Universitat de Lleida

Determinants of Country Risk: Portfolio Theory, Efficient Market Hypothesis And Social Media on Sovereign Credit Spreads

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TESIS DOCTORAL

Determinants of Country Risk: Portfolio Theory, Efficient Market Hypothesis And Social Media on Sovereign Credit Spreads.

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Memoria presentada para optar al grado de Doctor por la Universidad de Lleida

Programa de Doctorado en Derecho y Administración de Empresas

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Mayo 2022

Abstracta

La investigació de tesi doctoral aquí continguda utilitza els preceptes de la teoria moderna de carteres (portafolis) per calcular una variable de risc intrínseca per a Colòmbia, l'Equador i el Perú, tres països que comparteixen característiques similars i alhora contrasten en aspectes fonamentals que n'impacten el risc país. Aquest risc intrínsec o endogen en una economia és el resultat d"analitzar sèries de temps trimestrals d"activitats econòmiques com si fossin un conjunt d"actius financers en una cartera composta per totes les activitats econòmiques. La suma dels components de l'activitat econòmica, cadascun amb la seva proporció i taxa de creixement, de la mateixa manera que el creixement, el rendiment i la variabilitat d'un actiu individual, contribueixen al perfil de rendiment i risc d'una cartera de actius financers. A més, aquesta variable de risc endogen es va analitzar en conjunt amb els índexs macroeconòmics, les característiques dels instruments del mercat de capitals, com ara liquiditat, qualificacions creditícies i, finalment, es va calcular un índex sobre l'impacte de les xarxes socials als rendiments de títols sobirans de deute. Després es van analitzar les sèries temporals d'aquestes variables i factors per entendre quines i de quina manera impacten sobre el risc d'un bo sobirà, tal com ho capta la diferència entre els rendiments d'un bo sobirà versus la taxa lliure de risc del bo del Tresor dels Estats Units, una variable comunament coneguda com a diferencial de rendiment creditici (credit yield spread). Els resultats obtinguts indiquen que la variable de risc endògena és un determinant important del risc país per a l'Equador. Per als altres dos països, Colòmbia i Perú, les variables del tipus de canvi tenen un impacte més significatiu..

Abstracto

La investigación de tesis doctoral aquí contenida utiliza los preceptos de la teoría moderna de carteras para calcular una variable de riesgo intrínseca para Colombia, Ecuador y Perú, tres países que comparten características similares y a la vez contrastan en aspectos fundamentales que impactan su riesgo país. Este riesgo intrínseco o endógeno en una economía es el resultado de analizar series de tiempo trimestrales de actividades económicas como si fueran un conjunto de activos financieros en una cartera compuesta por todas las actividades económicas. La suma de los componentes de la actividad económica, cada uno con su propia proporción y tasa de crecimiento, de la misma manera que el crecimiento, el rendimiento y la variabilidad de un activo individual, contribuyen al perfil de rendimiento y riesgo de una cartera de activos financieros. Además, esta variable de riesgo endógeno se analizó en conjunto con los índices macroeconómicos, las características de los instrumentos del mercado de capitales, tales como liquidez, calificaciones crediticias y, por último, se calculó un índice sobre el impacto de las redes sociales en los rendimientos de títulos soberanos de deuda. Se analizaron las series temporales de estas variables y factores para entender cuáles de ellas y de qué manera, impactan sobre el riesgo de un bono soberano, tal como lo capta la diferencia entre los rendimientos de un bono soberano versus la tasa libre de riesgo del bono del Tesoro de los Estados Unidos, una variable conocida como *credit spread*. Los resultados obtenidos indican que la variable de riesgo endógeno es un determinante significativo del riesgo país para Ecuador. Para los otros dos países, Colombia y Perú, las variables de tipo de cambio tienen un impacto más significativo.

Abstract

This research utilizes the precepts of Modern Portfolio Theory to calculate an intrinsic variable of risk for Colombia, Ecuador, and Peru. These countries share characteristics and conversely differ on other crucial aspects that affect their risk profile. This intrinsic or endogenous risk of an economy is the result of analyzing quarterly time series of economic activities as if they were a set of financial assets in a portfolio composed of all economic activities. The sum of the components of economic activity, each having its own proportion and rate of growth, affect its risk in the same way an individual asset's return and variability contribute to the return and risk profile of a portfolio of financial assets. Furthermore, this variable is analyzed in conjunction with macroeconomic indices, characteristics of the country's debt instruments, such as liquidity, credit ratings, and finally, an index of the impact of social media. A time series of these variables and factors are analyzed to understand the impact they have on the risk of a sovereign bond, as captured by the difference of its returns versus the risk-free rate of the United States Treasury bond. The results obtained indicate that the endogenous risk variable is a significant determinant of country risk for Ecuador. For the other two countries, Colombia and Peru, the exchange rate variables have a more significant impact.

DEDICATION

To my children, Valentina, Irene and Juan Esteban, to my parents, Claudia and Esteban, to my sister Diana and my brother Antonio, because I want to make them all proud. To my colleague and friend Martinelli for endowing me with the peace of mind and focus this process required. To Sara for her contagious, refreshing curiosity, and her relentless desire to learn which propelled me to take this work across the finish line.

ACKNOWLEDGEMENTS

I am grateful to Universitat de Lleida for welcoming my application and accepting me into the Doctoral Studies Program. I specifically would like to thank Professor José Luis Gallizo Larraz for directing and improving my work. I would also like to take this space to express my gratitude to: Professor Candy Abad my superior at Universidad San Francisco de Quito -USFQ, to Professors Pablo Lucio Paredes and Santiago Mosquera for accepting to read and evaluate my research, and finally a heartfelt thanks to all the Professors from Universitat de Lleida whom I met in Santiago de Chile whilst preparing to embark on this satisfactory and illuminating endeavor, a special mention for Dr. Eduard Cristobal-Fransi is in order for his decided enthusiasm about my prospects as a PhD candidate.

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1.0 The Cross-National Comparison

The Andean Group

The Andean Group (*Pacto Andino*) was born in 1969 with the promise of integration and prosperity, through the elimination of barriers to reciprocal intra-regional trade, an accord on the establishment of a common external tariff and on the collaboration of economic planning. The member nations who comprised the Andean Group were Bolivia, Chile, Colombia, Ecuador, and Peru (Petras 1978). Venezuela joined the group in 1973 and Chile withdrew from the group in 1976 arguing lack of alignment with the objectives of their brethren as the reason for leaving. These countries were once part of a symbol of South American integration shortly after independence from Spanish colonization, with two of them –Colombia and Ecuador— having been part of a larger nation known as the Gran Colombia, to distinguish it from what is currently the country of Colombia (Kirkpatrick, F. A. 2013).

Even before the creation of this agreement of cooperation and free trade, the three most tightly integrated countries of the Andean Group were the three countries subject of my dissertation Colombia, Ecuador, and Peru (Adkisson 2003). After the creation of the Andean Group the sentiment of nationalism which initially bound these countries together was paradoxically the sentiment which made it falter. The Andean Group's objectives wallowed without a positive trend to its name until 1989.

The Trujillo Protocol was signed in 1989, an accord which led to trade activity intensifying especially between Colombia, Peru and Ecuador. For this reason, these countries have been jointly analyzed in multiple studies delving into the

economic relationships by which they are bound, especially from the perspective of their ability to substitute imports with Import Substitution Initiatives (ISI), attract Foreign Direct Investment (FDI) flows, and gauge the impact of these efforts on economic growth (Camacho 2020). Furthermore, these three countries' geographic proximity, common external tariffs, and their similarity in comparative advantages (especially agrarian capabilities) place them as competing destinations for capital, often vying for resources from multinational corporations and governments (Castro-Gonzalez 2017).

As referred to previously, Colombia, Peru, and Ecuador are emerging economies (EMEs) part of the Andean Group free trade area. These countries' economies are highly dependent on commodities as seen in Figure 1 and they often face financing dilemmas due to the volatile nature of supply and demand of prices of these very same commodities on which they rely. In addition, all three are emerging market economies EMEs whose access to financing is especially impacted in times of distress as seen in the multiple crises facing the region in the 1990s and more recently the global financial crisis of 2008 (Caballero, J., Fernández, A., & Park, J., 2019) and the Covid-19 Pandemic (Cottani 2020).

As can be logically surmised from the fact that the most fluid of resources is capital, these countries not only compete for more stable and enduring FDI but also for financial resources to nurture their shorter term accounts and finance not only their infrastructure and public investment needs, but also temporary imbalances. For this reason, it is imperative that they maintain access to financing through capital markets and multilateral organizations, both of whom provide funds at acceptable rates and with reasonable conditions, attributes which are essential by large infrastructure

projects, recurring fiscal deficits and countercyclical measures which buoy countries in times of need.

In January of 2000 Ecuador somewhat abruptly (although authorities at the time argued that the plan had been in place for a longer period, the country went from inception to adoption of the US dollar in a mere 4 months' time) adopted the US dollar as its currency, an event which had both immediate and longer lasting repercussions on all aspects of economic activity. Specifically, on the issue of balance of payments and terms of trade, Ecuador would be negatively impacted, and their competitors (Colombia and Peru) conversely benefited by making Ecuadorian exports less competitive since the country was devoid of the possibility of currency exchange management. Conversely, on the capital flow side of the balance of the payment argument, Ecuador garnered the attention of the international community with the prospects of a subdued inflation, a fixed exchange rate regime and the possibility of longer term commitments (Mahuad 2021). These prospects quickly dimmed for Ecuador as had been the case in the not so distant past, during what was referred to as the lost decade of Latin American nations (Sachs, J. 1989).

Similarities Dissipate

Since the liberalization of financial markets (Eatwell & Taylor, 1998) and a few years later, with the adoption of the Brady Plan[1] (Sachs, J. 1989), the similarities

[1] The Brady Plan initiative introduced in 1989 by Nicholas F. Brady, Secretary of the US Treasury during the presidency of George HW Bush, for lending institutions to accept an orderly process of sovereign debt reduction

between these three countries begin to dissipate. Although parallels persist in aspects like their reliance on commodities (Figure 1), Colombia and Peru have had a more stellar recent past by attaining Investment Grade standing from credit rating agencies, as a result of relatively robust levels of reserves and significant Foreign Direct Investment (Appendix, Figures 28A, 30A, 34A, 36A). Ecuador on the other hand, has had a more problematic set of circumstances these past few years.

With the adoption of the US dollar as its currency, Ecuador's intention was to stave off hyperinflation and prevent a potential massive run on the banking system whose troubles had been brewing for years (Lucio-Paredes, P. 2017). In the years leading up to the adoption of the US Dollar, political upheaval constantly met the threat of thinning reserves, increased borrowing costs and pervasive trade and fiscal deficits (mostly because of structural inefficiencies). These troubles have not changed but have been compounded by an overvalued currency which impeded competitive exports, generates current account deficits, and leads to economic contractions, what De la Torre and Pallares have termed the triple claw (De la Torre et al 2017).

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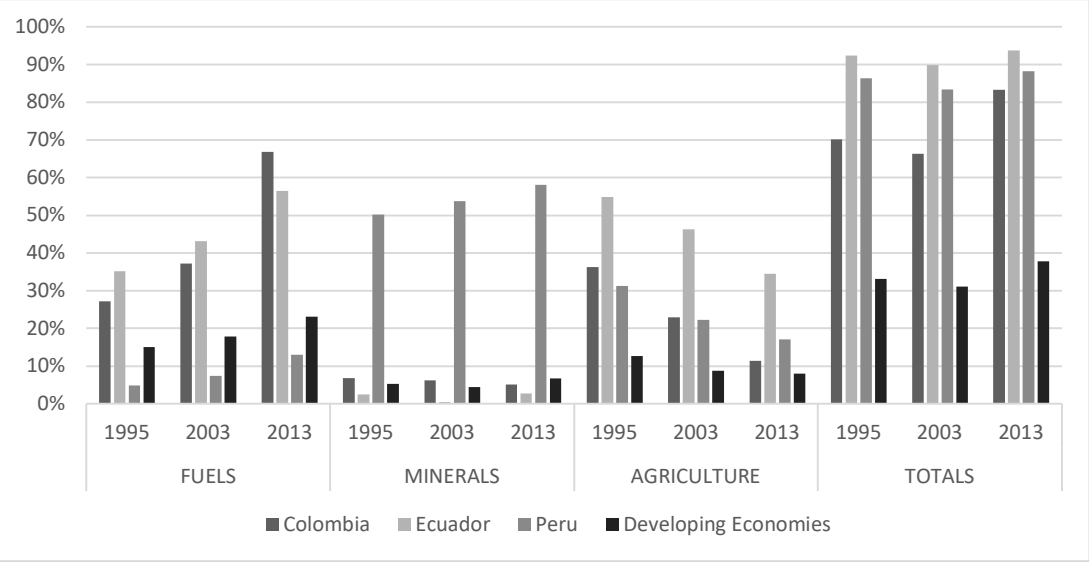
for South American nations. The plan was articulated to address the debt crises of Latin American Nations in the early 1980s when several countries of that region faced higher interest rates and lower commodity prices. "The basic tenets of the Brady Plan were relatively simple and were derived from common practices in domestic U.S. corporate [loan relief] work-out transactions: (1) bank creditors would grant debt relief in exchange for greater assurance of collectability in the form of principal and interest collateral; (2) debt relief needed to be linked to some assurance of economic reform and (3) the resulting debt should be more highly tradable, to allow creditors to diversify risk more widely throughout the financial and investment community." (Sachs, J. 1989). For an eloquent summary of The Brady Plan please visit https://www.emta.org/em-background/the-brady-plan/.

All in all, these three countries share several characteristics, yet the economic fortunes and misfortunes that have ensued are in stark contrast with each other. From my perspective this contrast merited further analysis along the lines of identifying which aspects of their trajectory resulted in a higher or lower perceived risk by their creditors and thus a divergent EMBI Spread.

Figure 1: Dependence on Commodities



Note. Adapted from Ocampo, J. (2017). Commodity-led Development in Latin America. In Carbonnier G., Campodónico H., & Vázquez S. (Eds.), Alternative Pathways to Sustainable Development: Lessons from Latin America (pp. 51-76). Table 4.1 Natural resource dependence of Latin American exports pages 57, 58. LEIDEN; BOSTON: Brill.

2.0 Introduction

This research focuses on the study of the causal relationships revealed by the analysis of macroeconomic fundamentals, sovereign bonds trading activity, and news sentiment as predictors of JP Morgan's Emerging Markets Bond Index (EMBI) spread for the countries of Colombia, Ecuador, and Peru. The risk of a country's sovereign bond has extensively been proxied by the literature as the spread or difference between the return of a specific country's EBMI versus the return of an equivalent maturity US Treasury security.

The time frame selected for this research (2000–2019) is the period following Ecuador's adoption of the US Dollar as its official currency (Mahuad 2021), an event that resulted in an ad hoc experimental setting conducive to the research of these three geographically neighboring, but more importantly, commodity-dependent countries (Ocampo 2017). Furthermore, the exchange rate policies of these three countries also provide an appealing contrast, ranging from non-existent (Ecuador) to managed exchange rate and inflation targeting policies as exhibited by Colombia and Peru (Libman 2019).

The yield and return of the sovereign bonds which comprise the EMBI are the results of the periodical variations in the marked-to-market pricing of these bonds, whereby the holding period return is affected by two concurrent factors. On the one hand, the expectations of default based on the actual and perceived track record of a country's overall economic fundamentals typically inform an investor via the ratings released by entities that analyze the sovereign risk of a specific issue (bond) and issuer (country). In addition, a bond's yield is also the result of transactions and

regular trading activity in the capital markets motivated by factors such as the liquidity of a security, daily foreign exchange rates affecting the issuer's currency, and any information which percolates to the news media about the country, all of which is commonly referred to as market sentiment (JP Morgan 1999).

As classified by Mari del Cristo and Gómez-Puig (2017), research attempting to identify the causes of country risk fall under three categories. In the first category, macroeconomic and political variables act as determinants of country risk, the second category emphasizes exogenous factors (such as market or investor sentiment, contagion effects, capital flows) as determinants, and the third and final group emphasize exchange rate regime as a determinant of country risk.

I performed OLS regressions of 14 independent variables covering these three categories of research against three variants of the dependent EMBI spread. From the literature reviewed, there appear to be three independent variables that constitute a differentiated contribution in the study of country risk determinants: endogenous risk and the impact of Twitter ® activity from both regular and financial news outlets. The literature provides extensive research about market sentiment; according to Gan et al. (2020), these studies can be categorized by the sentiment measure they use. Namely, measures of fundamental market variables extracted from textual sources and sentiment scores extracted from proprietary vendors such as Thomson Reuters MarketPsych ® and RavenPack ®.

In the first category of research, results for the three countries studied confirm the findings of the causal relationships between the level of indebtedness (positively affecting risk premium) and reserves (negatively affecting risk premium) to the EMBI spread, as revealed by Edwards (1986). Being a variability measure of

macroeconomic activity, I place the posited endogenous risk variable in this category, and it is only of relative significance for Ecuador, negatively affecting its level of country risk.

In the second category of exogenous factors, the results are mixed. Corruption levels positively affect Colombia's risk premium. Conversely, a positive business environment, not surprisingly, negatively affects its country's risk level. Peru's spreads are influenced by the liquidity of its traded debt issue.

Under the third category of exchange rate regime effects, the variable capturing the standard deviation of the foreign exchange rate positively affects the EMBI spread of Peru and Colombia while, as expected on account of the country's fixed exchange rate, having no relevance to Ecuador's country risk level.

Why The EMBI Index?

Beyond its broadly recognized visibility and use in the financial practice, the technical reasons for favoring the EMBI index as a benchmark of country risk is not the focus of my research. I do hone on the fact that the EMBI Spread, in and of itself, represents an after the fact variable simply derived as a distance to the US Treasury benchmark rate measured in basis points (1/100 of 1%), yet little can be gauged in terms of the underlying and complex causalities brought about by globalization from this measured distance to the US Treasury base rate.

As reported by Eatwell and Taylor (1998) and Merton, R., Billio, M., Getmansky, M., Gray, D., Lo, A., & Pelizzon, L., (2013), the beginning of this modern and complex process of financial globalization dates back to the early 1970s after the United States of America abandoned the binding of its currency to gold, what is widely

known as the Gold Standard (Bretton-Woods), thus promoting the adoption by some developed countries of a floating exchange rate for their currencies. In effect, this event transferred the exchange rate risk to the private sector. Since then, the interconnectivity of capital between regions has experienced an accelerated growth rate, thus elevating the risk of contagion from financial and banking crises between these regions (Eatwell & Taylor, 1998). This situation has increased volatility, and many have supported the thesis that such volatility is precisely the result of globalization (Calvo & Mendoza, 1997).

To discern the root causes of risk, academic efforts and private empirical analyses of practitioners from the consulting industry have attempted to define the risk level for the geographic destination of investment capital both in practical and scientific terms (Dincecco, 2009; García-Herrero, A., Ortíz, A., & Cowan, K., 2006). From a practical perspective and given its widespread use in the industry and financial media the JP Morgan Emerging Markets Bond Index (EMBI), Euromoney Country Risk, and the Bloomberg & Barclay's EM USD Aggregate index are all used as references of risk, specifically of country risk (JP Morgan, 2017; Euromoney Country Risk, 2017; Moody's, 2017; Fitch, 2017).

