A LOOK AT SOVEREIGN CREDIT RATINGS AND THEIR DETERMINANTS THROUGHOUT THE FINANCIAL CRISIS

by

Milton-Andres Bernal
BMOS, Finance with Economics, University of Western Ontario, 2007

and

James Chang
Honours Bachelor of Science, Statistics, University of Toronto, 2005

PROJECT SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

MATER OF FINANCIAL RISK MANAGEMENT

In the
Faculty of Business Administration

SIMON FRASER UNIVERSITY

Summer 2011

Approval

Names: **Milton-Andres Bernal and James Chang**

Degree: **Master of Financial Risk Management**

Title of Project: **A look at sovereign credit ratings and their determinants throughout the financial crisis**

Supervisory Committee:

____

Dr. Peter Klein
Senior Supervisor

____

Dr. Derek Yee
Second Reader

____

Jean-Francois Tardif
Second Reader

Date Approved: ____

Contents

1. Abstract

The determinants of sovereign credit rating are becoming increasingly more important as many rating agencies have been more active in adjusting their ratings. Our paper analyzed the determinants based on Standard & Poor's sovereign credit ratings, for the period 1995-2009. Using a linear regression framework, we examined several variables under the political, economic, external, fiscal and monetary categories. The relationship between each determinant was analyzed by isolating each credit rating, and by further employing transformation on specific variables. The results indicate a good performance of the estimated model with a high level of fit. GDP per capita, inflation, default history and advanced economic regions have a significant impact on a country's credit rating.

2. Introduction

Standard & Poor's (S&P) defines sovereign credit ratings as the willingness and ability of the sovereign (central government) to repay its financial obligation to commercial creditors on time and in full. Sovereign credit ratings are instrumental in determining borrowing costs for central governments in international markets. Another reason sovereign ratings are important are various funds may have constraints in place regarding the quality of sovereigns they are able to hold, for example, the Student Investment Advisory Service (SIAS) is restricted from purchasing bonds lower than BBB quality. Also, by virtue of association sovereign ratings can affect the ratings of financial institutions and companies that are domiciled in that country. Finally, credit ratings help guide and manage institutional and retail investors' fixed income portfolio composition based on the credit risk of the sovereign perceived through their credit rating. It is imperative given the volatile economic climate and as we witness numerous sovereigns being downgraded by the three main rating agencies, S&P, Moody's, and Fitch, that we understand what factors are driving these ratings.

This paper looks at the determinants of the credit ratings using empirical analysis of foreign-currency sovereign debt ratings. This is done by performing OLS estimation on various fundamental macroeconomic variables following S&P's model. We chose to use S&P's model for our research because, based on our reference paper's analysis, the significance of their variables were the closest aligned to what are most relevant during this critical economic time. Also, it is one of the most well established rating agencies and has received a lot of media attention recently for their U.S. downgrade.

The extension of this paper updates and compares the predicable power of the time period employed in our reference paper, Alfonso, Gomes, and Rother (2010). The precedent paper used a time period of 1995-2005; however, using our model we forecasted out to 2010 from 2005. The main reason for this is to capture the effects of a severe financial crisis, in 2008, and observe whether there have been drastic changes in the determinants of the ratings during that time. This time period analyzed spans over multiple economic and political cycles.

Our empirical analysis is completed by performing OLS estimation, as was done in our precedent paper. The benefits of using OLS estimation are its simplicity and efficiency to manipulate to fixed or random effect models. Prior to the regression analysis, we examined each determinant in detail and studied the relationship between the determinant itself and the credit rating. We also analyzed the variation in ratings and their determinants by performing sub-period analysis and testing out of sample. The goal of sub-period analysis is to validate the process of using panel data in pooled OLS. We have also added value in our paper by transforming variables and extending the linearity to a higher order if necessary.

When back-testing the transformed model was used, it did an excellent job at explaining the sovereign credit ratings with an R^2 of 98%. The results seemed fairly consistent with those found in our reference paper and S&P methodology. For example, based on our model we found GDP per capita to be the single greatest explanatory variable and the key variable used by S&P to derive credit ratings. A significant observation in our results is a notable difference in GDP growth. Alfonso, Gomes, and Rother (2010) observed a positive correlation between GDP growth and credit ratings; however, while our analysis showed a positive correlation between GDP growth and credit ratings, the variable was found to be insignificant.

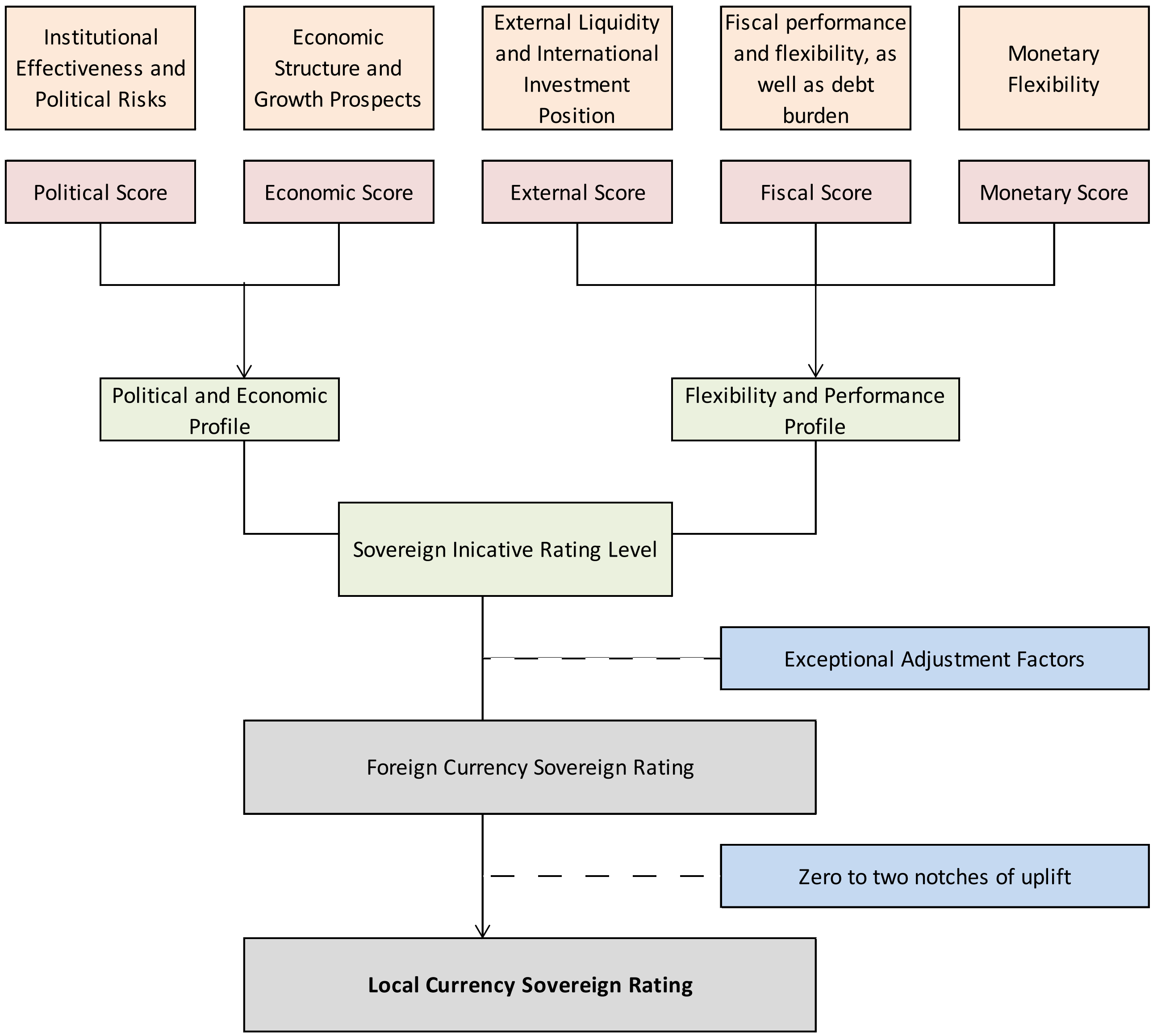
3. Literature Review

The topic of our paper is a very timely one as we are currently witnessing many sovereign's credit ratings fall. We also witnessed the United States' very first credit rating decrease since Standard & Poor's began assigning credit ratings on January 1, 1975. During this very turbulent time in the global economy and in discussing possible topics with Jean-Francois Tardif, we decided to take a closer look at the methodology employed by the ratings agency when assigning and managing credit ratings. This was done by performing a regression analysis against macroeconomic variables to the sovereign credit ratings. Then through reverse engineering we determined which variables S&P considers the most significant, this enabled us to forecast future ratings with a degree of accuracy. There have been a few papers written in the past couple of decades on this topic, each providing slight improvements to their models.

S&P – "Sovereign Government Rating Methodology And Assumptions"

It was imperative for us to first look at how S&P derives their sovereign ratings. They do not divulge the specifics on their model; however, they have recently increased its transparency. S&P – "Sovereign Government Rating Methodology And Assumptions" was used to analyze the methodology employed by S&P in deriving sovereign credit ratings. This paper tells us S&P uses five essential factors to come up with the rating; they are Political, Economic, External, Fiscal, and Monetary. Chart 1 provides a summarized overview of S&P's Sovereign rating framework.

