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Asset Pricing Model (CAPM) In Emerging Markets: Evidence in Brics Nations and Comparisons with Other G20

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ABSTRACT

The objective of this paper is to empirically investigate the applicability of the asset pricing model in a portfolio made up of groups of countries, the G20 for this case. In the meantime, it was intended to compare a complete sample of 14 constituent countries of the group, a subsample of four countries belonging to the BRICS and another of the countries that do not belong. The survey sample consisted of long-term interest rate data from these countries collected in the OECD database and also from the Central Bank of Brazil - BACEN. Based on the results of the regression of Panel Data on Fixed Effects, we found evidence that there is a statistically positive relationship between the market risk premium and the interest rate risk premiums. The regression betas showed that the interest rate risk premium is not sensitive when considering the full sample of the G20 countries but is sensitive in the BRICS sample.

Keywords: Asset pricing. BRICS countries. G20 countries. Long-term interest rates.

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Introduction

In the world literature there is a profusion of works dealing with variable income assets, while fixed income securities, for example, those of public debt (bonds) are scarcer. Barr & Priestley (2004) reported that in an economic context of relative interest rate stability, agents were able to hold their positions in bonds to maturity. The risk of default used to be the only measure of risk. However, the economic-financial scenario since the 1980s is characterized by more volatile interest rates, a fact that has intensified the market for these securities.

The purpose of this paper is to conduct an empirical investigation involving a database containing long-term government bond yields from a sample of G20 constituent countries. Based on the estimate of the CAPM consolidated model and Portfolio Optimization Markowitz (1952), it was intended to compare the excess of long-term interest rates that remunerate government securities of countries from a complete sample of the G20, those belonging to BRICS and other countries that make up the G20 group. For this purpose, a test of the mean of the interest rate of the bonds between the groups was first used, in order to infer if this statistic is statistically significant. The second step is to perform a fixed-effects panel regression to calculate the beta of the CAPM model of the entire BRICS and non-BRICS sample for comparison between these groups (Engel, 1994).

The results indicated that there is a positive and statistically significant relationship between the long-term government bond market variation and the interest rate risk premium of the G20 countries and the non-BRIC countries. For the BRICS group, the result is inconclusive. The beta coefficients, which symbolize the average risk of the group bonds, indicated that the securities of the first group are not sensitive to market variations, while the second group is sensitive to market variations since they presented results higher than 1.

This work is divided into 4 sections. The first section is the introductory part. The second section is made up of the literature that deals with the asset pricing model and some works are mentioned that used this model. The third section is understood by the methodological aspects, while the fourth section presents the empirical results. Final considerations close the sections.

Literature

Some works that suggest fundamental economic structural differences between emerging and developed markets are in the field of the international financial literature and have in their formulations the CAPM model. Hakim et. al (2015), for example, have found empirical evidence in three BRICS nations (China, India, and South Africa) that the partial integration of emerging markets with global markets limits CAPM's individual capacity and its global version to explain the return emerging markets. That is, they have confirmed their ability to capture returns in markets that behave differently.

Stulz (1984) reports that capital asset pricing models (CAPM) play a central role in finance theory.

However, the author reports that with the expansion of the use of models in an international context the research becomes more complex, for conjecture questions such as, for example, the choice of a portfolio in a world where interest rates are stochastic and differ among nations. In another case, it becomes complicated to apply a model where it is admitted that the market is efficient, something difficult to admit when considering the international market.

In the same segment of analysis, Copeland & Weston (1988) point out that in order to describe efficient capital markets it is important, first, to contrast them with the perfect capital markets. For these authors, the following conditions are necessary: i) there are no transaction costs or taxes, all assets are perfectly divisible and there are no restrictive regulations; ii) there is perfect competition in product markets and securities markets; iii) markets are efficient in information, that is, there can be no cost in obtaining the information and it must be received equally by all individuals; iv) all individuals try to rationally maximize expected benefits (Brealey, Myers & Allen, 2007).