Presently, the financial markets and the variables that exert influence over them are evermore interconnected since capital travels between different markets with greater speed. The relationship between geographies and among the financial entities that comprise it is also budding in complexity. Furthermore, the advent of the internet, social media and the resulting impact caused by round the clock news cycle in this era requires a deeper understanding of the causality of these effects on the financial market variables (Matutinovic, I. 2010).

3.0 Hypotheses Tests

I set out to investigate hypotheses 1–5 described below. Hypothesis 2, 3, and 4 test variables of macroeconomic, political, exogenous (such as sentiment), and foreign exchange nature, while Hypothesis 1 (endogenous risk) and 5 (Twitter ® activity) separately capture the novel variables posited by this research.

Hypothesis 1 (Endogenous Risk). The results of the research were anticipated to reject the null hypothesis (H_0) that endogenous risk contributed no statistically significant predictive ability in the determination of either variant of the EMBI spread for the countries studied.

Hypothesis 2. A hypothesis test was also conducted concerning the quantitative, survey and perception-based macro variables, STARTING A BUSINESS and CORRUPTION. I anticipated a weak predictive ability from the latter, yet sufficient to reject the null hypothesis H_0 that both variables contributed no statistically significant predictive ability in the determination of the EMBI spread for the three countries studied.

Hypothesis 3. Positive hypotheses were also formed with respect to capital market attributes such as liquidity, captured by the bid–ask spread, AVERAGE PERIOD RATING captured by a credit-rating score, the changes in value of local currency (only applicable to Colombia and Peru, since Ecuador adopted the US dollar as its official currency at the onset of 2000), FX DepR_AppR, and the standard deviation of these exchange rates STD. DEV of F/X. The more flexible versions of the credit ratings and bid–ask spread metrics, characterized in the form of binary

qualitative variables, investment grade or not AVG. invest. grd. (1) or not (0) and traded or not TRADED = 1 NON-TRADED = 0, were hypothesized in the same light.

Hypothesis 4. This hypothesis reiterates the impact from the macroeconomic indicators (e.g., FDI/GDP, Debt Svce./GDP, Reserves/GDP) extensively identified as significant in previous seminal research about the determinants of country risk (Edwards, 1984, 1985, 1986).

Hypothesis 5 (Twitter ® Activity). I anticipated the results to accept the null hypothesis H_0 since both ALL Tweet and FIN Tweet were deemed to have limited explanatory powers to determine the variants of the EMBI spread.

4.0 Motivation behind the research

The EMBI and its family of indices, as well as its brethren Euromoney Country Risk and Bloomberg & Barclay's EM USD Aggregate, can be characterized as ex-post risk measures, since these indices depend on the performance of returns of sovereign bonds issued by the countries that make up the index and, consequently, of their transactions in the capital markets.

The above referenced indices convey information about the risk of a certain geography by inferring a level of risk because of the spread of their yield to the US Treasury return. As such, a country's greater or lesser risk is simply the difference between the returns demanded of that investment by the participants in the financial market when compared to the perceived risk-free return of a US Treasury issue. The motivation behind the research lies in attempting to understand these cause-and-effect relationships better instead of accepting them at face value.

The influences that result in a yield spread when compared to a risk-free rate were segregated into classes and components to determine the most influential group or set of variables. For this research, I divided these influences into five (5) main components, captured by the hypotheses tested.

The first component of influence is calculated based on the premise that each economic sector or activity represents a portion of all activities in the examined economy, which when considered together, conform a portfolio of the economic activities of the country as a whole.

The second component of influence contains macro, survey-based variables and indices, such as perception of corruption and ease of doing business

indicators, which affect the perceived value of character or goodwill –or lack thereof– of a nation.

The third component examined capital market desirability, whether by virtue of a credit rating or by the nature of trade (liquid or illiquid) of a sovereign debt instrument. Foreign exchange management policies are also examined as part of this third component. The fourth element examined fundamental macroeconomic indicators which have been used extensively to characterize country risk.

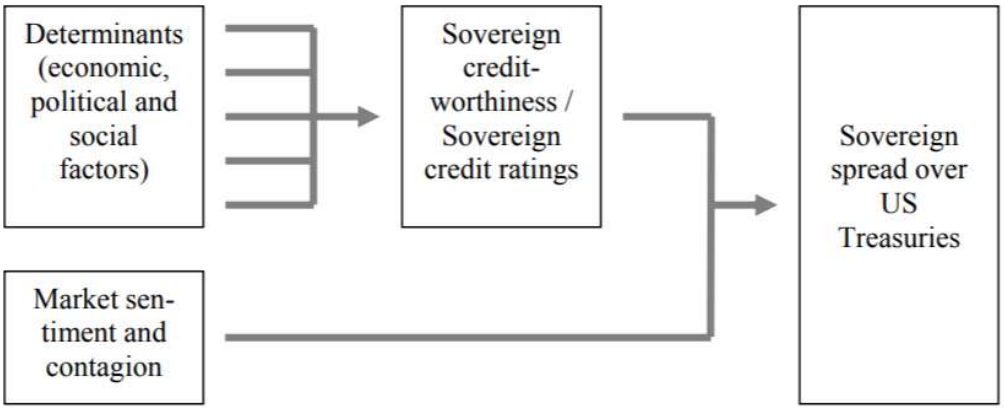
Finally, the fifth component attempted to identify what influence, if any, a specific social media platform (Twitter) has on the EMBI Spread. This latter measure is based on the notion that bonds and the countries behind them have brands and thus are subject to the impact of reputation and brand perception from investors. For this reason, all types of Tweets mentioning a country brand (ergo, Colombia, Ecuador, or Peru) for the corresponding period of analysis were tabulated to consider the impact they had on reputation. The notion being that an accumulated impact of Tweets from media sources extensively followed by investors of sovereign bonds (i.e. The Financial Times, The Economist Intelligence Unit), as well as Retweets and Likes about their Tweets, act as a seal of approval –or disapproval— much in the same way that a Rothschild or a Barings sponsoring bank acted in the past over a sovereign bond issue undertaken by these entities, effectively donning that sovereign issue with a lower yield than a sovereign issue sponsored by a lesser known or reputable intermediary (Flandreau, M., & Flores, J. H. 2009).

4.1 State of the Art –An Overview

Academic studies using macroeconomic relationships as independent variables which report the predictive capacity of the risk of default for a particular country abound (Cosset, J., & Roy, J. 1991; Vij, M. 2005; San-Martín-Albizuri, N., & Rodríguez-Castellanos, A. 2011). Thus, the analysis behind the decision to invest in this or that sovereign debt instrument is accompanied by thorough scientific and academic rigor about the underlying causes for default.

The article written by Rowland and Torres (2004) deftly describes these types of studies in Tables 2.1, 2.2 and 2.3 (their research paper) and then goes on to describe the theoretical framework in Figures 3.1 and 3.2 (also their research paper), adapted below (Figure 2) to portray a thorough representation of recent research along the topic of sovereign risk. The body of research in this area (sovereign risk, probability of default and spread to a benchmark rate) uses economic data, political and social factors, as well as market sentiment and contagion factors to measure the sovereign risk of a particular debt issue, as detailed by Figure 2. The referenced frameworks (Rowland, P. & Torres, J. 2004) are used as a building block to explore additional variables which seemingly have not been used in the context of sovereign debt instruments.

Figure 2: Theoretical Frameworks –Rowland and Torres (2004).



Note. Reprinted from "Determinants of spread and creditworthiness for emerging market sovereign debt: A panel data study," by Rowland, P., & Torres, J. L. (2004), *Borradores de Economía*; *No. 295.*, pages 17-18. Attribution-Non-Commercial-Share Alike 4.0 International (CC BY-NC-SA 4.0)

Closely related to the region of the countries of Colombia, Ecuador and Peru[2] studied in this research, and even before the Brady Plan, various risk of default analyses –the most prominent of them the seminal influential work by Edwards (1975)– were already trying to identify the variables that the empirical evidence suggested to be the determinants of the risk of non-payment for the countries whose debts were eventually restructured as part of the Brady Plan.

Later, Edwards (1986), empirical studies by the investment banking industry (Goldman Sachs, 2000), as well as central banks like Banco de la República-Colombia (Rowland, P. & Torres, J. 2004), and multilateral financial entities, like the World Bank Development Research Group (Min 1999), and the Bank for International

[2] Throughout this document the countries are referred to by their name or by their acronyms, COL (or COP when referring to the country's currency), PER (or PEN when referring to the local currency), and ECU.

Settlements (Kamin, S. B., & Von Kleist, K.1999) have all delved into the determinants of fair value and default risk probability of sovereign debt instruments. Most of these drivers of fair value and risk of default focus their attention on a time series of credit quality metrics along the lines of reserves to GDP and debt to GDP ratios, as well as capital market variables, such as liquidity and investment grade ratings of a particular sovereign bond. These time series are regressed against the actual EMBI spread, or some other similar measure of a distance to a base rate, as the dependent variable to determine their predictive ability of a metric.

Basis of Market Sentiment and Contagion

The Efficient Market Hypothesis (Fama,1960), EMH for short, posits that market efficiency be measured from three perspectives, the first and most basic form (called weak form) basically states that past behavior of securities prices fully inform current prices of securities. The second variant –referred to as semi-strong form— of the hypothesis gauges the timely impact on securities' prices of newly available public information. Lastly, the third, strong form variant of the EMH tests whether private, non-public information is reflected in market prices.

The underlying theory behind one of the research questions contributed by this dissertation boils down to understanding whether the EMH's semi-strong form postulated by Fama (1970) holds true, and to what degree (weak, semi-strong, strong) as the result of new information in the way of: (1) fundamental attributes: both qualitative (i.e., corruption perception, rankings and credit ratings) and quantitative (macroeconomic indices); (2) exchange traded attributes of sovereign securities, for

instance the fluctuations of foreign currency exchange rates of the issuers local currency, and the bid-ask spread for a particular sovereign bond issue; and/or (3) the influence of information broadcast through social media Tweets and Re-Tweets from relevant news media outlets.

Of significant interest to my research is the question of whether publicly available information broadcast through Twitter affects prices of sovereign bond securities or if this information is purely noise and consequently has neither real impact on the direction of the prices of said securities nor a predictive ability to forecast price and return variables. The regression results from Tweets and Retweets as independent variables (*Tables 1 and 2)* are not significant and dismiss the notion that Tweets or Retweets, whether from relevant non-financial or financial news media outlets, bear any significant impact on the yields of the sovereign debt issues studied.

Table 1: *Goodness of fit statistics (ALLTweet Accumulated Impact vs. AVERAGE EMBI Spread)*

	Colombia	Ecuador	Peru
Observations	289	301	292
R^2	0.003	0.003	0.055
Adjusted R^2	-0.00	-0.001	0.052

Note. For Larger data sets, biweekly accumulated impact of Tweets was calculated.

Table 2: *Goodness of fit statistics (FIN Tweet Accumulated Impact vs. AVERAGE EMBI Spread)*

	Colombia	Ecuador	Peru
Observations	286	225	292
R^2	0.015	0.000	0.055
Adjusted R^2	0.012	-0.004	0.052

Note. For Larger data sets, biweekly accumulated impact of Tweets was calculated.

Albeit the arguments that follow –which I did not research— are to be pondered when discerning the cause for the lack of significant impact on prices from

Twitter activity. First and foremost are the time frames of impact studied. The impact is measured by weighing the number of followers of a specific news outlet (Twitter handle), during a particular bi-weekly point in time, and computing a simple sum of the impact of *Tweets* by the number of *Likes* and *Retweets* caused by the original *Tweet*. Succinctly, the insignificant relationship of the model variables signal that new, publicly available information affects the prices and yields of sovereign bonds before the information makes its way onto a Tweet or Retweet, thus rendering the latter ineffective on the ensuing impact on prices and yields of sovereign bonds, since the previously revealed news will have already affected prices and yields. Conversely, the two other sources of information analyzed, macroeconomic and exchange traded activity, do inform the ability to predict prices and returns of the sovereign bond issues in question.

My research is approached by gathering information to shed light on the possible economic relationships to predict an outcome from these observed empirical data, what Friedman (1953) labels positive economics. A model tries to represent what is, not what ought to be from a dogmatic perspective. Thus, the models I portray, as is true with any regression model, can only capture a portion of the true relationships that inform the prices of securities. The hypotheses are established to discard the effect that new information emanated from a social media outlet –in the form of Tweets, Retweets and Likes— signals a timely change in prices and yields of sovereign securities. The precision of the model, gauged by its power to be an unbiased predictor of the dependent variable (in this case the yields of sovereign bond issues), is an abstraction of the real relationships between these variables. As such, fine tuning of the operationalization of the data could result in the same independent

variables becoming better predictors of the sovereign yield spread. This fine tuning was not performed, but it could very well be that the timeframe of measurable impact (i.e., modifying the biweekly measurement of impact to a different time frame for a more granular measurement of time and impact) affects the predictive ability of the model.

Still, as Fama (1991) relates in his sequel, Efficient Capital Markets II, market efficiency and the transmission of news (Tweets, Retweets and Likes in my research) to prices cannot be tested by itself. There must be some model of equilibrium, an asset-pricing model to jointly test the EMH. Here, I assume the spread to the US Treasury (dubbed simply *country risk* in financial jargon) as the basis to identify the true equilibrium price (in the case of the sovereign bond, the yield spread) of the sovereign bond security. The question thus remains, if the model and variables selected do not provide the desired predictability, is that the result of the spread to the Treasury being a poor gauge of relative risk or are the model independent variables at fault?

The advent of behavioral economics and finance –what Shiller (2003) calls finance from a broader social science perspective including psychology and sociology—provides a worthwhile perspective on the relationships between information, behavior, and the prices of securities (Shiller, R.J., 2003). The Efficient Market Hypotheses and Theory states that while markets are neither perfect nor totally irrational, they do provide reasonable rationality and efficiency in mulling information to provide price discovery of securities. Nevertheless, substantial noise is prevalent in the efficiency of securities' markets to have exposed EMH and this vulnerability provided an avenue of academic curiosity that incorporates behavior as a research

variable. Richard H. Thaler laid the groundwork in this field on his works titled *Advances in Behavioral Finance (Thaler, 1993)* and the sequel*, Advances in Behavioral Finance II (Thaler, 2005)* where he basically postulates that price behavior "entertains the possibility that some of the agents in the economy behave less than fully rationally some of the time."

One of the most recognized and time-honored theories about behavior is Feedback Theory which articulates the feedback loop or word-of-mouth (*Social Media like Twitter activity is the current version of word of mouth*) about the success or lack thereof of an investment provides in and of itself sufficient thrust (for a price increase) or drag (for a price reduction), thereby creating a price bubble or an unwarranted price devaluation. Yet, as well known as this theory is, it had not found its way onto financial academic research until recently, perhaps because the tales of speculation and bubbles like the Tulip Craze of the 17th Century were mostly the result of popular news media and dialogue, thus deemed unacademic.

Another prominent area of research in behavioral finance has been the Smart Money vs. Ordinary Investors argument. This area dissects one of the basic premises of EMH which says that all investors are rational. The supposition that all investors can perform sufficiently sophisticated analysis to wither away any irrational price behavior is divided into two driving forces in the market by the type of investor. Namely, a smart investor who can perform sophisticated calculations and the ordinary investor who follows a fad or a trend, the feedback theory investor, where the former offsets any irrational behavior incurred by the latter. Research in this area suggests that smart investors do not necessarily succeed in driving prices to fundamental valuations in the presence of irrational behavior from the ordinary investor. Anomalies

supported by the Smart Money vs Ordinary Investor argument which detract from EMH have been argued to offset with sufficient time, especially by Fama EMH author and proponent. However, skepticism about the efficiency of markets in general and EMH specifically, remains appropriately entrenched in current academic research (Shiller, R.J. 2003).

5.0 The Contribution of This Research

I analyze two novel variables in this research. The first relates to finding an argument to explain the country risk or the probability of non-payment or default, addressing the analysis from the context of Modern Portfolio Theory (MPT), based on the work from Markowitz, H. (1952), what I call Endogenous Risk. The second variable relates to understanding the effect of reputation through the interpretation of the possible social media impact on the credit spread of a specific country and this I dub Twitter Impact.

5.1 Endogenous Risk

The intention behind applying an MPT perspective attempts to contribute an explanation of risk that segregates its causes into those that are the result of the current structure of an economy and those that are not. This is accomplished in the same way that MPT treats risk by utilizing the *property of separation* for risky assets in the context of a portfolio of individual financial assets[3]. Therefore, an analysis that reveals the causes of risk, those inner causes, provides a reading on the endogenous risk of a country and could prove relevant with the intent to: a) establish public policies (such as levels of indebtedness), b) create incentives

[3] "Separation property: The property that implies portfolio choice can be separated into two independent tasks: (1) determination of the optimal risky portfolio, which is a purely technical problem, and (2) the personal choice of the best mix of the risky portfolio and the risk-free asset." (Bodie, Z., Kane, A., & Marcus, A. J. 2011).

to develop competencies (from a public investment policy initiative) in order to further a specific industry or activity and to disincentivize others, c) improve the capacity of a country to attract foreign investment for a certain industry (through the relaxation of levies and taxes), and d) to diversify the economic activities of a nation's economy.

Furthermore, the identification of an internal or endogenous risk variable also provides a technical context from which to project incentives that give rise to the nurturing of attributes that mitigate the referenced endogenous risk. This mitigation is necessary insofar as the change of the structural composition of an economy is not a task that bears fruit in the short-term and may not do so altogether, and perhaps is not sought after purposefully.

For instance, the over dependence to a specific sector may be difficult if not impossible to change overnight, because of the difficulty in changing the structure of an economy's activity profile in the short term, and also, because the incentives may simply not be there –Kuwait or Saudi Arabia and their reliance on Crude Oil comes to mind (https://www.weforum.org/agenda/2016/05/which-economies-are-most-reliant-on-oil/). Still, public policy could be directed to take measures that alleviate the dependence on a certain sector in order to act as a parachute in the case of the negative impact of the sector over which an economy is overly dependent. In this MPT context, the mitigation of risks adopted in the form of foreign currency reserves, low indebtedness and an overall soundly managed economy, would act in the same manner that a risk-free asset acts when considered as part of a complete portfolio.[4]

[4] "Complete Portfolio: The entire portfolio including risky and risk-free assets." (Bodie, Z., Kane, A., & Marcus, A. J. 2011)

In the context of Figure 1, this endogenous risk variable represents a contribution to the *Determinants* portion of the Theoretical Framework.

