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Konjunkturpolitik, Zeitschrift für angewandte Wirtschaftsforschung

*Suggested Citation:* Amelung, Torsten; Mehlretter, Thorsten (1986) : Early-Warning Warning Systems in Light of the International Debt Crisis, Konjunkturpolitik, Zeitschrift für angewandte Wirtschaftsforschung, ISSN 0023-3498, Duncker & Humblot, Berlin, Vol. 32, Iss. 5, pp. 257-281

This Version is available at:

<https://hdl.handle.net/10419/235689>

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## Early-Warning Systems in Light of the International Debt Crisis\*

By Torsten Amelung\*\* and Thorsten Mehlretter\*\*\*

### 1. Introduction

The recent debt crisis came as a shock for many lenders. This points to the fact that efficient early-warning systems are either non-existent or not in widespread use.

Since most early-warning systems to our knowledge were designed in the seventies, it is necessary to give renewed attention to their performance in the eighties. It is the object of this paper to assess the various types of models to be found in the literature with respect to their predictive power during the recent debt crisis. In addition to an overview of the early-warning systems used, the paper presents two such models, which were applied for the period of 1978 to 1983 based on the data for 12 developing countries.

### 2. "Traditional" Country Evaluation Systems As Early-Warning Devices

#### a) An Overview

The term "early-warning system" is usually applied to country evaluation systems attempting to use a forward-looking approach in the assessment of a country's debt servicing capacity rather than merely reflecting its past performance in this respect. Since these systems usually tend to make use of sophisticated statistical techniques, it is useful to first briefly look at the "traditional" country evaluation systems and discuss why they were generally considered unsuitable to serve as early-warning devices.

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\* This paper is a revised version of a preliminary draft presented at a conference (Febr. 12-14, 1986) during the Advanced Studies Program in International Economic Policy Research at the Kiel Institute of World Economics.

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Country evaluation systems can roughly be divided into qualitative and quantitative systems. A qualitative system consists of a report that takes into account a country's economic, political, and social conditions and prospects<sup>1</sup>. These reports differ in format and structure. They do not necessarily result in a final rating of the country in question. An advantage of this system is its flexibility and the ability to go beyond a superficial comparison of a group of indicators. Due attention can be given to a country's specific situation and unique problems. The political stability of a country, for instance, can be evaluated much more thoroughly. The analyst also has the freedom to elaborate on the various policies of the government to point out possible inconsistencies that may have an influence on the development and the stability of the country.

This approach does not, however, lend itself to cross-country comparisons unless each report adheres to a strict format. The reports also tend to be highly subjective and overly retrospective in nature.

Qualitative systems therefore do not seem to be recommendable as early-warning devices. Any prediction as to the occurrence or non-occurrence of a debt problem in a particular country for a certain time period is based primarily on the judgement of the analyst and does not follow systematically out of the evaluation system. In conjunction with a more rigorously standardized evaluation system, however, the strictly qualitative approach may prove to be quite useful.

Quantitative systems try to overcome the problem of subjectivity by relying on a set of indicators, that are chosen with respect to the risks involved in international lending and will be condensed into an overall score for the country in question to measure the potential risk of default. One can also use the indicators as the basis for a country ranking system where each country is assigned a position on an ordinal risk scale. The "Institutional Investor", for instance, publishes a country ranking list based on the information provided by international banks that use their individual evaluation system to rate the countries on a scale of 0 (very risky) to 10 (no risk). The scores of each bank are then weighted according to their relative importance in international banking as determined, for instance, by the size of their international portfolio<sup>2</sup>. This is going on the assumption that bigger banks pass better judgement on country risk. It is noteworthy that Mexico was ranked No. 29 out of 105 countries in March of 1982, shortly before the outbreak of the crisis in the summer of 1982<sup>3</sup>.

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<sup>1</sup> See *Blask* (1978), p. 66.

<sup>2</sup> See *Kramer* (1981), p. 150.

<sup>3</sup> See "Institutional Investor" as reported in *Frankfurter Allgemeine Zeitung*, June 19, 1982, p. 15.

Some of these so-called "checklist" or "scoring" systems are very elaborate, using indicators of political risk, for instance, which is clearly very difficult to measure. In one such model<sup>4</sup> the country analyst must rate the likelihood of war or takeover by extremist governments within a certain time horizon on a scale of 0 to 10. Although such systems may be quite extensive and very rigid in structure, the above example demonstrates that the quantitative approach may still leave great scope for subjectivity within the analysis.

In the following we will present an early-warning model developed by Petersen<sup>5</sup>, which takes into account the potential shortcomings mentioned above but stays away from econometric "high-tech", setting it apart from most of the other early-warning systems. Petersen's model will be tested in light of the recent debt crisis. The section thereafter will deal with the statistically more sophisticated early-warning systems. One such model will be tested and compared with that of Petersen.

#### b) The Petersen model

Petersen's objective was to develop a "pragmatic" early-warning system. There should be very few indicators used, that can be easily brought up to date, and the statistical techniques applied to evaluate the indicators were to be uncomplicated. Therefore the model uses only 7 indicators, all of which can easily be calculated on the basis of data provided in publications of the IMF and the World Bank. The analyst, therefore, cannot pass any marks according to his judgement. Since Petersen used the system to investigate the period of 1960-76, we took the data of 12 countries (namely Argentina, Brazil, Chile, Egypt, India, Indonesia, Israel, Korea, Mexico, Nigeria, Peru, and Venezuela) from 1978-83 to analyze how it performed during the recent debt crisis. The countries were selected so as to include some of the major debtor countries and at the same time strike a balance between rescheduling and non-rescheduling cases. This is to test whether the model gives signals pointing to an upcoming crisis when, in fact, it does not occur. Several of the countries selected are different from those included by Petersen to get a better impression of the model's out-of-sample performance. The results of our test will later be compared to those derived from a more sophisticated model using the logit analysis technique.