The above-mentioned work by Stulz (1984) was relevant to show how the fact that countries differ, affects the portfolio held by investors, the expected equilibrium returns and the financial policies of companies. In fact, these investors seek to compose an efficient portfolio and given the assumptions about the expected utility function of the investor. Therefore, the solution to the investor portfolio choice problem is a set of weights w_i, $i = 1$, ... n of the individual assets that maximize their expected real wealth, based on portfolio risk measured by their variance, and the sum of $w_{i's}$, is equal to 1. The formulation to solve the best $w_{i's}$, in which the investor maximizes the following Lagrangian function is as follows:

$$L = E\left(\sum_{i=1}^{n} w_i f_i\right) + \gamma\left(\sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \sigma_{ij} - K\right) + \mu\left(\sum_{i=1}^{n} w_i + 1\right)$$

This discussion above instigated research on the subject and focused on the public titles of groups of countries as the object of study, realizing that such a thematic would constitute a breach in the literature to be researched.

The optimization of the portfolio will be effective in obtaining the maximum return, for a given level of risk. Markowitz (1952) illustrates an efficient frontier as can be illustrated in Figure 1. Given a level of risk and a vertical line from this point on, the maximization of the investor's return will occur at the point where this line meets this border.

In considering the efficient frontier of a multi-asset portfolio, Copeland (1988) illustrates the efficient frontier with a number of risky assets, as can be seen in Figure 1.

According to Copeland (1988, p 178), a risk-averse investor will maximize its usefulness at a point given by the tangency between the efficient boundary and the highest indifference curve.

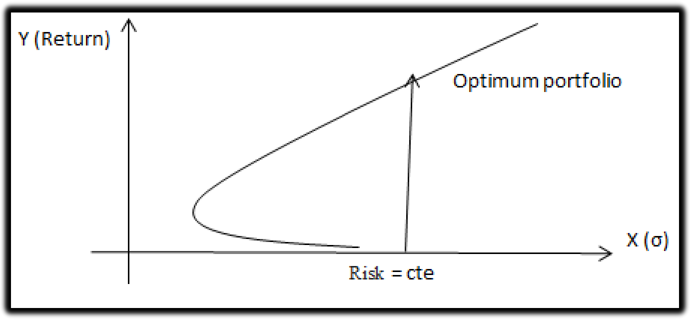


Figure 1: Optimum portfolio
Source: Copeland (1988, p.179)

When the risk-free asset is introduced in the analysis, the problem of asset selection is simplified (COPELAND, 1988). A risk-free asset usually has a relatively low expected return (R_f) with zero risks. In this new model, part of the funds will be invested in risk-free assets. Several combinations could be formed between risky assets and this asset. The representation of the efficient line will be a straight line, not a curve. Thus, the efficient boundary is given by the R_fMN line.

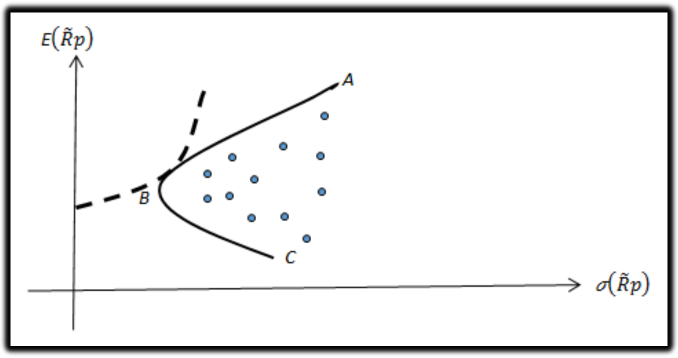


Figure 2: Set of Investment Opportunities with several assets at risk
Source: Copeland (1988, p.179)

The investor needs to know the combination of assets that make up his portfolio. Investor I is more risk-averse, takes a smaller risk, but has an expected return on the smaller portfolio, so it is more conservative, while investor II is less risk-averse, that is, it accepts to assume more risk since the expected value of the return is higher, so it is bolder compared to the previous one.