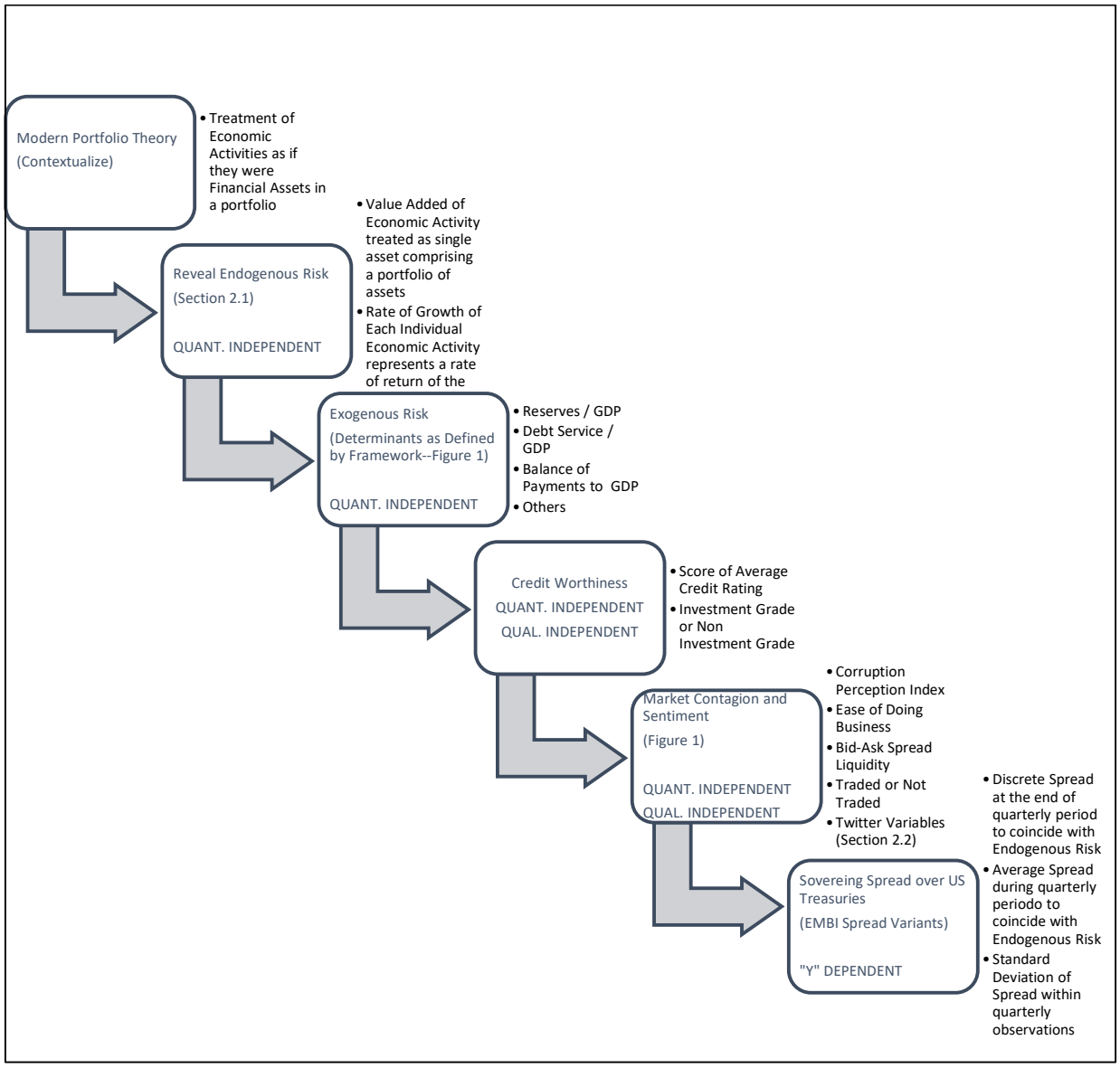
5.2 Twitter Impact[5]

The other novel contribution to the general study of the causes of credit spreads by this research is a variable that supplements the *Market Sentiment and Contagion* portion of the Theoretical Framework (Figure 2). This figure is the result of analyzing the population of Tweets mentioning the words Colombia, Ecuador or Peru for a given time period to coincide with the *Determinants* (Figure 2) portion of the examined data set for each of these countries. Twitter data was extracted directly from Twitter API (Application Programming Interface) through a third-party application named Track My Hashtag (www.trackmyhashtag.com). The measurement itself had to be defined from the information extracted to make it operational for the purpose of this investigation.

[5] Refers to the Social Media Platform Twitter (www.twitter.com) and the impact generated by its users on a country's name or brand and consequently theoretically affecting its cost of borrowing, ergo EMBI Spread.

6.0 The Research Question –A Pictorial Representation

Figure 3: Relationships studied in this thesis.



Note. QUANT.INDEPENDENT: Defined as Quantitative Independent Variables in Regression Analysis. QUAL.INDEPENDENT: Defined as Qualitative (Dummy) Variable in Regression Analysis. "Y" DEPENDENT: Predicted Dependent Variable in Regression Analysis.

6.1 The Research Question & Contextualization of Research

The basic purpose of this research is to determine the statistical significance of multiple variables, with a special focus on the two variables contributed by this research. Firstly, a unique and intrinsic measure of risk from the perspective and analytical framework of Modern Portfolio Theory (Markowitz) to provide a view that turns the gaze to a basic or fundamental attribute that defines that risk. Risk could then be described not only by traits of Economic, Political, Social, and Capital Market Factors, what Rowland and Torres (2004) refer to as Determinants and Market Sentiment and Contagion (Figure 2), but also from a deep-rooted risk calculation obtained from the variations and co-variations of returns of the industrial classification of activities from within a country's economy.

Another measure that sheds light on the outlined research question, rests on the context of specific risk and non-specific or systematic risk as defined by the investment finance literature (Sharpe, W.F. 1964). The general notion of specific risk defines that variable as the undiversifiable portion of risk when looked in the context of a complete portfolio of investments. The principle at hand here is one of diversification. In this context, rational investors participating in a market in equilibrium would only be compensated for the risks that cannot be mitigated through the diversification process of investment.

This research interprets this notion of a lack of diversification, whereby a higher cost of funds to a sovereign issuer (i.e., a larger EMBI Spread) is imputed by the investors and the market for not having attained a broadly diversified economy of its component industrial activities. To that end, a nation whose economic activity is

more diversified and less exposed to any single activity, the market would hypothetically warrant that sovereignty's bond issue a better cost of borrowing (*lower risk, thus return for the lender-investor*) when compared to that previously identified economy whose highly correlated activities would merit a larger cost of borrowing (higher risk, thus return for the lender- investor).

Furthermore, the context fits appropriately in my research effort for a country whose composition of economic activities is unavoidably, and longer term subjected to significant exposure to an economic sector (i.e., dependent on oil, or mining sector) and cannot, or does not wish to, diversify its economic activity in the short term. An economy with such characteristics would hypothetically reduce the specific risks borne by that reality by engaging in policies and managing its economy in a way that alleviates the intrinsic risk of a high correlation to one sector. Namely, such a country would theoretically pursue an environment of prudent fiscal and monetary policies that entail a proclivity towards higher reserves, lower levels of debt, and higher foreign direct investment, which would in turn require ease of doing business and low corruption, all themes would be pursued in order to lessen a specific sector's overabundant risk.

Concurrently in this contextualized investigation, there exist capital markets and transactional effects which a country could conceivably try to manage but which are largely the result of the appetite exhibited by investors in the capital markets for a particular sovereign bond issue. This appetite is determined by a proxy variable of Bid-Ask spread of transactions, where a narrower comparative spread means that the issue at hand is more sought-after, thus liquid, from the capital markets' perspective. Moreover, a prospection of transactions that reveals an absence of

spreads is logically concluded to have no trades. All these effects would necessarily have an impact on the magnitude of an EMBI Spread of a debt issue.

Lastly in this section, the impact of reputation or name recognition is contextualized. Recent studies have characterized this attribute as Popularity, thus the namesake of the model to price financial assets, the *Popularity Asset Pricing Model* (PAPM) (Ibbotson, R. G., Idzorek, T. M., Kaplan, P. D., & Xiong, J. X. 2018). Succinctly, this proposition hypothesis that more positive name recognition when analyzing investments, results in lower returns as a consequence of the investor paying a premium to attain that financial asset, and in so doing derives a lower return than had the investor placed his resources in an alternative, less popular financial asset where prices do not have a premium and thus the return, above and beyond the expected return, the *alpha,* is larger.[6] This effect, as is the case with the contextualization of specific risk above, would adopt the mirror image of the return argument based on the PAPM model. Namely, that a country's strong name reputation or popular sovereignty and bond issue would afford it a lower rate (thus a lower EMBI Spread) and consequently a lower return for an investor, than would otherwise be the case of a weak reputation or unpopular sovereign bond issue where the investor would earn a larger return and the country would, thus, pay a steeper cost of funds. This reputation could hypothetically be affected by social media and for the

[6] "Alpha: A stock's expected return beyond that induced by the market index; its expected excess return when the market's excess return is zero." (Bodie, Z., Kane, A., & Marcus, A. J. 2011)

purposes of this investigation, Twitter activity was tabulated and then computed to try and ascertain a quantitative measure of that reputational effect.

Reputation is concurrently affected by news or what has been dubbed by recent academic research as news shock (Dvorkin, M., Sánchez, J. M., Sapriza, H., & Yurdagul, E., 2020). In this line of reasoning, Twitter activity represents a modern form of news and information outlet and its impact on the EMBI Spread or probability of default is analyzed.

7.0 Theoretical Background & Foundation of Contributions: From Leontief to Markowitz

Wassily Leontief

The Input Output scheme proposed by Wassily Leontief in his seminal study to understand the interrelations of the US economy constitutes one of two underlying theoretical pillars for my computations of endogenous risk –the other being Markowitz Modern Portfolio Theory discussed later. Leontief's major contribution to the accounting of economic activity lies in the simplicity of his arguments. He treats the analysis of economic activity as if it were covered by an all-encompassing accounting system. This comprehensive accounting system involves framing a matrix of outputs and their corresponding inputs by type of activity, from which production (supply) and consumption (demand) curves are estimated simultaneously.

The tabulation follows a principle similar in fashion to an accounting double-entry system, whereby the entry on the input side is corresponded by an entry on the output side. One of the fundamental benefits of establishing this double-entry system for economic accounts lies in the fact that any entry identified on the input side but unaccounted for on the output side is simply tabulated as errors and omissions. Even if this omission is by no means insignificant in terms of relative value, it constitutes the basis from which to initiate further exploratory alternatives for the underlying reasons for unaccountability of a sector or segment and its units of account within an economy. Furthermore, this unaccountability of certain items does not preclude the main objective of the matrix analysis which is to "reveal the typical

productive and distributive interrelations which determine the structure of the national economy." (Leontief, 1936).

The basic assumption of Leontief's IO Matrix or model is that one unit produced needs other goods as inputs of production and as such establishes a relationship or interdependency between them. Each subsegment in an economy is both an origin and a destination of goods which are inputs in one section and become outputs in another section. This scheme functions, as the namesake of the model indicates, a matrix which is structurally consistent and thus considers the interdependency between its elements or cells within that matrix.

Leontief's IO model tabulates the goods or services with respect to its inputs and outputs and captures the nature of economic transactions and the original work contemplated tabulating them by type of business, separated into industries and even geographical distinctions to complete a *Tableau Economique.*[7] These transactions classified in whichever form chosen is fundamentally coherent as they always yield a consistent result. Namely, the aggregate of sector inputs is always the same as the aggregate of sector outputs. This leads to another useful aspect of the scheme which is the weighting or proportioning scheme of each sector, what Lahiri (2000) refers to as the coefficients or vectors of output, which establish the additive nature of an economy, meaning that the scheme represents the sum of the value added outputs classified by sectors of an economy. Succinctly, Input-Output analysis

[7] From French 17th century economist François Quesnay (1766) who established the relationships of an agricultural nation.

rests on the recognition that all the interconnections and relationships of economic activity can be characterized by a general solution of an extended system of equations in matrix algebra (Leontief 1965).

Beyond its academic achievement, Input Output economics' cornerstone triumph lies in its extensive use from the concept's very inception. The US involvement in World War II stretched the country's industrial capacity to its limits and the analysis of the interdependency of economic activity posited by Leontief was instrumental in providing a basis from which to procure and commit the necessary resources to reach the production targets put forth for war time capabilities. For instance, when President Roosevelt summoned the country to produce 50,000 airplanes, the managerial strain on the production of aluminum and its input components was partly alleviated by the IO Matrix developed by Leontief (1965). Furthermore, this work, often referred to as the Leontief Matrix, and its evolutions from static to dynamic IO matrices, form the basis of what is now known as the Social Accounting Matrix (SAM), a framework utilized throughout the world's economies to identify the aggregation of production classified by sectors (Lahiri, 2000).

Leontief's Matrix represents his finished product, yet for the contextualization of the endogenous risk variable used in my research I also draw from his forerunner or byproduct – I refer to the work as a byproduct because studying the works of a prolific academic, despite having the date of publication, one seldom knows whether the works were chronologically simultaneous or precursors of each other—*Interrelation of Prices, Output, Savings, and Investment* (1937). This publication theorizes the mathematical scheme which underpins the general precepts later captured by IO economics. At its most basic, Leontief's attempts to apply the

economic theory of general equilibrium or interdependence using empirical data to elucidate the interrelations between them through the computation of covariations of prices, outputs, investments, and incomes. He does so by identifying the appropriate theoretical basis, developing an appropriate analytical framework, and gathering information from factual quantitative data to be applied to that analytical framework.

I draw from Leontief's scheme in this work to establish a similar architecture of analysis from which to compute the endogenous risk variable for my research. As mentioned from the onset, the endogenous risk variable attempts to capture the inherent risk of an economy from a general equilibrium (interdependence) perspective by capturing the variability of growth of each economic subsector as it relates to every other sector and to the economy as a whole. Certainly, there are other attributes of risk which cannot be elucidated by a model and its variables, the intricacies of economic activity are by no means so simple. However, as Leontief (1937) himself expressed, it is hard to imagine how an alternative intuitive or common-sense approach to understanding the interrelations of an economy would yield a better explanation than a data driven model which tries to capture the essence of these relationships.

Markowitz (1952) draws from Leontief when theorizing about portfolio selection and the optimization function which evolved into Modern Portfolio Theory. His static approach to the value of securities and the selection process by a mean-variance analysis is fundamentally an input-output matrix applied to a more constraint universe of securities in a portfolio of the same.

Harry Markowitz

Markowitz (1952) has been recognized as the pioneer of what academia and practitioners widely recognize as Modern Portfolio Theory (MPT). The genesis of the concepts that supported him for the development of what at present day are considered key contributions to the understanding of the returns, diversification, and risk of securities and upon which Markowitz bases his analysis, can be seen in the essay that he wrote many years later entitled Trains of Thought (1993), which we will discuss further ahead.

From the turn of the 20th century, an argument with pronounced diligence and academic precision begins to be outlined dealing with the uncertainty of results and profits. Frank H. Knight's (1922) work establishes the distinction between mere uncertainty, which is a random result with no known probabilities, and on the other hand, the use of the known probability variable associated with ambiguity, whereby that attribute more accurately identifies a measure of uncertainty and today we define this as simply risk.

Likewise, in his work The Theory of Uncertainty and Profit J.R. Hicks (1931) expands on what Knight (1922) studied, whom Hicks describes as the pioneer in defining a line of thought around risk, upon which further scientific contributions can be built. Although Hicks (1931) agrees with the majority of Knight's (1922) claims, the former expands to the discussion of risk and uncertainty by developing the concept of risk reduction or redistribution in an entrepreneurial activity, in contrast with the sharp elimination of risk as suggested by Knight, a point on which these two authors differ. The forerunners of the concept of uncertainty and risk in the search for profit laid the

foundations for the discussion of the prolific period that would come thirty years later from the1950s onward.

As we referred to earlier, in his reflective essay Trains of Thought (1993) Markowitz gives credit for sowing the seeds of his earlier works, Portfolio Selection and Utility of Wealth of (March; April 1952), which are now renowned contributions to modern finance. These prior investigations deal with applications that model productive capacity with dynamic variables and with alternative production models, which in turn study concepts seen in Leontief's Input-Output Model (Leontief, W. 1951; Dietzenbacher, E. et al 2004). Markowitz (1993) also relates a Theory of Investment Value in this reflective essay, a book by John B. Williams (1938) which started the discussion around equity returns and their variations from statistical optics, building on the foundations of Knight (1922) and its "known probability of risks." Williams' book refers to how the prices of the securities are only the present value of expected returns, a concept that is now evident, but that at that time led to an enriching discussion that infected the world with the fundamental or intrinsic value of securities.

The anecdotes that Markowitz recounts in his essay confirm the close ties that exist, from the onset of research efforts in this field, between modern finance –understood as the application of economic theory to explain the phenomena in the capital markets– and economic theory. These modern finance research efforts were pursued to better understand the behavior of individuals in the face of financial investment decisions and the risk that inevitably accompanies them, that is, to borrow Knight's (1922) definition, decisions about obtaining wealth in an environment of uncertainty with known probabilities.

The referenced works, Portfolio Selection (PS) and Utility of Wealth (UW), detail the decisions that rational individuals would make regarding risk variables, defined as the dispersion with respect to the expected value, and the expected return itself (PS) contrasting these with the risk aversion (UW) of each individual. In the case of the optimal selection of the components of a portfolio of risk assets, Markowitz (1952) details a model where ideal and dominant positions or proportions are calculated based on a basket or portfolio of securities that includes all the possibilities of risky assets. Succinctly, it eliminates the possibility of an isolated analysis of securities or investments since the associative statistical metric, the covariance, is the most relevant, Markowitz argues, when measuring the risk contribution of an individual asset to a portfolio or set of risky assets. Markowitz (1952) intertwines his works of PS and UW since to the latter he adds a utility function (factor) that would govern as a constraint or limiting variable for an optimal selection of risky assets.

Later works complementary to those referred to by Markowitz (1950; 1952) would be carried out separately by both William F. Sharpe (1964), the most prominent and notorious of them, and John Lintner (1965) and Jan Mossin (1966), when developing a model of financial asset valuation based on Markowitz (1952), for which all three receive credit. Perhaps less recognized, but equally important in this field, is the chronologically earlier work of James Tobin (1958) to which I will return later.

Sharpe, Lintner and Mossin develop a risky asset valuation model, the widely recognized and frequently reviled CAPM (Capital Asset Pricing Model). Recognized because it represented a synoptically valuable contribution through assumptions, among which the most relevant is equilibrium. Namely, the model

hypothesizes that the market portfolio “M” is efficient in the classic dimensions of expected value of returns and variance (mean-variance efficient), and the other assumption of homogeneous expectations, which states that investors share common beliefs and therefore, the appropriate level to value those assets consisted of just these two dimensions, succinctly, the expected return or return on the asset and a coefficient known as the Beta (ß) that relates it to the common risk of all assets in this set –the market risk.

In contrast, the CAPM has detractors because those same assumptions that constitute the bases that support the model are unrealistic and do little or nothing to help explain the expected return of the analyzed asset when changes in the market dimension or market capitalization are introduced in the analyzed risk asset (Fama, E., & French, K. 1996). Subsequent articles from Fama & French (1996) emerge from time to time, with equally suggestive titles questioning the vitality of the Beta, hinting at the key variable in the model (Hsia, C., Fuller, BR, & Chen, BYJ, 2000; Timpano, J., & Bacon, F. 2012). What is undeniable, is that despite its multiple detractors, CAPM is still used today by practitioners and academics, and is an essential part of any university curriculum in the world of finance. Perhaps the most appropriate quote which could very well define criticisms to the CAPM, attributed to the late Milton Friedman (1953), who explained, “a model should be judged on the power of its predictions, not the realism of its assumptions.”

Returning to the investigative contribution of Tobin (1958) only mentioned in passing above, this research deals with the preference of liquidity as an essential behavior of an investor to compensate for risk. Tobin (1958) uses John M. Keynes’s (1937) concept of liquidity preference theory and proposes what is known as

the separation property, which indirectly contributes to the CAPM model, giving it an anchor or starting point about the asset with a Beta equal to zero (0) or without risk (the risk-free asset).

