\partial I^i h(v)$$

$$+ (1+\delta)^{-1}\phi U'[(1+r)I^e]I^e\frac{\partial r}{\partial I^i}(1-\pi)h(v) = 0$$

where

$$\frac{\partial(1-\pi)}{\partial I^i} = \frac{1+u}{Q_2(v_1 - v_0)} + \frac{D - I^e}{Q_2(v_1 - v_0)}\frac{\partial r}{\partial I^i}$$

and

$$\frac{\partial r}{\partial I^i} = \frac{2(D - I^e)\lambda(1+u)}{4(D - I^e)^2} -$$

$$\frac{2(D - I^e)\, \frac{1}{2}\, X^{1/2} 2[\lambda Q_2(1 + v_1) + \lambda(1 + u)I^d]\lambda(1 + u)}{4(D - I^e)^2}$$

as a monopsonist, government takes the role of making investment decisions. A government's goal is to maximize the expected social welfare.

$$(27)' \quad \frac{\partial EU}{\partial I^e} = - \psi'(I^e)U'(C_1)+(1+\delta)^{-1}(1-\phi)(1+r)h(v)Q_2^{-1}$$

$$[U(B)-U(C)]$$

$$+(1+\delta)^{-1}(1-\phi)(I^e-D)h(v)Q_2^{-1}[U(B)-U(C)]\, \frac{\partial r}{\partial I^e}$$

$$+ (1 + \delta)^{-1}\phi U[(1 + r)I^e]$$

$$\cdot\left[\frac{1 + r}{\lambda Q_2(v_1 - v_0)} - \frac{D - I^e}{Q_2(v_1 - v_0)}\, \frac{\partial r}{\partial I^e}\right] h(v)$$

$$+ (1 + \delta)^{-1}\phi\{(1 + r)U'[(1 + r)I^e]$$

$$+ I^e U'[(1 + r)I^e]\partial r/\partial I^e\}\, (1 - \pi)$$

$$= 0$$

where

$$1 - \pi = \frac{\lambda(1 + u)I^d + \lambda Q_2(1 + v_1) -(1 + r)(D - I^e)}{\lambda Q_2(v_1 - v_0)}$$

$$\frac{\partial r}{\partial I^e} = \frac{1}{4(D - I^e)^2}\, [2(D-I^e)-\tfrac{1}{2}\cdot X^{1/2}\cdot 4(1+\rho)Q_2(v_1-v_0)\lambda]$$

$$- \frac{1}{4(D - I^e)^2} [Y \cdot (-2)]$$

and

$$Y = \lambda Q_2(1 + v_1) + \lambda(1 + u)I^d$$

$$- \sqrt{[\lambda Q_2(1+v_1)+\lambda(1+u)I^d]^2-4(1+\rho)(D-I^e)Q_2\lambda(v_1-v_0)}$$

Here the government makes the external investment decision subject to expropriation risk consideration, and this is a rational choice of the government.

$$(28)' \quad \frac{\partial EU}{\partial D} = -(1 + \delta)^{-1}(1 - \phi)(1 + u)Q_2^{-1}h(v)U(A)$$

$$+ (1 + \delta)^{-1}(1 - \phi)(1 + u)Q_2^{-1}h(v)U(B)$$

$$- (1 + \delta)^{-1}(1 - \phi)(1 + r)h(v)Q_2^{-1}[U(B) - U(C)]$$

$$+ (1 + \delta)^{-1}(1 - \phi)(I^e - D)h(v)Q_2^{-1}[U(B) - U(C)]\partial r/\partial D$$

$$+ (1 + \delta)^{-1}\phi U[(1 + r)I^e] [\frac{1 + u}{Q_2(v_1 - v_0)}$$

$$- \frac{1 + r}{\lambda Q_2(v_1 - v_0)} - \frac{(D - I^e)\partial r/\partial D}{\lambda Q_2(v_1 - v_0)}] h(v) = 0$$

where

$$\frac{\partial r}{\partial D} = \frac{2(D - I^e)}{4(D - I^e)^2} \{\lambda(1 + u) - \frac{1}{2} X^{1/2}[2[\lambda Q_2(1 + v_1)$$

$$+ \lambda(1 + u)I^d]\lambda(1 + u) - 4(1 + \rho)Q_2(v_1 - v_0)\lambda]\}$$

$$- \frac{1}{4(D - I^e)^2} \cdot (Y \cdot 2)$$

Y is the nominator of F(D), which is in the basic model. Acting as a monopsonist, the government exploits the lender's loan offer to borrow the amount which maximizes the expected social welfare. Combined with (30):

$$1 + r = \frac{[\lambda Q_2(1 + v_1) + \lambda(1 + u)I^d]}{2(D - I^e)} - \frac{X^{1/2}}{2(D - I^e)}$$

where

$$X = [\lambda Q_2(1+v_1)+\lambda(1+u)I^d]^2-4(1+\rho)(D-I^e)Q_2(v_1-v_0)\lambda$$

Then we have the complete first order conditions. If we totally differentiate the first order conditions and solve them simultaneously, the result is ambiguous in terms of sign properties. This is so because the process incorporates the interaction among endogenous variables, nonlinearity, and risk structures.

E. ECONOMETRIC IMPLICATIONS

Previous econometric work on credit rationing in international capital market includes Eaton and Gerovitz (1981) and Kharas and Shishido (1984). Both works try to link their econometric models closely to the theory. Eaton and Gerovitz establish a disequilibrium econometric model (short side rule) compatible with their theoretical part (which is based on disequilibrium theory). In addition to the unsatisfactory nature of the disequilibrium theory in general, there are at least three more problems in their econometrics: (1) they have interest rate (or debt obligation) in their theory to explain the amount of borrowing, but the interest rate does not show up in their econometric model; (2) the comparative static properties they test are based on a deterministic model, but then default will not occur at all (this is unrealistic, and it is especially inappropriate to estimate equations involving probability of default as endogenous variables); and (3) there is no specification about where C.E. and W.E. will occur, and no deeper testable structural properties (except a short side rule) attached to these two equilibria. K & S construct an econometric model based on the theory developed in Stiglitz and Weiss (1981). The theory itself is interesting, since C.E. is attained due to the lender's optimization behavior. The econometric test is also intriguingly designed and ends up with a disequilibrium econometric model (short side rule). But again there are at least three problems in their econometric model: (1) the interest rate is missing from their system; (2) they did not consider the nonlinearity of the loan offer and demand curves that is required from the theory; and (3) they did not test the theory according to the knowledge of exactly where credit rationing occurs (in Stiglitz and Weiss, C.E. always occurs at the inflection point of the loan offer curve, but K & S did not address this). The result is that the econometric work is not really testing Stiglitz and Weiss's credit rationing theory.

The most important characteristic of my econometric model is that it is precisely designed to capture the central feature of the theory. Uncertainty, nonlinearity, interest rate, simultaneity and the exact specification of the W.E. and C.E. are captured in the econometric model. It is a serious effort to link econometrics and theory. The exact specification of the econometric model is the main thesis of essay 3, which includes considering the possible downward sloping and upward sloping demand curve; exhausting all the possible interactions between the supply and demand curves; assigning appropriate densities and probabilities to W.E. and C.E.; and finally, estimating the model, making predictions, and testing various hypotheses. The econometric model will be developed in essay 3.

F. CONCLUSION

The presence of sovereign risk has pervasive impact on the international capital market. Credit rationing is probably more prevalent in the international capital market because of the unenforceable nature of the sovereign loan contract and the ubiquitous moral hazard.

This paper explores the ground for differentiating Walrasian Equilibrium and Credit Rationing Equilibrium. I claim that the market structure on the borrower side needs to be perfect competition, or no meaningful distinction can be made between these two equilibria. Repudiation risk often causes the loan offer curve to be first upward sloping and then backward bending. This particular shape of loan offer curve makes credit rationing possible. The interaction between the loan offer and loan demand determines Walrasian Equilibrium and Credit Rationing Equilibrium.

In my basic model, terms of trade are assumed to be uncertain. The utility function is assumed to be nonlinear to provide ground for differentiation of equilibria. The demand curve then has a negative slope so long as expected output is larger than a certain value. The two equilibria are then differentiated both according to the structural equations and the reduced-form equations in terms of the differential of interest rate, amount of borrowing and probability of default. Sign properties in the Credit Rationing Equilibrium are mostly clear-cut while this is not the case in the Walrasian Equilibrium. Although in terms of econometric estimation, the sign properties of the parameters of the simultaneous structural equations are mostly clear-cut (which correspond to W.E.). The aggregation problem on preference is approached by assuming quasi-homothetic preference.