Petersen examined 41 indicators with respect to data availability for the countries analyzed (Argentina, Brazil, Chile, Ghana, India, Indonesia, Khmer Rep., Pakistan, Peru, Turkey, and Zaire), that he considered "classical" debtor

<sup>4</sup> See for example Nagy (1979), p. 38.

<sup>5</sup> See Petersen (1977).

countries. He then screened the remaining 25 indicators for their ability to forecast a debt crises based on whether "the values of the 25 indicators chosen for further investigation were, in those 3 to 5 years preceding a multilateral debt settlement, on average notably different from those in 20 other countries, for which until recently no such arrangements have been made"<sup>6</sup>. The resulting indicators and their critical values are presented in Table 1.

**Table 1: Indicators and their Critical Values According to the Petersen Model**

Indicator	1st threshold	2nd threshold
1. Debt/exports ratio	120%	160 %
2. Gross foreign investment income/exports ratio <sup>1)</sup>	10 %	—
3. Current account balance/imports ratio	20 %	—
4. Reserves/imports ratio	2.5 months	—
5. Changes in reserves	0 %	-20 %
6. Inflation rate	12 %	—
7. Growth of real GNP	3 %	0 %

from Petersen (1977), p. 100.

<sup>1)</sup> Foreign investment income: interest, profits, etc. (debit).

Note that only the debt/export ratio, the change in reserves, and the growth of real GNP indicators have two threshold values. As will later become evident through the application of the model, this results in giving the aforementioned indicators a larger weight than the others.

In calculating the indicators for the period 1978 to 1983, we used the same definitions and generally the same data sources as Petersen did for his study. The only exception was the growth of real GNP indicator, which we replaced by the growth of real GDP. This was done because such a time series already existed in the IMF, international Financial Statistics<sup>7</sup>.

Although indicators were only calculated up to 1983, countries rescheduling in 1984 were also considered rescheduling countries to take account of the fact that resettlement negotiations usually take some time.

It should be mentioned that we considered the indicator values of every year within the sample period whereas Petersen only looked at the average

<sup>6</sup> See Petersen (1977), p. 98.

<sup>7</sup> See Petersen (1977), p. 107, for the exact definitions of indicators and the data sources.



value of an indicator over the 3 to 5 year time period preceding a debt resettlement. This was done to test whether trends would show up that could help to improve the early-warning characteristics of the model. We did, however, also calculate the model adhering strictly to Petersen's methodology but did not receive superior results.

The results of our study are presented in Table 4 in the Appendix. The model appears to be capable of discriminating between rescheduling and non-rescheduling countries. An optimal classification rule might be to consider a country a problem case if more than 5 signals are lighting up sometime within the sample period. Using such a simple rule, one would classify correctly all countries except for Korea and Egypt, that would falsely be considered rescheduling cases, and Venezuela, which would not be recognized as a problem country. In the case of Korea, however, the critical score of 5 signals is exceeded only once, in 1980, when it reached 6. Otherwise the scores were quite low never even reaching 5. The model fails completely with respect to classifying Venezuela. Scores always remain well below 5. There is absolutely no indication for an upcoming crisis. Chile is another "close case". Only in 1983 did the score exceed 5 to point to a potentially dangerous situation. Comparing Chile with Korea, the other border case, however, one will still find the average score of Korea well below that of Chile. For the remaining 8 countries the model is right on the mark. All rescheduling countries exceed the critical score of 5 more than once.

Obviously the model seems to perform reasonably well as far as classification over the whole sample period is concerned. Since it was designed as an "early-warning" model, however, the question is whether it succeeds in triggering enough signals well in advance of the crisis to give the decision maker enough time to react accordingly. We may therefore investigate the period of 1978 to 1980 to find out whether rescheduling countries generally had higher scores than non-rescheduling countries or whether they showed a clear trend to place the decision maker into a position where he can make reliable predictions of future scores. Although there are countries, such as Brazil and Mexico, that had high scores right from the beginning of our sample period, there are others, such as Argentina, Chile, Egypt, and Venezuela with relatively low scores. There also do not appear to be general trends observable for problem countries. As a matter of fact, scores dropped in the first three years for many of them. The strongest example for this would be Nigeria, which went from 5 in 1978 to 0 in 1980 and shot up to 6 in 1981.

We can conclude, therefore, that the use of such a model as an "early-warning" system appears to be rather limited, at least for the sample considered. The model may be of some value for a decision maker, however, in that it gives a general impression of where a country stands in comparison with the

others and does not require any subjective judgement on the part of the evaluator. But as the sole instrument for a "yes" or "no" decision on a loan other than a very short term one, it may lead to making big mistakes.

In addition to the problems associated with this particular model that became evident through the interpretation of its results, there are several further shortcomings of a more general nature that apply to many other scoring systems as well. As Petersen points out himself, it lacks an underlying economic theory, as far as the causes of debt problems and the selection of indicators are concerned. Indicators are chosen on the basis of their past ability to forecast upcoming debt crisis. It is questionable, however, whether these indicators will perform as well in the future. Furthermore, it must be tested to what extent indicators are correlated with one another. Two highly correlated indicators, for instance, may possibly contain the same information. One of them would be superfluous. Giving them both the same weight within the system, can lead to an overrepresentation of a particular aspect of a country's economy. The determination of critical values also is a problem. Why should the first threshold value for the debt/exports ratio be 120 % — why not 125 %? The reason is, of course, that the system performed best with the critical values set forth in the paper for the countries investigated in a specific time period. They may prove to be rather unreliable for another sample, however. It should also be pointed out that the selection of a critical score range, such as 6-10 in our case, tends to be highly dependent on the time period considered. Note that this range was determined *ex post* when we knew the scores of all countries for the entire sample period. Since the critical score values are not based on any economic theory, one should be very careful in relying on them for the future. Finally there is the question of appropriate weights for the indicators. In our model the debt/exports ratio, the changes in foreign reserves, and the real GDP growth rate were implicitly given a greater weight since they could trigger an additional signal if their values exceeded a previously determined mark. Again these weights are solely based on the empirical experience within a specific time period rather than economic plausibilities. This must be borne in mind when the system is applied to another sample.