Chart 1 – S&P's Sovereign Rating Framework



Each score is derived from a number of qualitative and quantitative factors, based on a rating from 1 to 6, with 1 being the strongest. The factors used to derive the five primary scores in the S&P model are summarized below; these factors are either qualitative or quantitative factors.

Table 1 – S&P's Sovereign Credit Rating Factors

Score	Factors	Qualitative/Quantitative
Political	Effectiveness, stability, and predictability of sovereign's policymaking and political institutions	Qualitative
	Transparency and accountability of institutions, data, and processes, as well as the coverage and reliability of statistical information	Qualitative
	Government's payment culture	Qualitative
	External security risks	Qualitative
Economic	Income levels	Quantitative
	Growth prospects	Quantitative
	Economic diversity and volatility	Quantitative
External	Status of a sovereign's currency in international transactions	Quantitative
	Country's external liquidity	Quantitative
	Country's external indebtedness	Quantitative
Fiscal	Nominal general government debt as a percentage of GDP (Fiscal Performance)	Quantitative
	Fiscal flexibility, long-term fiscal trends, and vulnerabilities	Qualitative
	Sustainability of sovereign's debt level	Quantitative
Monetary	Ability to use monetary policy to address domestic economic stresses particularly through its control of money supply and domestic liquidity conditions	Qualitative
	Credibility of monetary policy, measured by inflation	Quantitative
	Effectiveness of mechanisms for transmitting the effect of monetary policy decisions to the real economy	Quantitative

As noted above the political factors are essentially all qualitative, while the other scores are mainly quantitative. Also, note that fiscal score reveals the sustainability of a sovereign's deficits and debt burden, with the two segments are scored separately. Fiscal score is calculated as the average of fiscal performance and flexibility and debt burden. Also, monetary score reflects whether the monetary authority can support sustainable economic growth and shocks, it is a useful stabilization tool for economically instable sovereign states.

These scores derive the aggregated profiles. The political and economic score determine the political and economic profile, which reflects S&P's view of the resilience of the nation's economy, strength and stability of government institutions, and effectiveness of policy-making. The external, fiscal, and monetary score make-up the flexibility and performance profile, which reflects S&P's view of the sustainability of government's fiscal balance, debt burden, and fiscal and monetary flexibility. The combined score from the political and economic profile and flexibility and performance profile is used to derive the sovereign indicative rating. S&P generally applies a foreign-currency sovereign rating within one notch of the indicative rating based on the nation's positioning relative to its peers. The exceptional adjustment factors can deviate foreign-currency sovereign rating by more than one notch due to several reasons, notably very high political risk and high debt burden. Thus, a political score of 6 coupled with a debt score of 5-6 will receive a max rating of BB+ due to an unfavourable track record of sovereigns defaulting given poor levels in political and debt scores. Local-currency sovereign rating can be greater than foreign-currency sovereign rating due to individual powers within the sovereign's own borders supporting higher creditworthiness, such as issuance of local currency and regulatory control of their financial system. An example of this is Mexico, as of June 30, 2011 their local-currency rating was A, but their foreign-currency rating was BBB. Note that when a sovereign is a member of a union, ie. European Union, or when a sovereign uses another's currency, local-currency sovereign rating equals foreign-currency sovereign rating.

Recently, due to historical defaults, the effect of the 2008-2009 financial crisis, and the credit strength of certain sovereign governments, S&P has calibrated their sovereign rating criteria and believe that sovereign ratings are now more comparable with other S&P ratings across different sectors.

Richard Cantor and Frank Packer – "Determinants and Impact of Sovereign Credit Ratings"

As early as the 1990s the demand for credit ratings increased dramatically as sovereigns increased their appetite for risk and more corporations domiciled in riskier nations began to borrow in international bond markets. This led to the determination of what selected criteria is employed by the rating agencies in order to derive their credit rating. This paper looked at eight popular variables that were repeatedly seen as determinants. These variables included: Per capita income, GDP growth, Inflation, Fiscal balance, External balance, External debt, Economic development, and Default history. Per capita income, inflation, and external debt all demonstrated high explanatory of a high rating. GDP growth, fiscal balance and external balance did not have a strong correlation to ratings. Using ordinary least squares to model the eight variables to S&P and Moody's ratings the model explained 90% of the sample with a 1.2 notch standard error. The results presented impressive observations, such as the ability to predict large differences among ratings, ie. AAA vs. BB+ (S&P), but lacked in explaining small differences, ie. Ba2 vs. Baa3 (Moody's). The paper found all variables significant except for fiscal and external balances, which can be due to the market placing poor credit risks in stronger fiscal and external balance positions creating a low significance in these variables. Moody's and S&P place similar importance on the majority of the variables tested, with S&P placing a notable greater importance on per capita income, GDP growth, and default history.

Cantor and Packer (1996) also analyzed the correlation between credit spreads and ratings. They found that given public information, the determinants did a great job explaining the sovereign ratings; as a result, ratings were highly correlated to credit spreads.

Antonio Alfonso, Pedro Gomes, Philipp Rother – "Short and-Long-Run Determinants of Sovereign Debt Credit Ratings"

In determining which factor variables the main three rating agencies, S&P, Moody's, and Fitch, emphasized on in deriving their credit ratings, our reference paper was extremely useful. Alfonso, Gomes, and Rother (2010) looked at the effects of macroeconomic variables across the rating agencies over the short and long-term. They also looked at how the firms calculated rating upgrades and downgrades.

The methods used in the reference paper to model the variables in determining foreign-currency sovereign debt ratings included linear regression transformation and OLS estimation, random effects estimation, ordered probit and random effects ordered probit methods. The latter methods are more advanced in that they consider a normally distributed cross-section error. The ordered probit method assumes that the differences in credit ratings are not linear, which is also assumed by random effects estimation.

The paper utilized the time period from 1995 – 2005 when analyzing the data. The results showed that four variables have the largest effect in the short-term, GDP per capita, real GDP growth, public debt level, and government balance. Key long-term determinants were government effectiveness, external debt, and external reserves.

As evidenced in the paper, the benefits to using linear transformation is its simplicity and ability to use fixed and random effects estimation; however, it does have drawbacks as mentioned above, the assumption that the difference between ratings are linear. By using ordered probit to address this issue, another issue arises, ordered probit asymptotic properties do not generalize for a small sample and adjusting for panel data is complex due to a country specific effect. As a result, this paper looked at both methods and compared their results.

The explanatory variables employed in this paper were grouped into four categories: Macroeconomic, government, external, and other. These are similar to the categories S&P uses. Macroeconomic variables include GDP per capita, real GDP growth, unemployment, and inflation. Both models (random effects estimation and ordered probit) showed GDP per capita was the most statistically significant variable across all rating agencies; this is consistent with S&P's

methodology as their key driver for economic score is GDP per capita. The other three variables varied in terms of significance across the three rating agencies. Government variables include government debt, government balance, and government effectiveness. Results showed that both government debt and government balance were very significant across both models and rating agencies. Government effectiveness was significant within S&P and Fitch's models using both methods. S&P methodology places a great deal of weight on general government debt in their fiscal score category, so it makes sense this variable was statistically significant at the 1% level in both models. External variables consist of external debt, current account, and reserves. The random effects estimation results showed slight statistical significance (10% level) in external debt for S&P and Moody's but Fitch found it extremely significant (1% level). External debt demonstrated less significance in the ordered probit model for S&P and Fitch, but more significant for Moody's. Current account showed equal significance between models, with Moody's placing the greatest significance among rating agencies, followed by S&P, and Fitch. Reserves were only found to be significant with Moody's. S&P's external score category showed that external debt and reserves were not overly significant using the random effects model, but was found to be significant using the averages (long-term) of external debt and reserves variables in the ordered probit model, implying these variables were more relevant at explaining the long-term effects rather than short-term effects of the sovereign credit rating. The variables in the other variables category include default history, years since default, European Union, and regional dummies. Default history proved to be a very statistically significant variable among all rating agencies and both models. This proves that a sovereign who has defaulted before will be more willing to default again relative to a sovereign that has never defaulted.

The explanatory power, R^2, using the random effects estimation was extremely high for all rating agencies, for both the unrestricted and restricted (omitting statistically insignificant variables) versions, at roughly 95% for each. The paper found more significant explanatory variables for Moody’s and S&P, with a great deal of overlap between firms. Also tested in our reference paper was the effect of sub-periods. Sub-periods were used to test the robustness of the model during different time periods in history. For example, various economic cycles can likely differentiate the results of the model. The greatest difference during the 1996-2000 time period was current account was more important, whereas external reserves was more significant during 2001-2005.

Alfonso, Gomes, Rother (2010) proved the linear specification used in the ordered probit model is acceptable for data regression, meaning the rating notches for all three agencies are essentially equally distributed across the ratings range. They also demonstrated that OLS estimation is an acceptable and successful method when modelling explanatory variables in this case. The only small discrepancy lies at the lower end of the ratings range for Moody’s and S&P, they observe the ratings spread widens when sovereigns are crossing the threshold from speculative grade to investment grade.