The basic model is then extended to incorporate the lender's risk averse behavior. Again, the Walrasian Equilibrium and Credit Rationing Equilibrium are derived. A higher degree of risk aversion is likely to decrease the credit ceiling. Another extension is to incorporate the borrower's portfolio choice behavior, so we can consider borrowing for investment purposes. Here the uncertainty is assumed to be reflected in the repatriation from the external investment. Expropriation risk is introduced to explain the simultaneous inflow and outflow of capital. Walrasian and Credit Rationing Equilibra are derived. Precommitment is shown to increase the credit ceiling. Increasing the expropriation risk is shown to increase the external investment and decrease the internal investment.

Finally, an econometric model is initiated to differentiate W.E. from C.E.. It tries to capture the main features of the theoretical model.

Overall, this is a model with uncertainty and symmetric information between lenders and borrowers. Default, as employed in this model, means repudiation, which is a volitionally dishonest behavior (in the sense of Jaffee and Russell [1976]). It establishes a new rationale for credit rationing which is simple yet satisfactory in many respects. It extends previous works in terms of the borrower's market structure, and risk-averse behavior on both the borrower's and lender's sides, and employs expropriation risk in tandem with default risk to explain capital flight. The model also provides ground for an econometric work, and an innovative econometric model will be developed in essay 3.

APPENDIX A

Equation (9) is derived in this appendix.

Linking the borrower's behavior (given by (7)) with that of the lender (given by (3)) provides an equation system of three unknowns and five parameters. The three unknowns are the volume of sovereign loan (D), the rate of interest on a risky loan (r), and the probability of default (π). The parameters are the terms of trade (P_2), the range parameter of the probability distribution for terms of trade ($v_1 - v_0$), the output level (Q_2), the coefficient of default penalty (λ), and the safe asset interest rate (ρ). The solution for the three dependent variables is examined in terms of the latter five exogenous variables. Totally differentiating (7) and (3), we have:

$$(7)' \quad \dot{r}[(\ln A-\ln B)C_1-((1+r)C_1D/A)-(1+r)C_1(1-\lambda)D/\lambda B]$$

$$+\ \dot{D}[(1+r)(\ln A-\ln B)-(1+r)^2C_1/A-(1+r)^2C_1(1-\lambda)/\lambda B]$$

$$= \dot{\lambda}[-(1+r)^2C_1D/\lambda^2B]+\dot{P}_2[-(1+r)C_1(1+v_1)Q_2/A$$

$$+\ (1 + \delta)Q_2(v_1 - v_0)]$$

$$+\ \dot{Q}_2[-(1 + r)C_1P_2(1 + v_1)/A + (1 + \delta)(v_1 - v_0)]$$

$$+ (v_1 \dot{-} v_0)(1 + \delta)Q_2$$

(3)' $$\dot{r}+\dot{D}[\frac{1}{2D^2} \cdot \lambda P_2Q_2(1+v_1) - \frac{1+\rho}{D} X^{-1/2} \lambda P_2Q_2(v_1-v_0)$$

$$- \frac{1}{2D^2} X^{1/2}]$$

$$= \dot{\lambda}[\frac{1}{2D} (1 + v_1)P_2Q_2 - \frac{1}{2D} X^{-1/2} \lambda P_2^2Q_2^2(1 + v_1)^2$$

$$+ \frac{1}{D} X^{-1/2} (1 + \rho)P_2Q_2D(v_1 - v_0)]$$

$$+ \dot{P}_2 [\frac{1}{2D} (1 + v_1)\lambda Q_2 - \frac{1}{2D} X^{-1/2} \lambda^2P_2Q_2^2(1 + v_1)^2$$

$$+ \frac{1}{D} X^{-1/2} (1 + \rho)\lambda Q_2D(v_1 - v_0)]$$

$$+ \dot{Q}_2[\frac{1}{2D} (1+v_1)\lambda P_2-\frac{1}{2D} X^{-1/2} \lambda^2P_2^2Q_2(1 + v_1)^2$$

$$+ \frac{1}{D} X^{-1/2} (1 + \rho)\lambda P_2D(v_1 - v_0)]$$

$$+ (v_1 \dot{-} v_0)[(1 + \rho) X^{-1/2} \lambda P_2Q_2]$$

$$+ \dot{\rho}[X^{-1/2} \lambda P_2Q_2(v_1 - v_0)]$$

Solving (7') and (3') simultaneously, we have the Jacobian

$$J = \{(\ln A - \ln B)C_1 - (1 + r)C_1D/A + (1 + r)C_1D/B$$

$$- (1 + r)(C_1D/\lambda B - (1 + r)C_1/\lambda B$$

$$\cdot[\frac{1}{2D} \lambda P_2Q_2(1 + v_1) + \frac{1}{4} X^{-1/2} \lambda P_2Q_2)(v_1 - v_0)]\}\cdot$$

$$[\frac{1}{2D^2} \lambda P_2Q_2(1 + r_1) - \frac{1 + \rho}{D} X^{-1/2} \lambda P_2Q_2(v_1 - v_0)$$

$$- \frac{1}{2D^2} X^{1/2}]$$

$$- (1 + r)(\ln A - \ln B) + (1 + r)^2C_1(1 - \lambda)/\lambda B$$

which is ambiguous in sign. Since the Jacobian enters into each coefficient of the reduced form, the reduced form of D and r do not have properties that can be tested.

Taking the definition of π in (1) into consideration, we have

$$\dot{\pi} = \frac{D}{\lambda P_2Q_2(v_1 - v_0)} \dot{r} + \frac{1 + r}{\lambda P_2Q_2(v_1 - v_0)} \dot{D}$$

$$+ [\frac{- (1 + v_0)}{\lambda(v_1 - v_0)} - \frac{[(1 + r)D - (1 + v_0)\lambda P_2Q_2]}{\lambda^2P_2Q_2(v_1 - v_0)}] \dot{\lambda}$$

$$+ [- \frac{1 + v_0}{v(v_1 - v_0)P_2} - \frac{(1 + r)D - (1 + v_0)\lambda P_2Q_2}{\lambda P_2^2Q_2(v_1 - v_0)}]\dot{P}_2$$

$$+ [\frac{1 + v_0}{Q_2(v_1 - v_0)} - \frac{[(1 + r)D - (1 + v_0)\lambda P_2Q_2]}{\lambda P_2Q_2^2(v_1 - v_0)}]\dot{\rho}$$

$$+ \left[- \frac{(1 + r)D - (1 + v_0)\lambda P_2Q_2}{\lambda P_2Q_2(v_1 - v_0)^2}\right] (v_1 \dot{-} v_0)$$

Since r and D have ambiguous reduced form, this will have the effect of mixing the sign of π's reduced form.

In the above derivation, A, B, C_1, and X represent:

$$A = P_2(1 + v_1)Q_2 - (1 + r)D$$

$$B = \frac{1 - \lambda}{\lambda} (1 + r)D$$

$$C_1 = P_1Q_1 + D$$

$$X = [\lambda P_2Q_2(1 + v_1)]^2 - 4(1 + \rho)\lambda P_2Q_2D(v_1 - v_0)$$

APPENDIX B

Here we use the "Correspondence Principle" to try to pin down some signs of equation (9). According to Patinkin (1965), we have the price adjustment equation:

$$\frac{dP}{dt} = K \cdot ED$$

where P is the price, ED is the excess demand, K is a constant.

Then $\quad z = |KA| = |K| \; |A|$

where $\quad z$ is the eigenvalue of KA,

$A = \frac{\partial ED}{\partial P}$, and

$|KA|$ is the determinent of KA.

In my model, we can take the single market approach:

$$\frac{dr}{dt} = K \cdot ED \qquad K > 0$$

where r is the interest rate.

To have stability in this market, we need to have $|KA|$ to be negative, which implies that $|A|$ is negative. Here $A = \frac{\partial ED}{\partial r}$. To have Walrasian equilibrium in this market, we need $D^d - D^s = 0$.