### **3. Early-Warning Systems Using Statistical Methods**

#### **a) The Statistical Methods**

Most early-warning systems use rather sophisticated statistical techniques to determine a country's debt servicing capacity. With the sharp rise in commercial bank lending to developing countries during the 70's, there was

an increased interest in finding more effective methods of monitoring country risk. The statistical technique serves as a sort of "screen" for the relevant indicators. The objective is to make the selection, weighting, and interpretation of the indicators more rigorous in order to overcome some of the shortcomings of the models discussed earlier. The most commonly used techniques are discriminant analysis, principal components analysis, and logit analysis. In the following we will briefly describe how these techniques work and give an overview of the results obtained through their application<sup>8</sup>.

In principal components analysis the original set of indicators is substituted by a set of composite indicators (components) where each component is a linear combination of all the original indicators. A component's relative importance can then be measured by the proportion of total sample information it contains.

Dhonte<sup>9</sup> applies this technique to analyze the relationship between various indicators, which can be inferred from the components with the highest information content. He aims to find out what is distinctive about the rescheduling cases compared to the others in the sample. His main conclusions are not very surprising:

- problem countries will be overly "involved" in debt at poor terms. A balance must be struck between "involvement" in debt and the terms on which it is accumulated;
- the growth of external debt must keep up with the anticipated growth of export earnings.

In general, however, principal components analysis is primarily used to pre-screen a large set of indicators for the more relevant ones, which will then be considered to become part of the early-warning system.

Dividing a general population into two groups, in our case: countries that rescheduled their debt within a particular time period and those that did not, discriminant analysis can be used to determine to which group an observation that was not drawn from the sample will most likely belong. This method provides a way of measuring how the values of the variables describing the observation — e.g. debt service ratio, imports to GDP ratio, and other debt indicators — "resemble" those of samples drawn from each group where group membership is known. Contrary to logit analysis, which will be described hereafter, discriminant analysis assumes no causality running from the descriptive variables to group membership.

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<sup>8</sup> For a detailed discussion of discriminant and logit analysis as well as their applicability in business, banking, and finance, see *Altman et al.* (1981).

<sup>9</sup> See *Dhonte* (1975).



In the logit analysis model, however, group membership is assumed to be an endogenous variable determined by the values of the exogenous variables describing the debt situation of a particular country at a particular point in time and a disturbance term  $\epsilon$ . Specifically, the endogenous variable is the probability of default for country  $i$  ( $P_i = \text{Prob}(Y_i = 1)$ ), where  $Y_i$  can take the value of either 0 for non-rescheduling cases or 1 for rescheduling cases.  $P_i$  is conditional on the exogenous variables  $X_{ij}$  using the following functional form, which is the cumulative standard logistic function:

$$P_i = \text{Prob}(Y_i = 1) = \int_{-\infty}^{w_i} f(z) = \frac{1}{1 + e^{-w_i}}$$

$$\text{where } W_i = b_0 + \sum_{j=1}^m b_j X_{ij}$$

$$\text{and } f(z) = \frac{e^z}{(1 + e^z)^2} \text{ (standard logistic density function).}$$

$b_j$  is the coefficient to variable  $X_j$  out of a set of  $m$  variables for each observation. The coefficients  $B = (b_0, b_1, \dots, b_m)$  are to be estimated.

One advantage of the logit model is that the endogenous variable can only take on values between 0 and 1, as can be illustrated by the following graph:

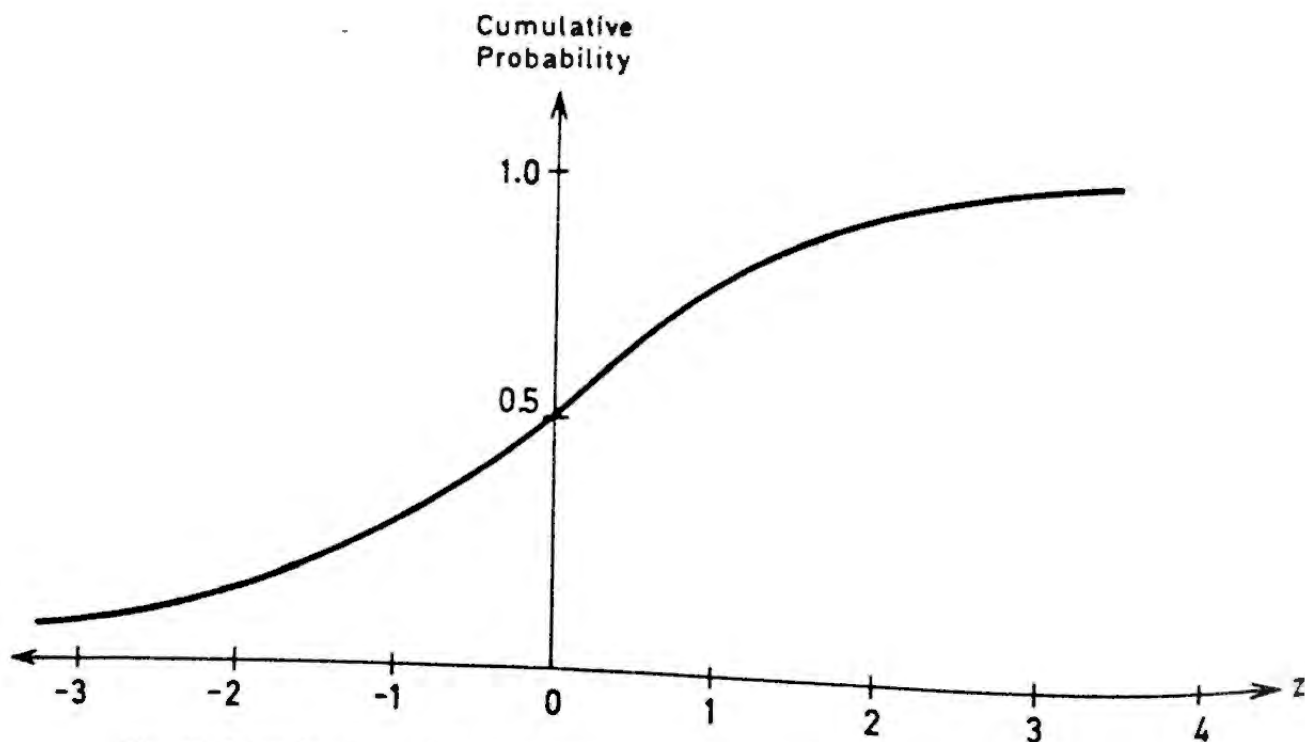


Fig. 1: Standard model and logistic cumulative distribution function<sup>10</sup>.