Our literature review has given us a great framework and foundation as to the derivation of sovereign credit rating methodology employed by S&P, as well as, providing insight into the various models used to explain the predictive and explanatory power of the macroeconomic, government, external, and other variables. In light of those results, we have decided to use OLS estimation as an acceptable and successful method when modelling our explanatory variables.

4. Methodology

1. Credit Rating Dependent Variable and its Linear Transformation

The framework employed to explain sovereign credit ratings is the following: the rating agency follows a continuous evolution of a country's creditworthiness, denoted as an unobserved latent variable R*. This latent variable is assumed to have linear dependence over a set of explanatory variables. A simple example of this linear relationship is shown in equation (1).

$$R^{*} = \alpha + \beta_1(GDP\ per\ caipta) + \beta_2(Fiscal\ balance) + \beta_3(External\ Debt) + \beta_4(Default\ History) \tag{1}$$

From this latent variable, the rating agency assigns a letter credit rating based on a set of cut-off points, c_1 to c_{16}, shown in equation (2)

$$R_{it} = \begin{cases} AAA & if & R_{it}^{*} > c_{16} \\ AA+ & if & c_{16} > R_{it}^{*} > c_{15} \\ AA & if & c_{15} > R_{it}^{*} > c_{14} \\ & \vdots & \\ < CCC+ & if & c_1 > R_{it}^{*} \end{cases} \tag{2}$$

Our paper focuses on the reverse engineering portion of the credit rating. We utilized the available sovereign credit ratings provided by Standard & Poor's. Based on the panel data, we studied the dependent relationship of the credit ratings to a wide range of explanatory variables, including macroeconomics, government, historical and regional factors. As the literature review has indicated, a linear transformation of credit rating provided a good fit and a great predictive power.

Further studies also verified that the underlying assumption of equally spaced numerical scale is valid. We adopted the linear transformation credit rating for this paper as shown in table 1.

Table 2 – S&P rating system and linear transformation

Characterization of debt and issuer		Rating S&P	Linear Transformation Scale 17
Highest quality	Investment grade	AAA	17
High quality		AA+	16
		AA	15
		AA-	14
Strong payment capacity		A+	13
		A	12
		A-	11
Adequate payment capacity		BBB+	10
		BBB	9
		BBB-	8
Likely to fulfill obligation, ongoing uncertainty	Speculative grade	BB+	7
		BB	6
		BB-	5
High credit risk		B+	4
		B	3
		B-	2
Very high credit risk		CCC+	
		CCC	
		CCC-	
Near default with possibility of recovery of recovery		CC	1
Default		SD	
		D	

2. Explanatory Variables

We have focused primarily on variables which explain the quantitative aspect due to the subjectivity, complexity, and difficulty to effectively input qualitative variables into our model. Although, we believe some qualitative factors can be explained through overlap in other variables. As was done in our reference paper, we also used the government effectiveness (included in political score) variable in our model. Based on historical data it is evident that a strong economic structure with sustainable economic growth provides a strong revenue base, boosts debt capacity, and enhances fiscal and monetary policy flexibility. As a result, market economies have been proven to promote higher levels of wealth due to increased efficiency in resource allocation leading to sustainable long-term growth. The most significant economic variable used in our reference paper and S&P's methodology (in the economic score category) is GDP per capita, which we also used. External score, which looks at a country's ability to generate receipts from abroad to pay its obligations to non-residents, was captured through the external debt and reserves variables. Fiscal score reveals the sustainability of a sovereign's deficits and debt burden, with the two segments scored separately. The key variables we employed from this segment were general government debt stock and government balance.

Based on our literature review and industry analysis, we targeted a full list of macroeconomic variables we believe will successfully explain the S&P model in deriving sovereign credit ratings. Below we listed the variables used in the 12-variable set model; the list contains the relationship on the ratings, a brief description, and the data source.

Table 3 – Explanatory Variables

Macroeconomic Variables						
Score	**Variable**	**Definition**	**Correl.**	**Data Source**	**Qual. or Quant.**	**Included in Variable Set** **12 Var.**
Economic	GDP per capita	Measures nation's income level and ability to pay down their debt obligations	+	IMF WEO NGDPDPC	Quant.	✓
Economic	Real GDP growth	Increases sovereign's ability to repay their debt obligations quicker through increased production	+	IMF WEO NGDPDPC	Quant.	✓
Economic	Unemployment	Increased unemployment unfavourable to advanced economies as this decreases government revenues and social program costs hindering sovereign nations ability to pay their outstanding debt levels	-	IMF WEO LUR	Quant.	✓
Monetary	Inflation	Higher inflation rates are most prevalent in emerging economies, i.e. China. A higher inflation rate implies issues at the macroeconomic level; however, the silver lining is higher inflation levels decreases outstanding debt stock in domestic currency	+/-	IMF WEO PCPI	Quant.	✓
Fiscal	Government Debt	Increased government debt over GDP will increase the sovereigns risk to fulfill its obligations to repay their debt stock, as this increases interest burden on the nation.	-	Jaimovich Panizza (2006)	Quant.	✗
Fiscal	Fiscal Balance	Fiscal surplus has a positive effect on ratings since a surplus means the government is receiving more revenue than it's paying out in costs, hence enabling them to pay down their debt stock quicker.	+	IMF WEO GGB, NGDPI	Quant.	✓
Political	Government Effectiveness	Measures the sovereign’s competence of public service and historical commitment in paying down its debt obligations.	+	WB AGI	Qual.	✓

External	External Debt	The greater the sovereign's external debt level signifies an increase in default risk to foreign-currency as the sovereign takes on more debt to pay non-residents, as a result, creating additional fiscal pressure.	-	WB	Quant.	✓
External	Foreign Reserves	The purpose of foreign reserves within central banks is to stabilize the domestic currency and used to pay for imports. The higher the foreign reserves the less likely the sovereign is to default on its outstanding foreign-currency debt	+	World Gold Council	Quant.	✗
External	Gold Reserves	Gold reserves are looked at similarly to Foreign Reserves. Gold is considered a monetary metal and excellent store of value; therefore it is used as a means to stabilize the sovereign's domestic currency.	+	World Gold Council	Quant.	✗
External	Total Reserves	This aggregated variable measures the central governments total reserves held and provides a hedge against their domestic currency.	+	World Gold Council	Quant.	✗
External	Current Account	A current account surplus enables the sovereign to use proceeds from net exports, dividends, and net transfers to pay down their debt obligations. However, more notably in emerging economies a higher current account deficit could be due to an increase in spending on investments, leading to increased GDP growth in the long-term.	+/-	IMF WEO BCA, NGDPD	Quant.	✓

Economic	Banks Total Liabilities over GDP	Financial institutions can make-up a large portion of a sovereign's total debt. During the financial crisis, central governments have bailed out, and even nationalized, banks on the brink of defaulting. A high ratio hinders the sovereign's ability to pay debt obligations and leads to an increase in default risk.	-	Bloomberg	Quant.	✘
Political	Default History	Historical defaults among sovereigns can signify acceptance of default on sovereign debt as a means to clear or reset their economy.	-	S&P	Qual.	✓
Political	Years since default	The longer the period since default is favourable to credit ratings as credibility among central government increases.	+	S&P	Quant.	✓
Political	European Union	Sovereigns that are members of the European Union follow strict regulations on economic policy and monitored by the European Central Bank. Also, the adopted currency, Euro, among member countries provides a natural hedge to domestic currency.	+	WB	Qual.	✓

Note: The negative relationship indicates the slope of the estimated linear regression is negative, while a positive relationship indicates a positive slope.

3. Regression Framework

An earlier study conducted by Monfort and Mulder (2000) and Mora (2006) used a linear panel model as shown in equation 3.

$$R_{it} = \beta X_{it} + \lambda Z_i + \alpha_i + \mu_i \tag{3}$$

Where
R – quantitative variable, obtained by a linear or by a non-linear transformation
X_{it} – a vector containing time varying variables that includes the time-varying explanatory variables
Z_i – a vector of time invariant variables that include regional dummies
index i (i = 1, …, N) denotes the country
index t (t = 1,…, T) indicates the period
α_i stands for the individual effects for each country i
assumed that the disturbance μ_i are independent across countries and across time

In this paper, we will focus on two methods to estimate this equation: pooled ordinary least square (OLS) and fixed effects estimation. Pooled OLS is a general model that does not hold any prior statistic. This model can be improved by imposing an assumption where the error term is not uncorrelated with the regressors; specifically, the country specific error is correlated with some dependent variables $E(\alpha_i \mid X_{it}, Z_i) \neq 0$. By incorporating this prior statistic, with a matrix of dummy variables, we generated the fixed effects model.