Therefore $\frac{d(D^d - D^s)}{d\lambda} = \frac{\partial(D^d - D^s)}{\partial r} \; \frac{\partial r}{\partial \lambda} + \frac{\partial(D^d - D^s)}{\partial \lambda} = 0.$

Now we know $\frac{\partial(D^d - D^s)}{\partial r} < 0$. In order to sign $\frac{\partial r}{\partial \lambda}$, we need to know the sign of $\frac{\partial(D^d - D^s)}{\partial \lambda}$, but we don't know it! As we can see from the table, $\frac{\partial(D^d - D^s)}{\partial \lambda} = \frac{\partial D^d}{\partial \lambda} - \frac{\partial D^s}{\partial \lambda} = (+)-(+)$, the sign is ambiguous. From Table 1:

Table 1

	$\partial X/\partial Y$	Y: Supply D^s	Demand D^d
	r	+	-
	λ	+	+
X:	P_2	+	?
	Q_2	+	?
	v_1-v_0	-	?
	ρ	-	

Similarly, it is not possible to determine the sign of $\frac{\partial r}{\partial P_2}$, $\frac{\partial r}{\partial Q_2}$, $\frac{\partial r}{\partial (v_1-v_0)}$, $\frac{\partial r}{\partial \rho}$ from the table and correspondence principle.

On the other hand, adding the commodity market simply complicates the situation without giving a definite result, which we can see from Table 2.

Table 2

	Probability π	Probability $1-\pi$
Demand	C_2^D	C_2^N
Supply	$(1-\lambda)P_2(1+v)Q_2$	$P_2(1+v)Q_2-(1+r)D$
Excess demand	$C_2^D-(1-\lambda)P_2(1+v)Q_2$	$C_2^N-P_2(1+v)Q_2+(1+r)D$

Weighted

excess demand $\pi[C_2^D-(1-\lambda)P_2(1+v)Q_2]+(1-\pi)[C_2^N-P_2(1+v)Q_2+(1+r)D]$

Now we have two markets; Walrasian equilibrium requires that (1) and (2) hold simultaneously:

(1) $L(r,P,\lambda) = 0$ which is the loan market equilibriuam equation.

(2) $F(r,P,\lambda) = 0$ which is the commodity market equilibrium equation referring to the above weighted excess demand. Differentiate both equations with respect to λ

$$\rightarrow \frac{\partial L}{\partial r}\frac{\partial r}{\partial \lambda} + \frac{\partial L}{\partial P}\frac{\partial P}{\partial \lambda} + \frac{\partial L}{\partial \lambda} = 0$$

$$\frac{\partial F}{\partial r}\frac{\partial r}{\partial \lambda} + \frac{\partial F}{\partial P}\frac{\partial P}{\partial \lambda} + \frac{\partial F}{\partial \lambda} = 0$$

To get the sign of $\frac{\partial r}{\partial \lambda}$ and $\frac{\partial P}{\partial \lambda}$ we need to know the sign of the Jacobian $\begin{vmatrix} \partial L/\partial r & \partial L/\partial P \\ \partial F/\partial r & \partial F/\partial P \end{vmatrix}$. But the problem is that $\partial L/\partial r$, $\partial L/\partial P$ are not signable.

APPENDIX C

There are some important variables which are not included in the basic model. First, the huge amount of debt overhang is always cited by the press as a potential cause of debt crisis. Second, income growth rate is always taken as an important factor by LDCs to solve the debt problem. Third, investment project financing is a traditional incentive for foreign borrowing. Therefore, I outline a model which incorporates these key variables. I will modify several key equations in the basic model, and the other equations and results can be modified accordingly.

$$(1)'' \quad \pi = \Pr\ [\lambda(P_2(1+v)Q_2+(1+u)I^d)<(1+r)D+\bar{D}]$$

$$= \frac{(1+r)D+\bar{D}-(1+v_0)\lambda P_2Q_2-\lambda(1+u)I^d}{\lambda P_2Q_2(v_1-v_0)}$$

where (1)" is the modified version of equation (1) in the basic model. $\bar{D}$ is the total indebtedness. The debt overhang is assumed to be the same for both period 1 and 2. This assumption matches the fact that the LDC debts are mostly of intermediate duration, and subject to constant rollover. The production technology is assumed to be linear with the marginal product of capital u. I^d is domestic investment.

$$(4)'' \quad EU = U(C_1) + (1+\delta)^{-1} \int_{v_0}^{v_0+\pi(v_1-v_0)} U[(1-\lambda)[P_2(1+v)Q_2+(1+u)I^d]]$$

$$\cdot\, h(v)dv + (1+\delta)^{-1} \int_{v_0+\pi(v_1-v_0)}^{v_1} U[P_2(1+v)Q_2+(1+u)I^d-(1+r)D-\bar{D}]h(v)dv.$$

We have here the modified version of equation (4). $\bar{D}$ and I^d enter conformably.

(5)" EU is maximized, subject to

(a) $C_1 = P_1Q_2/g + D$

(b) $C_2 = \text{Max}\ (C_2^D, C_2^N)$

(c) $C_2^D = (1-\lambda)[P_2(1+v)Q_2+(1+u)I^d]$

(d) $C_2^N = P_2(1+v)Q_2+(1+u)I^d-(1+r)D-\bar{D}$

(e) v is uniform on $[v_0, v_1]$

(f) $\pi = \Pr[\lambda[P_2(1+v)Q_2+(1+u)I^d] < (1+r)D+\bar{D}]$.

Here g is the real income growth rate. I^d and $\bar{D}$ enter conformably.

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CHAPTER FOUR

(ESSAY 3)

AN ECONOMETRIC FRAMEWORK FOR STUDYING THE INTERNATIONAL CREDIT RATIONING PROBLEM

A. INTRODUCTION

In the early 1980s, numerous instances of LDC debt moratoria and rescheduling pushed the debt problem to the forefront of international economic issues. The debt problem may be attributed to the world economic environment, debt mismanagement by LDC, and overlending by commercial-banks. The policy prescriptions for this problem are related to the structure of the international capital market. For example, the call for greater regulation of commercial bank sovereign lending presumes that banks cannot control the quality of their portfolio because of the absence of covenant and bankruptcy laws. An argument to support the assertion that lenders cannot manage country risk rests on the hypothesis that they did not ration credit to developing countries. The availability of credit is also a central feature of the traditional-debt management prescriptions to finance a temporary shock, but not a permanent one. If debtors are credit rationed, optimal borrower behavior will involve signalling, precommitments and the use of other devices to influence the contracts between borrowers and lenders. The inadequate legal structures of the international capital market produce the repudiation risk, which makes international credit rationing perhaps even more prevalent than domestic credit rationing.

In essay 2 of my thesis, I studied the structure of the international capital market and established a new theoretical rationale for credit rationing. A theoretical framework was established to study the international debt problem, which centers on the switching between Walrasian equilibrium and Credit Rationing Equilibrium. I reviewed some previous empirical papers based on disequilibrium or incentive credit rationing theory, and found them unsatisfactory in that: (1) their theoretical basis is not sound; and (2) their econometric framework does not capture the main features of the theory. While I tried to establish a simple yet useful theoretical framework in essay 2, in essay 3 I will try to provide an econometric framework which captures the main features of the theory and can be used in an empirical study of the credit rationing and LDC debt problems.

Here I briefly summarize the rationale of my theoretical model. I assume that information is symmetric between lenders and borrowers, and that all borrowers are potentially dishonest. I also assume that the lender's market and borrower's market are both competitive. In many circumstances, these assumptions imply an upward sloping and then backward-bending offer curve. The upper half of the loan-offer curve is inefficient (or irrelevant) because borrowers prefer the low-interest-rate loan package and the lenders are indifferent when choosing between a low-interest-rate package and a high interest rate package. If the demand curve intersects the lower half of the loan offer curve, we have a Walrasian Equilibrium. If the demand curve does not intersect the efficient part of the loan offer curve, we have a Credit Rationing Equilibrium at the interest rate level corresponding to the inflection point on the offer curve. The interest rate will not be pushed up at the credit rationing point simply because competition among lenders renders a higher interest rate inefficient, and therefore not available. The market switches* between a Credit Rationing Equilibrium (C.E.) and a Walrasian Equilibrium (W.E.). A formal model based on this rationale was established in my second essay. This theoretical model has interesting econometric implications which motivate the third essay.

Previous econometric studies on credit rationing are mainly disequilibrium models. The essence of these models is that markets are characterized by excess demands or supplies, and prices are rigid or slowly adjusted. The

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*When we say "switch", we mean that the market will result in a Credit Rationing Equilibrium or a Walrasian Equilibrium. Both equilibria have positive probabilities to occur.

first empirical work in this direction, which inspired a great deal of later work, was that by Fair and Jaffee (1972). However, their study did not use limited dependent variable methods, nor did the further analysis of their data by Quandt (1972) and Goldfeld and Quandt (1972), who suggested switching regression methods. The studies by Amemiya (1974) and by Maddala and Nelson (1974) showed how the correct statistical analysis of this model depends on the use of limited dependent variables methods. In this essay, an econometric model in the spirit of Maddala and Nelson (1974) will be established. My model, however, differs from M & N in two respects: (1) my model is based on the notion of switching between two equilibria; and (2) the details of the econometric specification are quite different.

