A STUDY OF COUNTRY-RISK FOR NON-DEVELOPED COUNTRIES IN , 1980 - 2000

GONZALEZ, Mariano
MINGUEZ, Roman*

Abstract

This article aims at discovering a coherent method for estimating country risk for non-developed countries, determining the components and most significant factors involved and thus avoiding the "black boxes" represented by external agency ratings. The data used form a panel of 40 non-developed countries, grouped into 5 geographical areas, during the 1985-2000 period (World Bank database, 2002). A credit rating is allocated to the countries concerned based on criteria similar to those applied to business solvency, and we then attempt to explain this rating by other macroeconomic factors obtained from the same database. The model employed to determine the probabilities corresponding to each individual at each moment in time and according to the allocated rating, is an ordered probit on panel data. The results obtained indicate that there is a high degree of time correlation in country credit ratings and, furthermore, that the probability of their insolvency is also influenced by random effects of heterogeneity.

Keywords: Country risk, panel data, external debt, national saving, ordered probit.
JEL clasification: C33, C35, F34, H63, O16

1. Introduction

In the early seventies, the entire foreign debt of OECD countries totalled 100 million dollars. By the end of the eighties, this debt

* Mariano González Sánchez, University San Pablo-CEU. Julián Romea, 23. 28003 Madrid (Spain). E-mail: gonsan@ceu.es and Román Mínguez Salido University San Pablo-CEU. Email: minsal@ceu.es

represented three trillion dollars on the public debt market. The economic situation in the 70's, with interest rates beneath the export growth rate, had a significant impact on the growth of countries' foreign debt levels, without the lenders, most of whom were part of the banking system, being aware of the risk associated to their loans. It was in August 1982, after Mexico announced that it was unable to pay foreign debt totalling 80 billion dollars, when the analysis and estimation of country risk started to be considered one of the major problems facing the international financial system. At the present time, we also have to consider the new Basel Capital Accord (2004), the purpose of which is to harmonise capital sufficiency in relation to the bank risks derived from its activity, in order to ensure a more solid and secure international financial system. In this context, Feder and Uy (1985) indicate that the definition and assessment of country risk is the greatest problem facing agents when choosing their investments.

Most of the studies conducted on country risk agree that it depends largely on two other factors. The first, the country's ability to respond to its payment obligations, fundamentally corresponding to economic and financial factors, the former usually being related to the impossibility of payment being made due to lack of resources, more associated to a structural problem the solution of which is certainly long-term and the latter linked to the eventual unavailability of resources, generally due to cash problems, and considered a temporary short-term situation (cash risk). The other factor causing country risk is the country's intention to pay its debts. Following Ciarrapico (1992), the traditional theoretical approach to country risk in economic literature can be classified in two groups described as informal and formal methods. The former develop indices and ratings based on subjective criteria from qualitative and quantitative information about the borrowing country. The subjectivity of such methods lies in the choice of variables to be considered, in how they are weighted and in the value judgments employed by analysts when establishing ratings for different countries. A rating is an indicator of the ability to pay the interest and principal part of a loan at the agreed time, which is even more important today in view of the lack of mediation on the financial markets. The best known examples are the

BERI (Business Environment Risk Index), the CPR (Country Potential Rating), the Euromoney index, the III (Institutional Investors Index), the Dun&Bradstreet index, the FDIC or Federal Deposit Insurance Corporation and the ratings published by agencies such as Standard&Poors and Moody's. There are also a large number of studies related to how these ratings work, their ability to forecast financial crises and their relation to the principal macroeconomic variables [Cantor and Packer, 1996; Feder and Uy, 1985; Lee, 1993] and their efficacy according to the degree of development of the country concerned [Erb et al, 1995]. On the other hand, the formal or statistical methods are based on estimating the likelihood of certain types of events involving economic-financial and political-administrative risk, using different statistical techniques. This is exemplified by work such as [Blejer and Schumacher, 1998; Cornelius, 2000; Ferson and Harvey, 1999; Harvey and Zhou, 1993]. There are also two subdivisions in this group. The former is represented by studies aiming at determining country risk premiums and default probabilities from the market prices of public debt (models free-arbitrage opportunities), which evidently requires the existence of liquid markets for its negotiation; and the latter involves a rating and its associated probability of insolvency according to the micro and macro variables used to describe it. Different econometric techniques are used including, among others, qualitative dependent variable models. Our study fits into this last group because of two aspects: firstly, because the financial markets usually active negotiate the debt of developed countries and, secondly, because we intend to study only non-developed countries.

The study is structured as follows: section 2 defines the country risk concept and a proposed measurement method. Section 3 starts by describing the panel data sample and goes on to develop the principal characteristics of the qualitative dependent variable econometric model used to explain the evolution of country risk. Section 4 provides the empirical results obtained when estimated the model. Finally, section 5 sets out the study's principal conclusions.

2. Approximation to the country risk concept for non-developed countries

2.1. Country risk as company risk: Credit risk is divided into counterparty risk and country risk. The former has its origins in the change in the solvency of one or several counterparties forming a clearly different group from the rest, either because of their activity, the market on which they operate, the geographical area or other factors. Country risk, however, represents the solvency of all the counterparties belonging to the same geographical area, politically and legally defined as a State, either for temporary or permanent reasons. The purpose of estimating country risk is to establish which countries present problems which could affect operations either with the State or the Public Administration, or with private counterparties in those countries, and the severity of these problems. Once they are classified, and according to the risk rating assigned to them, investors will require earnings in proportion to the risk involved. As we mentioned earlier, the causes of a country's insolvency can be either economic-financial or political, so that risk is thus classified according to its origin as:

1) Sovereign Risk, corresponding to two possible events: on the one hand, a State's repudiation of its debt (total or partial) or, in other words, non-payment based on the impossibility of being sued; and on the other, deferral or restructuring of the debt, involving provisional non-payment with a subsequent renegotiation of the contractual conditions on the country's debt.