For the pooled OLS estimation, we used the following model shown in equation (4)

$$R_{it} = c + \beta X_{it} + \lambda Z_i + \varepsilon \qquad (4)$$

For the fixed effect model, we used the following model shown in equation (5)

$$R_{it} = c + \alpha_i + \beta X_{it} + \gamma Z_i + \varepsilon' \qquad (5)$$

where
$R_{it} = rating\ of\ country\ i\ at\ time\ t$
$c = the\ intercept\ (a\ constant)$
$\alpha_i = the\ country\ effect\ for\ country\ i$
$\beta = coefficient\ for\ time\ varying\ independnet\ variables$
$X_{it} = time\ varying\ independent\ variables\ for\ country\ i\ at\ time\ t$
$\gamma = coefficient\ for\ time\ invariant\ indenpendent\ variables$
$Z_i = time\ invariant\ independnent\ variables$
$\varepsilon = country\ effect\ is\ inside\ the\ error\ term$
$\varepsilon' = the\ error\ term\ excluding\ the\ country\ effect$

5. Empirical Analysis

1. Data Source and Database Construction

For the sovereign credit rating dependent variable, we created a database from 1995 to 2010 based on S&P's "Sovereign Rating and Country T&C Assessment Histories" report. There are four different rating categories: Local-Currency Long Time, Local-Currency Short time, Foreign-Currency Long Time, and Foreign-Currency Short time. They are similar in score with foreign-currency, with occasionally one to two notches lower than that of its local-currency counterpart. The time reference for each rating was taken as of December 31st of that year. In this paper, we focused on Foreign-Currency Long Time, which included 125 countries with a rating in 2010. From this database, we mapped the credit ratings into 17 categories, by combing all ratings below B- into one group (see table 2).

Detailed data sources and descriptions regarding the independent variables (the determinants) can be found in Table 3. A relational database was created to link multiple databases and variables. Observations that were missing values were retrieved but later dropped from the analysis. For example, since the values for government debt were scarce and the reserve variable was missing prior years, both variables were dropped from the study.

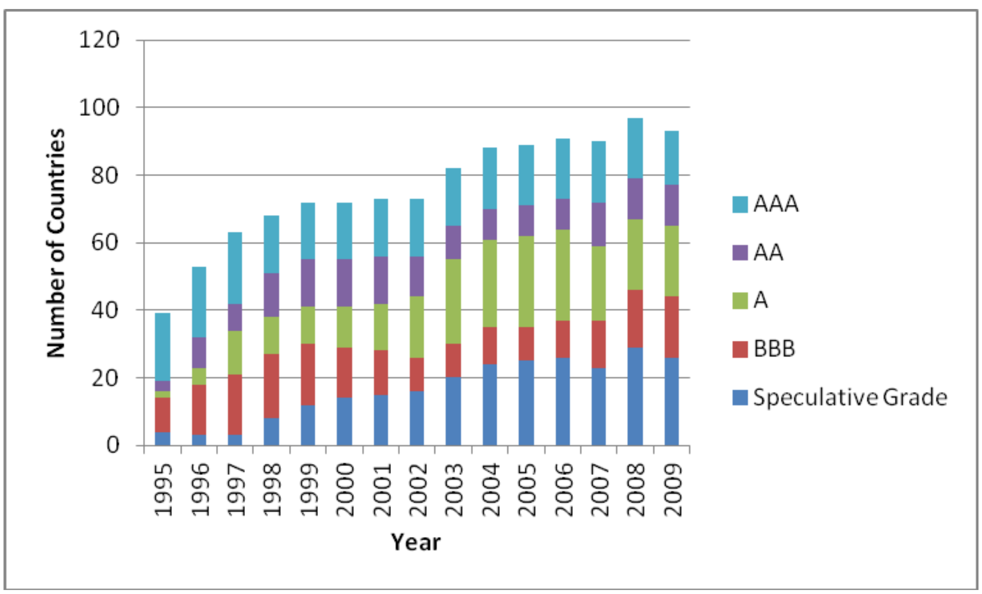
2. Descriptive Statistics on Explanatory Variables

Descriptive statistical analysis is a simple step of modeling yet it is often overlooked or omitted as it can be tedious and dull, should all assumptions be met. The purpose of this procedure is to validate the assumptions of the statistical model that we are using and modify ones that appears to be inappropriate. The basic building block of our model is a linear regression, and we needed to verify that the relationship between the independent variables and dependent variable is indeed meaningful and linear. In the following paragraphs we will look into the credit rating dependent variable, the relationships between each independent variable and the dependent variable, and the violation of linearity and its transformation.

Credit Rating Dependent Variable

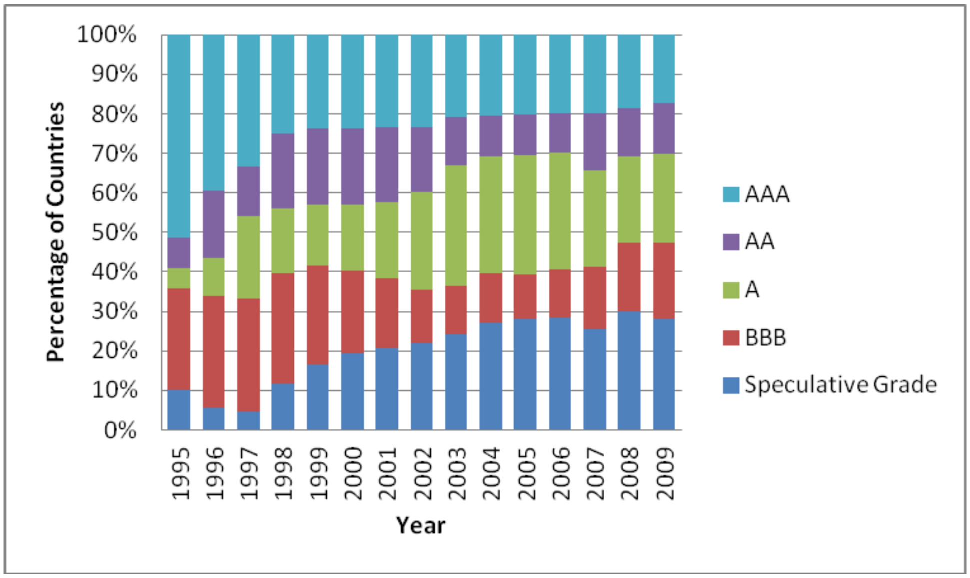
In figure 1, we can see that the total number of countries that are being rated steadily increased over time. The number of countries rated as speculative grade (BB or below) increased faster than that of courtiers rated as investment grade. The average annual continuously compound rates of growth are 8.21% and 4.32% respectively.

Chart 2 - Number of Sovereign Ratings by Grade Quality From 1995 - 2009



In Chart 2, we observed that although the number of AAA grade countries does not change much (minimum of 16 and maximum of 21 in the past fifteen years), the percentage decreases steadily over time. This is largely due to the increased number of countries rated as speculative grade.

Chart 3. Percentage of Sovereign Ratings from 1995 – 2009



The Relationships between Determinants and the Credit Rating Variable

The relationship between each determinant and the credit rating variable was examined. This process involved verifying the relationship between the expected effect and the observed slope coefficient. The scatter plots for all variables can be found in Appendix 1. All variables were consistent with our expectation with the exception of the bank debt variable, which is a new variable we added to our model. Bank debt captured a portion of the country's total debt. Total debt, including sovereign debt, private corporation debt and individual debt may be better suited for our study. This variable was dropped from the regression analysis as seen in the next section.

In addition to the relationship between variables, the significance level is important. All variables are significant (p-value < 5%), except real GDP growth rate (p-value = 9.34%). This means that the incorporation of this variable to the regression analysis in the next section is only marginally beneficial while it complicates the model.

Table 4 – Significance of Independent Variables and the dependent Variable

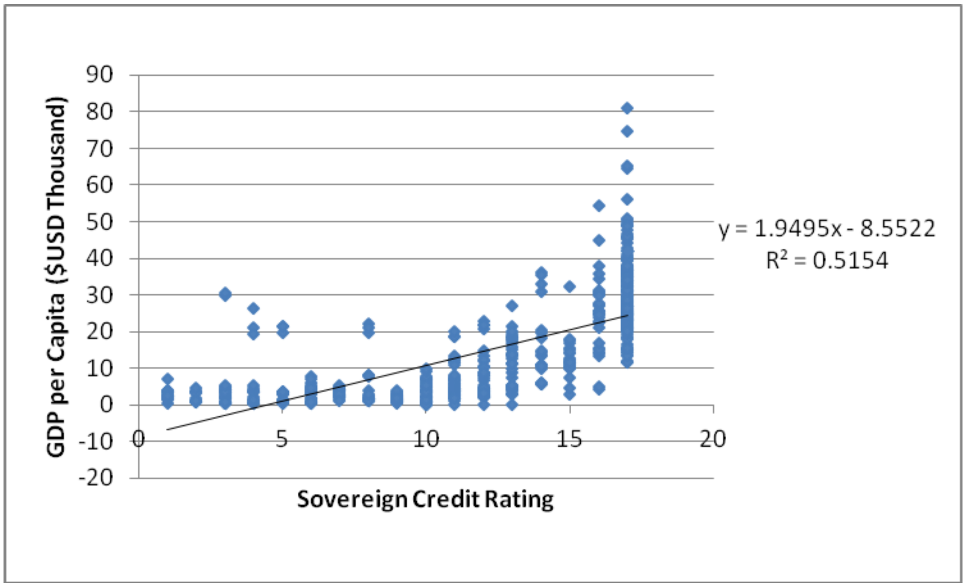
Determinant Name	Effect	Significance	T-statistics	P-values
Default History	Negative	✓	19.67651	0
Years Since the Last Default		✓	14.92096	0
Unemployment Rate		✓	9.843321	0
External Debt		✓	9.651693	0
Bank Debt		✓	10.37427	0
GDP per capita	Positive	✓	26.1915	0
European Union		✓	13.68423	0
Industrial Countries		✓	28.81488	0
Fiscal Balance		✓	6.138743	7.25E-10
Government Effectiveness		✓	4.807998	9.49E-07
Real GDP Growth		✘	1.321444	0.09341
Inflation	Uncertain	✓	12.11208	0
Current Account		✓	4.914931	5.63E-07

Note: The Significance box is checked when the p-value is smaller than 0.05 under Pearson Product-Moment Correlation Coefficient test.