The plan of this essay is as follows: In section B we shall add error terms to the theoretical model derived from essay 2. Therefore, we get the stochastic (econometric) version of the model. In section C the likelihood function of the linear demand curve based on complete sample separation assumptions is derived. The possibility of upward and downward-sloping demand curve is carefully considered. For the non-linear demand curve, we use Monte Carlo Integregration to evalute the likelihood function. In section D we specify the variables and parameters and consider the identification problem; the potential sources of data are also examined. In section E we summarize this essay and talk about a plan for future research: an empirical analysis of the debt and credit rationing problem based on the theoretical and econometric framework in essays 2 and 3.

B.. STOCHASTIC SPECIFICATION

In the second essay, we established the deterministic model. Here we add error terms to form the econometric model, and we will give justification for the following way to enter error terms:

(1) $D^{*}=\ell(r,x,\theta)+u_1$

equation (1) represents the loan offer curve, where D^{*} represents the amount of loan offered, θ represents parameters, x represents exogenous variables. The function $\ell(r,x,\theta)$ is given explicityly on the next page.

(2) $D^{max} = h(x,\theta)+u_1$

D^{max} is the maximum amount of loan offered, when there is a positive default risk, and $h(x,\theta) = \dfrac{\lambda P_2 Q_2 (1+v_1)^2}{4(1+\rho)(v_1-v_0)}$

(3) $r^{max} = m(x,\theta)$

r^{max} is the interest rate corresponding to D^{max}, and $m(x,\theta)= \dfrac{2(1+\rho)(v_1-v_0)}{1+v_1} - 1$

(4) $r^{min} = \rho$ — r^{min} is the risk-free interest rate.

(5) $d^{min} = n(x,\theta) + u_1$ — d^{min} is the maximum amount of risk-free loan offered at r^{min}, and $n(x,\theta) = \dfrac{\lambda(1+v_0)P_2Q_2}{1+\rho}$

(6) $D^{**} = g(r,x,\theta') + u_2$ — Equation (6) represents the loan demand curve where D^{**} represents the amount of loan demanded.

The deterministic part of equation (1) comes from equation (1) and (2) of essay 2. There we had

$$1 + \rho = (1+r)\left[\frac{\lambda P_2Q_2(1+v_1)-(1+r)D}{\lambda P_2Q_2(v_1-v_0)}\right], \text{ therefore}$$

(7) $\ell(r,x,\theta) = D =$

$$\lambda P_2Q_2(1+v_1)(1+r)^{-1}-(1+\rho)\lambda P_2Q_2(v_1-v_0)(1+r)^{-2}$$

The deterministic portion of equation (6) is derived from the borrower's utility maximization problem. If the utility function is quadratic, we get linear demand $g(r,x,\theta')$. If the utility function is constant relative-risk averse, we get non-linear demand, which is implicit in equation (7) of essay 2, that question is:

$$(8)\quad (1+r)\ln\left[\frac{P_2(1+v_1)Q_2-(1+r)D}{\frac{1-\lambda}{\lambda}\,(1+r)D}\right](P_1Q_1+D) = (1+\delta)(v_1-v_0)P_2Q_2$$

where $D = g(r,x,\theta')$

Let $G(x,r,\theta')$

$$= (1+r)\ln\left[\frac{P_2(1+v_1)Q_2-(1+r)D}{\frac{1-\lambda}{\lambda}\,(1+r)D}\right](P_1Q_1+D)-(1+\delta)(v_1-v_0)P_2Q_2=0$$

We can then pin down the comparative static properties of $g(r,x,\theta')$ via the implicit-function theorem, where $g(r,x,\theta')$ is implicit in $G(r,x,\theta')$. We cannot get the analytical solution of $g\,(r,x,\theta')$, but we can get the numerical solution.

Equation (2) - (5) are formulated conformably.

Now let us look at the stochastic equation (1) and (6) on the D - r plane, where D is on the horizontal axis (here D can be either D^* or D^{**}, and this D is the stochastic version of the D in the deterministic model), and r is on the vertical axis. The way we enter (u_1, u_2) implies that the shift of supply and demand curves due to disturbances is in the horizontal direction only. There are two justifications for this specification. The first is for convenience. If we allowed a shift in the vertical direction only, the credit ceiling would not be affected by any disturbance, since the offer curve is vertical at the credit ceiling point. If we allowed a shift in both the horizontal and the vertical directions, the likelihood function would be much more complicated and difficult to operate with. The second reason for this stochastic specification is an institutional one. It comes from the fact that the practice of renegotiation makes default quite unlikely. Therefore the risk premium is low and r^{max} is quite close to the safe interest rate (see Fokerts-Landau (1985)). On the other hand, the safe interest rate is relatively more stable as compared to the amount of lending, since overlending or credit rationing have been quite prevalent in the international credit market recently. Therefore, r is relatively stable as compared to D, and it is reasonable to add on disturbances in the "D" direction.

C. THE LIKELIHOOD FUNCTION

The shape of the demand curve is important in determining the likelihood function. The demand curve can be linear or non-linear, depending on the form of the utility function. If the utility function is quadratic, we have a linear demand curve. For many other utility functions, such as the constant-relative-risk-aversion utility function, we have a non-linear demand curve.

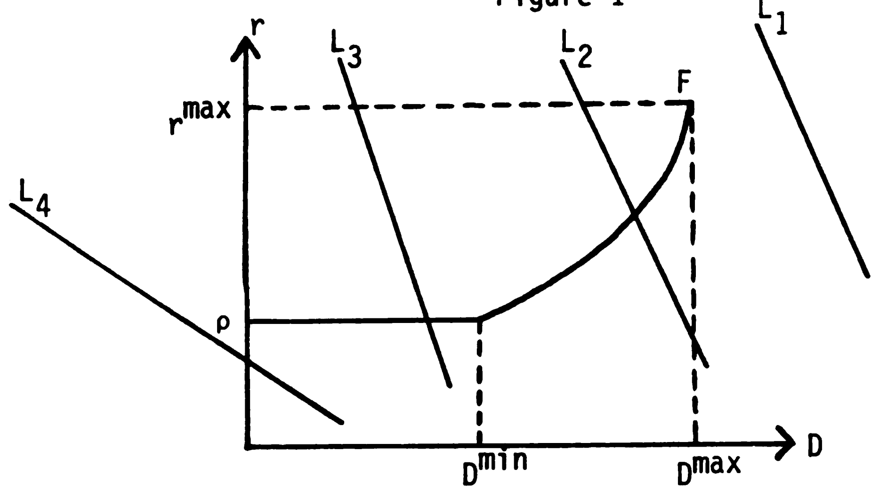
1. Linear Demand Curve

First of all, let us consider two types of linear demand curves, and the corresponding cases.

(a) Downward Sloping Demand Curve

In Figure 1, L_1, L_2, L_3, L_4 represent all the possible downward sloping demand curves; F is the offer curve, r is the risk-adjusted interest rate; ρ is the safe interest rate; D is the amount of borrowing or lending.

Figure 1



There are four cases (E_1, E_2, E_3^a, E_3^b), corresponding to whether and where the demand curve intersects the offer curve. They are:

E_1: $g(\rho, x, \theta') + u_2 < 0$

which is the degenerate case, and L_4 represents the relevant demand curve. Here we observe $D = 0$ where D is the transacted amount of loan and we do not observe r. Zero amount of borrowing gives the name "degenerate" case.

E_2: $g(r^{max},x,\theta') + u_2 > D^{max} = h(x,\theta) + u_1$

which is the credit rationing case, and L_1 represents the relevant demand curve. Here we observe $D = D^{max}$, $r = r^{max}$.

E_3^a: $0 \leq g(\rho,x,\theta') + u_2 \leq \ell(\rho,x,\theta) + u_1$

which is the default-free Walrasian case A, and L_3 represents the relevant demand curve. Here we observe $r = \rho$,

and D is on the demand curve.

E_3^b: $g(r^{max},x,\theta') + u_2 \leq D^{max} = h(x,\theta) + u_1$ and

$\ell(\rho,x,\theta) + u_1 \leq g(\rho,x,\theta') + u_2$

which is the normal Walrasian case B, and L_2 respresents the relevant demand curve. Here we observe r, D, where $D = D^* = D^{**}$.

We can thus calculate the density and probability for each event, and these results will be used in calculating the likelihood function for the downward sloping demand curve.

Event 1. Degenerate Case

$g\ (\rho,x,\theta') + u_2 < 0$

The amount of borrowing is zero in this event, so we call it the degenerate case.