<sup>10</sup> Compare Altman et. al. (1981), p. 17.

Using the logit model, it is possible, therefore, to determine the probability of debt rescheduling given the values of the indicators used. In actual loan decisions a cut-off rate must be fixed so that the loan would be granted only if the probability of debt rescheduling for the applying country is below the cut-off rate. This is usually done so as to minimize the risk of error while, at the same time, taking account of the risk preferences of the decision maker. It must be considered, however, that a particular cut-off rate may be optimal for one time period, but yield poor results for another.

The performance of an early-warning model can be tested by calculating Type I and Type II errors. A Type I error occurs when the model does not predict a debt rescheduling for a particular year although rescheduling did, in fact, take place. A non-rescheduling year being incorrectly classified as a rescheduling case would be considered a Type II error.

It would go beyond the scope of this paper to present the results of all major studies undertaken to find efficient early-warning systems<sup>11</sup>. We will, however, present an overview of the variables shown significant in statistical analysis of debt service "problem" situations (see Table 3 in the Appendix).

As Saini and Bates point out, a note of caution is necessary to not overinterpret- ing a comparison such as this. The studies differ by their respective sample sizes, periods covered, variables examined, and techniques employed<sup>12</sup>.

Just a brief glance at the large number of indicators shown to be significant reveals that choosing a single set of variables to adequately describe a debt situation is no easy task. The indicators found to be significant most often are the debt service exports ratio, the external debt/exports ratio, the external reserves/imports ratio, and the inflation rate. One must also consider that authors use different definitions of the variables (e.g. exports including or excluding services; reserves including or excluding gold). This can have a major impact on the results of the model.

As Walter (1983) points out, it is evident that most indicators are related to domestic supply side and balance of payments aspects as well as the adequacy of external reserves in the short run. Relatively little attention is given to the monetarist model of international adjustment<sup>13</sup>.

Nagy (1979) considers the monetary approach a "non-starter" for LDCs. Economic policies of public authorities leading to multiple exchange rates,

<sup>11</sup> See Saini and Bates (1984) for a more complete survey.

<sup>12</sup> See Saini and Bates (1978) for a comparison of discriminant and logit analysis as well as Schmidt (1984) for a comparison of logit, discriminant analysis, and univariate methods. In another article, Schmidt (1982) also includes principle components analysis.

<sup>13</sup> See Sargen (1977) for a comparison of monetary and structural variables as explanations for past reschedulings.



high tariffs, import licensing, capital controls, etc. make it very difficult to establish a significant relationship between changes in the domestic money supply and the balance of payments or debt servicing ability.

#### b) The Schmidt Model

In section 2.b. we used data from 12 countries for the period 1978 to 1983 to test the performance of a simple scoring model. Now we will take data from the same countries and the same time period to plug it into a more sophisticated model designed by Schmidt (1984) using the logit analysis technique. The results will then be compared to those derived from the Petersen model.

Schmidt used data from 52 countries from the period 1974 to 1978 to test the ability of 21 indicators<sup>14</sup> to point out potential problem countries.

Applying univariate methods as well as discriminant and logit analysis, he found four variables (supplier credit to total debt (SUPQ), total reserves minus gold to imports (REIM), total debt to GDP (DEBI), and interest payments to GDP (ZIBI) to be of remarkable overall stability over time and across countries. The sign of the coefficient of SUPQ is positive, indicating that an increase in the share of supplier credit will lead to a higher probability of default. As Schmidt explains it, suppliers cannot or will not reduce their credit to developing countries as quickly as financial lenders when a country runs into trouble. The coefficient of REIM is negative. The higher the total reserves to imports, the less likely is a country to default. The positive sign of the coefficient of DEBI means that a high level of debt relative to GDP results in a higher probability of rescheduling. ZIBI's coefficient shows a negative sign. This is surprising because one would expect high interest payments to increase the potential threat of default. Schmidt argues, however, that countries that get into critical situations receive low-interest loans from international organizations pushing down their interest payments/GDP ratio relative to other countries.

Using the variables and coefficients found by Schmidt, we received the following results for the period 1978 to 1983.<sup>15</sup>

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<sup>14</sup> For a complete list of all the indicators considered see Schmidt (1984), p. 361.

<sup>15</sup> We gratefully acknowledge the assistance of Prof. Reinhart Schmidt and Helmut Köster in this project.

Table 2: Probability of Multilateral Rescheduling for the Period 1978 to 1983 (in %)

	1978	1979	1980	1981	1982	1983	Years of multilateral debt resettlement within the period 1977 to 1984
Argentina	88.5 <sup>a</sup>	95.6	98.6	98.2	74.6	85.9 <sup>b</sup>	1984
Brazil	84.3	78.7	66.2	64.3	80.7	75.4	1983, 1984
Chile	5.4	46.7	55.2	55.6	9.5	8.6	1983
Egypt	26.1	84.7	88.7	60.3	97.9	98.5	no debt resettlements
India	99.4	99.1	99.6	99.9	99.8	99.9	no debt resettlements
Indonesia	82.6	63.5	91.9	95.8	97.5	97.0	no debt resettlements
Israel	10.2	12.4	9.7	2.1	1.3	1.0	no debt resettlements
Korea	52.2	77.7	44.6	29.3	57.4	83.4	no debt resettlements
Mexico	6.8	19.5	35.1	57.8	8.6	0.3	1983, 1984
Nigeria	99.7	98.7	98.2	98.9	98.0	99.4 <sup>b</sup>	1983
Peru	0.03	0.6	1.1	12.7	49.1	68.5	1978, 1979, 1983, 1984
Venezuela	78.1	67.6	28.1	59.1	60.5	58.4	1984

<sup>a</sup> This figure would indicate that the probability of a multilateral rescheduling in 1978 was 88,5 % for Argentina.