2) Transfer or Cash Risk, caused by the lack of sufficient means of payment to face foreign debt obligations. It therefore depends on the country's stock of means of payment at any given time.

3) Political or Administrative Risk, a consequence of permanent or temporary constraints on economic activity due to restrictions to market freedom or factor mobility. It corresponds to potential losses derived from a political and social change, and in a credit risk model it is represented by the likelihood of migration of worsening solvency conditions.

To identify these risks with actual economic situations and a country's finances, we will follow the proposals of Blejer and

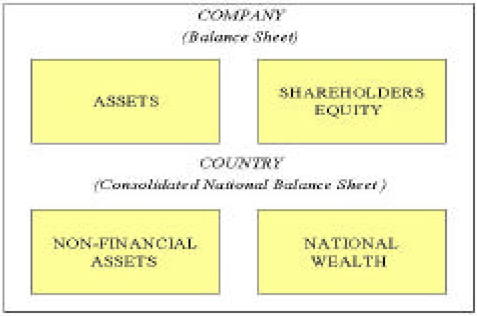
Schumacher (1998) and Cornelius (2000) and establish a simile between a country's insolvency and a company's insolvency, by seeking equivalences between a company's financial situation, as revealed in its financial statements, and that of a country, according to the European System of National Accounts or SEC95 [Consejo Europeo, 1996]. In the first place, we have to find a concept in the country similar to business capital, since this is ultimately the guarantee that creditors will be paid. We thus define national capital as the sum of the capital possessed by resident individuals and companies, together with State capital and the capital of other public agencies. This figure is for a national economy what private capital is to a company, but a series of eliminations have to be made, just like those made in the consolidated accounts of a business holding. Money, for instance, which is considered an asset when owned by an individual, is at the same time a liability for the bank who has issued it. From SEC95, we know that the account balance provided by a country's consolidated balance sheet is what is called national wealth, which is the variable we use as an approximation to the non-measurable concept of national capital, defined as the sum of net non-financial and financial assets with the Rest of the World. Thus, the net financial assets of a National Economy are comparable with the external account of assets and liabilities in relation to the Rest of the World sector, from the perspective of resident sectors. The different financial situations possible in a country and their business equivalences at a moment in time ***t*** are:

1.- Situation of equilibrium: In this situation, a country is either in a situation of absolute autarchy with no economic and/or financial relations with other countries, or the value of its financial assets is the same as the value of its liabilities with the rest of the world, thus leading to a zero balance in its external account.

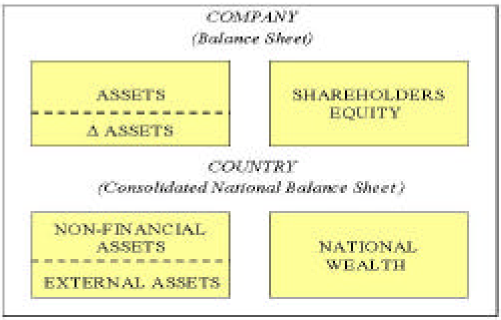
2.- Situation of deficit with the Rest of the World: Typical business situation in which company's often resort to external sources of financing.

3.- Situation of superavit with the Rest of the World: Finally, a country is lending money to the rest of the world when the value of its financial assets exceeds that of its external debt.

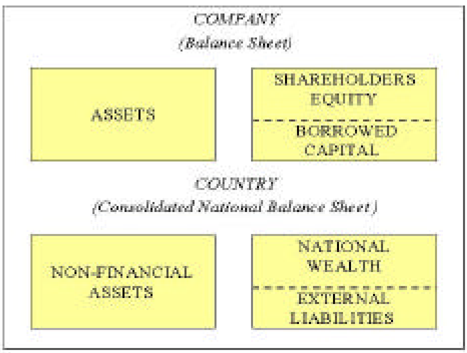
Graph 1. External account with zero balance



Graph 2: External account with credit balance

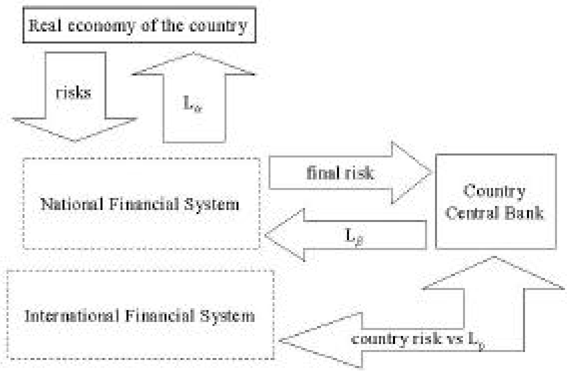


Graph 3: External account with debit balance



In spite of this comparison with a company's financial status, which would appear to make it easier to identify situations of risk, the approach is different, since the State is the ultimate guarantor of its own financial system and, as Kaminsky and Reinhart (1999) show, bank crises have been good forecasters of monetary crises. This means that the State, through its Central Bank, will have sold insurance on the national financial system's assets and, furthermore, the national financial system will have acted similarly with the real economy in its financing operations. In graph form, the movement of risks within a country's economy can be described as follows:

Graph 4: Transfer of country risk



Where L represents each of the situations that can generate country risk. Therefore, when a national economy is consolidated, the country risk can be considered as a put option bought by the Central Bank from external agents.