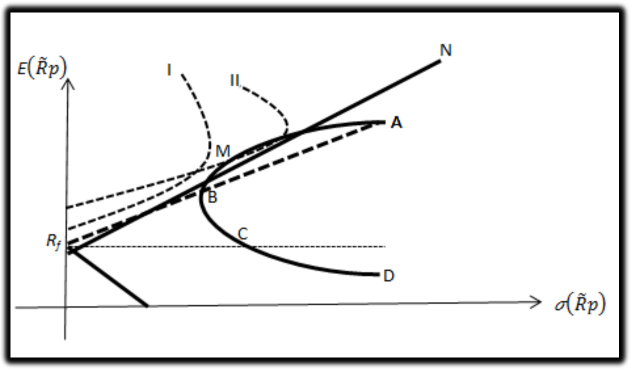


Figure 3: Efficient border with a risk-free asset and several risk-bearing assets
Source: Copeland (1988, p.179)

The portfolio of the asset market, comprising the full range of opportunities, represented by the RfMN line, will be the capital market line (CML), where the expected market return $E(\tilde{R}_m)$ and market risk $\sigma(R_m)$ are points on this line, and the slope is é $\frac{E(\tilde{R}_m)- R_f}{\sigma(R_m)}$. The equation for the CML is given by Copeland (1988, p.181) as:

$$E(R_p) = R_f + \frac{E(\tilde{R}_m) - R_f}{\sigma(R_m)} \sigma(R_p)$$

Sharpe (1964) formulated CAPM (Capital Asset Pricing Model), whose foundation is the deduction that the efficient portfolio would be the market portfolio itself. Sharpe deduces that the expected risk premium for a given asset would be proportional to the beta. Thus, the expected returns can be represented as points of the Straight SML (Security Market Line), as shown in figure 4.

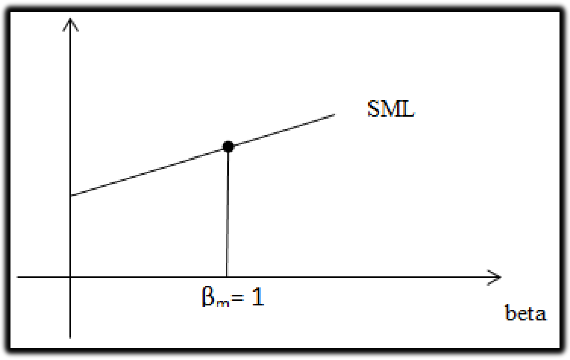


Figure 4: Security Market Line (SML) - Securities Market Line
Source: adapted from Guimarães & Guimarães (2006)

As Black (1972) reports, several authors have contributed to the development of a model that describes the price of capital goods under conditions of market equilibrium. From this, it presents the CAPM formula as:

$$\tilde{R}_j = R_f + \beta_j(\tilde{R}_m - R_f)$$

Where: $\tilde{R}_j$ is the return of asset j for the period; $\tilde{R}_m$ is the return of the market portfolio; R_f is the risk free return of the asset for the period; β_j é is the "market sensitivity" of the asset j and is equal to the slope of the regression line $\tilde{R}_j$ and $\tilde{R}_m$.

$$\beta_j = \frac{cov(\tilde{R}_j, \tilde{R}_m)}{var(\tilde{R}_m)}$$

According to Stulz (1984), this equation shows that the expected real return on an asset is a linear function of the beta version of the asset. In addition, the actual expected return on an asset is higher than the expected actual return on the beta zero portfolios. The market portfolio includes all the securities in the world and not just national bonds.

Henry (2007) in his discussion of the neoclassical model in predicting the flow of resources to developing countries in reducing the cost of capital, causing a positive and temporary increase in investment and growth and capital account liberalization impacting on cost of capital, in the investment itself and in the growth of the economy at a certain moment addresses the intricacies of the formulation of asset pricing.

In this discussion approach, the aforementioned author incorporates the configuration of risk assets in his analysis of the fundamental predictions of the deterministic neoclassical capital account model. He mentions that if one does not consider the risk, it is ideal to invest until the marginal product of capital equals the interest rate. When the risk is allowed, investment optimization (for example, in a portfolio of securities) occurs until the expected marginal product of capital equals interest rate plus a risk premium to compensate for the uncertain return to capital.

From then on, the CAPM model was used in the context of the capital price model. Consider, then, how θ the price of risk, γ, times the variation of the market return, so that the first order condition for the investment under uncertainty is:

$$f'^{(k^e)} = r + \gamma Var(\hat{r}m) + \delta$$

For its part, the CAPM model can also be applied to public government securities. Caldeira, Moura & Santos (2013) carried out a work, in which they used the Markowitz approach to optimize portfolios of public bonds

using factorial models to predict the interest curve and also to parsimoniously model the conditional covariance matrix of the various maturities. They found evidence through an empirical application involving a set of unpublished data containing Brazilian public securities with different maturities indicates that the optimized portfolios have a risk-adjusted performance.

