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Evolution of Sovereign Rating Models in the Current Crisis*

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Evolución de los modelos de riesgo soberano en tiempos de crisis
Evolução dos modelos de risco soberano em tempos de crise

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In this article we deal with the topic of the risk assessment of sovereign debt issuers by the main rating agencies. After selecting the macroeconomic variables that are reported in the literature to be the most relevant, we apply multiple linear regression models in which the dependent variable is the rating assigned to each country by the three main agencies. We analyse 82 countries in the period 2004-2011 and, as a result, a change is observed with respect to previous models. This is due, in part, to a new qualitative variable, regulatory quality, which is acquiring considerable weight in times of crisis.

En este artículo se aborda el tema de la calificación de los emisores soberanos por parte de las agencias de rating. Una vez seleccionadas las variables macroeconómicas, que aparecen como más relevantes en la literatura al uso, se utilizan modelos de regresión lineales múltiples donde la variable dependiente es el rating asignado a cada país por las agencias. Se utiliza un modelo de catorce variables que luego pueden reducirse a cuatro con resultados muy similares en cuanto al ajuste. Se analizan 82 países en el periodo 2004-2011 y, como resultado, se observa un cambio sustancial respecto a los modelos previos. Esto se debe, en parte, a la incorporación de una nueva variable cualitativa, la calidad regulatoria, que adquiere un considerable peso en época de crisis.

Neste artigo, aborda-se o tema da qualificação dos emissores soberanos, por parte das agências de rating. Uma vez selecionadas as variáveis macroeconómicas, que aparecem como mais relevantes na literatura referente ao tema que está em uso, utilizam-se modelos de regressão lineares múltiplos, onde a variável dependente é o rating atribuído a cada país pelas agências. Utiliza-se um modelo de catorze variáveis que, depois, se podem reduzir a quatro, com resultados muito parecidos, quanto ao ajuste. Analisam-se 82 países, no período de 2004-2011 e, como resultado, observa-se uma mudança substancial relativamente aos modelos prévios. Isto deve-se, em parte, à incorporação de uma nova variável qualitativa, a qualidade regulatória, que adquire um considerável peso em época de crise.

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1. Introduction

The determination of the sovereign *rating* of the Public Debt of various countries is currently of crucial importance on both the national and international scenes. The risk premium, a much-used variable in the world of finance, depends in part on the *rating* or grade assigned to the issuer of sovereign debt; this accounts for the importance of the *rating*.

For the many different parties interested in studying or trying to understand these variables, there is a problem: this is that the models used by the rating agencies are not sufficiently explicit. They have been described as a kind of "black box", at least for the investors in the market. This absence of transparency is due to purely commercial reasons, which are totally legitimate. The rating agencies are competing companies selling services to investors, for which they aim to make a profit.

However, at least since the 1990's, many authors have attempted to replicate the models and the resulting *ratings* assigned by the agencies. For this they have generally used macroeconomic variables of the countries of interest, in statistical models such as those of multiple linear regressions. The results differ but the coefficients of determination of the regressions usually present acceptable values.

This study is structured as follows:

- Relationship between *rating* and macroeconomic variables: previous studies.
- Relationship between *rating* and macroeconomic variables: current models.
- Conclusions.

KEY WORDS
Rating, sovereign issuer, risk premium, multiple linear regression model

PALABRAS CLAVE
Alificación crediticia, emisiones soberanas, prima de riesgo, modelos de regresión lineal múltiple

PALAVRAS-CHAVE
Qualificação creditícia, emissões soberanas, prémio de risco, modelos de regressão linear múltipla

2. Relationship between rating and macroeconomic variables: previous studies

In the USA, credit rating companies have existed since the early years of the 20th century. However, from the 1970's onwards, the work of these entities has become more important and active, with the increasing participation of companies and governments in international financial operations. In consequence there has been a great increase in activities for the construction of theoretical models to evaluate the risk associated with these financial operations and with financial investment of all kinds.

The credit rating agencies do not make public the models they have developed for defining the *rating* of a particular issuer of debt (i.e. a country or company seeking to borrow money, usually on a relatively large scale). Nevertheless, the methodology used by each agency is likely to be similar, since the *ratings* assigned by each are fairly close, even though they do not always coincide precisely and do not change at the same times. Despite the assumption that the determination of sovereign credit *ratings* depends on a large number of different factors, some studies have shown that there may be a relationship between the *rating* assigned to a sovereign issuer and a reduced set of fundamental variables.