There has been a substantial evolution resulting from empirical and academic research in the field of business and risk. From an entrepreneurial perspective with intentions of profit, the questions that at the inception of this field of study arose around the unknowable or what Knight (1922) coined as "the Uncertainty of Profit," to the present date in what is widely known as the risk of investments or invested capital. This area of research, presently, derived into a broad and exhaustive practice whose results and parameters are thoroughly studied and even taken for granted when these topics are addressed. Specifically, widely used terms like diversification of investment risk and cost of capital did not even exist less than a century ago, yet today are part of everyday news cycles and business activity.[8]

7.1 Sovereign Debt and The Conjectures About Its Risk

Sovereign, or government, debts are significantly older financial instruments than other high-risk assets, such as stocks. In his book The Ascent of Money, Niall Ferguson (2008) pegs the birth of the debt bond market during the Italian Renaissance period, where sovereign debt was used to finance the defense or expansion of territories, governments, and kingdoms in the mid-fourteenth century. Long-term public debt first emerged in Europe's autonomous smaller cities rather than

[8] Pablo Fernández (2007) makes a very complete comparison of all the methods and authors that are applied today both from the academy and from the financial practice to determine the cost of capital and its components.

in the larger territories. Tuscan city-states such as Florence, Pisa, and Siena financed their wars through loans from their inhabitants. City states were considered more creditworthy than larger territorial states and were thus able to access a lower interest rate. The Dutch Republic was the first territorial state which was able to obtain similar conditions to the smaller city states (Stasavage 2016).

Since the inception of debt instruments, the causality behind differing borrowing rates for distinct sovereignties has been empirically analyzed in an attempt to establish the attributes which determine the varying conditions faced by sovereign borrowers. For example, Dincecco (2009) suggested that the type of political regime, fiscal management, as well as cultural attitudes towards the responsibilities of an indebted country or territory were determinant variables for the probability of default. At the cusp of the modern era of finance, defined as the period after the gold standard was abandoned (Eatwell and Taylor 1998), empirical quantitative analyses of macroeconomic variables and indices have been conducted to establish the underlying causes of sovereign risk and their probability.

Since the mid-1970s, there has been a significant expansion of research around sovereign debts and the variables that determine their probability of default, especially of the countries now defined as emerging markets, more specifically Latin American nations. These countries came to represent 71% of the volume of debt which constituted the EMBI of JP Morgan (2017), which likely resulted in the incursion of this field of research for authors like Edwards (1984) and Grandes (2007), with close ties to the Latin American region.

The most visible works in this area come from the professor at the University of California Los Angeles UCLA, Sebastián Edwards (1984; 1986), and

Jeffrey Sachs (1982), Eaton, J., & Gersovitz, M. (1980) and Feder, G and Just, RE (1977) who analyze multiple regression models, postulating time series of macroeconomic indicators deduced as the foundations of the determinant of the differential or spread between a base rate (*at that time the LIBOR rate, today this spread is calculated between the yield on the sovereign bond and the current issuance of the North American Treasury bond*) as independent variables of the model, and the debt rate of the lesser developed country (LDC), this spread being the dependent variable. The authors Homi Kharas (1984) and Steven B Kamin and Karsten von Kleista (1999) analyze the risk of the debts of the lesser developed, developing or emerging countries –depending on the time frame studied these were the terms coined to define those countries– from the mid and late 1980s and until the end of the last century. In the latter, the authors separate the effects of the Brady Bonds to include other types of debts to countries that are not considered developed economies.

Parallel to this effort of academic nature surfaced similar studies from practitioners such as Goldman Sachs (2000) and their explanations about the determining variables of the spread. Goldman Sachs produced a model dubbed the GS-ESS (Goldman Sachs Equilibrium Sovereign Spread) which builds on the elements studied by Edwards (1986) to explain the yield spread. The achievement and valuable contribution from Goldman Sachs (2000) in this model is that it groups macroeconomic variables and indices, thus simplifying the work of Edwards (1986). Finally, already in this millennium Martín Grandes (2007) makes an analysis of historical prospecting about the determinants of yield spreads in Latin America, specifically relating the empirical evidence from Mexico, Brazil, and Argentina.

The academic curiosity which gave birth to this research thesis results from the prospection of bibliography and state of the art of the determinants of sovereign risk, where there is a notable absence of applications of MPT precepts on sovereign risk spreads. The use of MPT has a broad footprint, because at its most basic represents an optimization model with at least two opposing constraints. In the case of Modern Portfolio Theory these are variance and expected returns.

As an example of the broad scope of applications of MPT, Neumann, T., Ebendt, R., & Kuhns, G. (2016) use this theory to investigate traffic patterns using two-plane weighted averages – just as MPT does in the variance-return planes — the travel time or route and the speed thereof, thus optimizing these variables with a classic optimization approach. "Markowitz portfolio theory for soccer spread betting" by Fitt, A. D. (2009) is the title of a research paper that represents another equally fascinating example of the scope and dispersion of MPT's application in a field that transcends the borders of finance and securities, although it is attempted from a mathematical perspective.

Despite these particularities, which I refer mostly as an anecdote, no further evidence has been found of the application of the MPT approach to determine the relative risk of one country against another in any extent. This is not to imply in any way – it would be arrogant to do so – that the investigative and analytical techniques applied by Markowitz and his successors have not been used in the whole of academia to characterize the risk of sovereign debt securities. Descriptive, associative, and predictive statistics and regressions are the essence of the analysis of economic and financial phenomena, however, as was previously alluded to, a model

that specifically uses a similar optimization model as the one applied in Markowitz's Portfolio Selection (PS) (1952) were elusive to the author of this research.

7.2 Reputation: Beyond Intrinsic and Endogenous Risk

For nearly two centuries reputation and brand name recognition have lied at the center of the discussion of risk, more specifically of increased costs of borrowing. As indicated by Flandreau, M., & Flores, J. H. (2009), in the context of sovereign borrowings a good reputation and thus improved borrowing conditions were closely tied to the standing of the intermediary used when syndicating a country's debt. The borrowings channeled to investors through the likes of a Rothschild or Barings in the past had comparatively better conditions than those loans that were not sponsored by these staples of the loan syndication scene.

Reputational effects like the one described, which were understandably tied to the reputation of the sponsoring or *tombstone*[9] institution behind the credit facility, could have hypothetically been replaced by direct inferences made by the investor about the quality and thus rate or return expected of the investment at hand. This superior standing effect would be characterized as momentum in the capital markets. A momentum change in price is the result of "attention-causing events" which attract interest to a particular security and consequently increases its price through enhanced liquidity and/or trading activity (Ibbotson, et. al. 2018) without regard to the fundamental aspects of said security.

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[9] Tombstone was an advertisement required of the sponsoring entity by the Securities Act of 1933 after a new security issue had been floated or sold to the market (Geisst, C. R., 2014).

In the context of a traded security, the effect of an improved price, resulting from the enticing nature of the event, provides a lower return to the investor who got caught in the frenzy of the attention causing event. The opposite is also true, a security which is not attracting attention would logically have a depressed price and thus provide a larger than expected return to the investor who purchased that security. This effect is what Ibbotson, et. al (2018) have coined as the Popularity effect and where they derive the Popularity Asset Pricing Model (PAPM).

If this same logic is placed in a mirror image and the sovereign debt instruments are considered in this context, one could surmise that a popular debt security, influenced by some attention causing event, could provide a lower return and thus a lower cost to the issuer of that security, and the alternative is also true, providing a higher cost to the issuer of the sovereign debt security.

8.0 The Research: Definition of Variables and Regression Analysis

8.1 Dependent (Y) Variables

EMBIG – Spread – EMBIG (basis points): The EMBIG (Emerging Markets Bond Index -Global) Spread was retrieved for the three countries subject of this study from "Banco Central de Reserva del Perú" (n.d.) for the time series beginning in the year 2000. This is the most basic definition used in this research and it is simply the observable spread to coincide with the end of a quarterly period of industrial economic activity studied for each country. For example, in the case of Ecuador, the quarterly industrial economic activity is analyzed beginning with the first quarter of 2000 and thus the first observation of this independent variable is the EMBIG Spread for Ecuador observed on March 31, 2000, the last day of the first quarter. In case the last calendar day of a quarter corresponded to a day without trading activity or simply where the spread was not observable, the spread of the day immediately preceding it was used.

AVG. EMBIG – Spread – EMBIG (basis points): Calculated from EMBIG – Spread – EMBIG (basis points). The simple average of the observed daily spread for the quarter, to coincide with the quarterly industrial economic activity studied.

Std Dev of bp SPREAD in the same period: Calculated from EMBIG – Spread – EMBIG (basis points). The Standard Deviation of the Sample of Observations of the daily spread for the quarter, to coincide with the quarterly industrial economic activity studied.

Recent research suggests that the CDS (Credit Default Swaps) spreads better represent the default probability of sovereign debt (Rodríguez, I. M., Dandapani, K., & Lawrence, E. R., 2019), especially focusing on oil exporting or commodity based economies, like the three countries studied (Naifar, N., Shahzad, S. J. H., & Hammoudeh, S., 2020), yet these swap contracts are relatively recent phenomena and as such were discarded in favor of the EMBI Spread, a longer running and well established data series.

8.2 Independent (X) Quantitative Variables

ALL Tweets (*variable contributed by this research*): Tweet (from Twitter) activity was chosen as a research variable for this study as it is one of the most widespread and internationally disseminated social media platforms (Pastel, R. 2019). This social medium began activity on July of 2006 (Arrington, M.) and approximately a year thereafter hashtags were ubiquitously adopted.[10] Information was extracted from the Twitter API, through a third-party application named www.trackmyhashtag.com and by searching the hashtag (#) Colombia, Ecuador and Peru. In so doing, Twitter activity from prominent media sources mentioning the country's name was extracted in order to determine if reputation, a form of momentum, affected sovereign security prices, and consequently yields and EMBI Spreads of a particular country. An example of the

[10] Refers to the use of the hash (#) symbol – also known as the number or pound (in the USA) symbol—before a term or group of words with an attempt to track consolidated social media activity around that term's utilization.

information activity extracted is exhibited in Table 3. The news media outlets selected were determined by their credibility (Glader, P. 2017). [11]

Table 3: *Twitter Activity for #Ecuador from 2007-2019*

Name of Media	Screen Name (Twitter Handle)	Retweets Received	Likes Received
BILD	@BILD	170	225
Bloomberg	@business	6,105	5,879
Chicago Tribune	@chicagotribune	613	333
Daily Mirror	@DailyMirror	378	252
EL PAÍS	@el_pais	53,124	39,322
Financial Times	@FinancialTimes	2,223	2,224
The Boston Globe	@BostonGlobe	695	495
The Economist Intelligence Unit	@TheEIU	98	56
The New York Times	@nytimes	26,163	31,894
The Sun	@TheSun	219	181
The Sunday Times	@thesundaytimes	1,649	3,072
The Wall Street Journal	@WSJ	5,466	4,140
The Washington Post	@washingtonpost	6,152	8,460
TIME	@TIME	4,768	3,471
USA TODAY	@USATODAY	2,259	1,628

Source: Twitter, Inc., Twitter API (Application Programming Interface). Extracted with Third Party Application www.trackmyhashtag.com.

Tweet Impact Explained

The simple extraction of activity on the social medium Twitter was not enough since the operationalization of this variable, adopted to try and ascertain the impact of reputation on a country's EMBI Spread, needed refinement to be regressed against the observed dependent variable. For this reason, Tweets were first divided by origin

[11] Media outlets were selected from the referenced article (Glader, P. 2017) and from the author's experience and judgment regarding the potential impact from reputation on the studied variable.

of media, between those coming from financial media (FIN Tweets, defined later) and those from general news media (ALL Tweets, defined here).

Furthermore, each one of the media outlets studied had several Followers (a captive audience). The underlying hypothesis to be tested by this variable was that a larger captive audience would consequently create greater impact of reputation. Whether this impact is negative, positive, or non-existent, was not deemed of relevance to operationalize this variable, since the regression results would shed light on that determination.

The operationalized variable was arrived at by weighing the number of *Likes* and *Retweets* and summing this figure in the numerator, and later dividing it by the number of *Followers* of the media outlet at the moment and time of a particular Tweet containing the hashtag of the country's name. The weights of a *Like* and *Retweet* were determined by prospecting research work by Meier, F. et al (2014) around the behavior of users of the social media and the level of importance given to a both activities. Reasoning from this review, a *Retweet* was given twice as much importance as a *Like* in terms of the impact it could have. Finally, this proportional (# of Followers) was added for period studied to coincide with the economic activity data of the country and the observed EMBI Spread. The notion here being that the effect of the impact on the dependent variable could be surmised from the appropriate observations of impact.

Table *4*: *Twitter Impact Computation: An example*

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Date of Tweet	**Twitter Handle or Account Name**	**Text of Tweet Containing the Country's Name**	**Twitter Account Followers on Date of Tweet**	**Likes[1] (33%)**	**Retweets[1] (67%)**	**Twitter Impact**	**Proportional Impact [2]**	**Accumulated Sum of Proportional Impact**
						(5)x(33%) +(6)x(67%)	**(7)/(4)*1000**	
2/01/2020	@business (Bloomberg)	*"Mining giant Anglo American will pour its excess cash into mines in Peru and the U.K. https://t.co/K4Me34EfoU"*	5.9 million	200	1400	600	1.01^{-4}	1.01^{-4}
2/15/2020	@business (Bloomberg)	*"Peru's central bank keeps borrowing costs unchanged at a nine-year low https://t.co/d1WqJl8S6Y"*	5.9 million	800	1700	1100	1.86^{-4}	2.87^{-4}
3/01/2020	@business (Bloomberg	*Peru plans to stay out of international debt markets for now, sitting out a trend that saw neighbors from Mexico to Chile selling bonds this year https://t.co/0LbSRP4Z06*	5.9 million	1100	1800	1333.33	2.25^{-4}	5.13^{-4}

Note 1: The weight of Likes and Retweets follows the logic laid out by Meir F., et al (2014) around the conduct of users. The main notion behind the logic is that there is more credulity (and hence more weight) attributed to a retweet than a like.
Note 2: The Proportional impact computation was simply multiplied by a factor of 1000 to make the figure more manageable as an eventual regressor / predictor of an EMBI spread as per my research hypothesis.

Table 4 above further elaborates on the explanation of the computation utilized to glean the potential impact of Twitter activity on the EMBI Spread of a country's sovereign debt issue. The notion behind the computation of the last column (Accumulated sum of proportional impact) draws from the concept of a Gross or Target Rating Point (GRP or TRP in publicity jargon), a measurement of the reach of advertising or commercial messaging to a general (GRP) or homogenously classified

(TRP) group of consumers, eventually also classified by a persuasion or specific messaging instrument (referred to as PRP), i.e. a television, radio or other piece of advertisement in a non-traditional medium of communication (Findley et al 2020). In this context, the Tweet or the 140 character message from a prominent news source represents the messaging instrument and its impact or GRP equivalent.

In a commercial context where a product or service is promoted the effect of the message is measured by the eventual impact on the quantity or the change in the rate of quantity demanded by the consumer of the product or service, which is reliably attributed to the advertising instrument. In the financial context of my research the impact of the message would be evidenced by the increase or reduction of the EMBI spread, or relative measure of perceived risk (price of risk) caused by the message itself. It stands to reason to assume that an accumulation of impacts could cumulatively influence the EMBI Spread at the end or after a latency of impact has transpired from the broadcast of the message until a point in the future. This latency of impact has been arbitrarily defined as a 2-week period during which the effect is measured to contrasted with the level of the EMBI spread.

FIN Tweets (*variable contributed by this research*): Twitter activity extracted in the same manner explained for the ALL Tweets variable (above), but from financial news media outlet activity on Twitter. Specifically, Bloomberg ®, Financial Times ®, The Economist Intelligence Unit ®, and The Walls Street Journal ®.

Std. Dev. = Endogenous Risk (*variable contributed by this research)*: This variable was the main motivation behind the research undertaken for this thesis. As previously mentioned in the Endogenous Risk section, the academic intuition to operationalize this variable was to treat economic activity by industrial segments as if they were individual assets comprising a portfolio of assets, and apply the Portfolio Theory (Markowitz, H., 1952) to the analysis.

From that perspective, two options were considered. Firstly, one could utilize the value of capital in place – the result of capital formation or build up— for each individual industry to discover the return provided by those assets. This alternative was discarded for lack of comparable information and the complexity involved in determining the net return of each industrial activity across countries. Instead, the Value-Added of economic activity, classified with an ISIC (International Standard Industrial Classification) Structure provided a comparable basis from which to calculate the variability of an economy resulting from the interactions of each industry within it, a variable coined Endogenous Risk (United Nations. Statistical Division, 2008).

The following steps were taken to operationalize the Endogenous Risk independent variable:

1. For each country studied the longest available quarterly time series of Industrial Economic Value-Added Activity was retrieved (Table 5).

2. From the above information, the quarterly rate of change of each industrial activity was calculated. This calculation is analogous to calculating the rate of return from a time series of security prices.
3. Consequently, covariance and correlation matrices of these rates of change were calculated.
4. Each quarterly industrial economic activity was weighted to represent its proportion to the total economic activity. This calculation is analogous to calculating the proportion of a financial asset to the total assets in a portfolio of the same.
5. Utilizing the covariance matrices, the contribution of each individual industrial economic activity's quarterly variance of returns to the total variance of the whole of the economy was calculated, based on its respective weight.
6. The square root of the variance for each quarter resulted in the Standard Deviation or Endogenous Risk of each quarterly return for the economy, and this is the observable independent variable used in the regression against the variations of the EMBI Spread time series.

Table 5: *Country Quarterly Economic Activity in Current US$ Value Added per Industrial Sector*

Quarters 1-N	Sectors of the Economy[1]								
	A	**B**	**C**	**…**	**R**	**S**	**T**	**U**	**Total Economic Output per Quarter[2]**
1	a_1	b	c	…	r	s	t	u	$\sum_a^u 1$
2	a_2	b	c	…	r	s	t	u	$\sum_a^u 2$
3	a_3	b	c	…	r	s	t	u	$\sum_a^u 3$
4	a_4	b	c	…	r	s	t	u	$\sum_a^u 4$
N	a_N	b	c	…	r	s	t	u	$\sum_a^u N$

Note 1: Economic Sector as defined by International Standard Industry Classification (ISIC), sectors A-U
Note 2: Represents the sum of all economic activities, A-U (granularity depends on data availability) for the quarter.

In Table 5 above, the sum of each row is considered the total value of activities A through U for the quarter in question. Also, each segment or sector of the economy is represented by the value of each cell of the matrix. For instance, a_1 is the value added of industry A in quarter 1.

The total value of each row is treated as if it were a portfolio of securities (industrial activities A-U), and the value of each cell in the matrix as if it were the value of a security contained in that portfolio at the end of each quarter. As such, the weight of the sector in the economy is calculated simply by a_N divided by $\sum_a^u N$. This contextualization of Modern Portfolio Theory (MPT) provides the groundwork to calculate the variable of endogenous risk posited in my research.

From this basic matrix, the rate of change of economic activity per sector is calculated for each period of analysis (up to 20 years and 80 trimesters for the study period ranging from 2000-2019). The calculation produces a computation comparable to a holding period return (HPR) for a security as performed under Markowitz's MPT construct, such that the expected value of the rate of change is computed for each sector A-U with the simple mean of the quarterly observations of the rate of change, such that:

IF: Holding Period Return $HPR = \frac{P_t}{P_{t-1}} - 1$

WHERE P_t = *Price at time t*

THEN, from Table 3, the rate of change of quarterly activity = $\frac{a_2}{a_1} - 1$

With the expected value for each sector, the computation of the variance and covariance of the same is obtained, which in turn, when weighed by the relative magnitude of each economic sector in the economy, results in each sector's variance contribution to the total variance of the economy. The final computation is a mean-variance-covariance matrix which sums all its cells and provides a total variance of the quarterly variation of economic activity, from which a risk profile (variance and standard deviation) is gleaned for the quarter in question.