<sup>b</sup> GNP rather than GDP was used for DEBI and ZIBI.

Source: Own calculations based on the model of Schmidt (1984).<sup>16</sup>

<sup>16</sup> The variables were standardized by subtracting the mean and dividing by the standard deviation. Standard deviations were estimated on the basis of the data of 34 LDCs. Means and standard deviations of DEBI and ZIBI were approximated on the basis of the values for the debt/GNP and interest payments/GNP ratios. Data was taken from IMF, International Financial Statistics and World Bank, World Debt Tables.



On the whole the results appear to be rather disappointing. Although the probabilities of default are quite high for many of the rescheduling countries, such as Argentina, Brazil, and Venezuela, probabilities for some of the non-rescheduling countries are much too high. India, for instance, should be bankrupt by now. There are also several jumps in the probabilities, e.g. in the case of Mexico from 57.8 % in 1981 to 8.6 % in 1982. This particularly surprising since Mexico ran into great trouble in the summer of 1982.

In our opinion, these results are mainly due to the ZIBI indicator, which is given a very high weight in the model. The exact coefficients of the variables are:

Variable	Constant	SUPQ	REIM	DEBI	ZIBI
Coefficient	2.005	0.083	-0.189	0.135	-4.672

The influence of ZIBI is particularly great because all variables were standardized so that their values are roughly within the same range. This fact is also evidenced by the highly negative correlation coefficients between the probability of default and ZIBI relative to the other indicators. Take, for example, the case of Venezuela:

Variable	SUPQ	REIM	DEBI	ZIBI
Correlation coefficient between the probability of rescheduling and the variable	-0.19	-0.15	-0.14	-0.98

Now we can also explain the large decrease in probability from 1981 to 1982 for the case of Mexico. As GDP declined sharply (in US-\$ terms) and interest payments rose in 1982, the 1982 value of ZIBI was well above that of 1981 causing the probability of default to drop.

One has to consider that the model was estimated on the basis of data from 1974 to 1978. During this period reschedulings occurred mainly for low-income developing countries such as Togo, Zaire, and Sudan<sup>17</sup>. Here it would seem plausible that relatively poor, high-risk countries would receive loans

<sup>17</sup> See the overview of multilateral debt renegotiations in Table 5 in the Appendix.



mainly from international organizations on concessional terms causing the ZIBI value to be lower than that of other countries, whose better standing permits them to receive bank loans on market terms. During the recent debt crisis, however, the main concern was with the relatively rich Newly Industrialized Countries. The sign of the coefficient for the ZIBI variable should therefore have been reversed for the sample of our study.

This type of a problem is also likely to arise with other quantitative models that were developed in the 70's since all the estimations are highly influenced by developments in low-income developing countries. Obviously one must be very careful in applying for the future models that performed well in the past, particularly if there is little theory as the basis for the selection of the indicators. It is also evident that cross-section analysis may yield misleading results within the context of early-warning systems. It is quite possible that the model would have performed much better if we had selected only low-income developing countries for our sample.

Comparing this model with the simple scoring approach presented earlier, one must conclude that the Petersen model was superior in performance over the more sophisticated Schmidt model for the sample of our study. Neither of the models could be considered satisfactory as an early-warning system, however. Nevertheless, this does not mean that quantitative techniques are generally inferior to less sophisticated types of analysis. Schmidt's model would probably have performed much better if it had been specified differently. However, one should not blindly trust sophisticated statistical techniques.

One other critical issue should be addressed, which is of particular importance in estimating quantitative models, namely the role of the dependent variable. First of all, there is the question of proper definition. When can one consider a country to be in a state of default? Is it when the country falls behind on its debt service payments or when it formally repudiates its debt? Most studies have resorted to the occurrence or non-occurrence of a formal rescheduling arrangement within a particular year or time period as the dependent variable. It must be considered, however, that countries may circumvent formal reschedulings at least for some time by negotiating debt service delays or balance of payments support loans. They may also impose emergency controls on foreign exchange and imports. As Saini and Bates (1984) point out, such measures would not be reflected in the model. Furthermore, debt reschedulings must not necessarily be the result of debt servicing problems. A country may renegotiate its debt to receive better terms, for instance. One should therefore distinguish between voluntary and involuntary rescheduling<sup>18</sup>.

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<sup>18</sup> Saini and Bates (1978) incorporated these criticisms in their statistical work.

One must also decide to which period a resettlement is to be attributed. The data provided by the World Bank, for instance, is usually based on the date of final settlement. In the case of Mexico, debt servicing problems arose in the summer of 1982 whereas a formal rescheduling agreement was not reached until 1983. Obviously the use of binary-valued dependent variables is rather problematic.

Furthermore it should be mentioned that the number of observations for the statistical models is rather limited. Country defaults or debt resettlements are quite rare relative to the thousands of private company bankruptcies every year in the U.S., for instance. It is necessary, therefore, to include in the sample many different countries over a long time period to get significant statistical results. This, of course, can lead to problems of structural reliability, i.e. changing parameter values over time and across country groups.

There also is a problem of data availability. The data for the indicators must be available early enough to leave time for banks or public authorities to react to a potentially dangerous situation. Some improvement has been made in this respect, however, since the debt problems in the 80's have caused banks and international organizations to make an extra effort at making data available quickly.