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There have been numerous econometric studies aimed at assessing statistically the various possible determinants of the *rating*, and the relative importance of the role played by each of these determinants. These articles can usually be differentiated by the econometric techniques used, the period of time studied, the initial working hypotheses, the countries analysed, and other factors.

Since Edwards (1984, pp. 726-734) estimated the dependent variable country *rating* from the difference between the rate of interest of the loans and the LIBOR, a series of similar analyses have been published. Thus, Cheung (1996, pp.1-38) studied the Canadian experience, to present one of the first papers on the provincial *bond ratings*. Haque and others (1996, pp.688-724) carried out a study on data of 60 emerging countries in different years.

Cantor and Packer (1996, pp. 37-54), after evaluating a series of economic and financial criteria, explain the behaviour of the credit *ratings* using multiple linear regression, and rank-ordered logit and probit models.This last study has been continued by several authors, who obtained similar results although, when the original data were up-dated, it was found that the significant variables were modified and, in some cases, reduced in number. This is the case in the studies of Afonso (2003, pp. 56-74), Alexe and others (2003, pp. 1-40), Borio and Packer (2004, pp. 1-20), Martín and Téllez (2005, pp. 159-173), Butler and Fauver (2006, pp. 53-79), Afonso and others (2011, pp. 1-15) and Maltritz and others (2012, pp. 4679-4688). The rank-ordered probit model is used by Hu and others (2002, pp.1383-1406), Bissoondoyal-Bheenick and others (2006, pp. 136-154), Chen and Yang (2011, pp. 313-320), and Teker and others (2013, 122-132).

Apart from studies of this type the credit *rating* has been estimated using neuronal networks as a complement to the logit and probit models. Examples include Bennell and others (2006, pp. 415-425) and León-Soriano and Muñoz- Tarres (2012, pp. 13-23).

3. Relationship between *rating* and macroeconomic variables: current models

Taking the work of Cantor and Packer (1996, pp. 37-54) as the starting point, it is proposed to establish the relationship, if any, existing between the sovereign debt *ratings*, at the end of 2011, and a set of macroeconomic variables similar to those of the models previously cited, using data for the period 2004-2011.

3.1 Proposition of the model: definition of the variables

For this study the *ratings* determined by the three principal credit rating agencies are considered: Standard & Poor´s, Fitch and Moody´s, at 31 December 2011.

To convert the *ratings* into numerical data, the score or value 1 is given to all countries classified with C; for our purposes, that includes the *ratings* C, CC, and CCC (Table 1). A residual character is attributed to the category C since it is considered that those countries that are given that *rating* present a high probability of default, and that the agencies only differentiate between CCC, CC and C to help users identify small relative differences in the gravity of these serious situations. In continuation numerical scores are successively assigned until the value of 17 is reached for the highest *rating*, AAA. The category D is not scored because this indicates that a situation of default already exists; it is precisely the probability of this that a *rating* is intended to evaluate.

Table 1. Categorization of the dependent variable

S&P	Fitch	Moody´s	Adquisición
AAA	AAA	AAA	17
AA+	AA+	Aa1	16
AA	AA	Aa2	15
AA-	AA-	Aa3	14
A+	A+	A1	13
A	A	A2	12
A-	A-	A3	11
BBB+	BBB+	Baa1	10
BBB	BBB	Baa2	9
BBB-	BBB-	Baa3	8
BB+	BB+	Ba1	7
BB	BB	Ba2	6
BB-	BB-	Ba3	5
B+	B+	B1	4
B	B	B2	3
B-	B-	B3	2
CCC+	CCC+	Caa1	1
CCC	CCC	Caa2	1
CCC-	CCC-	Caa3	1
CC	CC	Ca	1
C	C	C	1
D	DDD		-

For this first study carried out by the authors, the starting point is the series of variables that Cantor and Packer studied in the initial model; these are:

Per capita income: The variable used is the GDP per capita of 2011, measured in thousands of dollars, corrected by purchasing power parity. The information has been obtained from the data

bases of the International Monetary Fund, World Economic Outlook (WEO)[1]. It measures the income or wealth generated per inhabitant of the country analysed.

GDP growth: The variable employed is the mean rate of GDP growth in the last eight years (2004-2011) at constant prices, that is, in terms of volume and in the local currency. The data are obtained from the WEO database. The arithmetic mean of the rate of annual growth of the years 2004 to 2011 is used. This informs regarding the economic cycle of the country analysed.

The two preceding variables should, theoretically, be relevant for the determination of the *rating* assigned to a sovereign debt issuer, since it is a measure of the fiscal strength of the borrower country, that is, its capacity to service the debt via tax revenue raised.