Table 6 below exemplifies the endogenous risk computations for each quarter for all three countries, Colombia, Ecuador, and Peru. This calculation provides one (1) quarterly observation of endogenous. In all, for the three countries studied, I performed 178 computations of quarterly endogenous risk matrices. The risk profiles

or evolution of endogenous risk is depicted by Figures 4-6 for all three countries subject of this study.

Table 6: *Calculation for each observation of endogenous risk.*

Sector of Economy → / Weight of Sector ↓		A	B	C	D	E	F	G	H	I	J	K	L
		8.1%	8.2%	17.5%	3.8%	4.1%	17.9%	4.3%	3.7%	10.8%	5.6%	13.4%	2.6%
A	8.1%	2.2E-05	4.4E-05	2.4E-05	2.2E-05	3.3E-05	2.6E-05	2.5E-05	2.6E-05	2.4E-05	3.2E-05	3.2E-05	2.6E-05
B	8.2%	4.4E-05	6.2E-04	2.0E-04	1.1E-04	1.4E-04	7.5E-05	2.1E-04	1.6E-04	1.4E-04	1.7E-04	1.1E-04	1.5E-04
C	17.5%	2.4E-05	2.0E-04	1.3E-04	3.7E-05	1.8E-05	1.8E-05	1.1E-04	1.2E-05	4.9E-05	2.2E-05	2.3E-05	4.1E-05
D	3.8%	2.2E-05	1.1E-04	3.7E-05	4.7E-05	7.3E-05	5.1E-05	4.6E-05	6.1E-05	4.5E-05	7.5E-05	6.5E-05	5.4E-05
E	4.1%	3.3E-05	1.4E-04	1.8E-05	7.3E-05	2.5E-04	1.3E-04	5.2E-05	1.6E-04	8.3E-05	2.2E-04	1.8E-04	1.2E-04
F	17.9%	2.6E-05	7.5E-05	1.8E-05	5.1E-05	1.3E-04	8.3E-05	3.7E-05	9.1E-05	5.3E-05	1.3E-04	1.1E-04	7.1E-05
G	4.3%	2.5E-05	2.1E-04	1.1E-04	4.6E-05	5.2E-05	3.7E-05	1.1E-04	4.3E-05	6.0E-05	5.7E-05	5.1E-05	5.8E-05
H	3.7%	2.6E-05	1.6E-04	1.2E-05	6.1E-05	1.6E-04	9.1E-05	4.3E-05	1.4E-04	7.4E-05	1.6E-04	1.2E-04	1.0E-04
I	10.8%	2.4E-05	1.4E-04	4.9E-05	4.5E-05	8.3E-05	5.3E-05	6.0E-05	7.4E-05	5.8E-05	8.7E-05	7.0E-05	6.6E-05
J	5.6%	3.2E-05	1.7E-04	2.2E-05	7.5E-05	2.2E-04	1.3E-04	5.7E-05	1.6E-04	8.7E-05	2.2E-04	1.8E-04	1.2E-04
K	13.4%	3.2E-05	1.1E-04	2.3E-05	6.5E-05	1.8E-04	1.1E-04	5.1E-05	1.2E-04	7.0E-05	1.8E-04	1.7E-04	9.3E-05
L	2.6%	2.6E-05	1.5E-04	4.1E-05	5.4E-05	1.2E-04	7.1E-05	5.8E-05	1.0E-04	6.6E-05	1.2E-04	9.3E-05	8.2E-05

Sum of the matrix equals its Variance = 1.27E-02. Observation of Standard Deviation (square root of variance) for the quarter = 11.2546%

The original endogenous risk variables calculated (Figures 4, 5 and 6) clearly showed a drift or unit root possibility and for this reason I subjected the endogenous risk time series to an ADF test whereby the unit root would be eliminated by differencing and lagging the time series. Performing this task was only relevant for the country of Ecuador since only for that country's ultimately selected regression model was the endogenous risk independent variable of significance (Table 7).

Table 7: *ADF test for non-stationarity time series of Endogenous Risk*

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Country	Tau-statistic	Tau-critical value	Stationary	AIC	BIC	Coeff.	P-value
Colombia	-1.260	-1.946	no	-9.844	-9.732	0.00246	>0.1
After ADF	*-10.206*		*yes*	*-9.947*	*-9.833*	*3.286*	*<0.01*
Ecuador	-0.645	-1.945	no	-7.527	-7.496	-0.0774	>0.1
After ADF	*-7.271*		*yes*	*-10.899*	*-10.669*	*-5.084*	*<0.01*
Peru	-1.133	-1.947	no	-10.139	-9.708	-0.0058	>0.1
After ADF	*-3.053*	*-1.948*	*yes*	*-10.169*	*-9.681*	*-15.677*	*<0.01*

Figure 4: Colombia Endogenous Risk Before and After ADF Correction

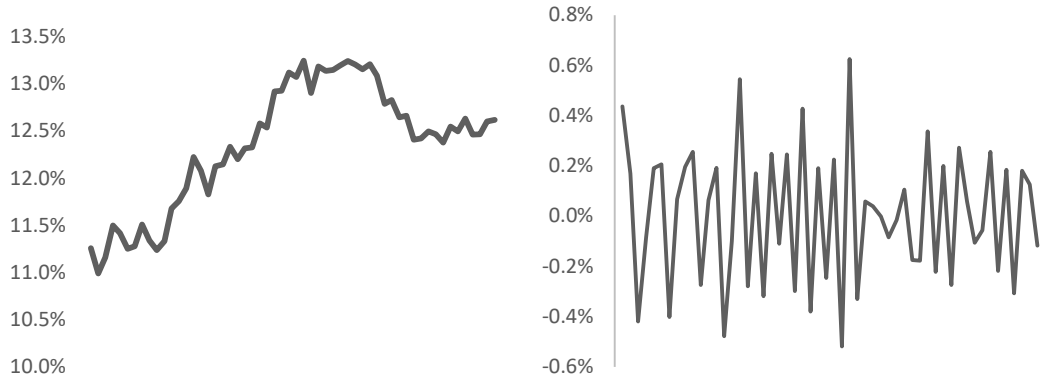


Figure 5: Ecuador Endogenous Risk Before and After ADF Correction

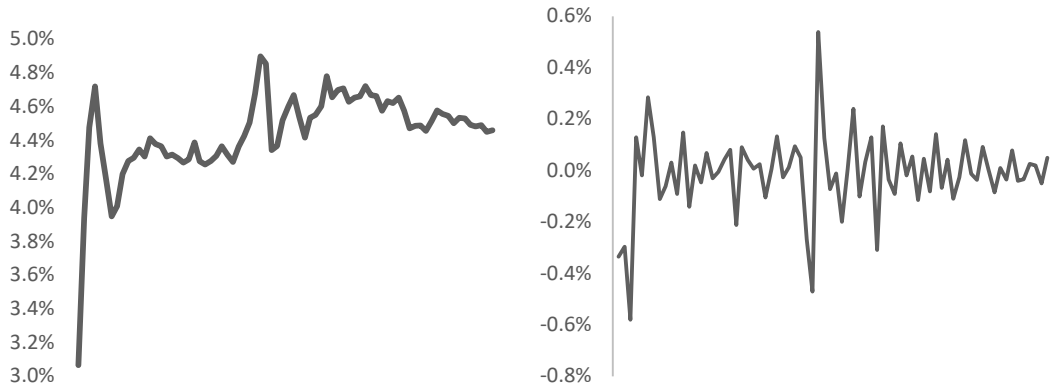
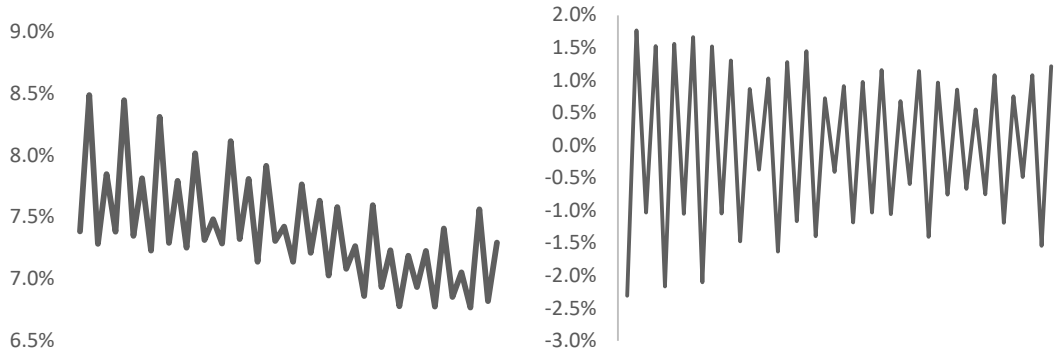


Figure 6: Peru Endogenous Risk Before and After ADF Correction



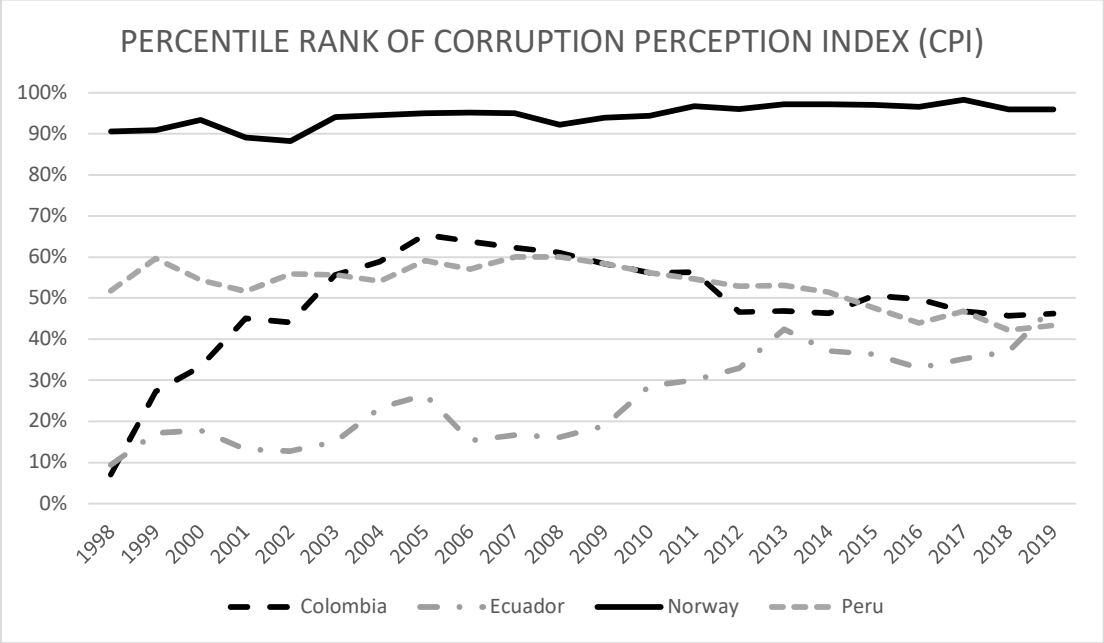
SURVEY-PERCEPTION INDEX VARIABLES

STARTING A BUSINESS: This is the yearly index calculated by the World Bank. "Distance to frontier score illustrates the distance of an economy to the "frontier," which represents the best performance observed on each Doing Business topic across all economies and years included since 2005. An economy's distance to frontier is indicated on a scale from 0 to 100, where 0 represents the lowest performance and 100 the frontier. For example, a score of 75 in 2012 means an economy was 25 percentage points away from the frontier constructed from the best performances across all economies and across time. A score of 80 in 2013 would indicate the economy is improving." (World Bank Data Catalog, hereafter WBDC, 2018).

CORRUPTION: This variable is a yearly, relative measure of corruption and represents a compilation retrieved from Transparency International's Corruption Perception Index (CPI) for the years to coincide with the EMBI Spread period of analysis (*Figure 5*). The Index Calculation methodology changed in 2012, consequently, to make the time series comparable throughout the period of analysis,

a percentile rank calculation was performed which computes a relative value of corruption perception for each one of the three countries studied in this research (https://www.transparency.org/research/cpi/overview).

Figure 7: Corruption Perception Index Percentile Rank



Note. Norway (top dark line) is shown to represent the upper limit of the highest percentile rank in the series.

MACROECONOMIC INDICES VARIABLES

FDI/GDP: Foreign Direct Investment (net) as a percentage of GDP. GDP is the quarterly data annualized (multiplied times 4). FDI data retrieved from the WBDC (2018), to coincide with the EMBI Spread time series. "Foreign direct investment are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the

investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows total net FDI. In BPM6, financial account balances are calculated as the change in assets minus the change in liabilities. Net FDI outflows are assets and net FDI inflows are liabilities. Data are in current U.S. dollars" (WBDC, 2018). This variable was utilized in the regression with a negative sign to characterize the notion that a net FDI outflow is an asset and a net FDI inflow is a liability.

Debt Svce./GDP: Debt service for all public debt as a percentage of GDP (WBDC, 2018). GDP is the quarterly data annualized (multiplied times 4). Debt Service Definition: "Public and publicly guaranteed debt service is the sum of principal repayments and interest actually paid in currency, goods, or services on long-term obligations of public debtors and long-term private obligations guaranteed by a public entity. Data are in current U.S. dollars" (WBDC, 2018).

Reserves/GDP: Reserves as a percentage of GDP (WBDC, 2018). GDP is the quarterly data annualized (multiplied times 4). "Reserves and related items is the net change in a country's holdings of international reserves resulting from transactions on the current, capital, and financial accounts. Reserve assets are those external assets that are readily available to and controlled by monetary authorities for meeting balance of payments financing needs, and include holdings of monetary gold, special drawing rights (SDRs), reserve position in the International Monetary Fund (IMF), and other reserve assets. Also included are net credit and loans from the IMF (excluding reserve

position) and total exceptional financing. Data are in current U.S. dollars" (WBDC, 2018).

CAPITAL MARKETS VARIABLES

AVERAGE PERIOD RATING: Rating refers to the average Credit Rating within a quarterly period to coincide with the EMBI Spread time series. A compilation of Ratings and a numerical score based on Bustillo et. al (2018) was computed (Table 8). An example of the tabulated ratings and computed score is exhibited in Table 9.

Table 8: *Letter Ratings given a numerical score.*

S&P	Moody's	Fitch	Score
AAA	Aaa	AAA	22
AA+	Aa1	AA+	21
AA	Aa2	AA	20
AA-	Aa3	AA-	19
A+	A1	A+	18
A	A2	A	17
A-	A3	A-	16
BBB+	Baa1	BBB+	15
BBB	Baa2	BBB	14
BBB-	Baa3	BBB-	13
BB+	Ba1	BB+	12
BB	Ba2	BB	11
BB-	Ba3	BB-	10
B+	B1	B+	9
B	B2	B	8
B-	B3	B-	7
CCC+	Caa1	CCC+	6
CCC	Caa2	CCC	5
CCC-	Caa3	CCC-	4
CC	Ca	CC	3
C	C	C	2
SD		RD	1
D		D	0

Note. Adapted from: Bustillo, I., Perrotti, D. E., & Velloso, H. (2018). Sovereign credit ratings in Latin America and the Caribbean: Trends and impact on debt spreads.

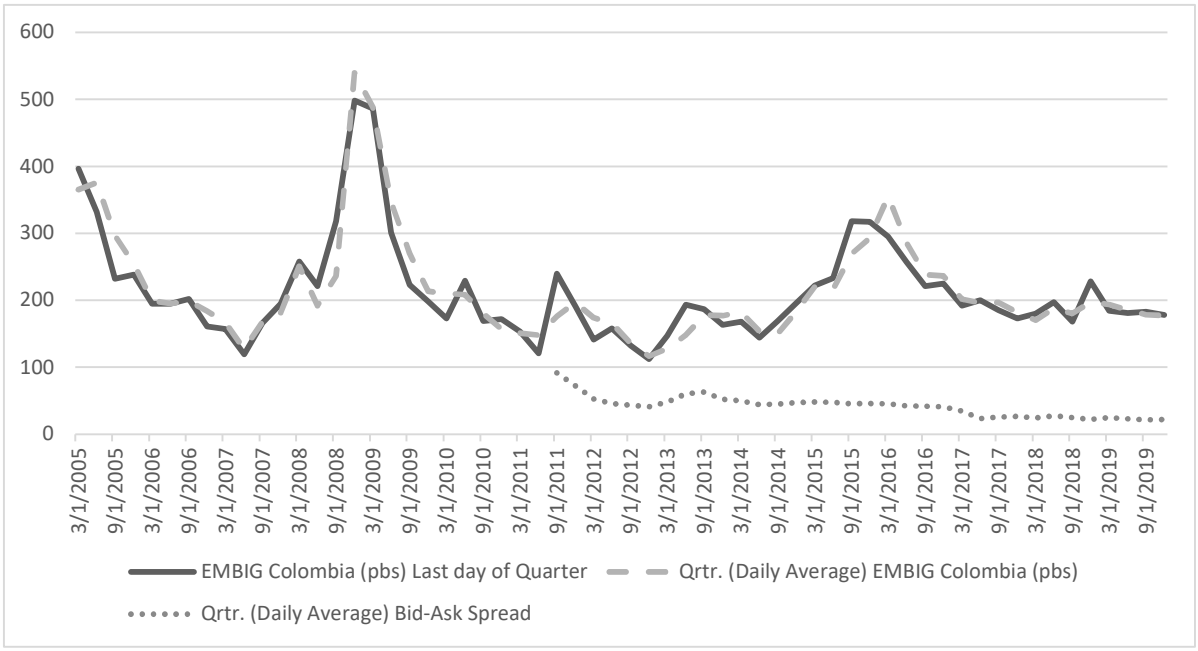
Table 9: *Peru Credit Ratings and Outlooks*

Agency	Rating	Outlook	Date	Score Ratings
Moody's	A3	stable	7/2/2014	16
Fitch	BBB+	stable	10/23/2013	15
S&P	BBB+	stable	8/19/2013	15
Fitch	BB-	negative	8/21/2002	10
S&P	BB-	stable	7/2/2002	10
Fitch	BB-	stable	4/29/2002	10

Note. Not a comprehensive list of Ratings and Outlooks for Peru. Table 9 merely portrays an application of the Score established in Table 8.