The points mentioned above raise some doubts as to the reliability of early-warning systems. Our test results indicate that this holds irrespective of the degree of statistical sophistication since the Petersen model actually outperformed that of Schmidt. Early-warning systems seem to be more descriptive rather than predictive in nature. They fail to perform well when applied to out-of-sample observations. This, of course, is really not all that surprising since debt problems are often caused by exogeneous shocks such as rising oil prices and interest rates, which cannot be anticipated in an early-warning system.

#### 4. Conclusions

In this paper we tried to analyze various models with respect to their predictive power concerning LDC debt servicing ability. We assessed early-warning systems to be found in the literature and tested two models in light of the recent debt crisis. Our findings revealed that both showed to be incapable of serving as an early-warning device. In summing up our findings, the following points should be stressed:

- Many of the models appear to overly rely on empirical experience rather than economic theory. As the selection of the variables seems to be mainly determined by data availability and the experience gathered

in previous studies, more care should be taken in the specification of the model.

- Statistical sophistication must not always yield superior results. Relatively simple analytical techniques may actually do better.
- Finding one model for all countries seems to be a very difficult undertaking. Early-warning systems should be more country-specific and less reliant on cross-section analysis since there has been an increased occurrence of debt problems among Newly Industrialized Countries, that were perceived to bear relatively low risks in the past.

## Appendix

**Table 3: Variables Shown to be Significant in Statistical Analyses of Debt-Service "Problem" Situations**

	Frank and Cline (1971)	Dhonte (1975)	Grinols (1976)	Feder and Just (1977)	Sargen (1977)	Mayo and Barrett (1978)	Saini and Bates (1978)	Abassi and Taffler (1982)	Schmidt (1984)	Cline <sup>bi</sup> (1984)
1. Debt Service payments/Exports	x			x	x					x
2. Debt Amortization/Total Debt	x			x						
3. External Debt/Exports		x	x			x		x		
4. External Debt/GNP or GDP		x	x						x	
5. External Reserves/Imports	x			x		x			x	x
6. Debt Service Payments/Import			x							
7. Debt Service Payments/External Reserves			x							
8. Net Transfers/Imports		x								
9. Debt Service Payments/Debt Disbursements		x	x							
10. Capital Inflows/Debt Service Payments		x		x						
11. IMF Reserve Position/Imports						x				
12. Gross Fixed Capital Formation/GDP						x				
13. Current Account Balance/Exports							x			
14. Disbursed Supplier Debt/External Debt									x	
15. Export Growth Rate		x		x						
16. Per Capita Income				x						
17. Disbursed External Debt		x <sup>u</sup>	x							
18. Domestic Inflation Rate					x	x	x	x		

Table 3: Variables Shown to be Significant in Statistical Analyses of Debt-Service "Problem" Situations

	Frank and Cline (1971)	Dhonte (1975)	Grinols (1976)	Feder and Just (1977)	Sargen (1977)	Mayo and Barrett (1978)	Saini and Bates (1978)	Abassi and Taffler (1982)	Schmidt (1984)	Cline <sup>b)</sup> (1984)
19. Interest Payments/GDP									x	
20. New Loan Commitments Per Capita								x		
21. Domestic Credit/GDP								x		
22. Money Supply Growth							x			
23. Growth of External Reserves							x			
24. Amortization Rate										x
25. Current Account Deficit/Exports										x
26. GDP Growth Rate Per Capita										x
27. Level of Global Borrowing										x
Analytical Technique	D	C	D	L	D	L	D (L)	D	D,L <sup>1)</sup>	L
Type I Error Rate <sup>c)</sup>	23 %	33 %	12 %	5 %	33 %	25 %	17%(17%)	10 %	N.A.	9.1 %
Type II Error Rate <sup>d)</sup>	11 %	13 %	6 %	2.5 %	8 %	13 %	15%(19%)	8.9 %	N.A.	13 %
Composite Error Rate <sup>e)</sup>	11.5 %	16 %	6.5 %	2.5 %	9 %	14 %	15.5%(19%)	9 %	N.A.	12.8 %

Notes: D = Discriminant Analysis. L = Logit Analysis. C = Principal Component Analysis.

Sources: Walter (1983); Saini and Bates (1984); and own research. <sup>a)</sup> Growth rate of disbursed external debt. <sup>b)</sup> Indicators used in his "C-model". <sup>c)</sup> Number of Type I errors divided by number of observed rescheduling cases. <sup>d)</sup> Number of Type II errors divided by number of observed non-rescheduling cases. <sup>e)</sup> Total number of errors divided by total number of observations. <sup>f)</sup> No error rates reported.



Table 4: Early-Warning Systems for Forecasting Debt Crisis: Indicator Values and "Critical" Signals Lighting up as Critical Marks are Passed.

Country	Years of <sup>a)</sup> Multilateral Debt Settle- ment within the Period of 1977 to 84	Year	Indicators							Signals (x or xx), i.e. Critical Values Exceeded or Attained							
			Debt/ Exports %	Foreign Invest- ment Income/ Exports %	Current <sup>b)</sup> Account Deficit/ Imports %	Foreign Reserves/ Imports Months	Changes in For- eign Re- serves %	Inflation Rate %	Real GDP Growth Rate %	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Argentina		1978	86.1	12.7	-30.7	11.8	55.9	172.6	1.0	x				x	x	3	
		79	86.8	16.3	4.9	13.3	94.0	163.2	6.8	x				x		2	
		80	91.0	24.8	29.8	7.0	-20.0	100.0	0.9	x	x		xx	x		5	
		81	89.6	39.0	28.7	3.7	-46.2	104.0	-6.3	x	x		xx	x	xx	7	
		82	163.3	54.5	19.4	4.5	-10.0	165.2	-4.8	xx	x		x	x	xx	7	
		1984	83	251.9	—	19.9	2.8	-36.9	344.2	3.0	xx	—		xx	x		(5) <sup>c)</sup>
Brazil		1978	208.8	33.7	32.6	6.8	63.8	38.6	6.2	xx	x	x		x		5	
		79	198.0	37.4	36.8	4.1	-19.3	52.8	6.4	xx	x	x		x	x	6	
		80	171.0	36.1	35.3	2.3	-30.1	82.8	7.2	xx	x	x	x	xx	x	8	
		81	166.1	43.3	30.2	2.3	8.8	105.6	-1.6	xx	x	x	x		x	xx	8
		82	212.5	63.9	41.0	1.2	-46.6	98.0	0.9	xx	x	x	x	xx	x	x	9
		1983, 1984	83	238.3	—	21.9	1.8	14.1	142.0	-3.2	xx	—	x	x		x	xx
Chile		1978	146.0	17.8	26.1	4.0	115.7	40.2	7.3	x	x	x		x		4	
		79	101.0	16.9	19.7	5.4	93.7	33.3	8.3		x			x		2	
		80	75.3	19.7	23.6	5.9	51.8	35.1	7.8		x	x		x		3	
		81	80.1	36.2	45.3	4.5	-5.8	19.7	5.5		x	x		x	x	4	
		82	101.5	49.2	30.4	4.1	-33.2	9.9	-14.1		x	x		xx		xx	6
		1983	83	141.5	—	17.8	5.3	0.9	52.5	-0.7	x	—			x	xx	(4)