Inflation: The variable used is the arithmetic mean of the rate of annual growth of the CPI in recent years (2004-2011); again these data are obtained from the WEO database of the IMF. It measures the average increase in consumer prices in the period studied.

Fiscal balance: The deficit or surplus of the public sector, as a percentage of the GDP in the last eight years, is used for this variable. The data for determining this variable are also obtained from the WEO database although, for some countries, the data are previsional. The information obtained is compared with that from other additional sources: the World Bank, the ECLA, the European Commission, the African Development Bank and other national sources. In previous studies the balance of the central government as a percentage of the GDP has been used since information was lacking on the complete public sector[2].

External balance: The variable employed is the mean for the last eight years (2004-2011) of the balance of the country's current account (exports minus imports of goods and services, incomes from capital and current transfers) as a percentage of the GDP. The balance of the external sector of the economy of the country analysed is measured with this variable. The data are obtained from the WEO database of the IMF in September 2011.

External debt: A high external debt[3] increases the risk of default and indicates a greater possibility of the occurrence of situations of insolvency. In this case we employ the liabilities generated by debts of residents with non-residents (in dollars) as a percentage of the income on the current account (exports) of the balance of payments. It is difficult to obtain statistical information of the external debt of all the countries in one single database; for this study we have used those published by the World Bank, the CIA and Reuters.

1. The IMF data for these variables have been obtained from the following Internet address: http://www.imf.org/external/pubs/ft/weo/2011/02/weodata/weoselgr.aspx, in December 2011, and are checked against those from Eurostat and The World Factbook (CIA).

2. Alonso, N. (2009): "Rating y spreads de la deuda soberana: un análisis aplicado a Latinoamérica" apply this datum, general government balance in percent of GDP, obtained from the IMF, in April 2005 (WEO, http://www.imf.org/external/pubs/ft/weo/2005/01/data/dbcsuWB.cfm).

3. Certain discrepancies exist on how to define the concept of External Debt. The World Bank, in an explanatory note in the External Debt Statistics Guide for Compilers and Users and the IMF (2003), considers that "The gross external debt is the amount outstanding at any particular moment of the real and non-contingent current liabilities assumed by residents of a national economy, with respect to non-residents, with the commitment to make payments of principal, interest or both, in the future". In contrast, the Bank of International Settlements (BIS) considers that the economic relevance of this concept resides in the obligations to make payments in foreign currency independently of the residence of the owner of the asset in question.

Economic development: This dichotomous variable tells us whether or not the country has reached the level of industrialization according to the IMF criteria[4]; it takes the value 1 for the countries considered industrialized, and 0 for the rest.

Previous payment behaviour: Those countries that have had some episode of default in the past are more risky. A variable is created that takes the value 1 if the country has had a default of some kind, and 0 otherwise.

Table 2. List of variables used in the models

Variable	Definition	Units of measurement	Source
Rating	Rating on 31/12/11 by S&P, Moody´s, Fitch and the mean of the three	Numerical score given to each rating category, in Table 1	S&P, Moody´s, Fitch
GDP per capita	GDP per capita 2011	Thousands of dollars PPP at average exchange rates	IMF (WEO Sept. 2011)
GDP growth	Mean of the rate of annual growth of GDP, 2004-2011	In % per annum, at constant prices and local currency	IMF (WEO Sept. 2011)
Inflation	Mean of the annual growth rate of the Consumer Prices Index, 2004-2011	In % annual change	IMF (WEO Sept. 2011)
Fiscal balance	Mean of the annual balance (deficit/surplus), as % of GDP 2004-2011	Percentage figure	IMF, WB, ECLAC, EU, Central Banks (WEO Sept. 2011)
External balance	Mean of the annual current account balance, as % of GDP 2004-2011	Percentage figure	IMF, WB, Moody´s, FRBNY, OECD (WEO Sept. 2011)
External debt	External debt ratio in % of exports 2011	Percentage figure	WB, CIA, Moody´s, FRBNY
Economic development	IMF classification in September 2011	1=Industrialized 0=Non industrialized	IMF (WEO Sept. 2011)
Payment behaviour	Default since 1970	1=Default 0=No default	S&P, Moody´s, Fitch
Control of corruption	World Bank Classification	2.5=Country without corruption -2.5=Very corrupt country	Worldwide Governance Indicators (WGI)
Government effectiveness		2.5=High effectiveness -2.5=Low effectiveness	
Political stability		2.5=High stability -2.5=Low stability	
Regulatory quality		2.5=High quality -2.5=Low quality	
Rule of law		2.5=High security -2.5=Low security	
Voice and accountability		2.5=High freedom -2.5=Low freedom	

4. In September 2011, the IMF established, in the World Economic Outlook (WEO), a classification of countries in two large groups: the Advanced economies and the group of Emerging and Developing economies. At this date, the group of advanced economies comprised 34 countries whose total GDP accounted for 58.44% of the world total; and the other group was comprised of 150 countries with a collective GDP accounting for 41.56 % of the world total.