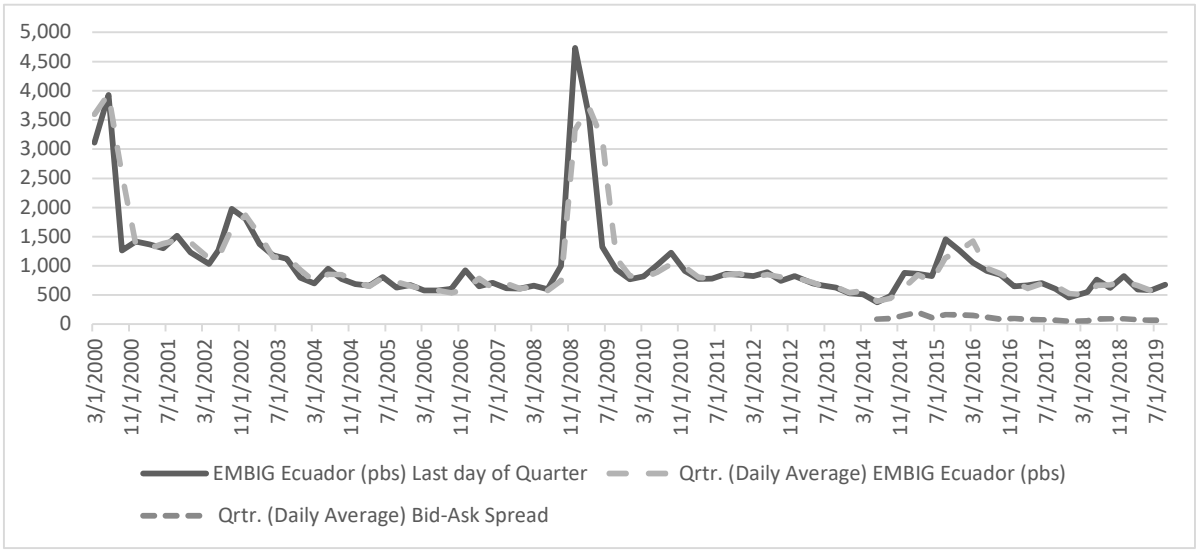
Bid-Ask Spread (Liquidity): The price differential between the Ask and the Bid, known as Bid-Ask Spread, is widely used by the investment industry as a proxy for liquidity. This measure refers to how much a security is bought and sold in the capital markets. The supposition here is that the greater liquidity, the less return an investor would demand, and thus, a lower cost and lower EMBI Spread. The shortest-dated issue (the issue with the longest available history) for each country analyzed in this study was selected as a proxy of liquidity and the difference between the Ask Price and the Bid Price was calculated with reference to the Ask Price. Then, the Bid-Ask Spread quarterly daily average was calculated to coincide with the quarterly economic activity data. Figures 8, 9, 10 depict the Spreads part of this research in a graphical context, one of them being the Bid-Ask Spread.

Figure 8: Colombia Spreads



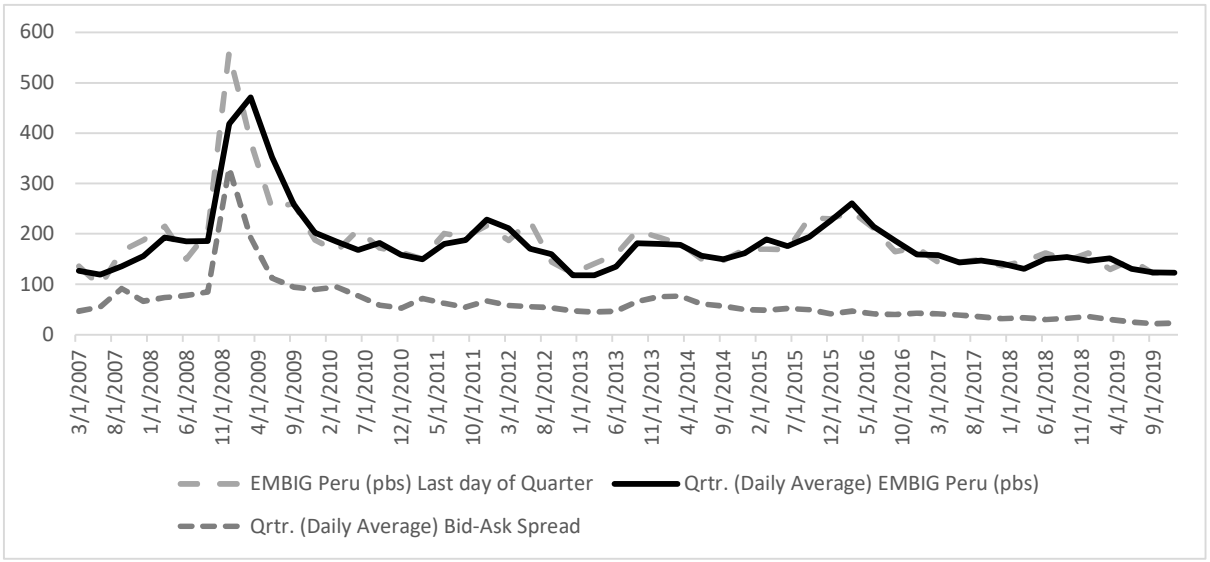
Note. Bid-Ask Spread depicted only when there are recorded Bid-Ask prices.

Figure 9: Ecuador Spreads



Note. Bid-Ask Spread depicted only when there are recorded Bid-Ask prices.

Figure 10: Peru Spreads



Note. Bid-Ask Spread depicted only when there are recorded Bid-Ask prices.

FX DepR AppR: This variable depicts the appreciation or depreciation of the currency against the US Dollar to coincide with the quarterly observations of macroeconomic data. Data for foreign exchange quote was extracted from Bloomberg (2020a).

STD. DEV. of F/X: This variable depicts the standard deviation of the foreign exchange in direct quote terms (LOCAL CURRENCY / USD) corresponding to the quarterly time series of macroeconomic observations.

8.3 Independent (X) Qualitative (Dummy) Variables

TRADED vs. NON-TRADED: In the absence of a Bid-Ask Spread, this variable was studied to reflect the qualitative nature of a traded or non-traded security. Whereas the magnitude of the Bid-Ask Spread would hypothetically determine the magnitude of the EMBI Spread, the hypothesis tested with this variable was to identify the simpler

binary notion that a non-traded security would result in larger EMBI Spread than the alternative of a security with trading activity.

Investment Grade vs. Non-Investment Grade: In a similar fashion to the previous qualitative variable, this is also a simpler version of the Average Period Rating quantitative variable. In the former, the hypothesis was to determine the impact of the average period rating by attaching a numerical score to the credit rating of a sovereign issue, whereas in this latter variable, the simpler notion of the rating being either investment grade or not was put to the test to gauge its predictive ability in determining the EMBI Spread of a sovereign issue.[12]

[12] Investment Grade or Non-investment grade refers to the credit rating threshold to be considered apt for investment or not. For a thorough explanation visit https://www.spglobal.com/ratings/en/about/understanding-ratings.

8.4 Empirical Findings From Regression Analysis

All of the independent variables used for this investigation were initially regressed against the three variations of the dependent variables to correspond with the series of quarterly observations of macroeconomic activity, hereafter referred to as the complete regressions (CRs).

First, however, separate regressions were conducted for all instances where the independent variables retrieved contained more observations than the quarterly observations of macroeconomic activity. These separate regressions were performed to further confirm the relationships determined from the CRs since there were concerns regarding the possibility that restricting the number of observations from certain variables due to their lack of correspondence to the quarterly macroeconomic variable would handicap the predictive ability of the variable in question.

In so doing, these regressions gauged the unique predictive ability of the larger dataset of the independent variables against the also larger available dataset of the de-pendent EMBI spread. For instance, the ALL tweets, FIN tweets, and bid–ask spread variables were separately regressed against the three variants of the dependent EMBI spread variable. The resulting calculation for these series concluded in a weak explanatory power (R2 less than 0.06 for all three countries) to predict the spread (Table 10).

Table 10: *Goodness of fit statistics (Daily Bid-Ask Spread vs. Daily EMBI Spread)*

	Colombia	Ecuador	Peru
Observations	2321	1551	1551
R^2	0.001	0.089	0.013
Adjusted R^2	0.001	0.088	0.012

As mentioned at the beginning of this section, all independent variables were regressed against the three variations of the EMBI Spread (End of Quarter Spread, Average Spread for the Quarter, Standard Deviation of the Spread within the Quarter). In all, three regressions (*CRs*) for each country for each variation of the dependent EMBI Spread with all the independent variables described to coincide with the quarterly time series of macroeconomic activity were performed. Below is a detailed description of the procedure followed for the data gathered for Colombia, Ecuador, and Peru, with the ensuing criteria used to favor the selection of a model deemed to be the best fit to predict one of the three variations of the dependent EMBI Spread variable.

COLOMBIA

Considering its higher Adjusted R^2 of 0.9, the Qrtr. AVG. EMBIG variable (Table 11) was selected for further analysis and exploration.

Table 11: Goodness of fit statistics for all three (3) variations of the dependent EMBI variable**.**

	Colombia EMBIG (basis points) End of Qrtr	Colombia Qrtr. AVG. EMBIG (basis points)	Colombia Std.Dev. bp SPREAD Qrtr
Observations	30	30	30
DF	17	17	17
R^2	0.81	0.94	0.74
Adjusted R^2	0.67	0.90	0.55

Note. There are 56 total number of quarterly observations for Colombia, but missing data from independent variables across all Ys, eliminated 26 observations.

Upon further analysis, the following VIF (Variance Inflation Factors) were eliminated after detecting excessive multicollinearity, and once these variables were eliminated, the qualitative independent variables were dropped across all Y's for lack of correspondence to the number of observations regressed against the dependent variables.

Table 12: *Eliminated Variables After VIF test for Multicollinearity.*

	Colombia Endogenous Risk	Colombia STARTING A BUSINESS	Colombia CORRUPTION	Colombia Debt Svce./GDP	Colombia Reserves/GDP	Colombia AVERAGE PERIOD RATING
Tolerance	0.05	0.03	0.04	0.09	0.03	0.35
VIF	18.8	35.5	23.2	11.4	33.0	2.85

Table 13: *After removal of high VIF variables, the following Model LR1 parameters were calculated.*

Source	Value	Standard error	t	Pr > |t|
Intercept	120.28	31.1	3.9	**0.001**
Colombia FDI/GDP	-272.5	663.1	-0.4	0.69
Colombia FX DepR_AppR	422.9	127.2	3.3	**0.003**
STD. DEV of F/X	1.306	0.2	8.0	**<0.0001**
Colombia ALL Tweets	19.828	20.9	0.95	0.35
Colombia FIN Tweets	-74.126	60.2	-1.23	0.23
Colombia Bid Ask Spread (Liquidity)	5,155.3	3,802.6	1.36	0.19

Table 14

Goodness of Fit for Model LR 1	
Observations	30
Sum of weights	30
DF	23
R^2	0.76
Adjusted R^2	0.70

Model Equation

$$\begin{aligned} &Colombia\ Qrtr.AVG.EMBIG\ (basis\ points) \\ &\quad = 120.27 - 272.52 * Colombia\ FDI/GDP + 422.96 \\ &\quad * Colombia\ FX\ DepR\_AppR + 1.31 * STD.DEV\ of\ F/X + 19.83 \\ &\quad * Colombia\ ALL\ Tweets - 74.13 * Colombia\ FIN\ Tweets + 5{,}155.25 \\ &\quad * Colombia\ Bid\ Ask\ Spread\ (Liquidity) \end{aligned}$$

Figure 11a: Residual Plots for Model LR1 Colombia

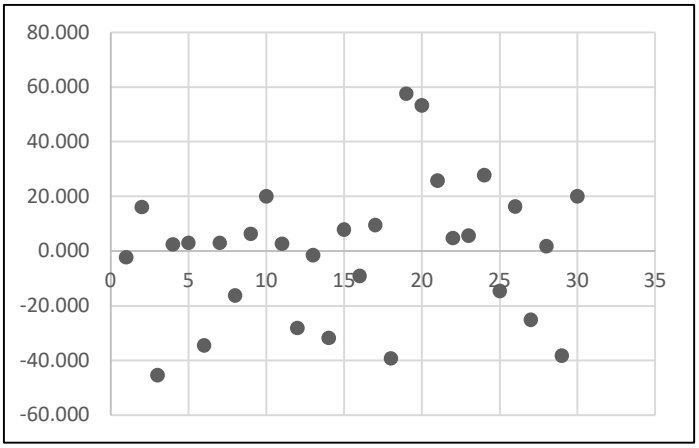
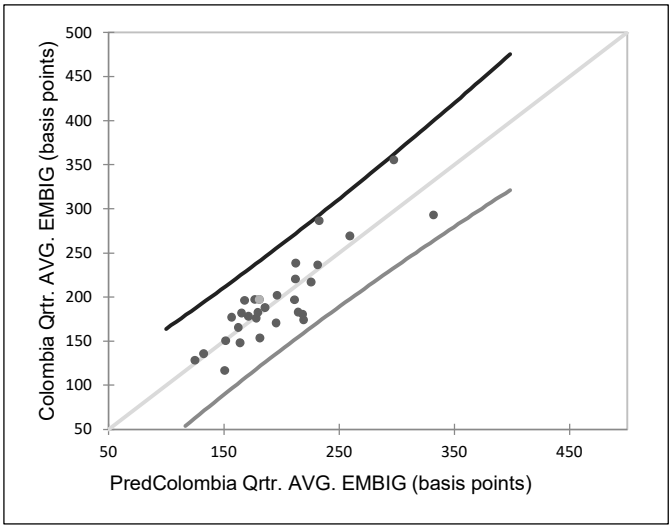


Figure 11b: Observed versus Predicted EMBIG



Model LR 1 Colombia

Despite Model LR 1's significant Adjusted R^2 upon further inspection of Type III Sum of the Squares Analysis suggested eliminating variables that added limited explanatory power to the dependent variable. Based on the Type III sum of squares, the following variables do not bring significant information to explain the variability of the dependent variable Colombia Qrtr. AVG. EMBIG (basis points): Colombia FDI/GDP, Colombia ALL Tweets, Colombia FIN Tweets, Colombia Bid Ask Spread (Liquidity) and were thus removed to estimate an alternate model. However, the Adjusted R^2 for this alternate model was considerably impacted and dropped to 0.097, thus Model LR1 was deemed the better option (*Table 15*). Furthermore, multicollinearity VIF tests detailed in Table 13 (*below*) indicate variables with low multicollinearity for Model LR1 thus reasserting its validity.

Table 15

Model LR 1 Colombia VIF Multicollinearity test

	Colombia FDI/GDP	Colombia FX DepR_AppR	STD. DEV of F/X	Colombia ALL Tweets	Colombia FIN Tweets	Colombia Bid Ask Spread (Liquidity)
Tolerance	0.82	0.45	0.65	0.54	0.45	0.839
VIF	1.2	2.2	1.5	1.9	2.2	1.2

ECUADOR

Two *CRs* were computed for the country of Ecuador whose results are depicted in Tables 14 and 15. The model resulting from the first *CR* (Table 14) was discarded for its low number of observations which resulted from the limited data of the Bid-Ask Spread variable thereby eliminating time series and variables across data for all Ys. Moreover, the Durbin-Watson (DW) statistic being above 2.5 for all three dependent estimations, as well as the Q^2, a measure which should preferably be closely tied to Adjusted R^2, gave clear indications of a defective model and with potential for improvement.

In eliminating the Bid-Ask Spread Variable, the modelled data attained more robustness and became more consistent across all variations of the dependent variable, as shown in Table 16 and judged by the Adjusted R^2. Further explorations with these independent variables against the three variations of the dependent variable were undertaken in conjunction with a perusal of the VIF test for multicollinearity.

Table 16: First CR: Goodness of fit statistics for all three (3) variations of the dependent EMBI variable

	Ecuador EMBIG (basis points) End of Qrtr	Ecuador Qrtr. AVG. EMBIG (basis points)	Ecuador Std.Dev. bp SPREAD Qrtr
Observations	19	19	19
DF	8	8	8
R^2	0.82	0.96	0.59
Adjusted R^2	0.59	0.92	0.07

Table 17: *Second CR: Goodness of fit statistics for all three (3) variations of the dependent EMBI variable*

	Ecuador EMBIG (basis points) End of Qrtr	Ecuador Qrtr. AVG. EMBIG (basis points)	Ecuador Std.Dev. bp SPREAD Qrtr
Observations	41	41	41
DF	30	30	30
R^2	0.83	0.82	0.84
Adjusted R^2	0.77	0.75	0.78

Model LR 1 Ecuador

Although all three variations of the dependent variable regressed against the remaining independent variables – once the scant Bid-Ask Spread variable was removed— showed similar levels of fit, Tables 18 below depicts the best relationship between the independent variables and the Standard Deviation of the Quarterly EMBI Spread, a regression dubbed Model LR 1 Ecuador.

Table 18: *Model LR 1 Regression of variable Ecuador Std.Dev. bp SPREAD Qrtr.*

Observations	41
Sum of weights	41
DF	35
R^2	0.8
Adjusted R^2	0.77

Table 19: *Ecuador VIF Multicollinearity test for independent variables*

	Ecuador Endogenous Risk	Ecuador CORRUPTION	Ecuador FDI/GDP	Ecuador Reserves/GDP	Ecuador FIN Tweets
Tolerance	0.66	0.61	0.63	0.54	0.80
VIF	1.5	1.63	1.59	1.84	1.25

Model LR 1 (Table 18) captures the relationship between the independent variables and the corresponding standard deviation of the EMBI spread, however robust this calculated relationship is, it does not contribute toward predicting the actual value of the EMBI spread, thus, the models predicting the other two variations of the dependent were further analyzed and Model LR 2 (Table 20) was chosen as the best option.

Table 20: *Model parameters LR 2 Ecuador*

Source	Value	Standard error	t	Pr > |t|
Intercept	20,518.5	3,605.6	5.7	**<0.0001**
Ecuador Endogenous Risk	-374,112.6	77,362.9	-4.8	**<0.0001**
Ecuador CORRUPTION	-8320.4	1,131.1	-7.4	**<0.0001**
Ecuador FDI/GDP	65,192.6	22,141.9	2.9	**0.006**
Ecuador Reserves/GDP	15,937.8	4,810.8	3.3	**0.002**
Ecuador FIN Tweets	-3,157.6	1,106.6	-2.9	**0.007**

Table 21: *Model LR 2 Ecuador*

Observations	41
Sum of weights	41
DF	35
R^2	0.777
Adjusted R^2	0.745

Model Equation

$$Ecuador\ EMBIG\ (basis\ points)\ End\ of\ Qrtr = 20{,}518.5 - 374{,}112.6 * Ecuador\ Endogenous\ Risk - 8{,}320.5 * Ecuador\ CORRUPTION + 65{,}192.6 * Ecuador\ FDI/GDP + 15{,}937.9 * Ecuador\ Reserves/GDP - 3{,}157.6 * Ecuador\ FIN\ Tweets$$

Figure 12a: Residual Plots for Model LR2 Ecuador

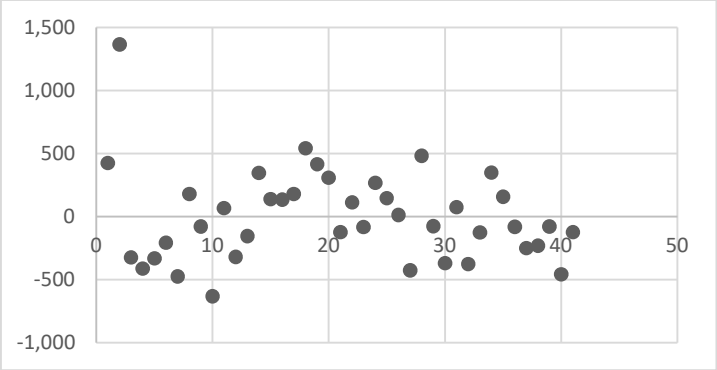
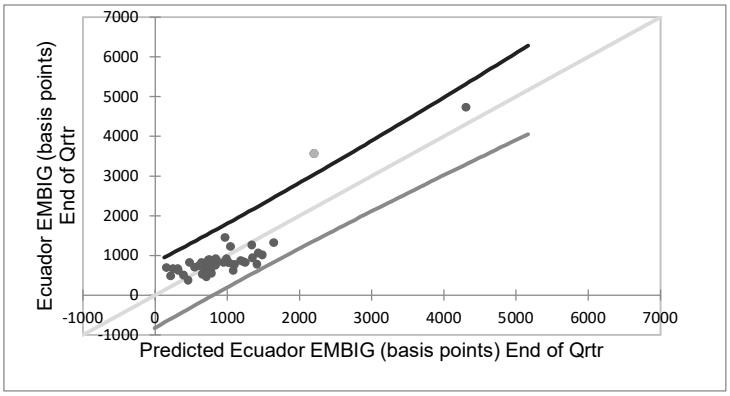


Figure 12b: Observed versus Predicted EMBIG



PERU

Two sets of CRs (*Complete Regressions*) were performed with the retrieved data for the country of Peru. The first CR included the ALL Tweet and FIN Tweet Variables and the Adjusted R^2 were low for all three variations of the EMBI Spread dependent variable (0.23, 0.39 and 0.51). Furthermore, upon inspection of Type III Sum of the Squares Analysis which indicated a limited contribution by the

Tweet variables, and also because, to further detriment, these variables significantly reduced the number of observations across all Y's on the complete regression, the inevitable conclusion was to remove these variables and perform the regressions without them. After eliminating the Tweet variables, the resulting Adjusted R^2 improved on all three models of the dependent variable (0.88, 0.72, 0.83). The Standard Deviation of the EMBI Spread dependent showed the strongest Adjusted R^2 of 0.883.