At this point, and based on the simile between the financial status of companies and States, we have to formally identify each of the possible components of country risk. An estimation of the risk of repudiation and the risk of renegotiation requires an analysis of the evolution of the country's financial standing, of its capitalisation or decapitalisation over time as the result of its productive activity; on the other hand, an analysis of the cash or transfer risk depends on the amount of international reserves that the country has to cover its payment obligations with non-resident creditors. Therefore, our proposal is based on a fundamental double-entry equation and the country's financial standing at a moment in time ***t*** based on the position of its different components. We thus define Assets ($\boldsymbol{A_t}$) as a country's economic structure or, in other words, the destination or application of its financial resources in order to increase its productive capacity. As for the financial structure, the Liabilities ($\boldsymbol{P_t}$) represent external sources of financing (in this case, from the rest of the world) used to finance investment in assets not covered by the country's equity or net wealth ($\boldsymbol{N_t}$):

$$A_t \equiv P_t + N_t \tag{2.1}$$

This identity relates a country's wealth and is based on the balance between financial resources classified by origin and investments made classified according to the use made of said resources. Aware that equation (2.1) is true throughout time ***t***, we obtain:

$$A_{t+1} \equiv P_{t+1} + N_{t+1} \tag{2.2}$$

Therefore, if we subtract the two equations, we obtain:

$$\Delta A_{t,t+1} \equiv \Delta P_{t,t+1} + \Delta N_{t,t+1} \tag{2.3}$$

In other words, increasing a country's productive capacity is either financed its own wealth or by external resources, or a combination of the two. To analyse the components determining the variables in equation (2.3), we use the macroeconomic identities adopted by the SEC95, thus obtaining a country's annual Disposable Income ($\boldsymbol{Yd_t}$) from the country's Production at market prices ($\boldsymbol{PIB_t}$), from its Net Income external balance ($\boldsymbol{RN_t}$) and from its net current transfers ($\boldsymbol{TCN_t}$) with the rest of the world:

$$Yd_t \equiv PIB_t \pm RN_t \pm TCN_t \tag{2.4}$$

Continuing with Economic Theory, an economy's disposable income is either spent of end Consumption ($\boldsymbol{C_t}$) or kept as Savings ($\boldsymbol{S_t}$), in order to finance future investments in the country's economic structure:

$$Yd_t \equiv C_t + S_t \tag{2.5}$$

On the other hand, the investments in assets made by a nation on a yearly basis, which is decisive for its economic growth, is called Gross Capital Formation ($\boldsymbol{FBK_t}$), and consists of Fixed Gross Capital

Formation (***FBKfixed$_t$***) or net investment in new capital goods, Fixed Capital Consumption (***CKfixed$_t$***) or depreciation of the country's assets and Variation in inventories (***VInv$_t$***). Thus:

$$FBK_t \equiv FBKfixed_t + CKfixed_t \pm VInv_t \qquad (2.6)$$

We can say, then, that a country's variation in assets between two moments in time (***t***, ***t+1***) depends on the net investment made (***FBKfixed***), on the Variation in Inventories (***VInv***) and the acquisitions less transfers of non-financial assets not produced by the country's economy (***AT$_t$***):

$$\Delta A_{t,t+1} \equiv FBKfixed_t \pm VInv_t + AT_t \qquad (2.7)$$

As we mentioned earlier, financial assets are part of the definition of an economy's liabilities. Therefore, the variation in a country's debt will depend on the balance on its net international investment status, which in turn will depend on net acquisitions of financial assets less the net liabilities incurred during the period considered. Thus:

$$\Delta P_{t,t+1} \equiv P_{t+1} - P_t \qquad (2.8)$$

Finally, the SEC95 defined a country's Annual Variation in Net Wealth (a concept similar to the balance of a company's profit and loss account) as the saving generated by its economy (***S$_t$***) after covering the consumption or depreciation of its productive goods (***CKfixed$_t$***) during said period, increased or decreased by the net balance of the capital transfers (***TKN$_t$***) performed with the rest of the world:

$$\Delta N_{t,t+1} \equiv S_t - CKfixed_t \pm TKN_t \qquad (2.9)$$

2.2. Formalisation: The proposed ratings in this paper, for each one of the categories of country risk, are tried only for non-developed countries, as we saw in the introduction. The debt of these countries have not enough liquidity in the markets and the disposable information about solvency of these ones, used to be limited. Therefore, to become a general model, including developed countries, previously it would require to establish a new rating adding the information referred to debt markets. Once the macroeconomic variables involved in a non-developed country's financial standing and its calculation has been established (2.7), (2.8) and (2.9), we have to identify each of the country risk situations as follows:

1.- Risk of repudiation: In our proposal, we consider that this risk arises when a country generates negative flows derived from its economy, which are continuous and growing in absolute value; a decreasing and negative evolution of its net wealth. Thus, if we define the situation or risk rating of country ***i*** at time ***t*** as $\boldsymbol{Y_{i,t}}$, where ***j*** is the country risk rating, which in the case of repudiation will be ***j=3***, then:

$$Y_{i,t} = \begin{cases} = 3 & if \left[\Delta N_{t-1,t} < \Delta N_{t-2,t-1} < 0 \right] \\ \neq 3 & otherwise \end{cases} \tag{2.10}$$

2.- Risk of renegotiation: For the purpose of this study, we understand that the risk of renegotiating a country's external debt arises in the first period in which the economy generates negative flows, or immediately after that period when, in spite of consuming its own resources, it presents a positive relative variation from the previous period. In other words, in this cases the rating is ***j=2***:

$$Y_{i,t} = \begin{cases} = 2 \quad if \begin{cases} \left[\Delta N_{t-1,t} < 0 < \Delta N_{t-2,t-1} \right] \\ or \\ \left[\Delta N_{t-2,t-1} < \Delta N_{t-1,t} < 0 \right] \end{cases} \\ \neq 2 \qquad otherwise \end{cases} \tag{2.11}$$

Equation (2.11) includes both the case in which a country generates negative variation in its net wealth although that variation was positive in the immediately previous period, and situations in which, although the variation in wealth is negative, the flow has improved compared with the previous period.