In addition, in our model we also observe the behaviour of other variables, and then analyse whether these influence the *ratings* assigned by the agencies to the various countries.

The new variables to which we refer are: the control of corruption, the effectiveness of the government, political stability and the absence of violence, regulatory quality, juridical security and freedom of expression. These six indicators are obtained from the information provided by the World Bank, and are included in a database named Worldwide Governance Indicators (WGI). See Table 2 with respect to this.

Control of corruption: This reflects the perception of how public power is exercised. It takes into account both small-scale corruption and control of the State by minorities pursuing private interests. The scores are determined within the range -2.5 to +2.5, and the highest positive value reflects the determination of the lowest degree of corruption. The same measurement scale is also used for the following variables.

Government effectiveness: This variable rates the quality of public services, and the independence of government administration with respect to political pressures.

Political stability and absence of violence: This measures the perception of the probability that the government may be destabilized or overthrown by unconstitutional or violent means.

Regulatory quality: This refers to the capacity of the government to formulate and apply correct policies and regulations that allow and promote the development of the private sector.

Rule of law: This measures the perception of the respect shown by the agents towards the law-based rules of the society. In particular it takes account of quality in the enforcement of legal contracts and ownership rights, in policing procedures and in the courts, together with exposure to possible risks of violence.

Voice and accountability: This captures the perception of the degree to which the citizens of a country are free to participate in the election of its government, freedom of individual expression, freedom of association, and the freedom of the press.

3.2 Relationship between the dependent and independent variables

The next step is to evaluate how the values attributed to the variables, discussed above, influence the determination of the *rating* assigned to each country. In the model proposed the influence of the independent variables is determined both individually and collectively. In other words, we analyse how each of the variables has an independent influence on the *rating*, as well their global impact on the *rating*.

Information has been obtained on the *rating* assigned to each of 82 countries on 31 December 2011. In the majority of the data bases consulted as sources of information, references are found to 184 countries in total. However, in making a joint study of the *ratings* assigned by the three main credit rating agencies, it is found that the information obtained from the data bases and the *ratings* of the three agencies only coincide for a total of 82 countries. Fitch is the agency that analyses

the fewest economies/countries -104; Moody´s issues *ratings* for 119 countries; while Standard & Poor´s covers the most countries - 125.

As stated previously, the specific objectives researched are the following:

- Individual analysis of each of the independent variables with respect to the dependent variable (the country's credit rating).
- Analysis of the correlation, if any, between the independent variables.
- Multiple linear regression analysis.
- Individual analysis of each of the independent variables with respect to the dependent variable (the *rating*).

Shown in Table 3 are the variables studied ranked according to the *rating* assigned by each of the agencies; it can be seen that many of them are related to the *rating* assigned.

Table 3. Individual analysis of each of the variables with respect to the *rating*

MEAN		AAA/Aaa	AA/Aa	A/A	BBB/Baa	BB/Ba	B/B	C	D
GDP per cap.	SP	46.431.2	31.853.8	25.028.7	16.273.8	11.265.3	8.970.0	-	27.624.26
	FIT	45.284.3	34.243.3	23.912.3	14.715.3	11.927.2	9.218.8	27.624.2	2.505.44
	MOOD	44.202.0	31.084.5	24.665.1	14.398.7	14.224.0	8.283.9	17.979.7	
GDP growth	SP	2.33%	3.00%	3.44%	4.63%	4.64%	4.81%		0.15%
	FIT	1.98%	2.38%	4.10%	4.54%	4.80%	5.12%	0.15%	5.92%
	MOOD	1.93%	4.23%	2.96%	4.36%	4.92%	5.37%	2.18%	
Inflation	SP	2.03%	2.71%	2.79%	4.95%	7.65%	9.96%		3.25%
	FIT	2.05%	2.73%	2.80%	5.17%	8.11%	10.47%	3.25%	4.91%
	MOOD	2.11%	2.68%	3.08%	5.75%	6.18%	10.55%	3.62%	
Fiscal balance	SP	1.16%	1.24%	-2.09%	-1.29%	-1.88%	-3.38%		-8.65%
	FIT	-0.09%	4.09%	-1.97%	-1.64%	-2.38%	-2.42%	-8.65%	1.66%
	MOOD	-0.07%	4.61%	-2.53%	-1.54%	-1.50%	-3.16%	-4.19%	
External balance	SP	5.85%	3.99%	0.01%	-1.56%	-3.53%	-0.60%		-9.37%
	FIT	4.31%	5.89%	0.94%	-1.83%	-3.57%	-0.96%	-9.37%	-0.13%
	MOOD	3.68%	9.53%	-1.56%	-2.85%	-1.86%	-1.08%	-4.30%	
External debt	SP	13.08	3.13	3.76	3.38	2.87	2.37		21.90
	FIT	12.92	2.64	2.53	2.75	4.18	2.12	21.90	0.61
	MOOD	12.25	1.33	3.29	2.62	4.63	2.04	11.37	
Control corrupt.	SP	2.04	0.96	0.74	-0.08	-0.06	-0.74		-0.12
	FIT	1.92	1.21	0.49	-0.12	0.07	-0.71	-0.12	-1.14
	MOOD	1.95	0.89	0.52	-0.11	0.08	-0.69	-0.50	
Govt. effect.	SP	1.87	1.10	1.07	0.23	0.13	-0.48		0.52
	FIT	1.83	1.08	0.97	0.22	0.14	-0.45	0.52	-0.75
	MOOD	1.83	0.91	0.95	0.22	0.22	-0.43	-0.08	