<u>GDP Per Capita - Violation of Linearity and its Transformation</u>

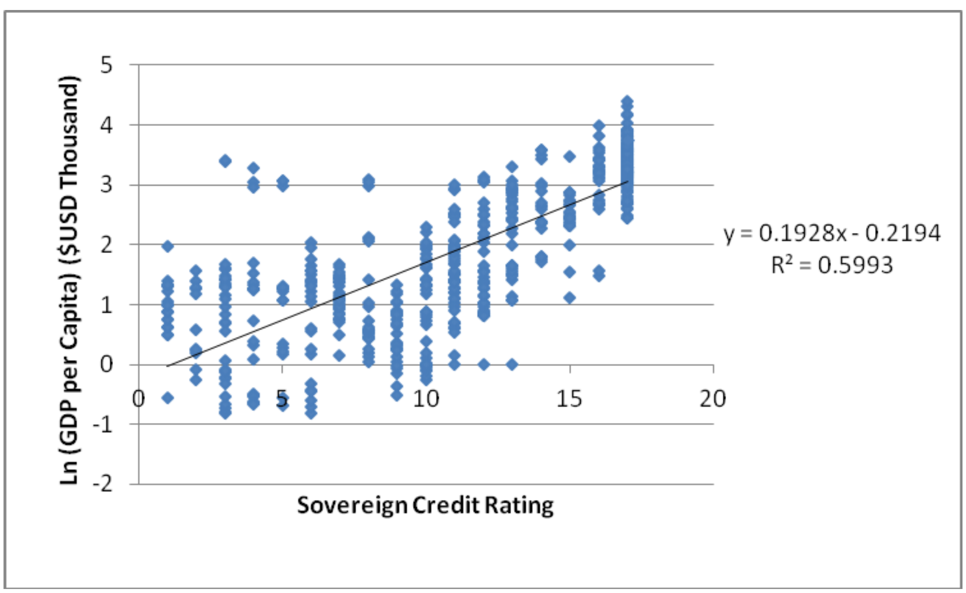
GDP per capita is positively correlated with credit rating (as indicated with a positive slope), this is consistent with our prediction that high GDP per capita has a positive impact on ratings. In addition, the correlation between these two variables is high with R-square equal to 0.5154 as shown in Figure 3. However, from the scatter plot, we observe a recognizable non-linear pattern.

Chart 4. GDP per capita and Sovereign Credit Rating Scatter Plot (1995 – 2005)



Several transformations were tested and we observed that the square root conversion yields the highest R-square (0.5993) as shown in Chart 5.

Chart 5. Transformation: Squart root of GDP per capita and Sovereign Credit Rating Scatter Plot (1995 – 2005)



3. Regression Analysis and Results

The procedure and the time period (1995-2005) for the following regression analysis is the same as that in the precedent paper, Alfonso (2007). The differences include the precedent paper using both long-term and short-term effects; however, we only focused on short-term effect. In addition, in the precedent paper, it had government debt and reserve variables which we did not include. Overall, there are 25 variables in the precedent paper and we only had 12 variables. Therefore, we would expect our R^2 to be lower than that in the precedent paper.

Full Model

The results produced by the fixed effect model ($R^2 = 0.94$) is better than that of pooled OLS ($R^2 = 0.76$) (see Table 5). This is reasonable because there are more variables in fixed effects by the nature of its design. This is also consistent with the precedent paper where it had a higher R^2 in fixed effect model than that in a pooled OLS model. (0.99 vs. 0.95). Overall, our model, by repeating the same procedure, yields a satisfactory result as we only used 12 variables whereas Afonso's (2007) used 25 variables.

In the following discussion, we divided explanatory variables into three categories in the context of our regression model: high explanatory power (p-value < 0.01); no explanatory power (p-value > 0.1); low explanatory power ($0.01 <$ p-value < 0.1). Explanatory variables that had the highest explanatory power in both precedent paper and in our model were GDP per capita, inflation, default history dummy, and advanced economy. Explanatory variables that had low explanatory power in both precedent paper and in our model were GDP growth rate; external debt; and EU. Explanatory variables that had low explanatory power, but had high explanatory power in our model and low or no explanatory power in another model, were unemployment rate; government balance; government effectiveness; current account; and since last default.

The interpretation of no or low explanatory power cannot be generalized to the usefulness of such variable. This is because the credit rating does not necessarily explain the “real” probability of sovereign debt default, but rather S&P’s view of default probability. As we have learned from the literature review, rating agencies deem different variables to be important in explaining/predicting probability of default. For example, based on Afonso (2010) external debt is an important short-term determinant for Moody’s, but not S&P.

Table 5 – Regression Coefficient Estimations and t-statistics for S&P

	Pooled OLS		Fixed Effect	
	(1)	Alfonso (2007)	(2)	Alfonso (2007)
Constant	8.567	4.521	6.392	10.301
	(14.076)***	(3.64)***	(12.937)***	(136.51)***
GDP per capita	0.079	1.339	0.070	1.452
	(6.131)***	(4.65)***	(5.252)***	(7.14)***
GDP growth	-3.978	5.715	-0.467	8.221
	(-1.267)	(1.95)	(-0.236)	(3.37)***
Unemployment rate	-0.036	-1.450	0.059	0.062
	(-1.528)*	(-0.008)	(2.902)***	(2.63)***
Inflation	-6.210	-0.586	-2.030	-0.219
	(-5.381)***	(-2.39)***	(-2.486)***	(-5.33)***
Government Balance	0.085	5.892	0.081	4.430
	(3.404)***	(1.81)*	(4.345)***	(2.01)**
Government Effectiveness	8.487	0.385	7.635	0.371
	(3.355)***	(1.30)	(4.498)***	(2.33)**
External debt	-1.232	-0.004	-8.741	-0.003
	(-0.524)	(-1.81)*	(-2.165)**	(-1.65)*
Current Account	0.026	-6.338	-0.043	-3.476
	(1.451)*	(-2.85)***	(-2.917)***	(-1.96)*
Default Dummy	-6.102	-1.032	-7.606	-1.353
	(-9.807)***	(-3.62)***	(-12.636)***	(-5.48)***
Since Last Default	0.206	-0.010	0.592	-0.025
	(2.366)***	(-0.31)	(4.725)***	(-0.34)
Advanced Economy	3.564	2.446	4.771	-
	(9.482)***	(8.24)***	(9.638)***	-
EU	0.421	1.068	0.241	0.291
	(1.572)	(6.07)***	(0.593)	(1.55)
R2	0.759	0.951	0.935	0.987
Observation	647	564	647	564

Notes: the t statistics are in parenthesis. *,**,***- denoted statistical significance at 10, 5, and 1 percent. The variables in bold denoted high explanatory power.

4. Back-Testing

R^2 in the context of a simple linear regression (one independent variable as shown under descriptive statistics section) indicates the relationship between two variables, whereas, R^2 in the context of multiple linear regression (more than one independent variable as shown under regression analysis and results) indicates the goodness of fit for the model. The direction of their relationship is measured by the sign in front of this parameter (either positive or negative) and the magnitude of their relationship is measured by its absolute value. In the back-testing analysis, we quantified the goodness of fit in a more intuitive approach.

After we obtained the coefficients for the independent variables from the regression in the previous section, we plugged the entire database back into this equation to determine the quality of our estimations. There are two approaches for this test: in-sample analysis and out-of-sample analysis. In-sample analysis uses the same database that yields the regression coefficient and out-of-sample analysis uses a new database that has not yet been employed by the regression. In both the precedent paper and our paper, we use 1995-2005 to generate the regression coefficients. For the out-of-sample analysis, we will use data from 2006-2009.

Afonso's (2010) in-sample analysis predicted roughly 98% accuracy within 1 ratings notch. Our transformed in-sample analysis estimated 88% were correctly predicted (approximately 99% within 1 notch), but only 74% was accurately predicted (97% within 1 notch) for out-of-sample analysis.

Table 6 - Goodness of Fit: Back-Resting for both In- and Out-of-Sample Analysis

Afonso (2010) In-Sample Analysis

	Estimation Errors (notches)											
	5	4	3	2	1	0	-1	-2	-3	-4	-5	Total
Pooled OLS (count)	0	0	1	6	80	392	83	2	1	0	0	565
Pooled OLS (%)	0%	0%	0%	1%	14%	69%	15%	0%	0%	0%	0%	100%

Transformed In-Sample Analysis

	Estimation Errors (notches)											
	5	4	3	2	1	0	-1	-2	-3	-4	-5	Total
Pooled OLS (count)	0	0	0	2	45	571	29	0	0	0	0	647
Pooled OLS (%)	0%	0%	0%	0%	7%	88%	4%	0%	0%	0%	0%	100%

Transformed Out-of-Sample Analysis

	Estimation Errors (notches)											
	5	4	3	2	1	0	-1	-2	-3	-4	-5	Total
Pooled OLS (count)	0	0	0	6	30	246	48	3	0	0	0	333
Pooled OLS (%)	0%	0%	0%	2%	9%	74%	14%	1%	0%	0%	0%	100%

6. Conclusion

In this paper, we studied the determinants of global sovereign debt ratings from Standard & Poor's, for the period 1995-2009. The usage of regression analysis was popular to determine the unknown variables when the credit rating methodology was not transparent. Numerous studies have been published in a quest to solve this mystery. With increased transparency from the rating agencies in recent years, regression analysis has become a less useful tool in searching for the unknowns, but a method to compare different rating agencies based on a set of common determinants in a systematic approach.