Egypt	1978	271.8	11.3	18.2	1.9	24.7	11.0	10.1	xx	x	x		4			
	79	261.5	9.6	18.8	2.6	70.8	9.9	8.7	xx				2			
	no debt	80	196.2	9.0	4.5	3.1	28.0	20.6	10.4	xx		x	3			
	resettle-	81	205.7	13.0	19.0	1.8	-16.3	10.4	3.9	xx	x	x	5			
	ments	82	214.2	15.1	19.2	1.9	-69.4	14.9	5.6	xx	x	xx	x	7		
		83	213.8	—	6.9	1.8	-6.1	16.1	6.7	xx	—	x	x	x	(5)	
India	1978	181.1	5.1	-7.0	10.6	36.7	2.6	5.9	xx				2			
	79	151.4	4.6	-0.4	11.4	42.1	6.3	-5.2	x			xx	3			
	no debt	80	142.5	4.0	10.2	8.3	1.7	11.5	6.8	x			1			
	resettle-	81	147.3	—	15.1	5.4	-32.5	13.0	5.8	x	—	xx	x	(4)		
	ments	82	152.8	—	13.9	5.4	1.6	7.9	2.9	x	—		x	(2)		
		83	—	—	—	—	-0.3	21.2	7.7	—	—	—	x	x	(2)	
Indone- sia	1978	116.3	17.8	11.1	2.5	5.5	9.4	3.0	x	x		x	3			
	79	85.5	15.9	-6.7	3.5	57.1	20.6	2.1	x			x	x	3		
	no debt	80	67.4	15.0	-14.8	4.2	61.8	18.4	2.0	x			x	x	3	
	resettle-	81	64.0	12.6	2.2	2.9	-8.2	12.2	1.9	x		x	x	x	4	
	ments	82	87.6	—	19.9	2.0	-27.0	9.5	1.8	—		x	xx		x	(4)
		83	109.2	—	24.1	2.2	7.5	11.8	1.8	—	x	x			x	(3)
Israel	1978	139.5	15.2	9.2	3.6	68.6	50.7	8.5	x	x		x	3			
	79	128.8	17.2	7.4	3.8	27.8	78.2	3.7	x	x		x	3			
	no debt	80	128.9	20.1	6.0	3.6	9.8	130.9	2.7	x	x		x	x	4	
	resettle-	81	136.4	22.4	9.6	3.2	-2.1	116.8	2.8	x	x		x	x	5	
	ments	82	147.3	27.5	14.8	3.5	9.2	120.4	1.1	x	x		x	x	4	
		83	152.2	—	15.0	3.2	-6.9	145.6	1.8	x	—		x	x	x	(4)

Table 4: Early-Warning Systems for Forecasting Debt Crisis: Indicator Values and "Critical" Signals Lighting up as Critical Marks are Passed.

Country	Years of Multilateral Debt Settlement within the Period of 1977 to 84	Year	Indicators							Signals (x or xx), i.e. Critical Values Exceeded or Attained								
			Debt/Exports %	Foreign Investment Income/Exports %	Current Account Deficit/Imports %	Foreign Reserves/Imports Months	Changes in Foreign Reserves %	Inflation Rate %	Real GDP Growth Rate %	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
Korea	no debt resettle-ments	1978	65.9	6.0	5.8	1.8	-5.5	14.5	18.0				x	x	x	3		
		79	70.1	7.7	17.2	1.5	10.0	18.3	7.3				x		x	2		
		80	70.0	11.8	18.8	1.3	-0.3	28.7	-3.0	x			x	x	x	xx	6	
		81	66.9	13.4	14.3	1.0	-9.6	21.3	6.9	x			x	x	x		4	
		82	70.7	13.5	8.4	1.1	5.1	7.3	5.5	x			x				2	
		83	70.5	—	4.9	0.9	-16.4	3.4	9.5	—			x	x			(2)	
Mexico	1983, 1984	1978	223.4	28.5	21.5	1.8	17.1	17.5	8.3	xx	x	x	x		x	6		
		79	181.1	29.1	25.2	1.7	36.0	18.1	9.2	xx	x	x	x		x	6		
		80	136.3	22.6	24.7	1.5	35.2	26.4	8.3	x	x	x	x		x	5		
		81	138.5	33.9	31.1	1.3	19.0	27.9	8.0	x	x	x	x		x	5		
		82	177.0	41.0	16.8	0.6	-64.3	59.0	-0.6	xx	x		x	xx	x	xx	9	
		83	240.8	—	22.8	2.5	169.8	101.8	-5.3	xx	—	x	x		x	xx	(7)	
Nigeria	1983	1978	20.4	4.5	25.2	1.6	-53.2	19.5	8.9			x	x	xx	x	5		
		79	18.1	4.0	-10.4	4.4	190.8	11.7	-5.7							xx	2	
		80	15.4	6.8	-23.2	5.8	80.3	10.0	6.0								0	
		81	20.0	6.9	23.5	2.0	-60.8	20.8	0.4				x	x	xx	x	x	6
		82	61.5	8.2	36.4	1.1	-53.8	7.7	-5.3				x	x	xx		xx	6
		83	107.0	—	30.6	1.0	-35.0	23.2	-2.2	—			x	x	xx	x	xx	(7)