MEAN		AAA/Aaa	AA/Aa	A/A	BBB/Baa	BB/Ba	B/B	C	D
Political Stability	SP	1.03	0.56	0.27	-0.15	-0.01	-0.64		-0.11
	FIT	0.97	0.57	0.33	-0.15	-0.22	-0.33	-0.11	-0.85
	MOOD	0.98	0.43	0.33	-0.16	-0.10	-0.43	-0.37	
Regul. Quality	SP	1.73	1.03	1.06	0.34	0.22	-0.51		0.65
	FIT	1.65	1.03	1.00	0.38	0.17	-0.56	0.65	-0.54
	MOOD	1.66	0.86	1.00	0.33	0.35	-0.46	-0.25	
Rule of law	SP	1.80	1.08	1.01	0.05	-0.02	-0.76		0.62
	FIT	1.78	1.13	0.82	0.05	-0.00	-0.75	0.62	-0.93
	MOOD	1.78	0.87	0.85	0.03	0.05	-0.63	-0.28	
Voice and account.	SP	1.29	0.58	0.77	0.02	0.21	-0.24		0.90
	FIT	1.33	0.56	0.58	0.06	0.09	-0.18	0.90	0.07
	MOOD	1.35	0.13	0.79	0.10	0.13	-0.26	0.31	
FREQUENCIES Number of countries	SP	13	12	8	20	17	11	0	1
	FIT	15	8	11	23	12	11	1	1
	MOOD	16	8	11	19	13	13	2	0
Econ. Dev.	SP	13	9	5	1	2	-	0	0
	FIT	15	6	6	1	2	-	0	0
	MOOD	16	4	7	1	2	-	0	0
Payt. Behav.	SP	-	0	1	8	5	7	0	0
	FIT	-	0	1	9	3	8	0	0
	MOOD	-	0	2	8	3	7	1	0

In particular, a high income per capita appears to be closely associated with a high *rating*: in the thirteen countries with the maximum *rating* (AAA, Aaa) assigned by Standard&Poor´s, the fifteen assigned by Fitch and the sixteen assigned by Moody´s, the mean of the income per inhabitant is around $45,000. At progressively lower *ratings* the GDP per capita is progressively lower; the countries with the B *rating* have a mean income per inhabitant of $8,800 dollars. The countries assigned the C *rating* present a higher mean income per capita because Greece is in this group, and the income per inhabitant of Greece was $27,624 in 2011.

A negative relationship exists between the *rating* that the agencies assign to each of the countries studied, and the GDP growth; in this period studied, the countries that have grown most, at a mean rate of 6.88% p.a., are those assigned the BB-*rating*; and some of those that have presented lower growth are countries with the maximum *rating*, whose mean GDP growth between 2004 and 2011 is 2.08% p.a.

Another of the representative indicators is Inflation; the countries with high *ratings* have a low rate of inflation; and, in line with the decrease in *rating*, inflation is higher. All countries rated as AAA, AA and A have a rate of inflation of around 2%; this is considered an acceptable percentage for keeping the growth and economic stability of the country under control.

A high level of economic development, measured by the dichotomous indicator of the IMF, increases the probability of having a *rating* of Aa /AA.