Our methodology was based on linear regression methods by means of pooled OLS and fixed effect estimation employed in the precedent paper. We also used the same twelve variables from the precedent paper and added two new variables. To expand, we examined each variable in detail and made transformations and added a higher order term when necessary.

Descriptive statistical analysis is a simple yet important step to check model assumptions. Square root transformation of GDP per capita was introduced during this analysis. The rational for this transformation was to ensure linearity between the independent variables and dependent variable. The result of this transformation brought the explaining power of the fixed effect model from R^2 = 0.94 to R^2 =0.98.

Our results showed GDP per capita, inflation, default history dummy, and advanced economy dummy are variables with high explanatory power shown in both our study and the precedent paper. GDP growth rate, external debt, and European Union region dummy are variables consistently shown to have no explanatory power in the context of our model. Unemployment rate, government balance, government effectiveness, current account; and since last default are variables shown to have low explanatory power.

With regards to back-testing in-sample analysis, 88% of our data was correctly predicted and 99% was within one notch from the true credit rating, compared to only 69% correctly predicted in the precedent paper. The estimation power decreases to 74% correctly predicted and 97% within one notch for the out-of-sample analysis. This is satisfactory for two reasons as suggested in the precedent paper. 1) This model predominantly incorporated quantitative variables, while S&P stated they use both quantitative and qualitative variables. 2) This model used historical data but the rating agency often uses projected estimates, thus, a more comprehensive model with forward-looking numbers may improve the estimation power.

7. References

Alfonso, A., Gomes, P., and Rother P. (2007). What "Hides" Behind Sovereign Debt Ratings? European Central Bank.

Alfonso, A., Gomes, P., and Rother P. (2010). Short and Long-run Determinants of Sovereign Debt Credit Ratings. International Journal of Finance and Economics.

Cantor, R., and Packer F., (1996). Determinants and Impact of Sovereign Credit Ratings.

Dimitrijevic, A., Beers, D. T., Chambers, J., Kraemer, M. (2011). Sovereign Government Rating Methodology And Assumptions. Standard & Poor's.

Jaimovich, D., Panizza, U. (2006). Public Debt Around The World: A New Dataset Of Central Government Debt. Inter-American Development Bank.

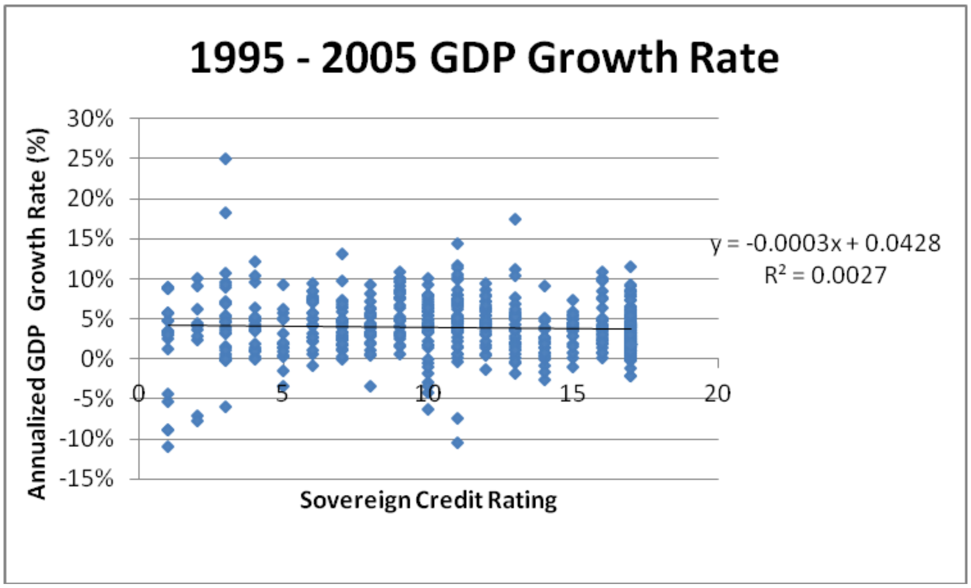
Monfort, B. and Mulder, C. (2000). Using credit ratings for capital requirements on lending to emerging market economies - possible impact of a new Basel accord. IMF Working Papers 00/69.

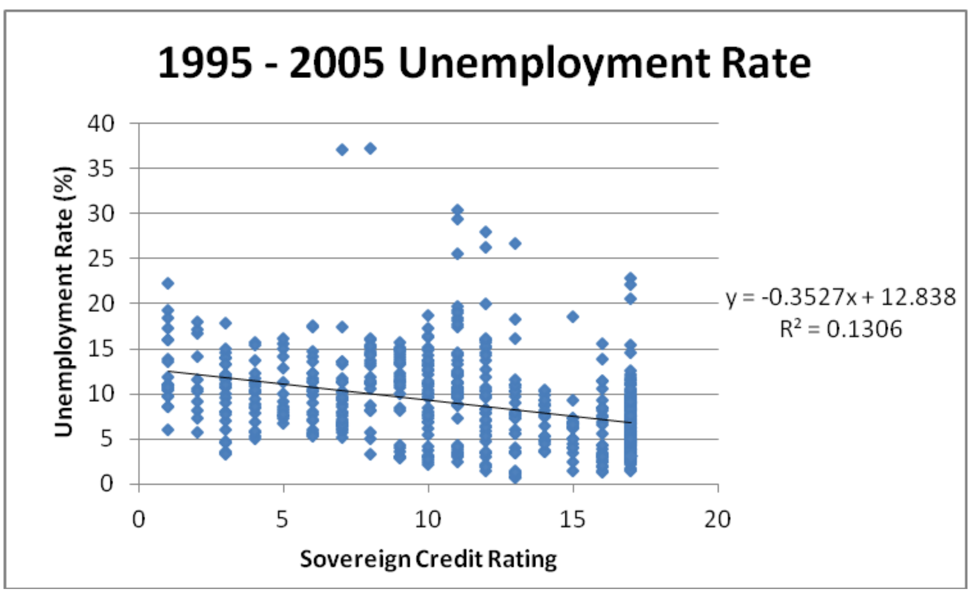
Mora, N. (2006). Sovereign credit ratings: Guilty beyond reasonable doubt? Journal of Banking and Finance, 30, 2041-2062.

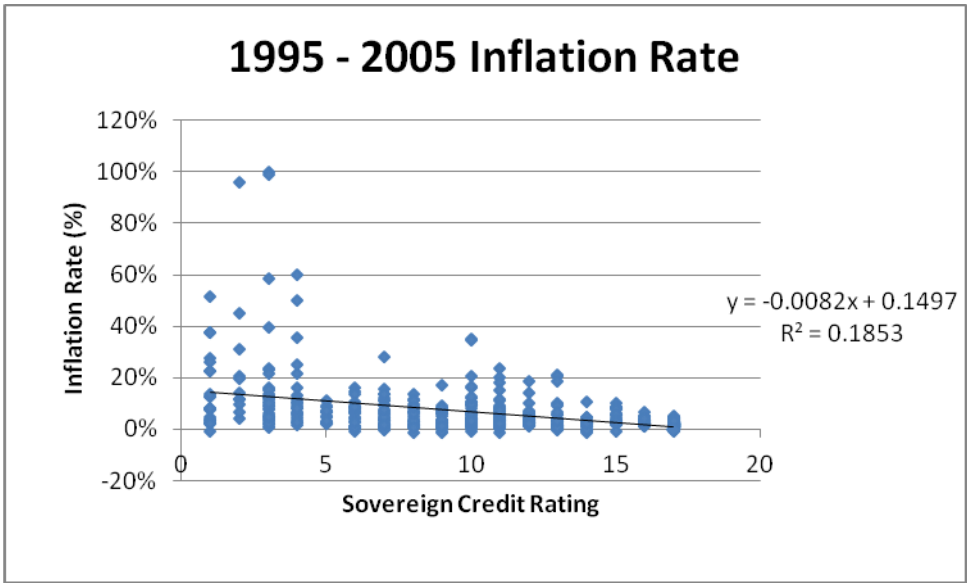
Panizza, U. (2008). Domestic And External Public Debt In Developing Countries. United Nations Conference on Trade and Development (UNCTAD).