3.- Transfer or cash risk: A country's cash risk is perceived as the situation in which the current value of the short-term external debt ($\boldsymbol{P^{c/p}_t}$) for its entire consolidated economy, is greater than the current value of its international reserves ($\boldsymbol{R_t}$) at time ***t***. Therefore, if the rating assigned in this case is ***j=1***, the country's cash risk is defined as:

$$Y_{i,t} = \begin{cases} = 1 & if \left[R_t < P_t^{c/p} \right] \\ \neq 1 & otherwise \end{cases} \tag{2.12}$$

The difference between the amount of international reserves and the short-term debt, if negative, is called Foreign Exchange Shortfall. Finally, the ***j=0*** rating is reserved for countries exempt from risk.

4.- Administrative risk or risk of political-social change: It is determined by the probability of the country's situation changing to another in which it is less solvent. It therefore depends on the initial situation and the likelihood of it worsening, in which case the value of the debt will fall. This possible decrease in value represents the quantification of administrative risk. This final component of country risk will therefore depend on:

$$0 \le \Pr\left[Y_{i,t} > Y_{i,t-1} \middle| \mathsf{F}_t \right] \le 1 \qquad (2.13)$$

Where $\boldsymbol{F_t}$ is the information available at $\boldsymbol{t}$, given that it will be necessary to know a priori the estimations for that moment in time of the macroeconomic variables explaining risk situations.

3. Proposed method for estimating country risk for non-developed countries

3.1. Sample. The sample selected for the empirical study comes from Base 2002 World Development Indicators published by the World Bank. Of a total of 207 countries initially analysed, the sample in our analysis comprises a total of 40 countries grouped by geographical area[1] (see Table 1) for the 1980-2000 period.

This reduction from 207 to 40 countries is due to the restriction of the variables required to define the proposed risk situations, to the lack of information for the rest of the countries initially used and to the selection of countries which could be classified as "non-developing", since it is precisely here where the estimation of country risk is most useful, given the lack of cash markets where their public debt is negotiated. Data frequency is annual and the panel is balanced.

[1] As we will see later, countries are grouped by geographical area to avoid over-parameterising the model.

Table 1. Geographical areas and country groupings

Africa	Central America	South America	Asia-Pacific	Arabic Countries
Cameroon	Costa Rica	Argentina	India	Egypt
Central African Republic	Dominican Republic	Brazil	Indonesia	Jordan
Chad	Guatemala	Chile	Korea, Rep.	Morocco
Cote d'Ivoire	Honduras	Ecuador	Nepal	Tunisia
Ghana	Jamaica	Peru	Pakistan	Turkey
Kenya	Mexico	Uruguay	Philippines	
Madagascar	Nicaragua	Venezuela, RB	Sri Lanka	
Malawi			Thailand	
Mali				
Mauritania				
Niger				
Nigeria				
Senegal				

The explanatory variables selected in our study respond to the need to find different indicators justifying the evolution of the risk situation of the countries in the sample. These variables are:

- The Gross Domestic Product was selected as an indicator of the economy's driving force. This variable has been taken broken down into added values in order to determine which of them is or are truly significant when establishing risk situations. We used the Value Added of the Primary Sector (***VA1***), which includes farming, livestock breeding and fishing, the Value Added of the Secondary Sector (***VA2***), comprising industry and construction, and the Value Added of the Tertiary Sector (***VA3***) corresponding to the service sector.
- Given that another of the risk situations analysed is cash risk, for this purpose we consider several related macroeconomic variables, specifically ***M3*** (disposable money supply) and ***M2*** (money and

quasi-money), both measurements of an economy's standing. As an explanatory variable, we include the difference between the two, called ***M32***.

- Domestic Loans (***CD***) from the banking sector are included because they are an indicator of the indebtedness of a country's resident sectors, so it would be an important variable representing the principal component in bank assets and indicating the level of indebtedness of one of the State's economic components, the private sector. We should also remember (Graph 4) that there is a transfer of risk from banks to the Central Bank and this variable could therefore have an impact on country risk.
- The total Private Sector Debt (***DP***), unlike the previous variable, would add external indebtedness, indicating how much of the risk of a State's agents has been transmitted to the Rest of the World.
- Bank Liquidity (***LIQ***), measured as the ration between the current accounts held by banks in Central Banks and their total assets. This variable was selected because of its possible relation to the internal liquidity of the financial system, which a priori could affect agent insolvency situations, with the subsequent impact on the economy as a whole.
- Inflation (***G***) is measured as the growth rate of the consumer price index obtained from a selection of goods and services and calculated using the Laspeyres method. This indicator enables us to determine how the price level can have a negative impact on the solvency of all the agents comprising a State.
- The annual Exchange Rate (***TC***) of local currency with the United States dollar. This variable will indicate the expectations of the international financial markets concerning the economy in question. With regards to this variable, we should mention that, as some "dollarised" countries maintain (Panama) or have maintained (Argentina) the parity of their local currency with the U.S. dollar, there are other countries in the sample for which the price of its currency in dollars is the same throughout the period analysed. This is true of geographically close countries such as Central Africa, Cameroon, Chad, Ivory Coast, Mali, Niger and Senegal. This may mean that this variable will not be included in the baseline because it is not statistically significant.