The six new factors incorporated in this model (Control of corruption, Government effectiveness, Political stability and absence of violence, Regulatory quality, Rule of law and Voice and accountability) represent data that show a strong correlation with the *rating* assigned. In contrast, four factors (GDP growth, Fiscal balance, External balance and External debt) show no clear relationship with the *rating*[5].

The *ratings* may lack a positive relationship with GDP growth because many economies in development tend to grow more rapidly than mature economies. More surprising, however, is the lack of a clear relationship between the *rating*, the fiscal balance and the external balance. This finding may reflect endogeneity in these indicators; that is, countries that seek to improve their credit *rating* may opt for conservative fiscal policies, diminishing their surplus. With respect to the external balance, it may be deduced that the endogeneity is in consequence of the restriction in the supply of international capital for the countries with a low *rating*. Lastly, a high external debt is also associated with a higher *rating*; this may occur in consequence of the very high level of indebtedness that the developed economies are usually capable of sustaining.

- Analysis of the correlation, if any, between the independent variables.

Presented In this part is the analysis of the correlation matrices, Table 4. The objective is to check empirically the degree of relationship that exists between the variables under study.

The income per capita is closely correlated with the control of corruption, the government effectiveness, and the rule of law. The correlation is less, although still significant, in respect of economic development, regulatory quality, political stability and voice and accountability. With the rest of the variables, the income per capita has a correlation of less than 0.55; the negative sign of the correlation with GDP growth should be noted, as previously remarked.

Inflation appears to be a variable correlated negatively with the rest. This variable is also more closely correlated with the qualitative than with the quantitative variables.

It is also seen that the variables: control of corruption, government effectiveness, political stability, regulatory quality and rule of law, are all fairly closely correlated one with another, as would be expected.

5. However, this variable was found to be significant in the models presented.

Table 4. Matrix of correlations (82 countries)

Independent Variables	GDP per cap.	GDP growth	Inflation	Fiscal Bal.	Ext. Bal.	Ext. debt	Econ. Dev.	Payt. Behav	Control Corr.	Gov. effect	Polit. Stab.	Reg. qual	Rule of law	V. and acc.
GDP per capita	1.00	**-0.46**	-0.56	0.20	0.32	0.54	**0.77**	-0.40	**0.83**	**0.83**	**0.66**	**0.78**	**0.83**	**0.61**
GDP growth		1.00	0.49	0.20	0.25	-0.19	-0.45	0.15	-0.56	-0.56	-0.42	0.57	0.55	0.63
Inflation			1.00	-0.13	-0.05	-0.14	-0.16	-0.13	-0.62	-0.67	-0.40	0.69	0.64	0.48
Fiscal balance				1.00	0.05	-0.61	0.58	0.62	-0.61	-0.63	-0.52	0.63	0.62	0.63
External balance					1.00	0.32	0.08	0.04	0.34	0.34	0.32	0.33	0.34	0.28
External debt						1.00	0.30	0.19	0.98	0.99	0.94	0.99	0.98	0.98
Econ. develop.							1.00	0.99	0.29	0.30	0.28	0.30	0.30	0.29
Payt. behaviour								1.00	0.18	0.19	0.17	0.19	0.18	0.18
Control corrupt.									1.00	**1.00**	**0.97**	**1.00**	**1.00**	**0.99**
Gov. effective.										1.00	**0.96**	**1.00**	**1.00**	**1.00**
Political stability											1.00	**0.96**	**0.97**	**0.97**
Regul. quality												1.00	**1.00**	**1.00**
Rule of law													1.00	**1.00**
Voice and acc.														1.00

- Multiple linear regression analysis

Because some of the 14 variables are correlated one with another, a multiple regression is performed to be able to quantify the explanatory power of each of them, together with the individual contribution of each variable to the determination of the *ratings*.

The first step is to check whether these variables follow a normal distribution since, otherwise, it will be necessary to improve the fit by applying logarithms. Applying the Jarque-Bera test, it is found that the quantitative variables that do not follow this distribution are: GDP per capita, GDP growth, inflation, fiscal balance, external balance and external debt. In addition, in the variables GDP growth, inflation, fiscal balance and external balance, a change of scale has been made since some of the data give negative results. This arithmetic change is also made with a view to facilitating a better fit of the regressions; these modifications become necessary in all the models that are presented in this paper.

Models to be studied:

- Multiple linear regression of 82 countries, 14 variables, 2004-2011.
- Adjusted multiple linear regression of 82 countries, 3 variables, 2004-2011.