Probability of this event $\equiv P_1$

We observe $Q = 0$; r is unobserved.

We assume $\begin{pmatrix} u_1 \\ u_2 \end{pmatrix} \sim$ Bivariate Normal $\left\{ \begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{21} & \sigma_{22} \end{bmatrix} \right\}$.

Let $V(u_1, u_2)$ represents the joint density function of

u_1, u_2:

$$V(u_1, u_2) = \frac{1}{2\pi\sqrt{\sigma_{11}\sigma_{12}(1-\S^2)}} \cdot \exp\{-\frac{1}{2(1-\S^2)}\left[(\frac{u_1}{\sqrt{\sigma_{11}}})^2\right.$$

$$\left. - 2\S\,(\frac{u_1}{\sqrt{\sigma_{11}}} \cdot \frac{u_2}{\sqrt{\sigma_{22}}}) + (\frac{u_2}{\sqrt{\sigma_{22}}})^2\right]\}$$

where $\S$: correlation coefficient

σ_{11}: variance of u_1

σ_{12}: covariance between u_1 and u_2

σ_{22}: variance of u_2

$$V_2(u_2) = \int_{-\infty}^{\infty} V(u_1, u_2)\, du_1 = \frac{1}{\sqrt{2\pi\sigma_{22}}} \exp\left[-\frac{1}{2}(\frac{u_2}{\sqrt{\sigma_{22}}})^2\right]$$

$$P_1 = \int_{-\infty}^{-g(\rho,x,\theta')/\sqrt{\sigma_{22}}} \frac{1}{\sqrt{2\pi\sigma_{22}}} \exp\left[-\frac{1}{2}(\frac{u_2}{\sqrt{\sigma_{22}}})^2\right] du_2$$

$$= \Phi(-g(\rho,x,\theta')/\sqrt{\sigma_{22}})$$ where Φ: standard normal CDF.

<u>Event 2. Credit Rationing Case</u>

$g(r^{max},x,\theta') + u_2 > D^{max} = h(x,\theta) + u_1$

$\rightarrow u_2 - u_1 > h(x,\theta) - g(m(x,\theta), x,\theta')$

Probability of this event $\equiv P_2$

where we observe: $D = D^{max}$, $r = r^{max}$. Therefore,

$P_2 = 1 - \Phi\{[h(x,\theta)-g(m(x,\theta),x,\theta')]/\sqrt{\sigma_{11}+\sigma_{22}-2\,\sigma_{12}}\}$

Density $(D,r|E_2)$ = Density $(D = D^{max}|r = r^{max}$,

$u_2-u_1 > h(x,\theta) - g(m(x,\theta),x,\theta')) = \int_{u_2\rightarrow C.R.} f(u_1,u_2)\cdot$

Jacobian $\cdot\, du_2/P_2 = \int_{u_2 > D-g(r^{max},x,\theta')} f(D-h(x,\theta),u_2)\cdot$

Jacobian $\cdot\, du_2/P_2$. Substitute $D^{**} = u_2 + g(r^{max},x,\theta')$

for u_2 above $\rightarrow$ Density $(D, r \mid E_2)$

$$= \int_{D^{**} > D} f(D-h(x,\theta),\ D^{**}-g(r^{max},x,\theta'))dD^{**}/P_2,$$

where the Jacobian = 1.

Event 3a. Walrasian Case A

$\ell(\rho,x,\theta) + u_1 \geq g(\rho,x,\theta') + u_2$

and $g(\rho,x,\theta') + u_2 \geq 0$

$\rightarrow u_2 - u_1 \leq \ell(\rho,x,\theta) - g(\rho,x,\theta')$

and $u_2 > -g(\rho,x,\theta')$

Probability of this event $\equiv P_3^a$

$$P_3^a = \Phi\{[\ell(\rho,x,\theta) - g(\rho,x,\theta')]/\sqrt{\sigma_{11} + \sigma_{22} - 2\sigma_{12}}\} - \Phi(-g(\rho,x,\theta')/\sqrt{\sigma_{22}})$$

We observe $r = \rho$ and D is on the demand curve.

Therefore $D = g(\rho,x,\theta') + u_2$.

Density $(D, r \mid E_3^a) =$

$$\text{Density}(D \mid r=\rho, u_2-u_1 \leq \ell(\rho,x,\theta)-g(\rho,x,\theta'))$$

$$= \int_{u_1 \rightarrow E_3^a} f(u_1, D-g(\rho,x,\theta')) \cdot \text{Jacobian} \cdot du_1/P_3^a$$

$$= \int_{u_1 \geq D-\ell(\rho,x,\theta)} f(u_1, D-g(\rho,x,\theta'))\, du_1/P_3^a$$

If we substitute $D^* = \ell(r,x,\theta) + u_1$ into the above equality, we get:

$$\text{Density } (D, r \mid E_3^a) = \int_{D^* > D} f(D^*-\ell(r,x,\theta),\ D-g(\rho,x,\theta'))dD^*/P_3^a$$

Event 3b. Walrasian Case B

$g(r^{max},x,\theta') + u_2 \leq D^{max} = h(x,\theta) + u_1$

and $\ell(\rho,x,\theta) + u_1 \leq g(\rho,x,\theta') + u_2$

Probability of this event $\equiv P_3^b = 1 - P_1 - P_2 - P_3^a$.

If this event occurs, set $D^* = D^{**} = D$.

We observe r, D. Therefore,

Density $(D, r | E_3^b) = |J| \cdot V(u_1, u_2)/P_3^b$

$$= |J| \cdot \frac{V(D - l(r,x,\theta), D - g(r,x,\theta'))}{P_3^b}.$$

$$\text{Where} \quad |J| = \begin{vmatrix} \partial u_1/\partial D & \partial u_1/\partial r \\ \partial u_2/\partial D & \partial u_2/\partial r \end{vmatrix}$$

$$u_1 = D - \ell(r,x,\theta)$$

$$u_2 = D - g(r,x,\theta')$$

$$\partial u_1/\partial D = 1$$

$$\partial u_1/\partial r = - \partial\ell(r,x,\theta)/\partial r$$

$$\partial u_2/\partial D = 1$$

$$\partial u_2/\partial r = - \partial g(r,x,\theta')/\partial r$$

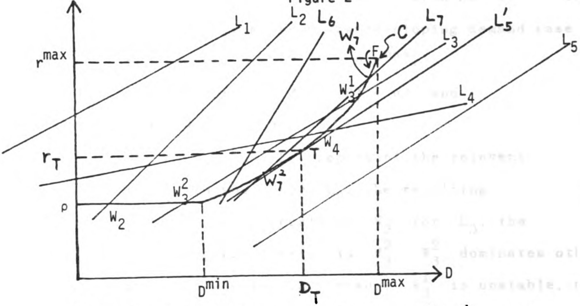
(b) Upward Sloping Demand Curve

If the probability of default is sufficiently high, the demand curve can be upward sloping. The reason is that the borrowers may borrow more in the first period and default in the second period.

In Figure 2, L_1, L_2, L_3, L_4, L_5, L_6, L_7 represent all possible upward sloping demand curves; F represents the offer curve.

As a preliminary for later discussions, we need to establish some dominance properties. For example, W_3^2 is preferred to C (Credit Rationing Equilibrium) by borrowers. The proof is deferred to the appendix. Similarly, we can prove that the degenerate point at $r = \rho$ dominates C.

Figure 2



There are again four cases (E_1, E_2, E_3^a, E_3^b), each corresponding to some constraints.

E_1: $g(\rho, x, \theta') + u_2 < 0$

where L_1, L_4 represent the relevant demand curves. It is obvious that L_1 is a degenerate case. The same is true for L_4, because W_4 is unstable; and (as we have mentioned earlier) the degenerate case dominates the credit rationing case. So both L_1 and L_4 are relevant in this case. It is similar to the downward-sloping demand case. We observe $D = 0$, and we do not observe r.

E_2: $g(r_T, x, \theta') + u_2 > D_T$

where L_5 is to the right hand side of L_5' and represents the relevant demand curve, where L_5' is tangent to the loan offer curve at T. It is different from the downward-sloping demand case. We observe $D = D^{max}$, $r = r^{max}$.

E_3^a: $g(\rho, x, \theta') + u_2 \leq \ell(\rho, x, \theta) + u_1$ and

$g(\rho, x, \theta') + u_2 \geq 0$

where L_2 and L_3 represent the relevant demand curves. For L_2, the resulting equilibrium obviously is W_2; for L_3, the resulting equilibrium is W_3^2. W_3^2 dominates other possible equilibria, because W_3^1 is unstable, and W_3^2 dominates C (the proof is given in the appendix). The characteristics of E_3^a here are similar to those of the downward sloping demand case. Here we observe $r = \rho$, and D is on the demand curve.