- An economy's Net Capital Flows (***FN***) to the exterior. This and the previous variable indicate the weight of a State's economy in relation to the Rest of the World.

Given that most of the economic variables present heavy trends, and are not therefore stationary, the usual statistical inference is not applicable. In order to homogenise the information on the variables used, considering that they are not stationary, we have expressed them as relative variation rates, thus losing the first value of the sample, except for variables which are rates by definition (inflation).

The following sections present the formal model:

3.2. Model: To suitably specify the rating model, we assume that each rating decision for each country at each point in time depends increasingly on a random index function $V_{i,t}$ which related a continuous measurement of underlying utility, as a dependent variable, to the value of the macroeconomic variables as regressors. If we assume a linear specification, the random index equation will be given by the usual regression model. The only difference from the regression model is that the dependent variable is not observable. The rating decision observed will depend on whether the non-observable value exceeds certain fixed thresholds, with $g_0 \leq g_1 \leq g_2 \leq \cdots \leq g_{J-1}$. Therefore, the rating, observed as an ordinal variable, depends on the position of the random utility. We can then map a quantitative, but non-observable, variable on an observed ordinal variable. The value of the random index has a systematic component depending on $x_{i,t}$ variables and a random component included in term of disturbance $u_{i,t}$. When specifying a random distribution for $u_{i,t}$ we obtain the models usually found in the literature (see Arellano and Bover, 1997). Logistic distribution and normal distribution are usually employed.

The model is described by the following equations:

$$\begin{aligned} & V_{i,t} = b_0 + b_1 x_{1,i,t} + \ldots + b_k x_{k,i,t} + u_{i,t} = X_{i,t}^T \cdot b + u_{i,t} \\ & u_{i,t} \text{ i.i.d.} (0,1) \qquad (3.1) \\ & i = 1,\ldots,N \quad t = 1,\ldots,T \quad k = 1,\ldots,K \end{aligned}$$

And

$$Y_{i,t} = \begin{cases} 0 & if \quad V_{i,t} < 0 \\ 1 & if \quad 0 \le V_{i,t} < g_1 \\ 2 & if \quad g_1 \le V_{i,t} < g_2 \\ \vdots & \qquad \vdots \\ J & if \quad V_{i,t} \ge g_{J-1} \end{cases} \qquad (3.2)$$

$$0 = g_0 \le g_1 \le \cdots \le g_{J-1}$$

This normalisation does not affect the observed rating, since the random utility values correspond to the same section as before, whereas the other parameters are obtained.

From equations (3.1) and (3.2) above, the probability of each rating observed, for each individual I and moment in time t can be expressed as:

$$\begin{aligned} &\Pr(Y_{i,t} = 0) = \Pr(V_{i,t} < 0) = \Pr(u_{i,t} < -X'_{i,t}b) \\ &\vdots \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (3.3) \\ &\Pr(Y_{i,t} = j) = \Pr(g_{j-1} \le V_{i,t} < g_j) = \Pr(g_{j-1} - X'_{i,t}b \le u_{i,t} < g_j - X'_{i,t}b) \\ &\vdots \\ &\Pr(Y_{i,t} = J) = \Pr(g_{J-1} \le V_{i,t}) = \Pr(g_{J-1} - X'_{i,t}b \le u_{i,t}) \end{aligned}$$

Equation (3.3) shows that, given the observed values of the $\boldsymbol{X_{i,t}}$ variables, the probability of each choice will depend on the value of parameters $b_{\boldsymbol{k}}$ (***k*** = 1, …, ***K***) accompanying the regressors, on thresholds $g_{\boldsymbol{j}}$ (***j*** = 1, …, ***J-1***) and the distribution function assumed for noise $\boldsymbol{u_{i,t}}$. With regards to ***t*** he latter, we have to remember that, since the model includes panel data (the sample corresponds to a set of countries observed for a certain period of time), although the noise has been normalised, the structure of the variance-covariance matrix of the disturbances may be relatively complex if random heterogeneity effects and time dependences by individual are permitted. If, in this case, the disturbances of the random utility equation $e \sim N(0,\Omega)$ are expressed as (3.1), we obtain the Ordered Probit model for panel data [Cheung, 1996; Hausman et al, 1991]. The final formulation of this model will depend on the hypotheses considered concerning matrix Ω.

The different types considered in this study are similar to those used in [Ackerber, 1999; Berg and Coke, 2004; Hajivassiliou and McFadden, 1990]:

1) In this case, we assume that there are no individual random heterogeneity effects or time correlations. Therefore, given that $var(u_{i,t})=1$, matrix Ω will be the identity matrix and the resulting model will be equivalent to an Ordered Probit with cross section data.

2) There is now an individual random effect a for each country, although the variance of the random effect is always the same. Therefore, the variance of the disturbances will remain constant and the covariances between the disturbances of the same individual will not be zero.

3) In this case, there is time correlation generated by an AR(1) with the same parameter r in all individuals. Matrix Ω is with diagonal blocks again and the sub-matrices (Σ_i) on the principal diagonal have the usual structure of disturbances in first order regressive models.

4) This is similar to case 2, but diversity between the random effects of the different individuals is now permitted, so the structure of matrix Ω is identical to type 2 but with a different parameter $s^2_{a_i}$ in each sub-matrix Σ_i.

5) In this option, the dynamics may be different for each individual and the structure of matrix Ω is similar to type 3, but with a different parameter r_i in each sub-matrix Σ_i.