3.3 Multiple linear regression model (2004-2011)

In order to carry out this study, information has been obtained for 82 countries, and the reference date taken is 31 December 2011, Table 5. It has already been stated that there are variables that do not follow a normal distribution; with the object of seeking a better fit in the regressions, the logarithms of the quantitative variables have been used with their corresponding arithmetic fits. The series of these variables span a very wide range of values; there are some very large values, and other very small values; and this makes them relatively distant from the mean value. This separation can influence the results. The application of logarithms reduces the range, thus helping the regression to fit better.

Table 5. Linear regression study 2004-2011 (82 countries)

Variable	Mean Rating		S&P Rating		Fitch Rating		Moody´s Rating	
	Co-efficient (B)	p-value	Co-efficient (B)	p-value	Co-efficient (B)	p-value	Co-efficient (B)	p-value
Constant	-1.781	0.851	-5.175	0.592	-0.084	0.993	-6.128	0.576
GDP per capita	-0.212	0.752	-0.131	0.847	-0.253	0.713	-0.086	0.911
GDP growth	-0.139	0.991	5.695	0.648	-3.0562	0.807	-1.300	0.926
Inflation	-14.291	0.136	-13.068	0.178	-14.903	0.128	-9.177	0.402
Fiscal balance	12.698	0.319	16.421	0.204	10.836	0.404	17.853	0.224
External balance	23.439***	0.0003	21.601***	0.0008	24.359***	0.0002	20.234***	0.005
External debt	-0.426	0.273	-0.562	0.155	-0.358	0.367	-0.747	0.097
Economic development	3.123***	0.0009	3.054***	0.0013	3.157***	0.001	2.435***	0.021
Payment behaviour	0.549	0.431	0.672	0.342	0.488	0.493	0.540	0.500
Control of corruption	-0.457	0.626	-0.303	0.749	-0.534	0.577	-0.262	0.808
Government effectiveness	-0.387	0.764	-0.011	0.992	-0.575	0.663	0.453	0.760
Political stability	-0.093	0.844	-0.013	0.977	-0.133.	0.784	-0.195	0.722
Regulatory quality	2.906***	0.0024	2.717***	0.0049	3.001***	0.002	3.065***	0.005
Rule of law	1.488	0.187	1.268	0.267	1.599393	0.166	0.949	0.463

Variable	Mean Rating		S&P Rating		Fitch Rating		Moody´s Rating	
Voice and accountability	-0.401	0.423	-0.460	0.365	-0.371991	0.467	-0.478	0.406
Durbin-Watson	2.284		2.286		2.263		2.433	
Adjusted R2	0.828		0.823		0.822		0.782	
F statistic	28.761	0.000	27.844	0.000	27.689	0.000	21.695	0.000

* 90% confidence level.

** 95% confidence level.

*** 99% confidence level.

The conclusions drawn from Table 5 are the following:

- The first indicator to be interpreted is the significance of the variables studied. The external balance and economic development are significant (at more than 99%). Of the additional qualitative variables used only regulatory quality is significant. For Cantor and Packer the significant variables were the GDP per capita, GDP growth, inflation, external debt, economic development and the payment behaviour; whereas the external balance was not significant. Thus only economic development coincided with our model in significance.
- The variable GDP growth presents a sign different from that expected in principle, and is also found not to be significant. This is probably because, currently, the emerging countries are growing faster than the developed ones, as already noted.
- The explanatory power of the model is therefore high, since the corrected coefficient of determination is 0.828, for the mean of the *ratings* of the agencies.
- There are no problems of multicolinearity between the variables. When the coefficients of simple linear correlation between the significant variables are studied, a low correlation between them is observed.
- The Durbin-Watson statistic reaches a value of 2.284; being higher than 2.087, the absence of autocorrelation between the residuals cannot be guaranteed.

It can also be observed in Table 5 that the results produced for the different agencies are similar, although some further comments should be made:

- The model estimated for the *ratings* assigned by Standard&Poor´s is the one that fits best, having a higher R^2 value, although it is followed very closely by the model for Fitch. Moody´s is the agency that fits less well to the conclusions obtained.
- The absence of autocorrelation between the residuals in the three models cannot be determined, as said before.
- When qualitative variables are added, in line with what the credit rating agencies do when they establish the *ratings*, the degree of fit of the regressions increases.

3.4 Adjusted multiple linear regression model (2004-2011)

In the light of the results obtained in the regression model of 14 variables, and as a consequence of the low percentage of significance of some of the indicators studied, we evaluate a new adjusted model using just the 3 most significant variables. The regression is performed on the variables: external balance, economic development and regulatory quality.

For the study of this new model the sources of information are the same as those of the previous part. Information for 82 countries is obtained and the period taken is that from January 2004 to December 2011. Similarly, logarithms have been taken in the necessary variables.