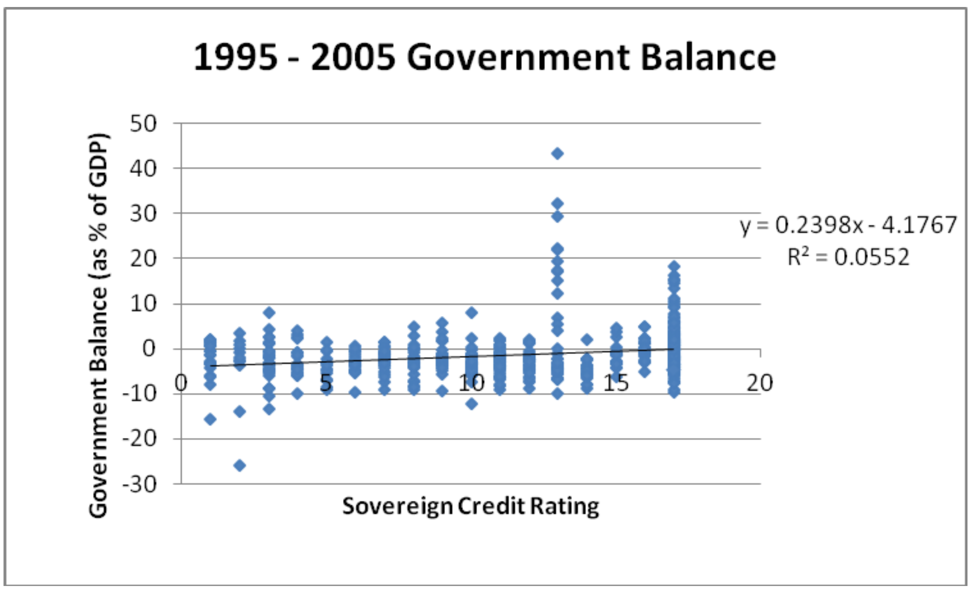
8. Appendix

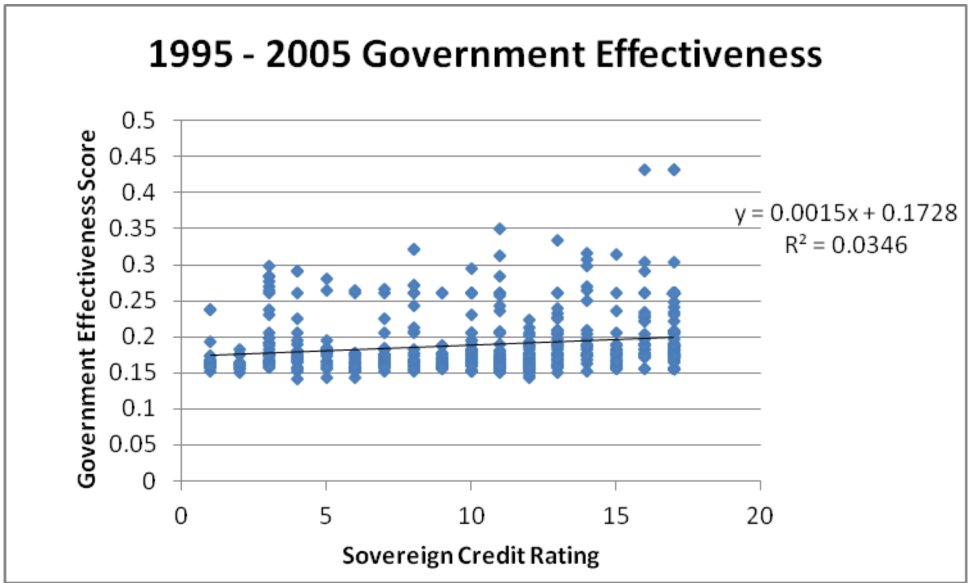
1. Relationship between Independent variables and dependent variable



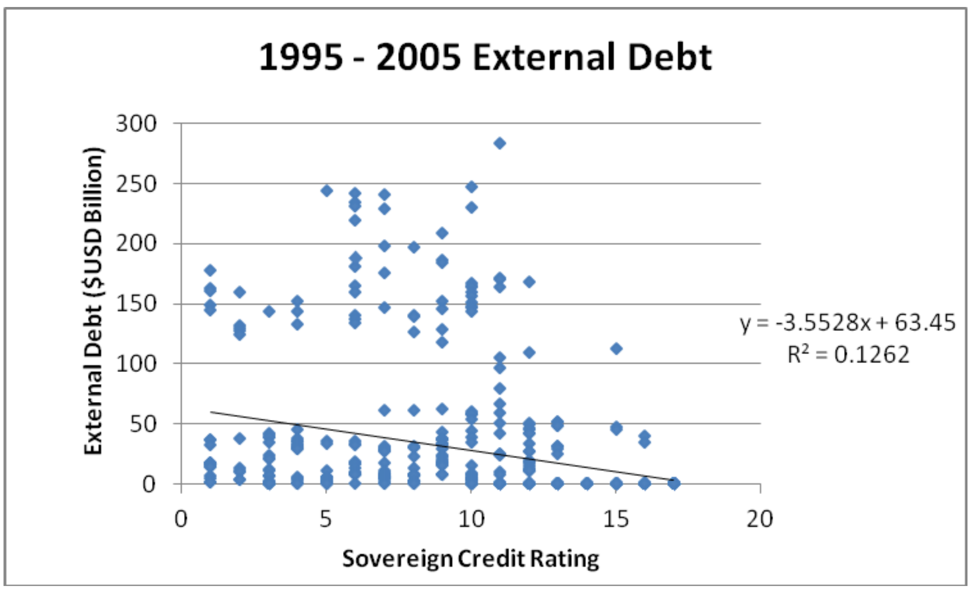



1995 - 2005 Inflation Rate
Inflation Rate (%)
120%
100%
80%
60%
40%
20%
0%
-20%
0
5
10
15
20
Sovereign Credit Rating
y = -0.0082x + 0.1497
R² = 0.1853

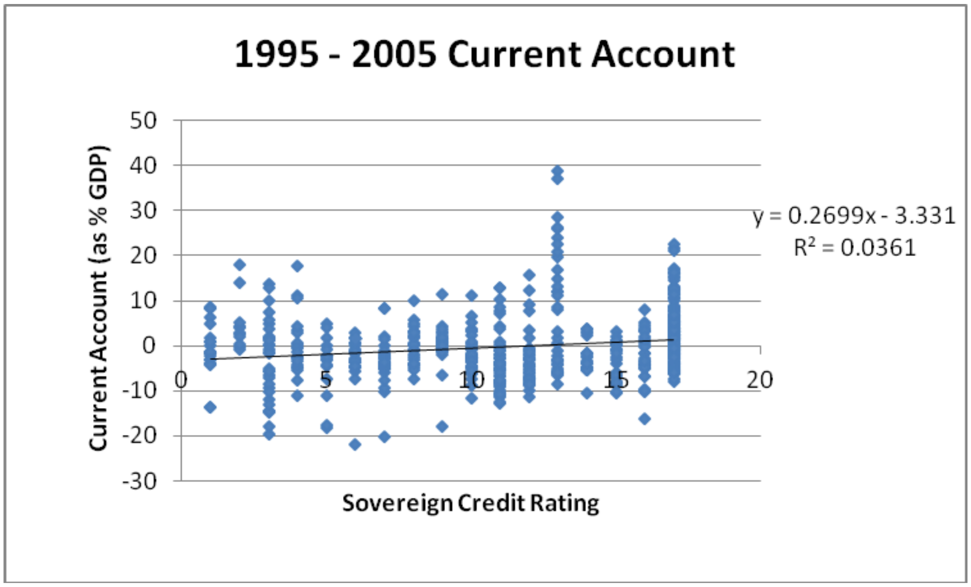

1995 - 2005 Government Balance
Government Balance (as % of GDP)
50
40
30
20
10
0
-10
-20
-30
0
5
10
15
20
Sovereign Credit Rating
y = 0.2398x - 4.1767
R² = 0.0552