As already mentioned in the introduction of this paper, the objective is to compare the excess of long-term interest rates that remunerate BRICS public bonds with other countries that make up the G20 group. For this purpose, a test of the difference of interest rate averages will first be used in order to infer if this statistic is statistically significant. The second step is to perform a fixed-effects panel regression to calculate the beta of the CAPM model of the entire sample of BRICS and non-BRICS countries.

Methodology

Sample

This work comprises four of the five BRICS nations, namely Brazil, India, Russia, and South Africa. The non-inclusion of China refers to the lack of access to the country's interest rate data in the bank of OECD data. The behavior of interest rates in these countries should vary, which provides an opportunity to test models in different contexts. Annual interest rate data representing the price of the public securities of these countries were used over a period ranging from 1990 to 2016. Interest rates in the BRICS countries, with the exception of Brazil, were collected in the OECD. For Brazil, SELIC interest rate data were obtained from the Central Bank of Brazil.

The countries were selected by the criteria: 1) belong to the bloc of the BRICS emerging countries, here called BRICS and 2) countries belonging to the G20 that are included in the OECD database and do not belong to the BRICS. Those countries that met the criteria established in each year are shown in Table 1 below:

Table 1: Selected countries in this article

Group of countries	Number of countries	Name of countries
BRICS	4	Brazil, India, Russia, South Africa
G20	10	Germany, Canada, United States, France, Great Britain, Italy, Japan, Mexico, Australia, South Korea.

Source: Own elaboration based on OECD data.

Variables Used

Risk-Free Asset (Rf): Public securities used in the United States as approximations to the risk-free rate are treasury bonds (T-Bonds) with maturity for 30 years.

Long-term interest rate risk premium (Ri_Rf): Difference between the rate of interest of country i by the risk-free rate. Long-term interest rates refer to government bonds maturing in ten years.

These interest rates are implicit in the prices at which government securities are traded on the financial markets. In all cases, they refer to bonds whose repayment of capital is guaranteed by governments.

The premium for the long-term interest rate risk of the market (Rmkt_Rf): Difference between the market interest rate m of securities and the risk-free rate. The market interest rate followed the criterion of choosing a financial portfolio using the Markowitz Portfolio selection model, by optimizing an efficient portfolio of the securities of the smaller variance countries, contrary to what Reinhart & Rogof (2008) stated that it is important to underscore the fact that the right benchmark is the return on illiquid assets from high-risk, non-highly liquid low-risk assets. Similar to the model used by Stulz (1984), the formulation of this work to define an optimal portfolio for a representative market proxy, in general terms was:

$$\sigma_p^2 = \sum_{i=1}^{n} w_i^2 \sigma_i^2 + 2 \sum_{J=I+1}^{n-1} \sum_{j=i+1}^{n} w_i w_j \rho_{ij} \sigma_i \sigma_2$$

Where: w_i e w_j are the fractions of the investment portfolio allocated to securities *i* and *j*; ρ_{ij} is the correlation coefficient between i and j; n = number of securities in the investment portfolio and $\sigma_i\sigma_2$ is the variance of the return on i and j.

The portfolio optimization by the Markowitz model was performed by the Solver function of the Excel software, based on the long-term interest rate of the following countries: the United States, Japan, Germany, France, Australia, Canada, and Great Britain.

Model

The model is Sharpe's Asset Pricing Model (CAPM) (1964), which refers to the Bonds of the G20 countries.

$$Ri_{it} - Rf_{it} = \beta_1 (Rm_{it} - Rf_{it}) + \epsilon_{it}$$

Where: Ri and Rf are the returns of securities i and the risk-free rate, respectively, Rm is the return of the market portfolio and $\beta 1$ is the beta value of the title. The beta value of security reveals the volatility of the security, the sensitivity of the return i to the variation of the asset/bond market as a whole.