Based on the Type III sum of squares for the Standard Deviation of the EMBI Spread Model yielded the conclusion that the following variables do not bring significant information to explain the variability of the dependent variable: Peru STARTING A BUSINESS, Peru CORRUPTION, Peru FDI/GDP, Peru Debt Svce./GDP, Peru Reserves/GDP, Peru FX DepR_AppR, Peru AVERAGE PERIOD RATING, Peru AVG. Invest. Grd. (1) Or Not (0). Upon further consideration of multicollinearity VIF figures, the variables in (Table 22) not only brought insignificant contribution to the model as per Type III Sum of the Squares analysis, but concomitantly had high VIF scores, indicating a high likelihood of multicollinearity, and were thus removed in order to hone an improved model.

Table 22: *Variance Inflation Factor Analysis*

	Peru CORRUPTION	Peru Reserves/GDP	Peru AVERAGE PERIOD RATING	Peru AVG. Invest. Grd. (1) Or Not (0)-0	Peru AVG. Invest. Grd. (1) Or Not (0)-1
Tolerance	0.05	0.11	0.04	0.12	0.12
VIF	18.8	9.56	27.22	8.44	8.44

Model LR 4 Peru

Once this decanting of variables was performed, the remaining independent variables of the resulting linear regression possessed better suited VIF factors, yet subsequent Type III sum of the squares analysis once again suggested removing variables with limited explanatory power, until finally arriving at the LR 4 Peru model depicted in *Table 21*. Although LR 4 Peru had a slightly lower Adjusted R^2, the model selected was judged as the better alternative for its comparatively improved parsimonious (simpler is better) attribute. More specifically, LR 4 Peru had a slightly lower Adjusted R^2 with only two explanatory variables, (1) STD. DEV of F/X and (2) Peru Bid Ask Spread (Liquidity).

Table 23: *Peru Complete Regressions CR*

	LR 1 Peru	LR 2 Peru	LR 3 Peru	LR 4 Peru
Observations	48	48	48	48
Sum of weights	48	48	48	48
DF	39	43	44	45
R^2	0.89	0.89	0.88	0.88
Adjusted R^2	0.88	0.88	0.87	0.87
Number of Independent Variables	8	4	3	2

Table 24: *Model parameters LR 4 Peru*

Source	Value	Standard error	t	Pr > |t|
Intercept	-8.38	2.05	-4.09	**0.000**
STD. DEV of F/X	131.31	58.44	2.25	**0.030**
Peru Bid Ask Spread (Liquidity)	3,573.32	226.88	15.75	**<0.0001**

Model Equation

$$Peru\ Std.Dev.bp\ SPREAD\ Qrtr = -8.38 + 131.31 * STD.DEV\ of\ F/X + 3{,}573.32 * Peru\ Bid\ Ask\ Spread\ (Liquidity)$$

Figure 13a: Residual Plots for Model LR4 Peru

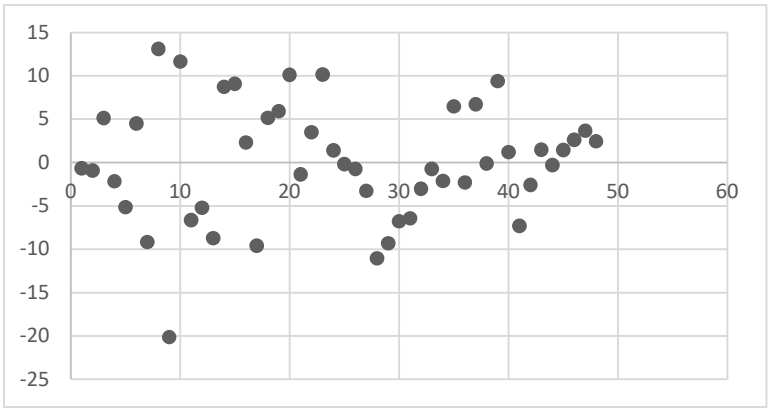
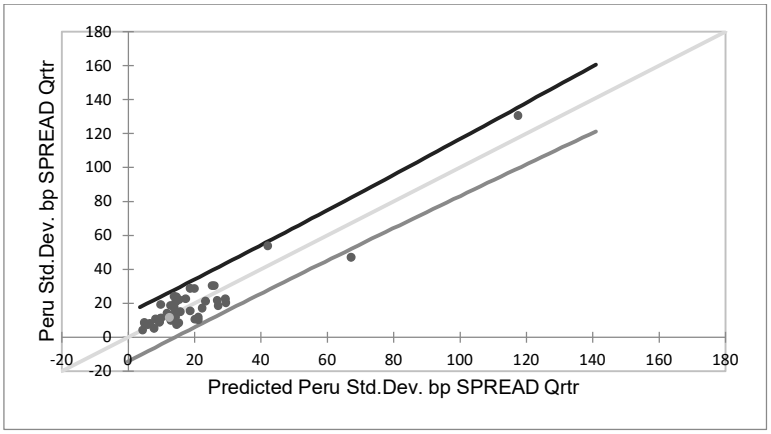


Figure 13b: Observed versus Predicted EMBIG



8.5 Closing Remarks on Regression Analysis

The following three aspects were reflected upon for each model selected:

1. Normality of Residuals.
2. Analysis of unit root for dependent variables.

3. Correlation test with the Residuals of each model to determine the possibility of Endogeneity of independent variables.
4. Possibility to recast the models with interactions among independent variables.

As can be seen from the plotting of residuals for all three countries, their behavior for each selected model do not represent a source of concern.

On the second aspect form the list above, the question of the presence of a unit root was explored, discarding it as seen from Table 25 below.

Table 25: *ADF test for non-stationary time series Average EMBI Spread.*

Country	Tau-statistic	Tau-critical value	Stationary	AIC	BIC	LAGS	Coeff.	P-value
Colombia	-3.76	-3.48	yes	10.78	10.93	1	-0.35	0.025
Ecuador	-6.40	-3.46	yes	14.69	14.81	1	-0.43	< .01
Peru	-4.16	-3.49	yes	10.30	10.46	1	-0.40	< .01

The third cause for concern, the presence of endogeneity would be indicated by a high correlation between the residuals and the independent variables of the model, whereby some element would be missing from the true model. For instance, a missing independent variable could be some measure of a long-standing democracy in the country analyzed, and since this variable was not measured, a significant correlation between the error term and the independent variables would surface (Tables 26-28).

Table 26: *Correlation of Independent Variables and Residuals for Colombia to check for Endogeneity.*

Variables	FDI/GDP	FX DepR_AppR	STD. DEV of F/X	ALL Tweets	FIN Tweets	Residual
FDI/GDP	**1**	0.36	-0.09	-0.05	-0.05	**0.0**
FX DepR_AppR	0.36	**1**	-0.51	-0.23	-0.53	**0.0**
STD. DEV of F/X	-0.09	-0.51	**1**	0.36	0.36	**0.0**
ALL Tweets	-0.05	-0.23	0.36	**1**	0.61	**0.0**
FIN Tweets	-0.05	-0.53	0.36	0.61	**1**	**0.0**
Residual	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1**

Table 27: *Correlation of Independent Variables and Residuals for Ecuador to check for Endogeneity.*

Variables	Endogenous Risk	CORRUPTION	FDI/ GDP	Debt Svce./GDP	Reserves/GDP	FIN Tweets	Residual
Endogenous Risk	**1**	0.16	0.34	-0.29	0.27	-0.26	**0.0**
CORRUPTION	0.16	**1**	0.31	-0.51	0.58	0.28	**0.0**
FDI/GDP	-0.34	0.31	**1**	-0.06	0.36	0.35	**0.0**
Debt Svce./GDP	-0.29	-0.51	0.06	**1**	-0.71	0.01	**0.03**
Reserves/GDP	0.27	0.58	0.36	-0.71	**1**	0.15	**0.0**
FIN Tweets	-0.26	0.28	0.35	0.01	0.15	**1**	**0.0**
Residual	**0.0**	**0.0**	**0.00**	**0.03**	**0.0**	**0.0**	**1**

Table 28: *Correlation of Independent Variables and Residuals for Peru to check for Endogeneity.*

Variables	STD. DEV of F/X	Bid Ask Spread (Liquidity)	Residual
STD. DEV of F/X	**1**	0.35	**0.0**
Peru Bid Ask Spread (Liquidity)	0.35	**1**	**0.0**
Residual	**0.0**	**0.0**	**1**

For all three selected models, the presence of endogeneity is not a source of concern as the correlation between the residuals/errors of each model and their independent variables are close to zero, a result which indicates the absence of endogeneity.

Furthermore, the question of interactions among independent variables. There is certainly an argument to be made about the interaction between variables affecting the predicted, dependent EMBI Spread. For instance, the consequences of a country's debt issue having poor liquidity in the capital markets, and thus a higher

Bid-Ask Spread, coupled with a Non-Investment Grade Rating, could have result in a magnifying effect of the sovereign issues' EMBI Spread. Similarly, corruption levels gauged by the CPI (Corruption Perception Index) could be affected by Tweet impact resulting from these measures, and both variable together would have magnifying impact on the sovereign issues' EMBI Spread. However, the analysis of interactions has been left for future research.

9.0 Results and Interpretation of Principle of Separation

From the outset of this thesis, the contextualization of the Principle of Separation (Bodie, Z., Kane, A., & Marcus, A. J. 2011), also referred to as the Separation Theorem (Tobin, 1958), used in investment analysis, was laid out as a central purpose of this research. The notion was to attempt an explanation of the behavior of sovereign yield spreads utilizing the models selected to predict the variations of said EMBI Spread of the three countries researched, within the Principle of Separation / Theorem framework.

The framework of the Principle/Theorem of Separation posits that optimal portfolio choice within in an individual's investment context is attained by first identifying an efficient portfolio of risky assets, through the application of Markowitz Optimal Portfolio Theory (1952) and later recognizing the risk aversion of an individual with an indifference curve or utility function, from which the proportion invested in the optimal portfolio of risky assets is ultimately achieved. This proportion invested in the risky asset is complemented by the investment in the risk-free asset to arrive at the total or complete portfolio.

The above framework viewed in the context of EMBI Spread or sovereign issue yields that this research thesis postulates, implies the following train of thought:

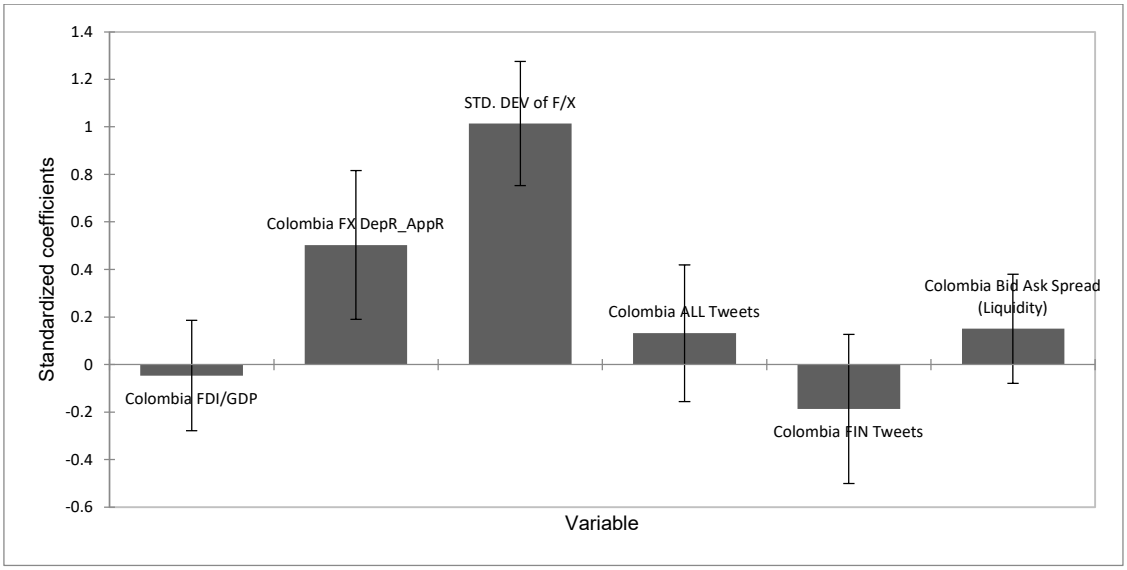
1. The aggregation of a country's activities, their rates of growth and the covariations of these rates of growth represent the portfolio of risky assets of the country. This analysis resulted in the variable dubbed Endogenous Risk.

2. The Endogenous Risk variable does exist in isolation but is rather complemented and influenced by other factors (macroeconomic, sentiment and perception, and capital market activity indicators) which affect the yield, thus the relative risk, borne by the country through a higher cost of borrowing (EMBI Spread).
3. Some of these complementary influences have an aggravating (increasing the EMBI Spread) or attenuating effect (lowering the EMBI Spread), as judged by the coefficient of the independent variable from the models. In some instances, these complementary factors could be even more relevant in and of themselves, to the point of rendering the Endogenous Risk variable mute in its predictive ability of the EMBI Spread (this is the case for Colombia and Peru, not so for Ecuador).
4. The aggravation or attenuation effect of these complementary variables act as a risk factor, thereby increasing or reducing the yield or EMBI Spread of the country in question and acting in the same fashion that the proportion invested in the risk-free asset acts in reducing or increasing the risk in a complete portfolio.

Table 29: *Selected Model Parameters Colombia*

Source	Value / Coefficient
Intercept	120.28
Colombia FDI/GDP	-272.52
Colombia FX DepR_AppR	422.96
STD. DEV of F/X	1.31
Colombia ALL Tweets	19.83
Colombia FIN Tweets	-74.13
Colombia Bid Ask Spread (Liquidity)	5,155.25

Figure 14: Colombia Qrtr. AVG. EMBIG (basis points) / Standardized coefficients (95% conf. interval)



Note. Figure 11 is portrayed to visualize the impact of each independent variable on the EMBI Spread.

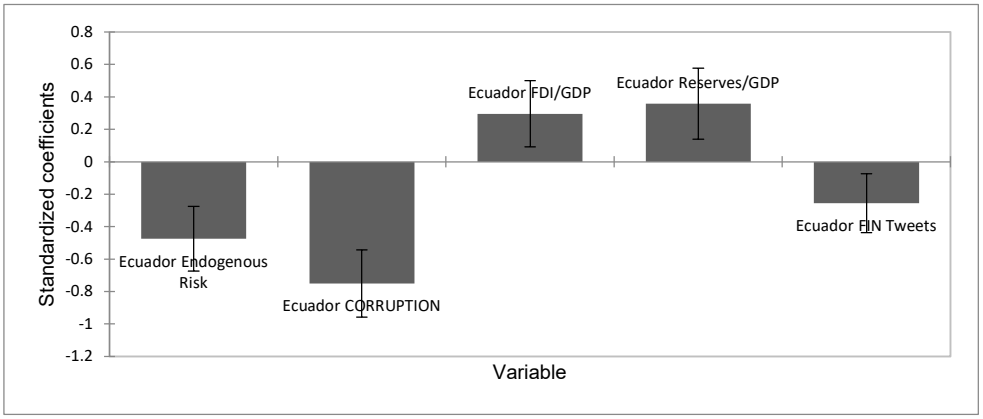
Table 26 and Figure 16 represent the model selected to predict the EMBI Spread (Average for the Quarter variant). Figure 16 more acutely depicts the impact of each standardized independent variable, where the variables related to the management of the local currency (the Colombian Peso COP) exchange rate against the US Dollar account for the largest weight of the impact on the predicted EMBI Spread. For this reason, in the context of the principle of separation described above,

a concerted effort to manage the level and fluctuation of the COP-USD exchange rate acts as risk reducing component and predictably results in a lower EMBI Spread. It is also intriguing to note the level of influence of what can be dubbed sentiment or impending perception (via the Tweet variables) on the sovereign spread. Further, the only surviving macroeconomic variable in the model (FDI/GDP) has the lowest influence, albeit one that reduces the Spread. Finally, for Colombia, the larger the Bid-Ask Spread, a proxy for liquidity for the sovereign issue in the capital markets, the larger the EMBI Spread, meaning a less liquid issue pays a premium in terms of the spread against the risk-free rate, as would be expected.

Table 30: *Selected Model Parameters Ecuador*

Source	Value
Intercept	20,518.469
Ecuador Endogenous Risk	-374,112.637
Ecuador CORRUPTION	-8,320.455
Ecuador FDI/GDP	65,192.629
Ecuador Reserves/GDP	15,937.879
Ecuador FIN Tweets	-3,157.582

Figure 15: Ecuador EMBIG (basis points) End of Qrtr / Standardized coefficients (95% conf. interval)



Note. Figure 12 is portrayed to visualize the impact of each independent variable on the EMBI Spread.

Table 30 and Figure 15 above depict the model's variables and their relative impact to predict the EMBIG Spread for Ecuador (End of Quarter variant). Figure 15 describes the magnitude and direction of impact on the EMBI Spread. The largest impact comes from the Corruption Perception Index variable and its magnitude and direction is no surprise. The larger value implies a higher percentile rank (lower relative perceived corruption), and this would imply a lower EMBI Spread. The coefficient with the next greater impact is the Endogenous Risk variable. The impact of this variable was unexpected and counterintuitive since the coefficient points to a greater EMBI Spread with a lower Endogenous Risk (an indirect relationship). Two different reasonings could be devised for this phenomenon. The first is that there is a selection bias with the dates and time series used in the regressions. Specifically, the quarterly periods selected for Ecuador are not representative of the overall population behavior of the data. An alternate explanation is that the variability of growth of economic activities is impacted by a positive event (for instance high prices of crude oil are of major impact on the country's economic activity) and the markets perceived this variation in economic activity, which causes an increase in the variability of returns (the definition of Endogenous Risk) as a default reducing situation. Such a scenario, whereby an abrupt increase in the price of crude causes a subsequent abrupt increase in economic activity, would in turn increase the variability of growth, however that increased variability represents a lower risk of default to the sovereign debt and thus a lower EMBI Spread.