The intention is to arrive at conclusions similar to those for the previous model; that is, to demonstrate that the use of only a few appropriately selected economic variables offers a model of sufficient explanatory power with respect to the *rating* that the agencies assign to the various issuers of sovereign debt.

The conclusions drawn from the data in Table 6 for the mean *rating* of the three agencies are the following:

- The first indicator to be interpreted is the significance of the variables studied. The external balance, economic development and regulatory quality are significant to more than 99% confidence level.
- The Durbin -Watson statistic reaches a value of 2.215; this falls within the range $d_u/4\text{-}d_u$. Therefore, there is no autocorrelation between the residuals.

Table 6. Linear regression study: 6 variables (82 countries)

Variable	Mean Rating		S&P Rating		Fitch Rating		Moody´s Rating	
	Coefficient (B)	p-value	Coefficient (B)	p-value	Coefficient (B)	p-value	Coefficient (B)	p-value
Constant	2.787	0.0000	2.547	0.0000	2.907	0.0000	2.682	0.0001
External balance	30.23***	0.0000	31.50***	0.0000	29.603	0.0000	30.964***	0.0000
Economic development	2.638***	0.0003	2.641***	0.0004	2.637	0.0003	2.095*	0.0108
Regulatory quality	3.406***	0.0000	3.319***	0.0000	3.449	0.0000	3.636***	0.0000
Durbin-Watson	2.215		2.176		2.222		2.294	
adusted R2	0.833		0.823		0.831		0.787	
F statistic	136.582	0.000	126.782	0.000	133.429	0.000	100.885	0.000

* 90% confidence level.

** 95% confidence level.

*** 99% confidence level.

Using the regressions with the data of the different agencies separately, it can be observed that the results produced are similar, although certain considerations need to be made:

- All the models consider as significant variables: the external balance, economic development and regulatory quality. All the variables are significant with a level of confidence higher than 99%, except economic development for Moody´s (which only reaches a level of confidence of 90%). The signs of the coefficients are also as expected.
- The model estimated for the ratings assigned by Fitch is the one that fits best, having a higher R^2 value, although it is followed very closely by the model for Standard&Poor´s.
- There is no autocorrelation between the residuals in any of the models.

We can conclude by stating that, using models with very few variables, the *rating* assigned to the issuers of sovereign debt can be explained, to a high percentage; some of the variables are of the qualitative type.

4. Conclusions

The objective of the study reported here was to demonstrate the existence of a relationship between the *rating* that the credit rating agencies assign to the issuers of sovereign debt, and a reduced number of economic variables.

The conclusion reached is that, by using only a few variables, relatively satisfactory results are obtained in the fit of the models. The model first proposed was one of fourteen variables; this was then modified to one of only three variables with hardly any adverse effect on the coefficient of determination.

In the model of fourteen variables, six of those used are quantitative in character, two are dichotomous and six qualitative. In the model of three variables, these are reduced to one quantitative, one dichotomous and one qualitative. The last of these variables, regulatory quality, is one of the most significant in the regression. Given that Regulatory Quality is defined as the perceived capacity of a government to formulate correct policies that promote growth and development, so necessary in times of crisis, we deduce that there has been a notable change of approach by the agencies.

In the model that we present, therefore, the qualitative variables have acquired greater specific weight against the traditional quantitative variables. In particular, a qualitative variable reflecting the quality of regulation in the economy has become highly relevant. If we compare the models, presented here with the original model of Cantor and Packer we see that the significant variables have changed substantially from those identified in the 1990's to those that appear in the early 2000's. This change in the weight of variables could point to a change in the methodology used by the agencies, particularly since 2007, with the commencement of the current economic and financial crisis, as already stated in this paper.

There would appear to be a divergence between the rating models employed by the credit rating agencies, based on a relatively large number of variables, and the models presented here with fewer variables. What could be the explanation for such differences in the number of variables used? Several answers are possible. Probably the agencies are not using all the variables that appear in their lists; these variables represent more a panel or menu of data from which are selected those considered most relevant for each country in question. Moreover many variables are strongly correlated with each other, which makes some of them redundant.

Further, it is possible that some significant variables, such as some of those used in this study, might serve for a first approximation to the provisional *rating*, and that, in a second stage, variables of less significance may be used for a finer adjustment of the definitive *rating*.

Lastly, the use of qualitative variables introduces a certain degree of discretionality to the issuing of a *rating*, particularly those of non-typified character, unlike those used in our models based on the World Economic Outlook (WEO) of the IMF.

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