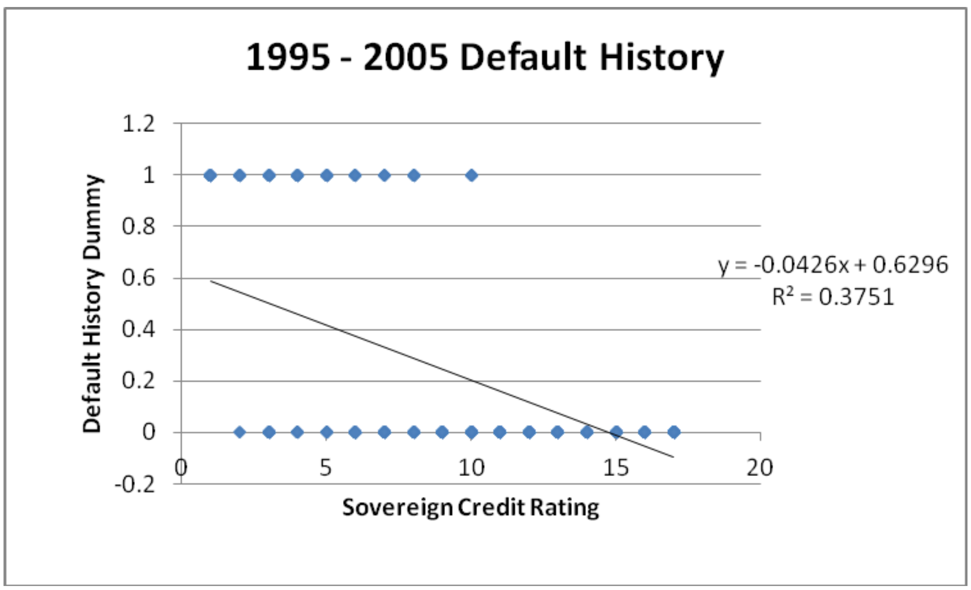


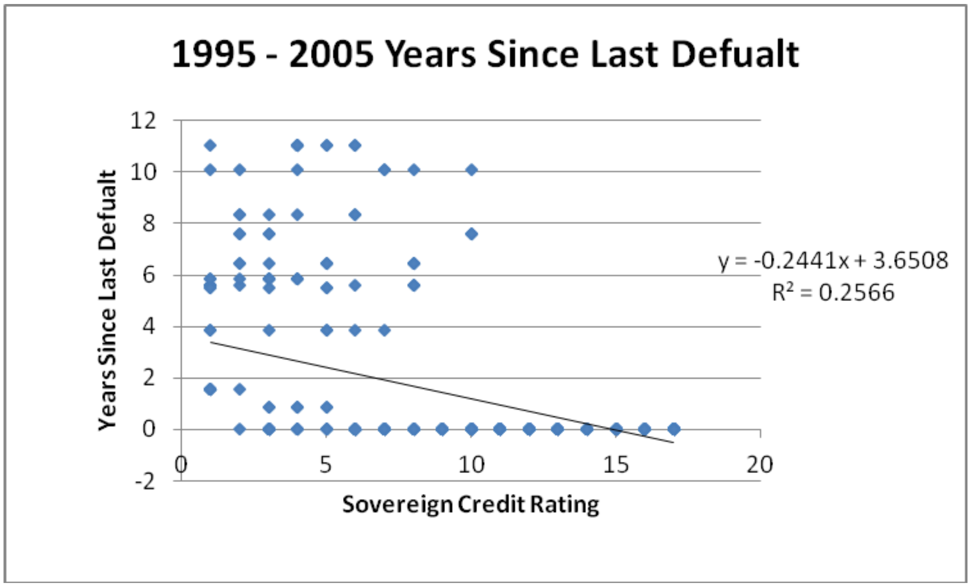
1995 - 2005 Government Effectiveness
Government Effectiveness Score
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
Sovereign Credit Rating
y = 0.0015x + 0.1728
R² = 0.0346

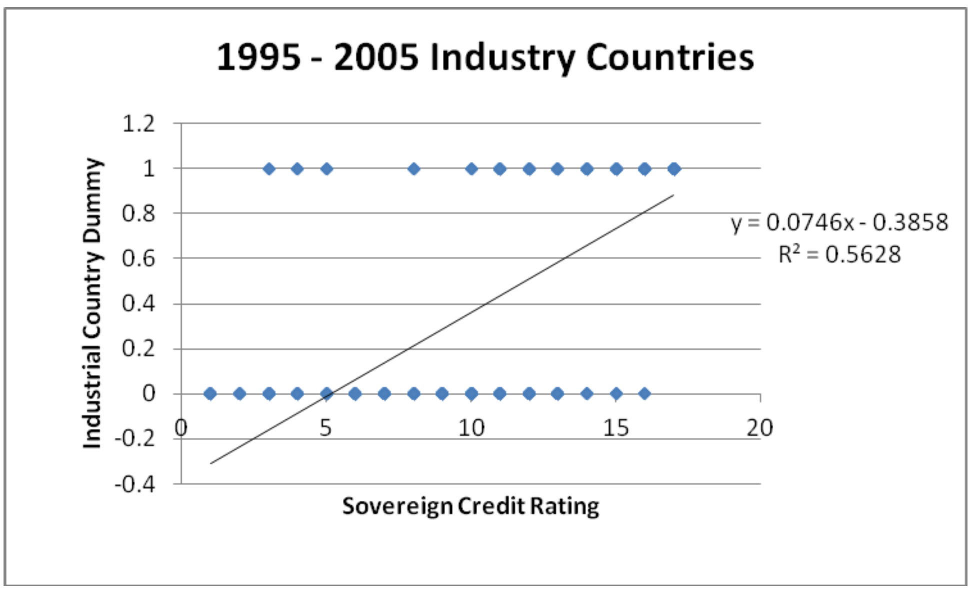


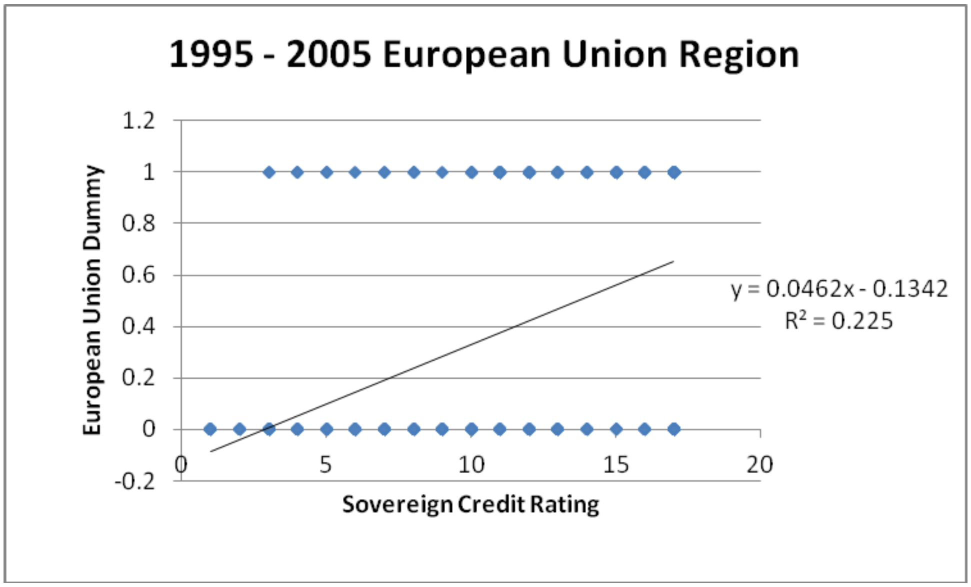
1995 - 2005 External Debt
External Debt ($USD Billion)
300
250
200
150
100
50
0
0
5
10
15
20
Sovereign Credit Rating
y = -3.5528x + 63.45
R² = 0.1262

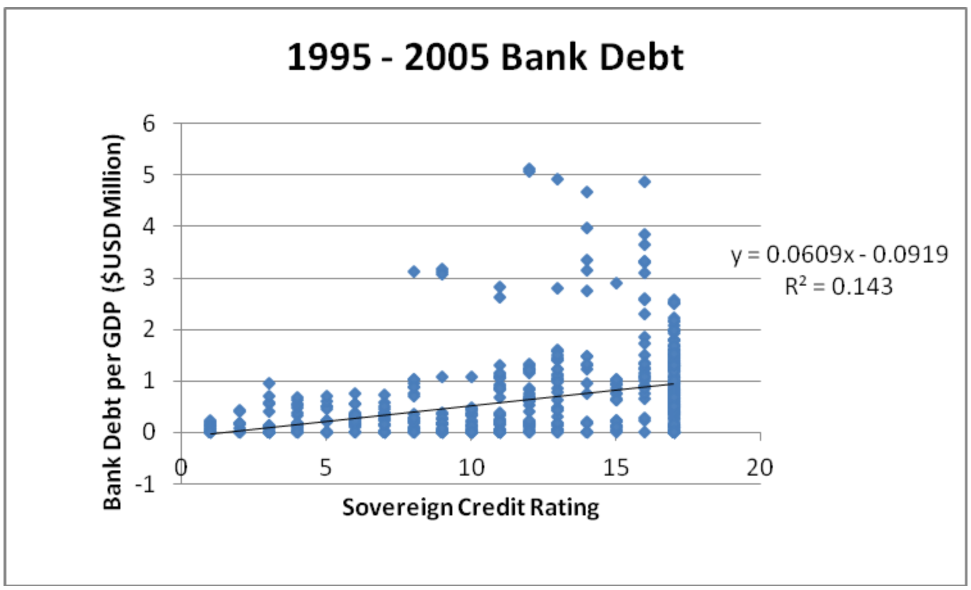

1995 - 2005 Current Account
Current Account (as % GDP)
50
40
30
20
10
0
-10
-20
-30
0
5
10
15
20
Sovereign Credit Rating
y = 0.2699x - 3.331
R² = 0.0361


1995 - 2005 Default History
Default History Dummy
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
5
10
15
20
Sovereign Credit Rating
y = -0.0426x + 0.6296
R² = 0.3751


1995 - 2005 Years Since Last Defualt
Years Since Last Defualt
Sovereign Credit Rating
y = -0.2441x + 3.6508
R² = 0.2566


1995 - 2005 Industry Countries
Industrial Country Dummy
Sovereign Credit Rating
y = 0.0746x - 0.3858
R² = 0.5628


1995 - 2005 European Union Region
European Union Dummy
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
5
10
15
20
Sovereign Credit Rating
y = 0.0462x - 0.1342
R² = 0.225


1995 - 2005 Bank Debt
Bank Debt per GDP ($USD Million)
6
5
4
3
2
1
0
-1
0
5
10
15
20
Sovereign Credit Rating
y = 0.0609x - 0.0919
R² = 0.143