This model explains variations in the rate of return of security as a function of the rate of return of a portfolio, which consists of all publicly traded securities, that is, the market portfolio. In general, the rate of return of any investment is measured against its opportunity cost, which is the return of a risk-free asset. The resulting difference calls the risk premium since it is the reward for a risky decision.

Empirical Results

Descriptive Statistics

Table 2 shows the statistics of the variables used in the regression models. The Dataset sample consists of 378 observations (316 for the Ri_Rf variable, due to missing). It is noticed that the proximity of the mean values with the medians of the variables approximates the distribution to normality.

Table 2: Statistics of the variables of the Models

Stats	Ri_Rf	Rmw_Rf	Ri	Rmw	Rf
N	316	378	316	378	378
Mean	1.883	0.810	6.285	5.511	4.701
p50	0.628	0.744	5.493	5.260	4.575
Max	12.391	2.414	15.094	10.970	8.556
Min	-4.623	0.133	0.690	2.100	1.735
Sd	3.417	0.493	3.744	2.109	1.863

Source: Own elaboration based on OECD and BACEN data.

The distance between the minimum and maximum value of all variables, with the exception of the market risk premium, leads to the suspicion of violation of the constant variance hypothesis of the residuals, however, that the data are heteroskedastic.

Table 3 represents the correlation matrix of the variables. A regression of the model was performed in OLS to diagnose the residues. The presence of multicollinearity was tested by the FIV test, and this hypothesis was denied.

Table 3: Pearson Correlation Matrix

	Ri_Rf	Rmw_Rf	Ri	Rmw	Rf
Ri_Rf	1.000				
Rmw_Rf	0.030	1.000			
Ri	0.879	0.182	1.000		
Rmw	-0.058	0.588	0.416	1.000	
Rf	-0.071	0.401	0.414	0.977	1.000

Source: Own elaboration based on OECD and Bacen data

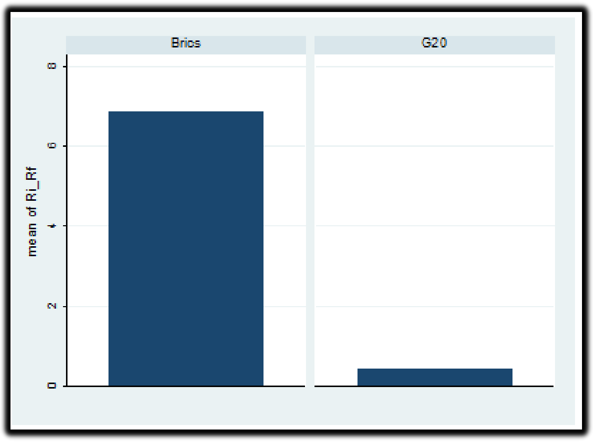
The Jaque-Bera test confirmed the non-normality of the waste distribution at a level of 5% (p-value <0.01). For the correction of heteroskedasticity, the regression model has used the robust function of STATA (Hoechle, 2011). The Ramsey test identified that the model is appropriately specified because it detected that there were no omitted variables (p-value = 0.9859).

Since this work is based on a consolidated model in the theory (CAPM), it was solved by fidelity to it, and estimated by the fixed-effects method in the panel and later also using the model Fama-Macbeth (1973).

Mean Difference Test of The Brics Countries and not BRICS

It can be seen from figure 1 that, on average, the countries belonging to the BRICS require a higher risk premium. The performance of this chart was already expected since public sector debt securities pose a greater risk for this group of countries.

Graph 1: Average risk premium of the countries



Source: Own elaboration based on OECD and BACEN data.

Table 4 presents the descriptive statistics (number of observations, mean, standard deviation and confidence interval) of the G20 countries belonging to the BRICS and those that do not belong.

In order to compare if the results confirm the observation of Graph 1, the t-test was performed to verify if the means of the independent variable are statistically different from each other.

As shown in Table 2, on average, the BRICS countries present higher risk premiums compared to non-BRICS countries, respectively 10.90 and 4.94.

The statistical test of the difference between the two groups was statistically significant (p-value <0.001).

From this fact, it is inferred that there is a difference between the means of the two groups in terms of risk premium. It should be noted that the mean difference tests are used for the purpose of a descriptive analysis of the data.