6) This case permits the existence of both a random effect and a time correlation for each individual, although parameters s^2_a and r must be the same for all the individuals. Matrix Ω is in diagonal blocks again.

7) This case generalises type 6, permitting heterogeneity between both the random effects and the time correlations of each individual. Matrices $?_i$ of the principal diagonal will be similar to the above, but with different parameters $s^2_{a_i}$ and r_i for each individual.

The set of alternatives considered above is not exhaustive and different variance-covariance schemes can be implemented, giving rise to different matrix Ω structures. However, we believe that the alternatives considered are broad enough to contemplate the individual and time dependencies observed in actual cases. One interesting generalisation would be to permit the existence of non-zero correlation between the random effects of different individuals. However, in this case the diagonal block structure of matrix Ω would be broken and the computational estimation problems increase enormously. To estimate parameters b and g, and those included in the covariance matrix Ω, we have to maximise the likelihood function logarithm expressed, under the hypothesis of normality, as[2]:

$$\ln L\left(b,g,\Omega \middle| Y,X\right)=\sum_{i=1}^{N}\ln\Pr\left(Y_{i,1}=j_{i,1},\cdots,Y_{iT}=j_{i,T}\right)= \tag{3.4}$$

$$\sum_{i=1}^{N}\ln\Phi\left(g_{j_{i,1}-1}-X'_{i,1}b\leq e_{i,1}\leq g_{j_{i,1}}-X'_{i,1}b,\cdots,g_{j_{i,T}-1}-X'_{i,T}b\leq e_{i,T}\leq g_{j_{i,T}}-X'_{i,T}b\right)$$

Where the choices $\boldsymbol{j_{i,t}}$ of the i-th individual belong to the set of alternatives ($\boldsymbol{j}$=0, …, $\boldsymbol{J}$) and parameters $g_{\boldsymbol{i,t}}$ are included in the threshold vector (0, $g_{\boldsymbol{1}}$, …, $g_{\boldsymbol{J-1}}$). Function $\Phi(\cdot)$ is the normal multivariate distribution, so we have to consider that, if the covariance matrix is between types 2 to 7, the likelihood function requires calculating normal multidimensional distribution integrals the dimension of which grows[3] with T. To evaluate the multidimensional integrals of the likelihood function, we need to use simulation methods, of which the most commonly used in this context is the GHK simulator[4] [Börsch-Supan and Hajivassiliou, 1993; Hajivassiliou and McFadden, 1990; Hajivassiliou et al, 1996; Inkmann, 1999; Train, 2003; Börsch-Supan Waelbroeck, 2003].

[2] The likelihood logarithm can be considered by individual, since there are no correlations between them. However it cannot be broken down over time since there may be time correlations within each individual. This form of likelihood is a direct consequence of the diagonal block structure of matrix Ω, with non-diagonal ? $_{i}$ sub-matrices.

[3] If matrix Ω was not in diagonal blocks due to the existence of correlations between individuals, the normal multidimensional integral would be in the order of NxT which, on this level, is of an impossible to solve computational complexity.

[4] There are other alternative simulation methods such as those described in, among others [Börsch-Supan et al, 1990; Breiung and Lechner, 1998; Chib and Greenber, 1996; Fleming and Mae, 2002; Geweke et al, 1994; Green, 2002; Honoré, 2002].

4. Empirical results

Tables 2 to 6 summarise the estimation results of models type 1 to type 7 described above, using the database of the 40 countries available for the 1980-2000 period. This database, described earlier in subsection 3.1, includes both rating values for each country and the values of the economic variables explaining such ratings. For the number of parameters not to be excessive in types 4, 5 and 7, the countries are grouped into 5 geographical areas (Africa, Central America, South America, Asia-Pacific and Arabic Countries) so that the individual parameters are the same for all the countries in the same area. This considerably reduces the number of individual parameters to be estimated and, if countries in the same area behave similarly, does not represent a significant loss of generality, contemplating the diversity associated to different geographical regions.

To select the independent variables to be included in each type of model (which evidently do not necessarily have to coincide with the same regressors in each model) and maximise the corresponding simulated likelihood, we go from a general to specific approach in the following stages: 1) Start in the type 1 model (T1). 2) Establish a minimum and maximum number of lags in the independent variables (in our case, 1 and 2 respectively[5]) and include all the regressors in the model. 3) Maximise the simulated likelihood function[6], as described in the previous section, and compare the individual significance of each parameter. 4) Eliminate the variables of which the parameters are not significant on a 10% level and return to step 3. 5) If all the variables are significant, go on to the next type of model and start again at step 2. If the type is 7, end the process.

Analysing the results obtained, in the estimations of the thresholds g_j on table 2 we can observe that, as the covariance matrix becomes

[5] Contemporary regressors are not included because, when the rating for a year is calculated, the data for the current year is not usually available.
[6] As usual with simulation methods, the same random values have been generated in each of the iterations in the optimisation process with the BFGS.

more complex, the value of the threshold increases. We could therefore conclude that there is a direct relationship between the inclusion of random and time effects and the threshold values. This relationship is most important in the case of time correlations. Although the third threshold is not significant in some types of model (especially when time correlation is included), this is due to the re-parameterisation carried out when optimising. Actually, threshold 2 and 3 are parameterised as $\gamma_j = \gamma_{j-1} + \exp(\kappa_j)$ and the t-test significance statistic refers to parameter k_j of the exponential, so if it is not significant, it is indicating that the difference from the previous threshold is not statistically different from the unit. Typical deviations are not included in the first threshold since, for all models, it is normalised in the null value.