E_3^b: $g(\rho, x, \theta') + u_2 > \ell(\rho, x, \theta) + u_1$, and there is at least one intersection between the upward sloping portion of the loan offer curve and the demand curve. Here L_6 and L_7 represent the relevant demand curves. As for L_7, the intersection point W_7^1 is unstable, and W_7^2 dominates C due to the same rationale that I have established in the appendix. This case has the same density but a different probability as compared to the downward sloping demand case. Here we observe r, D, where $D = D^{*} = D^{**}$.

Accordingly, we can derive the probability and the density function for the upward-sloping demand curve. Upward-and downward-sloping demand curves have the same probabilities and densities except in the credit rationing case and the default-free Walrasian case A. Now we can derive the probabilities and the density functions corresponding to the four cases.

Event 1. Degenerate Case

$g(\rho, x, \theta') + u_2 < 0$

which gives the same probability P_1, and density function as in event 1 of the downward-sloping demand curve. Here we observe $D = 0$; r is unobserved.

Event 2. Credit Rationing Case

$g(r_T, x, \theta') + u_2 > D_T = t(x, \theta) + u_1$

$\rightarrow u_2 - u_1 > t(x, \theta) - g(r_T, x, \theta')$

Note that in Figure 2, L_5' is tangent to the offer curve at T, and L_5' separates the plane into two parts. All the demand curves to the right of L_5' belong to the credit rationing case. The probability of the credit rationing case $\equiv P_2$. In the credit-rationing case, we observe: $D = D^{max}$, $r = r^{max}$. Therefore,

$P_2 = 1 - \Phi\ \{[t(x,\theta)-g(r_T,x,\theta')]\ /\sqrt{\sigma_{11}+\sigma_{22}-2\sigma_{12}}\}.$

Here r_T is the interest rate at the point where the loan offer curve is tangent to the demand curve. We can equalize the slope of the offer curve and demand curve at (D_T, r_T) to get r_T. r_T is non-random.

Density $(D,r|E_2)$ =

Density $(D{=}D^{max}|r{=}r^{max},\ u_2 - u_1 > t(x,\theta) - g(r_T,x,\theta'))$ =

$\int_{u_2 \to C.R.} f(u_1,u_2) \cdot \text{Jacobian} \cdot du_2/P_2$ =

$\int_{u_2 > D_T - g(r_T,x,\theta')} f(D_T-t(x,\theta),\ u_2)\ du_2/P_2$ (since Jacobian = 1). We can also substitute

$D^{**} = u_2 + g\ (r_T,x,\theta')$

for u_2 above → Density $(D,r|E_2)$ =

$\int_{D^{**}>D} f(D_T-t(x,\theta), D^{**}-g(r_T,x,\theta'))dD^{**}/P_2.$

<u>Event 3a. Walrasian Case A</u>

$g(\rho,x,\theta') + u_2 \leq \ell(\rho,x,\theta) + u_1$ and

$g(\rho,x,\theta') \geq 0$

which gives the same probability P_3^a and density function as in the event 3a of the downward sloping demand curve.

<u>Event 3b. Walrasian Case B</u>

$g(\rho,x,\theta') + u_2 > \ell(\rho,x,\theta) + u_1$, and there is at least one intersection between the upward sloping portion of the loan offer curve and the demand curve. Probability of this event $\equiv P_3^b = 1 - P_1 - P_2 - P_3^a$. If this event occurs, set $D^* = D^{**} = D$. We observe r, D. Therefore, Density $(D,r|E_3^b) = |J| \cdot V(u_1,u_2)/P_3^b = |J| \cdot V(D-\ell(r,x,\theta),D-g(r,x,\theta'))/P_3^b$. Though the P_3^b here is different from the P_3^b in the downward sloping demand curve case, $|J|$ and V are exactly the same in the two cases.

For both the downward-sloping and the upward-sloping linear demand curves, we need to make a sample-separation assumption before we can calcuate the likelihood function.

(c) <u>Sample-Separation Assumption: Complete Sample Separation</u>

If we have sufficient information to classify observations into the four cases mentioned above, i.e. we can observe events E_1, E_2, E_3^a, E_3^b, then we have "complete sample separation". While r^{max} relates to the observability of E_2, ρ relates to the observability of E_3^a. In our model, r^{max} is a function of ρ and (v_1-v_0). Therefore, conditional on the parameters ρ and (v_1-v_0), we can recognize observations in E_2 and E_3^a. We also recognize observations in E_1, where $D = 0$. E_3^b incorporates the observations not in E_1, E_2 and E_3^a. In all, we can have complete sample separation conditional on parameters ρ and (v_1-v_0). The only problem is that the samples attached to the four events will be changed, when ρ or v_1-v_0 change their values. These characteristics need to be considered when we maximize the likelihood function with respect to the parameters, where ρ and v_1-v_0 are part of them. The appropriate general likelihood function for both the downward sloping demand and the upward sloping demand is:

$$\begin{aligned}\mathcal{L} = & \prod_{obs \to E_1} (\text{density of } D, r|E_1) \cdot P_1 \\ & \cdot \prod_{obs \to E_2} (\text{density of } D, r|E_2) \cdot P_2 \\ & \cdot \prod_{obs \to E_3^a} (\text{density of } D, r|E_3^a) \cdot P_3^a \\ & \cdot \prod_{obs \to E_3^b} (\text{density of } D, r|E_3^b) \cdot P_3^b\end{aligned}$$

(d) <u>The Likelihood Function Under Complete Sample Separation</u>

Now let us substitute the components of the general likelihood function by more specific forms. We then obtain the exact likelihood function as follows (note that X is a vector of exogenous variables which will be defined in the next section):

(i) <u>Downward-Sloping Demand Curve</u>

$$\mathcal{L} = \prod_{obs \to E_1} \int_{-\infty}^{-g(\rho, x, \theta')/\sqrt{\sigma_{22}}} \frac{1}{\sqrt{2\pi\sigma_{22}}} \exp\left[-\frac{1}{2}\left(\frac{u_2}{\sqrt{\sigma_{22}}}\right)^2\right] du_2$$ ·

$$\cdot \prod_{obs\to E_2} \int_{D^{**}>D} f(D-h(x,\theta),\ D^{**}-g(r^{max},m(x,\theta),x,\theta'))dD^{**}$$

$$\cdot \prod_{obs\to E_3^a} \int_{D^{*}>D} f(D^{*}-\ell(\rho,x,\theta),\ D-g(\rho,x,\theta'))dD^{*}$$

$$\cdot \prod_{obs\to E_3^b} \left|-\frac{\partial g(r,x,\theta')}{\partial r} + \frac{\partial \ell(r,x,\theta)}{\partial r}\right| \cdot$$

$$V[D-\ell(r,x,\theta),\ D-g(r,x,\theta')]$$

(ii) <u>Upward-Sloping Demand Curve</u>

$$\mathcal{L} = \prod_{obs\to E_1} \int_{-\infty}^{-g(\rho,x,\theta')/\sqrt{\sigma_{22}}} \frac{1}{\sqrt{2\Pi}\ \delta_{22}} \exp\left[-\frac{1}{2}\left(\frac{u_2}{\sqrt{\sigma_{22}}}\right)^2\right] du_2$$

$$\cdot \prod_{obs\to E_2} \int_{D^{**}>D} f(D_T-t(x,\theta),\ D^{**}-g(r_T,D_r,x,\theta'))dD^{**}$$

$$\cdot \prod_{obs\to E_3^a} \int_{D^{*}>D} f(D^{*}-\ell(\rho,x,\theta),\ D-g(\rho,x,\theta'))dD^{*}$$

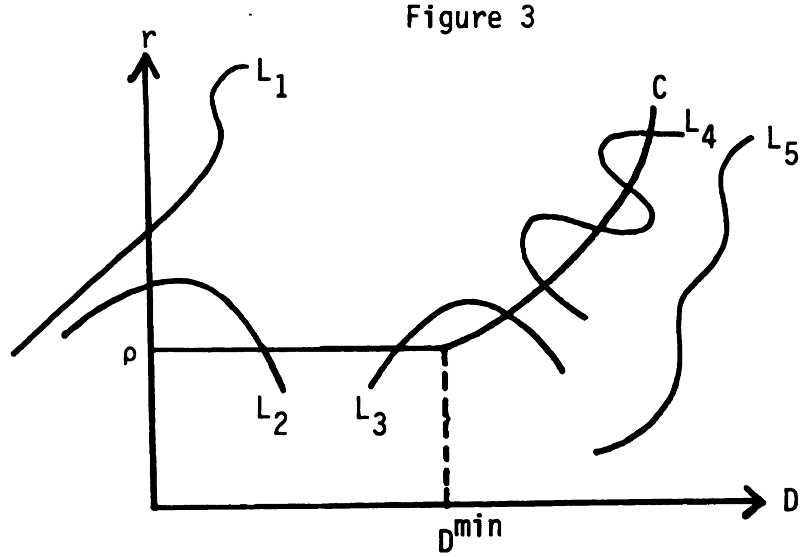
$$\cdot \prod_{obs\to E_3^b} \left(-\frac{\partial g(r,x,\theta')}{\partial r} + \frac{\partial \ell(r,x,\theta)}{\partial r}\right) \cdot$$

$$V(D-\ell(r,x,\theta),\ D-g(r,x,\theta'))$$

2. Non-Linear Demand Curve

For the case of a non-linear demand curve, the likelihood function is not analytically tractable. As we can see from Figure 3,

Figure 3



L_1, L_2, L_3, L_4 and L_5 represent some of the possible non-linear demand curves.