Table 4: Test difference between groups of countries in relation to excess interest rate return (Ri_Rf)

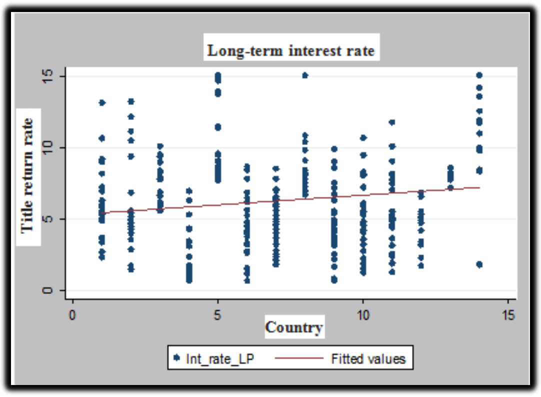
Table 4 performs the t-test to identify whether the means of the independent variable is statistically different from each other. Excess interest rate (Ri -Rf).

Group	N	Mean	Standard Error.	Standard deviation	[95% Confidence Interval]	
BRICS	71	10.90466	.4101265	3.455787	10.08669	11.72263
G20	245	4.946629	.1649255	2.581492	4.62177	5.271489
Diff		5.958034	.3774085		5.215465	6.700603
	p-valor= 0,0000					

Note: N is the number of observations-year from 2006 to 2013.
Source: Own elaboration.

Chart 2 is a Plot Scatter that captures the propensity for positive effects on the G20 public bond interest rate over the period of analysis. In general terms, the series has an upward trend line and indicates a higher expected interest rate for the countries in this group, therefore, higher risk premiums.

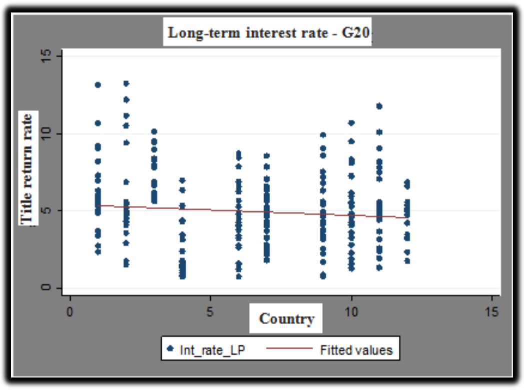
Graph 2: Plot Scatter of the G20 countries' interest rates



Source: Own elaboration based on OECD and BACEN data.

The trend line in Chart 3 indicates that long-term interest rates are negatively associated with the G20 countries, excluding the BRICS countries. This relationship leads to the expectation of a lower risk premium.

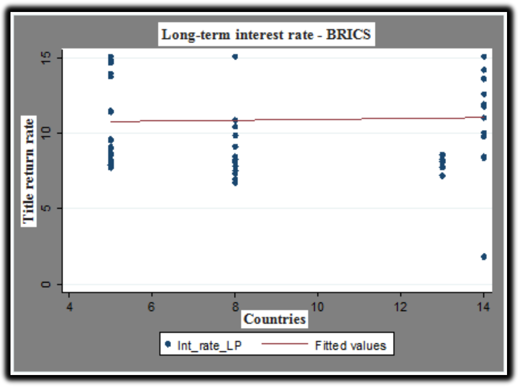
Graph 3: Plot Scatter of G20 interest rates, except for BRICS



Source: Own elaboration based on OECD and BACEN data.

Conversely, Chart 4 shows the growing trend line for the BRICS countries. Therefore, it is deduced that long-term interest rates are positively associated with BRICS countries. Therefore, higher risk premium levels are expected.

Graph 4: Plot Scatter of the G20 countries' interest rates, except BRICS



Source: Own elaboration based on OECD and BACEN data.

Before presenting the results of the regression of the panel data, it should be mentioned that three tests were carried out to choose between regression models (pooled, fixed effect or random effect), being Breusch-Pagan, which chooses between the best model pool and random effect; the Chow test for pooled or fixed effect and the Hausman test for between fixed effect and random effect. After the various tests, the model estimated by fixed effects was the most adequate.