Table 2. Values of g estimated in each type of model

Models	Threshold-1	Threshold-2	t-Test	Threshold-3	t-Test
Type 1	0.0000	1.8373	14.7097	2.428	-3.4168
Type 2	0.0000	2.5231	20.0828	3.2729	-1.8977
Type 3	0.0000	2.7103	20.9937	3.6605	-0.3282
Type 4	0.0000	2.5222	20.0430	3.2762	-1.8620
Type 5	0.0000	2.7188	21.2585	3.6534	-0.4369
Type 6	0.0000	2.7566	6.7748	3.7105	-0.3062
Type 7	0.0000	2.8232	21.8502	3.7281	-0.6488

The threshold columns record the value of g in equation (3.2). The value of Threshold-1 is always 0 due to normalisation. The t-Tests compare the individual significance of k_j in the expression: $g_j = g_{j-1} + \exp(k_j)$

The regressors which were finally significant for each model, and there corresponding beta values, are shown on table 3.When analysing the table, we see that in the type 1 model, the significant regressors are different from those in the rest of the models. This means that, when working with cross section discrete variable models, the choice of explanatory variables could be mistaken with respect to what would happen when considering random and time effects derived from the panel data. It also appears that the inflation variation rates at ***t-1*** and ***t-2*** are the variables showing part of the random effect and time correlation not assumed in the type 1 model. In the types of model contemplating time autocorrelation[7] (3, 5 and 6), the regressors are the same and also more numerous than in the other types. On the other hand, they are the only models presenting a significant variable at ***t-2***, Private Debt. Finally, in the types of model including random effects (2, 4 and 7), the regressors also coincide but in this case they only include one lag (***t-1***).

Table 3. Estimated values of *b*

Regressors	Type-1	Type-2	Type-3	Type-4	Type-5	Type-6	Type-7
Cte.	0.3409 (7.17)	0.5195 (3.18)	0.4070 (2.59)	0.4189 (2.38)	0.7477 (3.86)	0.4495 (2.49)	0.3528 (1.47)
DP t-2			0.1441 (1.52)		0.1277 (1.37)	0.1417 (1.44)	
G t-2	0.0116 (1.54)						
FN t-2			0.0136 (1.64)		0.0131 (1.56)	0.0119 (1.40)	
VA2 t-1		-0.4767 (-1.68)	-0.5877 (-2.15)	-0.4820 (-1.70)	-0.5999 (-2.18)	-0.6046 (-2.15)	-0.5107 (-1.78)
M32 t-1		-0.0525 (-1.91)	-0.0694 (-2.91)	-0.0525 (-1.91)	-0.0660 (-2.68)	-0.0681 (-2.76)	-0.0667 (-2.47)
DP t-1	-0.2558 (-2.19)						
LIQ t-1		0.0923 (2.52)		0.0932 (2.55)			0.0638 (1.75)
G t-1	0.0177 (2.26)						

Columns Type-1 to Type-7 report the estimations by maximum likelihood of b_k in equation (3.1). For each type, we only include the regressors selected in the model. The (t-Test) record the values of the individual significance test statistics.

We can conclude, therefore, that regressor selection will depend on the structure of the variance-covariance matrix chosen, so a correct

[7] Except in the type 7 model in which, although it includes autocorrelation, the regressors do not coincide with the rest.

procedure would involve using a likelihood ratio test to choose the most appropriate type of model for the data in order to determine the explanatory variables. Finally, the significant regressors in all the models (except type 1) are Value Added of the Secondary Sector at ***t-1*** and the M3-M2 differential (***M32***), also at ***t-1***; the former would indicate how the country is progressing with regards to ratings 2 and 3, whereas the appearance of the latter would be related to cash availability, the problem contemplated in rating 1. Tables 4 and 5 summarise the estimations of the parameters of the variance-covariance matrix Ω.

Table 4. Estimated values of s_a

Areas	Type-1	Type-2	Type-3	Type-4	Type-5	Type-6	Type-7
Africa	1.00	0.9575 (7.91)	1.00	1.0046 (4.24)	1.00	0.8777 (5.21)	1.1430 (3.91)
Central America	1.00	0.9575 (7.91)	1.00	1.0736 (3.53)	1.00	0.8777 (5.21)	6.92E-07 (6.12E-07)
South America	1.00	0.9575 (7.91)	1.00	1.2099 (3.40)	1.00	0.8777 (5.21)	0.8662 (0.5527)
Asia-Pacific	1.00	0.9575 (7.91)	1.00	0.4789 (2.71)	1.00	0.8777 (5.21)	6.81E-08 (1.99E-07)
Arabic Country	1.00	0.9575 (7.91)	1.00	0.8406 (2.61)	1.00	0.8777 (5.21)	0.6332 (0.71)

Columns Type-1 to Type-7 record the typical deviations of the random effects in the disturbances. The (t-statisti)c is not included in types 1, 2 and 5 because these models do not include random effects. In types 2 and 6, the value of s_a is the same for all the individuals

Table 4 shows the typical deviations s_{a_i} of the random effects. In the type 2 model (typical deviation common to all the groups), the estimation is significant and slightly below 1 (0.9575). On the other hand, when in type 4 the random effect is permitted to be different for each geographical area, the greatest typical deviation is 1.2099, corresponding to South America, whereas the lowest is Asia-pacific with 0.4789. If, however, in addition to the random effect we include time correlation (types 6 and 7), we find that in type 6, with the same random effect and autocorrelation for all the groups, the standard deviation of the random effect is lower (0.8777) than in type 2. Therefore, it at least partly appears that the heterogeneity contemplated by the random effect in type 2 will be included in the time correlation. In the type 7 model, in which different random effects and autocorrelation are permitted for each group, we see that the greatest typical deviation of the random effect is 1.143 in Africa, the only group in which it was significant.