We can still have four cases (E_1, E_2, E_3^a, E_3^b) as we had in the linear demand curve situation.

E_1: $g(\rho, x, \theta') + u_2 < 0$

where L_1 is one of the relevent demand curves. We can write down the density as in the linear demand case; however, the probabilitity of E_1 is not tractable as before. The source of the problem becomes clear if we look at L_2, where we cannot establish whether or not the degenerate point dominates the default-free Walrasian Equilibrium. Though we know the density to calculate the probability of E_1, the range of integration is not clear.

E_2: $g(r,x,\theta') + u_2 > \ell(r,x,\theta) + u_1$ where $r^{min} \leq r \leq r^{max}$. Note that if there is intersection between the offer and the demand curve, Walrasian equilibrium dominates C.E.. We can be sure that C.E. dominates W.E. only if the above inequality holds for the whole range between r^{min} and r^{max} (e.g. demand curve is L_5). Again, the range of integration becomes intractable.

E_3^a: $\ell(\rho,x,\theta) + u_1 \geq g(\rho,x,\theta') + u_2$ and $g(\rho,x,\theta') + u_2 \geq 0$.
Here L_3 is the representative demand curve. The density and the range of integration are the same as before and tractable.

E_3^b: Loan offer = Loan demand = transacted loan.
Here L_4 is the representative demand curve. The density is the same as in the linear demand case and tractable.

The main problem for the tractability of the likelihood function lies in the degenerate case and the credit rationing case, both of which do not have a tractable range of integration. To solve this problem, we can use Monte Carlo Integration (see Kloek & Dijk [1987], and Geweke [1987]) to evaluate the integral in the above two cases. We can also use Importance Sampling (unequal probability sampling) to help us get exact predictive densities. The expected utility for each case can then be evaluated, and all observations can appropriately be classified in the category which offers the highest utility.

D. MISCELLANEOUS ASPECTS OF THE MODEL

The intended data base is a cross-sectional one of developing countries in two years, 1980 and 1984. The 1980 data reveal the pre-crisis (1982 debt crisis) structure while 1984 data (where new structure becomes stabilized after debt crisis) reveal the post-crisis structure. One must ask whether it is reasonable to expect a macroeconomic pattern that is stable over countries. We think that developing countries share similar internal institutions, and so they should have similar responses to external factors. Aggregate private lending, which evens out individual lender's differences is likely to provide a uniform structure for lending to different countries. Taking these structures to be the same across countries, we have the following measures of the variables.

Endogenous Variables

D: Transacted amount of loan (debt) from private sources. This is calculated as the net change of the total external obligations of the borrower at year-end. The total external obligations are made up of public debt (including undisbursed) with maturity over one year, owed to suppliers, financial institutions and other private creditors. The data are taken from World Bank, World Debt Tables (1986). A weakness of this measure is that it does not include short term and private nonguaranteed debt.

r: Average interest rate of new debt commitments to private creditors. This is a weighted average of the interest rates for the new commitments, where the weights are taken as the amounts of the loans. The data is taken from World Debt Tables (1986).

Exogenous Variables

λ: Penalty of default.

This is measured by $\sigma_x^{\alpha} (\frac{M}{Y})^{\beta}$ where α, β are weights to be estimated. This summarizes the penalty of default from both financial and trade retaliation. σ_x is the export variation coefficient, and it is measured as in Eaton and Gersovitz (1981) by the standard error of fitting the logarithm of real export to its linear trend (using data covering several years). This is a measure of the penalty of default if the retaliation by the international community takes the form of an embargo on future lending, for it is likely to be more of a deterrent when there is higher export variability. M/Y is included in the measure for λ to cover the possibility that the penalty may take the form of trade-related retaliation, for the higher imports (M/Y) are, the more harmful is trade-related retaliation. The data are taken from IMF, International Financial Statistics (June, 1986).

Q/POP: Per capita real GNP.

This is a measure of real per capita output in this model. The nominal GNP in U.S. dollars is taken from the current issues of the World Bank Atlas and World Tables. These are deflated by the U.S. GNP deflator (from the Federal Reserve Bulletin). Q/POP corresponds to Q_1, Q_2 in the model.

P: Terms of trade.

In my model, I assume a country's output is used for exports only, and the proceeds are used to pay for imports. Therefore, terms of trade is equivalent to real exchange rate, ep^*/p, where e is the nominal exchange rate; p^* is the international price level; and p is the domestic consumer price index. The data are taken from International Fiancial Statistics (June, 1986). P corresponds to P_1, P_2 in the model.

For a complete econometric model, we need to incorporate real GNP growth rate, propensity to invest, total indebtedness, and public debt. These variables are proposed, but not developed in the theoretical model. They will be developed in the near future. For future reference, I would like to discuss the content and the measure of these variables here.

GY: Real GNP growth rate.

This variable reflects the growth due to technological change. In this model, it shows up if we substitute Q_2/GY for Q_1. A higher growth rate of income raises desired debt for the usual Fisherian reasons, i.e., some of the future higher income is desired now. On the other hand, higher growth may or may not raise the credit ceiling. A borrower with rapidly growing income may have less to fear from the future credit embargo, lowering the credit ceiling. It is constructed as in Kharas and Shishido (1984) by a three-year weighted average of past annual real-per-capita GNP growth rate. ($GY = 0.5\ g_t + 0.3\ g_{t-1} + 0.2 g_{t-2}$).

I/GDP: This is a measure of growth due to investment. Here investment is taken as exogenous. Since a major portion of borrowing is used for financing projects, which means that investment is endogenous, this specification is subject to criticism. However, this criticism may not be as relevant as it would be for the domestic credit market (see Kharas and Shishido [1984]), for two reasons. First, a considerable portion of borrowing is not directly used for investment. The incidence of rationing may fall on consumption, such that ex post consumption is lower than ex ante desired consumption. Such a rule for assigning the adjustment to a credit-rationing situation is consistent with the observed developing-country characteristic of maintaining its investment program even under financial austerity. Second, aggregate investment decisions in developing countries are likely to be based on domestic interest rates rather than foreign rates. Given the typical repressed domestic financial markets, the aggregate domestic investment and the international interest rate will not move together. We can get data on I and GDP from World Bank, World Tables (1986).

DS/GDP: Ratio of total debt service obligation to GDP. The huge amount of debt overhang (total indebtedness) has significant impact on the lender's offer and the borrower's demand for loans. It is easy to incorporate this variable in our theoretical model, and this will be done accordingly. A higher value of this ratio may weaken lender's confidence and increase borrower's desire to borrow. This variable will be lagged to prevent simultaneity bias. Data are from World Bank, World Debt Tables (1986).

PUBDT: Debt from public sources.

The sources include international organizations, DAC (Development Assistance Committee) governments and other governments (non-communist). We view this debt as predetermined by political and other considerations rather than as part of the economic decision-making process of a poor country; therefore we directly include PUBDT as an exogenous variable in both the demand and supply equations. However, if the private credit-disturbance terms in these equations are correlated with PUBDT, then we have a simulataneous equation problem. On the one hand, PUBDT and D (remember that D is a dependent variable, which is the debt from private sources) may be substitutes from the borrower's point of view, because both PUBDT and D can satisfy the demand for loan. On the other hand, private lenders may regard a high value of PUBDT as indicating that public lenders view the country to be generally stable. In addition, a high value of PUBDT may imply a general commitment by these public institutions to the country. Private lenders may thus expect public institutions to act as lenders of last resort if insolvency arises. Therefore, PUBDT has a positive effect on the credit made by private institutions, and PUBDT and D become complements. The use of PUBDT was suggested in Eaton and Gersovitz (1981). It is the outstanding (plus undisbursed) debt from official creditors. Data are from World Debt Tables (1986). They are divided by the U.S. GNP deflator from the Federal Reserve Bulletin.