In order to identify if the autocorrelation problem exists, the Woodridge test was used and the Wald test was used for the heteroresistance problem test. The hypotheses H0 of the absence of autocorrelation and absence of homoscedasticity were rejected at a significance level of 5%. Therefore, we have the problem of autocorrelation and heteroscedasticity. In this case, it is recommended to run the model using the robust or bootstrap STATA method.

Analysis of the Results of the Proposed Models.

The results of Panel data regressions on fixed effects are shown in Table 4. As can be seen in the results of the classic CAPM model for all G20 sampled countries, there is a statistically low (p-value <10%) between the market risk premium and the dependent variable. It is inferred, therefore, that economic agents expect an excess of the return on G20 government bonds to be lower than the market average, that is, for each percentage point of the risk premium expected by the market, 0.6223 times of premium over the long-term interest rate.

As the Beta is represented by the regression coefficient and its value expresses the volatility of the bond, it is inferred that, in the aggregate, the bonds are not sensitive to the variation of the public securities market as a whole. Table 4 presents the coefficients of the panel regressions, of the three cases, estimated by fixed effects.

Table 4: Results of panel regressions of the models

Variables	FULL(1)	G20(2)	BRICS(3)
	Ri_RF	Ri_RF	Ri_RF
Rmkt_Rf	0.6223*	1.0086***	-0.8483
	(0.3386)	(0.3031)	(0.7166)
const.	1.7166***	-0.4985	8.8992***
	(0.6610)	(0.6783)	(0.8211)
N	316	245	71
R-sq	0.175	0.482	0.43
adj.	0.101	0.42	0.093
Rmse	1.5510	0.7500	2.8017

Note. The coefficients of control variables per year group of countries were omitted from the table. The asterisks *, ** and * represent significant statistics at the 10% level; 5% and 1% respectively.**

Source: Own elaboration based on OECD and BACEN data

The second column expresses a strong positive and statistically significant relationship (p-value <0.01) between the market risk premium and the dependent variable. The Beta result of the regression equals 1.0086, for non-BRICS countries, showed that the risk is higher in relation to all countries in the sample.

The third column represents the sample of BRICS countries. This subset showed a negative relation to the market variation of long-term government bonds. However, the negative and statistically non-significant result becomes the analysis inconclusive.

Final Considerations

This article was an introduction proposal to the portfolio analysis of public debt securities of a group of countries, according to the classic asset pricing model, CAPM. To do this, we tried to test the statistical significance of the optimal formation of the bond portfolio of a sample of 14 G20 component countries.

Some results show that there is a statistically significant positive relationship between the market risk premium and the long-term interest rate risk premium of the full sample of the G20 constituent countries. It was also possible to verify that the result of the beta was positive and smaller than the unit. The figure of 0.6223 means that for a 1% increase in the market portfolio, the G20 portfolio of securities tends to rise only 0.6223%. However, in the case of a -1% decline in the portfolio representing the market, the portfolio of G20 securities tends to decline only 0.6223%.

The strong positive and a statistically positive relationship between the G20 countries, excluding the BRICS, indicates that for a portfolio formed by this group, the expected return of the excess long-term interest rates of these countries is expected to exceed those observed in the average from the market. A value greater than 1 means that if the portfolio returns rise by 1%, on average the portfolio of G20 countries' bonds grows by 1.0086%.

The results relevant to the BRICS were not conclusive. It is concluded that the bond market of the countries of this group is not relevant in the international financial market. It is also worth ratifying here that, on average, the BRICS countries maintain interest rates higher than those of other countries. This could be evidenced by the result of the mean test.

In the elaboration of this work were found some limitations to the study that deserves to be highlighted. First, the scarcity of literature. Not in relation to the literature, that deals with the thematic of the model of pricing of assets in international terms, but that which has the public bonds as the object of analysis. Second, attempts to estimate the model by more robust tests were not successful. The regression by the method Fama-Macbeth (1973) omitted the model-independent variable. It is suspected that this fact is subject to the proxy for the market. Thirdly, it is precisely in relation to this proxy. A rate representing the long-term interest rate of the government securities market was not found in the literature. However, these restrictions open up opportunities for advancing the study. It is hoped that in future research the CAPM model for this subject will be able to estimate the values by the above-mentioned methods and also a proxy that is closer to the international market of public bonds of the countries or groups of countries will be used.

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