To summarise, when time correlation is added, the importance of the random effect decreases because, to a large extent, the current rating is explained by the situation at the previous moment in time. Only in Africa does the random effect remain significant, which is logical considering the different development of this group in relation to the rest. Table 5 summarises the estimations of the parameters r_i including time correlations.

Table 5. Estimated values of r

Areas	Type-1	Type-2	Type-3	Type-4	Type-5	Type-6	Type-7
Africa	0.00	0.00	0.7910 (6.37)	0.00	0.6546 (3.42)	0.6823 (4.64)	0.3532 (2.38)
Central America	0.00	0.00	0.7910 (6.37)	0.00	0.8310 (2.65)	0.6823 (4.64)	0.8384 (2.62)
South America	0.00	0.00	0.7910 (6.37)	0.00	0.8833 (2.29)	0.6823 (4.64)	0.8190 (0.76)
Asia-Pacific	0.00	0.00	0.7910 (6.37)	0.00	0.7869 (2.68)	0.6823 (4.64)	0.7507 (3.05)
Arabic country	0.00	0.00	0.7910 (6.37)	0.00	0.8823 (1.67)	0.6823 (4.64)	0.7891 (1.30)

Columns Type-1 to Type-7 record the autoregressive parameters in the disturbances. The (t-statistic) is not included in types 1, 2 and 4, because these models do not include time correlations. In types 3 and 6, the value of r is the same for all the individuals.

When analysing the table, we detect a significant positive autocorrelation in all the types. For example, in type 3 (parameter r the same for all the groups), the estimation is 0.79; however, in type 5 (parameter r_i different for each group), the estimations obtained are around this mean value, with the lowest in Africa (0.65) and the highest in South America (0.883). On the other hand, when random effects and autocorrelation parameters common to all the groups are included (type 6), the estimated parameter decreases (0.68), as expected, since part of the performance over time is considered in the random effects. However, in type 7, which permits different random effects and time correlation for each group, the lowest is in the group with the only significant random effect (Africa), where the parameter is 0.35, whereas the highest value (0.84) corresponds to Central America. Both in South America and the Arabic countries, autocorrelation is not significant, probably because of its highly volatile ratings in the sample period.

Finally, to perform the best model, we include the information criteria obtained for each model in table 6. Both in the AIC and BIC cases, type 1 is the worst possible case, whereas the AIC selects type 7 as the best model and the BIC type 6 (this is due to the greater penalty associated to this criterion by including additional parameters). Invariably, the model selection criteria choose the best types as those considering time correlations, so they are more important than the heterogeneity effects contemplated in s_{a_i}.

Table 6. Likelihood, Information Criteria and Computational Time

Models	Log-Likel.	AIC	BIC	Computational Time
Type-1	-694.316	1400.63	1428.43	0:49:30
Type-2	-569.172	1152.34	1184.78	2:42:38
Type-3	-498.680	1013.36	1050.43	2:57:15
Type-4	-567.022	1156.04	1207.01	10:04:11
Type-5	-494.474	1012.95	1068.55	13:29:06
Type-6	-494.724	1007.45	1049.15	4:02:24
Type-7	-484.350	1000.70	1074.83	21:23:13
			TOTAL	55:28:17

The Log-Likel. column records the log likelihood values simulated at the optimum point (equation 3.4). Calculated on a Pentium IV computer with 3.0 GHz processor.

5. Conclusions

This paper presents a method for estimating country credit ratings aimed at avoiding three problems which mar arise on today's markets: in the first place, it avoids agency rating systems considered to be "black boxes"; secondly, it avoids the problem of measuring country risk if debt is not negotiated on cash markets; and finally, it is an advanced method for the internal measurement of country risk from the perspective of the recent Basel Capital Accord. This study introduces two main aspects:

- The first is the approach used to define country risk situations. It is an adaptation of other work performed on business solvency.
- The second is the model for estimating the probability of each possible rating. This model (Ordered Probit on panel data) enables us to contemplate different variance-covariance matrix structures, giving rise to the possibility of including time correlation, random effects or both.

All the above has been completed with a practical implementation of the model on a sample of 40 non-developing countries, during the 1980-2000 period, obtained from the Base 2002 of World Development Indicators published by the World Bank and grouped into 5 geographical areas (Africa, Central America, South America, Asia-pacific and Arabic Countries), under the hypothesis of similar behaviour in each group. The principal results obtained include the following:

1. The choice of variables explaining the ratings is different for the type 1 model, which does not consider either individual heterogeneity effects or time dependence, in relation to the other models which do contemplate heterogeneity and autocorrelation. Since the ratings published by agencies usually only consider the values of variables explaining the ratings and not the dependence structure, these ratings may be biased.

   On the other hand, the regressor explaining the different ratings for all except the cross section model (type 1 model) was the annual rate of variation of the Value Added of the Secondary Sector. Therefore, it seems clear that greater industrial development is the fundamental variable explaining a better rating. The thresholds distinguishing between different non-observable utility levels, which in turn generate the probability of each rating, are a direct function of the complexity of the covariance matrices of the disturbances.

2. When analysing information criteria (AIC and BIC), the preferred models are always those which propose more complex covariance matrices, so we conclude that default probability models should include heterogeneity, time autocorrelation and any other characteristic adding value to the model, even more than the search for a large number of regressors. This confirms the need for caution with the usual rating procedures, since they are usually based on cross section data and ignore the importance dependencies in the panel data.

Finally, one possible related line of research would be to include cross-correlation between individuals to permit the transmission of shocks between different areas and observe their impact on the different ratings.

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