Parameters

In our model, we have the following parameters, which are assumed to be the same across countries and need to be estimated:

$v_1 - v_0$ (range of uncertainty)

δ (social discount rate)

ρ (safe rate of interest)

$\left.\begin{array}{l}\alpha \\ \beta\end{array}\right\rangle$ (parameters in the measure of penalty of default)

Identification

Let us put down the offer and demand equations here:

Offer: $f = \lambda P_2 Q_2 (1+v_1)(1+r)^{-1} - (1+\rho)\lambda P_2 Q_2 (v_1 - v_0)(1+r)^{-2}$

let us represent the first part on the right hand side as A, the second part as B.

Demand: Implicit in the following equation (as g):

$$(1+r)\ln\left[\frac{P_2(1+v_1)Q_2-(1+r)g}{\frac{1-\lambda}{\lambda}(1+r)g}\right](P_1Q_1+g) = (1+\delta)(v_1-v_0)P_2Q_2$$

let us represent the right hand side as C.

Note that α and β, as components of λ, are parts of an exponential representation which is distinguished from the representation of other parameters. Therefore, α and β are identified. v_1 or $v_1 - v_0$ $(= 2v_1)$ is identified from part A. ρ is identified from part B. δ is identified from part C. Therefore, the whole system is identified.

Test of Structure Stability

We can also test the hypothesis of structural stability between the pre-1982 era and the post-1982 era. Using a Hausman test, let θ be the vector of parameters to be estimated, and let θ_1 and θ_2 be its 1980 and 1984 values. We wish to test the null hypothesis H_0: $\theta_1 = \theta_2$. If $\hat{\theta}_1$ and $\hat{\theta}_2$ are the respective estimates, the test statistic is $(\hat{\theta}_1 - \hat{\theta}_2)'[\mathrm{cov}(\hat{\theta}_1) + \mathrm{cov}(\hat{\theta}_2)]^{-1}(\hat{\theta}_1 - \hat{\theta}_2)$ and its asymptotic distribution under H_0 is $\chi^2_{\dim\theta}$.

Prediction

An interesting thing to investigate is the probability of rationing, which gives us an idea of whether credit rationing is prevalent. Each individual country can be predicted to be credit rationed if the probability of credit rationing is larger than 0.5 for this country. If credit rationing is found to generally prevail, the auto-regulating mechanism of credit rationing may have prevented widespread debt crisis if there are not too many drastic disturbances. Therefore, regulation in the international capital market is not advised.

Elasticities.

Once we get the estimates of the parameters, we can substitute them into the theoretical model from essay 2 to get the size of the elasticity of any endogenous variable with respect to any exogenous variable. These elasticities are among the most important piece of information about the structure of the model.

E. SUMMARY AND FUTURE PLAN

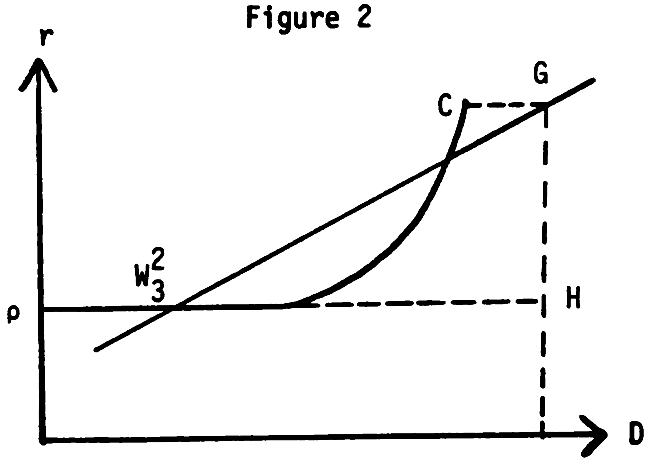
In this essay, I started by reviewing the institutional, theoretical and econometric strands of the international credit rationing problem, and then I specified the exact econometric model. This econometric model captures the main features of the theory developed in my previous essay. It also considers the impact of different linear demand curves and shows how the likelihood function is affected by the shape of the demand curve. The likelihood function is then specified by assuming complete sample separation. For the non-linear demand curve, Monte Carlo integration is needed to evaluate the likelihood function. The endogenous and exogenous variables are specified either directly from the theory or with good justifications. The parameters are all identified. In the future, we shall estimate the model by the maximum likelihood method. The estimated parameters can be used to calculate the size of the elasticities. The goodness of fit of the model provides evidence of the validity of the model. Structural stability will be tested. Credit-rationing status will be investigated and predicted. In all, a general empirical framework is set up to study the international (can also be applied to domestic) credit rationing problem.

A complete econometric model will require further sophistication of the theoretical model. As mentioned in essay 2, growth, debt overhang and investment can be incorporated into the theoretical model. This will provide a firm ground for the econometric model to incorporate these variables. We can also consider different distributional assumptions of the random variable which is the source of uncertainty in essay 2. Both of the above extensions have implications for the econometric model, and the latter should be modified accordingly.

APPENDIX

Here we want to establish that W_3^2 dominates C in Figure 2 of the main context. In general, any lower interest rate loan offer package dominates a higher interest rate loan offer package. Let us duplicate the relevant parts in Figure 2 as follows:

Figure 2



To prove that W_3^2 is preferred by borrowers to C, we adopt the following steps:

(1) Since W_3^2 lies on the demand curve, W_3^2 is preferred to H given ρ.

(2) H implies the consumption package $(C_1^H, \tilde{C}_2^H)$, where $\tilde{C}_2^H$ is random.

(3) H involves the same amount of borrowing as G, so $C_1^H = C_1^G$; however,

(a) G involves more debt repayment than H in states of the world in which repayment occurs, so $C_2^H > C_2^G$.

(b) In states of the world in which default occurs, H and G result in the same second- period consumption, $C_2^H = C_2^G$

(c) In states of the world in which default occurs at G but not at H, we must still have $C_2^G = C_2^H(D)$, where $C_2^H(D)$ is the second-period consumption under default given the realizations of P_2 (terms of trade). However, since the debtor does not default, it must be the case that $C_2^H \geq C_2^H(D) = C_2^G$.

Then, since (a), (b) and (c) exhaust all possible outcomes, we have shown that H dominates G.

(4) G lies on the demand curve, thus dominating any other bundle, given r^{max}; this includes C. Therefore, G is preferred by the borrowers to C. i.e. G > C.

Thus, $W_3^2 > H > G > C$ which implies $W_3^2 > C$ by transitivity.

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CHAPTER FIVE

CONCLUSION

To study the market-based, decentralized, exchange-rate-regime-choice behavior, I employ a multinomial logit model based on optimum currency area theory. The following major results are found in essay 1:

> Optimum currency area theory performs well, both in terms of predictive accuracy and hypothesis testing. This is valid for crude regime selection and also for finer regime choices.

Therefore, we can conclude that optimum currency area theory is empirically supported and can be used for practical policy recommendations.

A disappointing result is that recent data do not reveal improved regime choice behavior. More synchronous data and better measures are recommended for future research.

In essays 2 and 3, I study the impact of sovereign risk on capital market equilibrium. My main contribution is to establish a general theoretical framework and a conformable econometric framework to study the capital market equilibria. With few assumptions, the theoretical model in essay 2 shows and derives the credit rationing and Walrasian equilibria. Risk-averse behavior on both the borrower's and lender's sides are accommodated in the model; also, capital flight is incorporated.

The econometric model in essay 3 closely approximates the features of the theoretical model. This econometric model is exhaustive in considering all possible types of supply-demand interactions, and it considers both the linear and the non-linear demand curves. The development of the econometric methodology is in the direction of limited-dependent-variable and Monte Carlo Integration methods, but the detailed specifications are quite different from previous works.

The only weak assumption in the theoretical model is that the borrower's market is competitive: although this is a prevalent assumption, we recognize its limitation.

Empirical work based on essay 2 and essay 3 was proposed, and will be pursued in the near future. A possible future theoretical investigation of rescheduling and credit rationing based on game theory and reputation theory was proposed before (e.g. Crawford [1984]), and it is another high potential research topic.