Peru	1978	1978	224.3	—	7.2	2.8	18.2	57.9	-1.9	xx			x	xx	5	
	1979	79	143.2	—	-22.2	7.2	242.6	66.6	4.3	x			x		2	
		80	127.1	—	-1.3	6.8	32.6	59.2	2.8	x			x	x	3	
	1983, 1984	81	141.5	—	28.2	3.4	-37.4	75.4	3.0	x	x		xx	x	x	6
		82	164.0	27.8	27.0	4.0	13.3	64.4	0.9	xx	x	x		x	x	6
		83	206.3	—	17.7	4.6	-4.5	111.2	-11.8	xx	—		x	x	xx	(6)
Venezuela	1978	1978	63.5	—	35.4	6.4	-10.3	7.0	2.3		x		x	x	3	
	79	60.1	—	-2.3	10.2	53.2	12.4	1.3					x	x	2	
	80	48.9	—	-27.7	9.4	1.3	21.5	-2.0					x	xx	3	
	81	46.3	—	-19.9	7.6	-4.8	16.0	-0.3				x	x	xx	4	
	82	60.2	20.4	17.9	6.0	-7.1	9.7	0.7	x			x			2	
	1984	83	74.4	—	-32.9	10.7	1.7	6.3	-5.6	—					xx	(2)
Critical Values			$\geq 120\%$	$\geq 10\%$	$\geq 20\%$	$\leq 2.5$	$\leq 0\%$	$\geq 12\%$	$\leq 3\%$							
			$\geq 160\%$			months	$\leq -20\%$		$\leq 0\%$							

<sup>a)</sup> This information was taken from the World Bank, World Development Report, 1985, p.28. Years reported indicate when final agreement was reached.

<sup>b)</sup> Minus signs indicate a current account surplus.

<sup>c)</sup> Brackets indicate that the value for an indicator is missing in that year.

Source: Own calculations based on the model of Petersen (1977). Data from World Bank, World Debt Tables and IMF, Balance of Payments Yearbook.



**Table 5 : Multilateral Debt Renegotiations, 1975-84**  
(millions of U.S. dollars)

Country	Number of renegotiations, 1975-84	1975-1980		1981	
		Paris Club	Commercial bank	Paris Club	Commercial bank
1. Argentina	2		970		
2. Bolivia	2				444
3. Brazil	3				
4. Central African Rep.	2			55	
5. Chile	2	216			
6. Costa Rica	2				
7. Dominican Republic	1				
8. Ecuador	4				
9. Gabon	1	105 <sup>a)</sup>			
10. Guyana	3		29		
11. Honduras	1				
12. India	3	436 <sup>(1)</sup>			
13. Ivory Coast	2				
14. Jamaica	4		126		103
15. Liberia	6	30		25	
16. Madagascar	4			142	
17. Malawi	3				
18. Mexico	3				
19. Morocco	3				
20. Mozambique	1				
21. Nicaragua	3		582		188
22. Niger	3				
23. Nigeria	1				
24. Pakistan	1			263 <sup>(1)</sup>	
25. Peru	6	478	821		
26. Philippines	2				
27. Romania	4				
28. Senegal	4			77	
29. Sierra Leone	4	68			
30. Sudan	5	373			638
31. Togo	6	170	68	(92)	
32. Turkey	5	4,696 <sup>(1)</sup>	2,640		3,100
33. Uganda	2			(56)	
34. Uruguay	1				
35. Venezuela	1				
36. Yugoslavia	4				
37. Zaire	6	1,594	402	574	
38. Zambia	3				
Total	113	8,166	5,638	1,284	4,473

Note: Data cover arrangements expected to be signed by the end of 1984 plus commercial bank reschedulings agreed in principle but not signed through December 31, 1984. Figures indicate renegotiated amounts as reported by the countries or, if in parenthesis, as estimated by staff members.



Table 5: Multilateral Debt Renegotiations, 1975-84  
(millions of U.S. dollars)

1982		1983		1984	
Paris Club	Commercial bank	Paris Club	Commercial bank	Paris Club	Commercial bank signed or agreed in principle
					(23,241)
					(536)
		(3,478)	(4,532)		(5,350)
		(13)			
			(3,400)		
		97	1,240		
			497		
		(200)	(1,835)		(5,065) <sup>b)</sup>
	14				(24)
					(122)
				(153)	(306)
				(106)	(148)
	27	18		(17)	(71)
103				(120)	(195)
24		(30)	59		
		1,550 <sup>d)</sup>	(23,625)		(48,725) <sup>e)</sup>
		1,225	475		(530)
				(200)	
	102				
		33		(22)	28
			(1,920)		
		(450)	(380)	(1,000)	(1,415)
				(685)	(4,904)
(234)	(1,598)	(195)	(567)		
84		64			(97)
				88	(25)
174		502		(245)	
		114	74	(55)	
(22)			(815)		
					(20,750)
		(988) <sup>d)</sup>	(1,586)	(500) <sup>d)</sup>	(1,246)
		(1,317)			
		(285)		(150)	(75)
641	1,741	10,559	41,005	3,341	112,853

Cuba and Poland, which also renegotiated debt-service payments with official creditors and commercial banks, are not members of the World Bank and therefore are excluded from this table.

<sup>a)</sup> Denotes an agreement of a special task force.

<sup>b)</sup> Includes one agreement (for \$ 590 million) signed, and another in principle.

<sup>c)</sup> Denotes an Aid Consortium Agreement.

<sup>d)</sup> Technically this was an agreement of a creditor group meeting, not a Paris Club.

<sup>e)</sup> Includes debt of \$ 23,625 million previously rescheduled in 1983.

Source: World Bank, World Debt Tables.

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