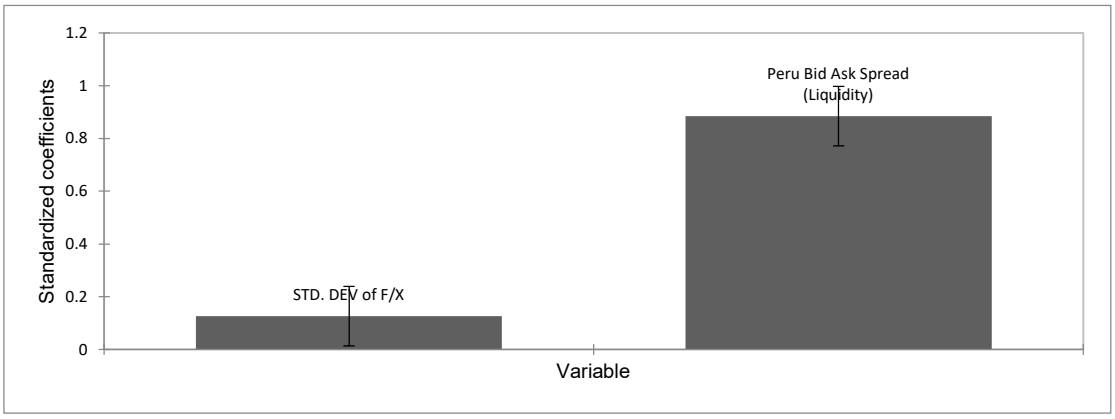
Of the three remaining variables, two are of macroeconomic nature (FDI/GDP and Reserves/GDP) and finally the sentiment Tweet variable. Starting with the latter, the FIN Tweet variable simply represents whatever effect the measured

Tweet impact had on the EMBI spread. In this instance, for the period of data analyzed, the Tweets from Financial media had a spread reduction effect. However, as anticipated previously, the relationship may be spurious and not much weight can be given to the Tweet measures. Finally, the two remaining macroeconomic variables both had a spread increasing effect as judged by their coefficients in the model. The FDI/GPD variable consists of investment assets (+) minus investment liabilities (-), for this reason the relationship was captured with the negative sign in front of the net inflow. It is thus no surprise that the greater net liability in FDI increases the EMBI Spread. Worthy of note is the fact that a significant portion of the period analyzed corresponds to China's great expansion into Latin America (Dollar, D. 2018), where, specifically in Ecuador, loans and sale of crude oil were exchanged and to the day of writing of this thesis, there is still little known about these transactions. The Reserves/GDP relationship is somewhat similar in nature in that it includes the net change in a country's international reserves and as such, increasing levels of financing accumulated in the financial accounts could result in an increase of the EMBI Spread for the anticipated increased levels of indebtedness.

Table 31: *Selected Model Parameters Peru*

Source	Value
Intercept	-8.377
STD. DEV of F/X	131.309
Peru Bid Ask Spread (Liquidity)	3,573.317

Figure 16: Peru Std. Dev. (bp) Spread for the Qrtr / Standardized coefficients (95% conf. interval)



Note. Figure 13 is portrayed to visualize the impact of each independent variable on the EMBI Spread.

Table 31 and Figure 16 show the relationship between the predicted Quarterly Standard Deviation of the EMBI Spread and the independent variables Standard Deviation of the exchange rate between the local currency (Peruvian Peso PEN) and the US Dollar, and the Bid Ask Spread of the sovereign debt instrument traded in the capital markets. Of the three countries studied this is the simplest, most parsimonious model. The most impactful variable on the outcome of the EMBI Spread (its quarterly standard deviation variant) is the level of liquidity of the sovereign instrument. The higher Bid Ask Spread (lower liquidity) results in a higher Standard Deviation of the EMBI Spread. Of lesser impact is the Standard Deviation of the exchange rate to the US Dollar of the local currency, the only other variable in the model. The higher standard deviation of the foreign exchange results in a higher variability of the EMBI Spread. Succinctly, the level of liquidity and the tame fluctuation of the exchange rate are sufficient to explain the variability of the EMBI Spread.

10.0 Discussion and Conclusions

In this work I investigate the relationship of various types of independent variables and the resulting EMBI spread for three countries for the period ranging from as early as 2000 (Ecuador) until 2018. I will separate this discussion between surprising and disappointing results as detailed in a research paper recently published (Serrano-Monge 2022).

The most significant result is impact of the variables related to foreign exchange rates of local currency vs the US Dollar on the EMBI Spread for the countries of Colombia and Peru. Namely, the standard deviation of the foreign exchange rate of the local currency had a positive impact on the EMBI spread. The larger the variability, the greater the EMBI Spread of the sovereign bond issue. This portends an interesting aspect related to the merits of prioritizing a stable currency management to rein in credit spreads.

The next most significant result is the impact that the trading liquidity of the sovereign issue had on the Spread for the country of Peru. This result clearly demonstrates the liquidity preference by the investors since the larger Bid-Ask spread of a traded issue demands a larger EMBI Spread. Finally, not surprising were the results from the macroeconomic fundamental and perception (*i.e. corruption index*) variables which do have an impact on the EMBI Spread of all three countries studied. This outcome is in line with previous research from Edwards (1984, 1985, 1986), Grandes (2007) and Goldman-Sachs (2000).

The insignificant and underwhelming result from this investigation is the fact that the Endogenous Risk which required meticulous design to be used

adequately (Section 8.2, Table 5 in this thesis) is only relevant for the country of Ecuador and the resulting direction of impact was opposed to the expected. In characterizing an economy as portfolio of assets, I anticipated that the larger Endogenous Risk (variability of economic activity) would result in a larger EMBI Spread, in the same way a larger variability of an asset return in the capital markets demands a higher return. However, the regression captures a negative relationship between these two variables. A plausible explanation, which warrants further research, is that despite the higher variability of an economy causing a larger Endogenous Risk, there is a larger more relevant impact related to economic growth (a variable not studied), for instance, which would be caused by a significant contribution from a particular economic segment, like oil exploration or mining. The notion being that although this significant impact from a particular economic segment would cause a larger correlation and thus a larger covariance of economic activities and larger Endogenous Risk, this impact would logically be conducive to the reduction of the EMBI Spread. Yet, this relationship between the jump in oil prices and the reduction in country risk has been demonstrated to be insignificant in oil exporting countries as reported by Bouri (2019).

11.0 Future Research, Limitations, and Advantages of My Work

Future research regarding the study of the determinants of Country Risk and more succinctly of EMBI Spreads, should involve interactions of interest between the explanatory variables delved into in this thesis and others that surface. Namely, coupling non-investment grade ratings and liquidity could provide an insight into their compounding effect on EMBI Spreads or their dispersion during certain periods of time. In addition, perception variables such as corruption or ease of doing business indicators, evermore present in the daily perusal of news and information, coupled with sentiment variables (like the pervasive use of social media) possibly muddle (augment or diminish) the resulting EMBI Spread and hence impact the cost a nation's cost of debt. Also, variables not considered in this study like insider (government or high ranking officials within a government) positions of outstanding debt issues, change of position of major holders of sovereign debt issues could both influence the price and return of debt and hence the EMBI spread. As such, governments and policy makers could anticipate price altering events derived from the impact of these variables.

Other aspect which merits further study is the sheer volume of debt in the markets or the participation of a country's debt outstanding against all sovereign debt issues. As of the writing of this section the country of Ecuador and Argentina (not part of this research) have both reached an agreement with their respective creditors (Bloomberg, 2020), albeit with a radically different approach. Argentina a more contentious one which started with a default and Ecuador with a more amicable one, yet the results do not appear to be radically different.

Another aspect deemed a limitation, and which should be considered, is the fact that the macroeconomic data utilized is not always available and synchronous with other data, a characteristic which makes corresponding time series a challenge. For instance, the perception and macroeconomic indicators provide yearly figures which are assumed to stay the same until the next yearly production of results is released, yet they were compared with quarterly value added of economic activities.

With regards to perception or reputation affecting credit spreads, current research about Twitter activity analysis, as is the case with most information (Big Data) produced these days is being subjected to machine learning and artificial intelligence applications. This feature would allow sentiment (positive, negative, or neutral) to be extracted from Twitter activity. Sentiment gauged from a Tweet would presumably have a corresponding effect on the EMBI spread.

Finally on the theme of future research, of the countries studied in this thesis, two of them have a local currency and thus manage their interests with a monetary policy to suit their needs, whereas Ecuador, the only country without a sovereign currency is void of this attribute. Future research could focus on countries which actively manage their currency and those who do not.

Regarding the advantages of my research, succinctly on the definition of the endogenous risk variable, I have established a simple framework. Drawing from the matrices utilized by both Leontief (1936) and Markowitz (1952), I provide an insight into the intrinsic risk of an economy based on its underlying architecture. Intuitively the granularity or frequency of the tabulation of economic activity with the advances of computational prowess could prove beneficial to hone the variable's significance and both government policy makers and sovereign debt market participants could gain

valuable information by understanding the interdependence and the impact on the perceived and real risk of an economy. This aspect could be managed by government policy makers to improve their borrowing conditions and by other sovereign debt market participants to mitigate their risk and improve a portfolios performance.

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13.0 APPENDIX

13.1 Abstract of Article Published in The Journal of Risk and Financial Management

Article

Inferences from Portfolio Theory and Efficient Market Hypothesis to the Impact of Social Media on Sovereign Debt: Colombia, Ecuador, and Peru

https://doi.org/10.3390/jrfm15040160

Abstract: For three countries of similar economic characteristics, I ratify previous studies of the impact of fundamental macroeconomic and foreign exchange variables influencing country risk, as captured by the Emerging Market Bond Index (EMBI). I contribute to existing research, first by calculating a proxy of risk I call endogenous risk that analyzes the quarterly variability of economic activity, and second, by calculating a variable of sentiment from Twitter activity. I gauge the impact of both on the country risk metric in addition to variables in existing research about the determinants of country risk. Foreign exchange variables are the most significant determinants of risk for the countries of Colombia and Peru, which actively manage their currency, while Ecuador's country risk is mostly affected by endogenous risk and macroeconomic fundamentals.

Keywords: efficient market hypotheses; portfolio theory; sovereign credit risk; country risk; social media

13.2 Descriptive Statistics of Variables

Table 1A

Summary of Quarterly Time Series Variables and Observations per Country

	Colombia	Ecuador	Peru
Dependent Variables (Y)			
EMBIG (basis points) End of Qrtr.	56	76	48
Qrtr. AVG. EMBIG (basis points)	56	76	48
Std.Dev. bp SPREAD Qrtr.	56	76	48
Independent Variables (X)			
Endogenous Risk	56	76	48
STARTING A BUSINESS	56	60	60
CORRUPTION	56	76	48
FDI/GDP	56	76	48
Debt Svce./GDP	56	76	48
Reserves/GDP	56	76	48
FX DepR_AppR	56	n.a.	48
STD. DEV of F/X	56	n.a.	48
ALL Tweets	43	41	39
FIN Tweets	35	41	33
Bid Ask Spread (Liquidity)	30	19	48
AVERAGE PERIOD RATING	56	76	48
TRADED = 1 NON-TRADED=0 (Qualitative)	56	76	n.a.
AVG. Invest. Grd. (1) Or Not (0) (Qualitative)	56	n.a.	48

Note. Ecuador's n.a.: F/X variables are irrelevant for the analysis as it uses the US Dollar as its currency. Peru's n.a.: Sovereign debt has been traded throughout period of analysis.

DEPENDENT (Y) VARIABLES

EMBI Spread- COMPLETE DATA SET: This is the data set utilized to extract the dependent variable for the research. Table 2A reveals descriptive statistics of the complete data set (5218 daily observations) of the daily EMBI Spread from December 31, 1999 until the same day of the year 2019. The dependent variables prepared for the research were computed from this data set and are described ahead. From this brief overview of the dependent variable studied, Colombia and Peru have similar

Standard Deviations, whereas Ecuador has a significantly larger figure for this statistic. All three countries' EMBI Spreads have a positive skewness, and again, Ecuador has an exceptionally large positive skew when compared to both Colombia and Peru whose skewness is positive but of a smaller magnitude.

Table 2A
Descriptive statistics. EMBI Spread- COMPLETE DATA SET.

Variable	Observations	Min.	Max.	Mean	Std. deviation
EMBIG Spread Colombia	5218	95	1,094	307	189
EMBIG Spread Ecuador	5218	337	5,069	1041	765
EMBIG Spread Peru	5218	91	901	271	175

Figure 1A: Histogram (EMBIG Spread Colombia)

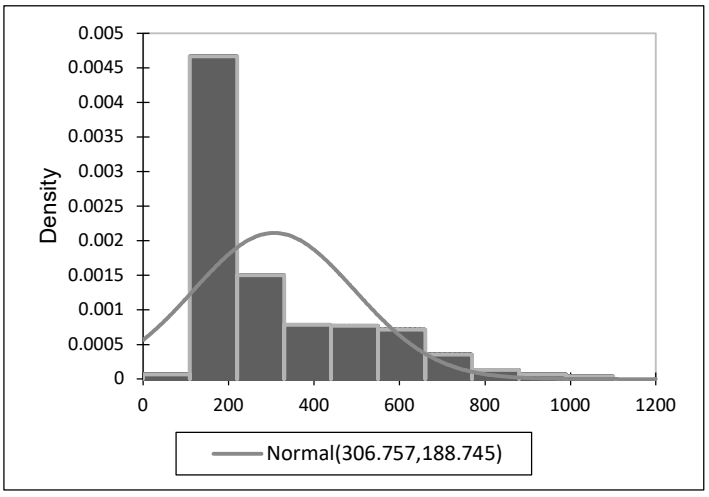


Figure 2A: Histogram (EMBIG Spread Ecuador)

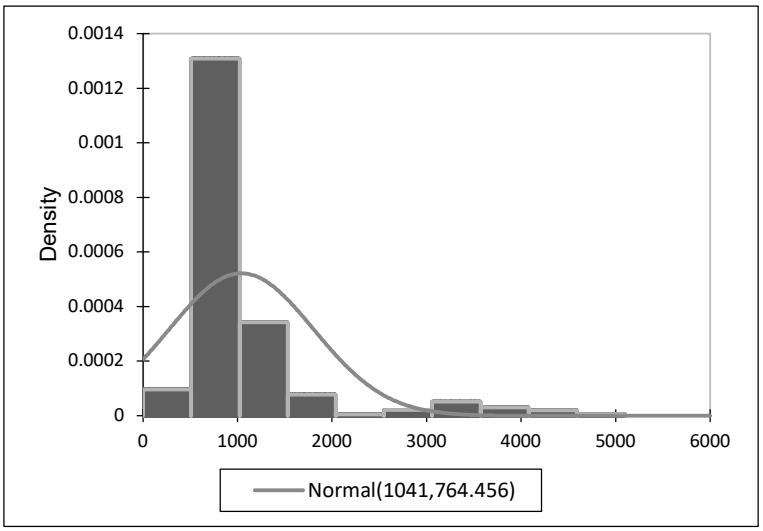
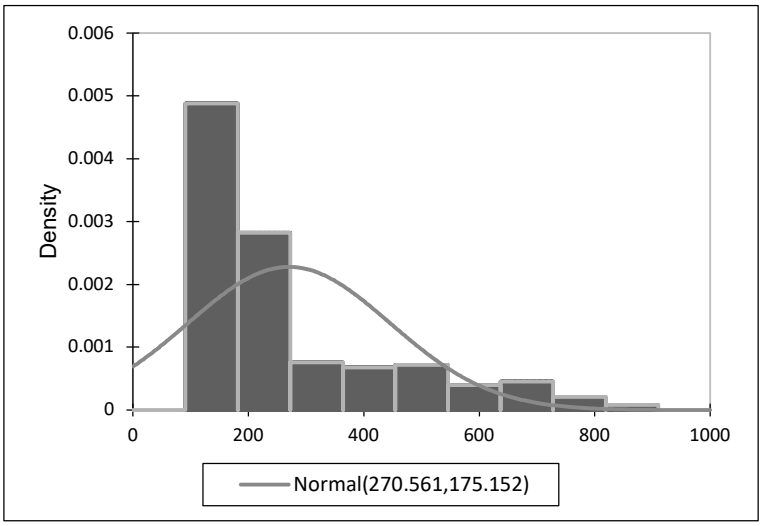


Figure 3A: Histogram (EMBIG Spread Peru)



From the complete data set of the dependent variable described above three variation of the EMBI Spread where computed. Firstly, an End of the Quarter EMBIS Spread observation to correspond with the quarterly macroeconomic data also used as cohort independent variables in multiple linear regressions. Secondly, the

average daily EMBI Spread over the quarter to correspond with the observed macroeconomic data. Thirdly, a computation of the Standard Deviation of the EMBI Spread over the quarter, again to correspond with the observed macroeconomic data.

Macroeconomic data used as independent variables were not from identical time series, for each country had its own range of dates of quarterly economic activity. Although this disparity was cause of some concern and also because yearly economic activity could have been used in the analysis to dissipate this concern, the decision to favor the use of quarterly data, albeit from differing time periods, superseded the decision to use such data from identical time periods, since the focus of the research called for identifying causality behind the EMBI Spread of each country and compare and contrast these findings. Consequently, the improved information that could be garnered from more frequent, quarterly observations, overtook the interest to have observations of economic indicators from identical time periods for all three countries.

Table 4A
Summary statistics: Colombia All Variations of Independent Variable EMBI Spread

Variable	Observations	Min.	Max.	Mean	Std. deviation
End of Quarter EMBIG	56	112	498	212	75
AVG. EMBIG - Spread -	56	116	540	218	83
Std Dev of bp EMBIG-Spread	56	0	77	18	13

Figure 4A: Histogram (End of Quarter EMBIG Colombia)

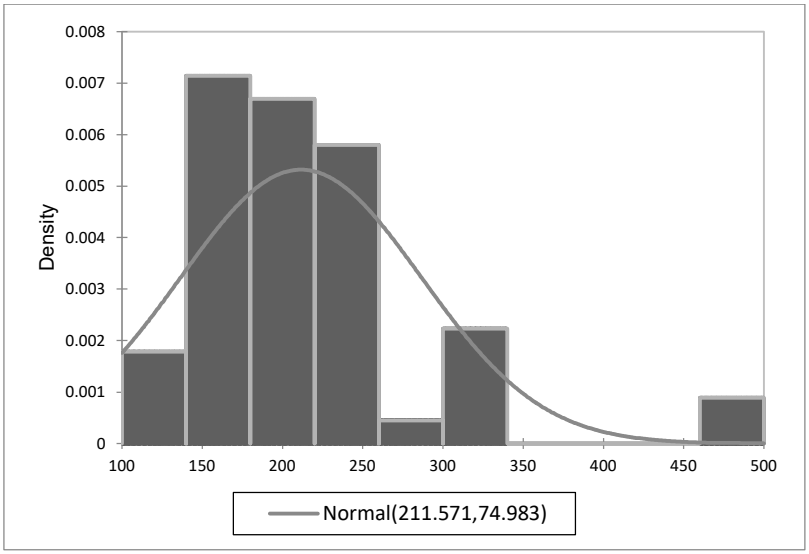


Figure 5A: Histogram (AVG. EMBIG - Spread – Colombia)

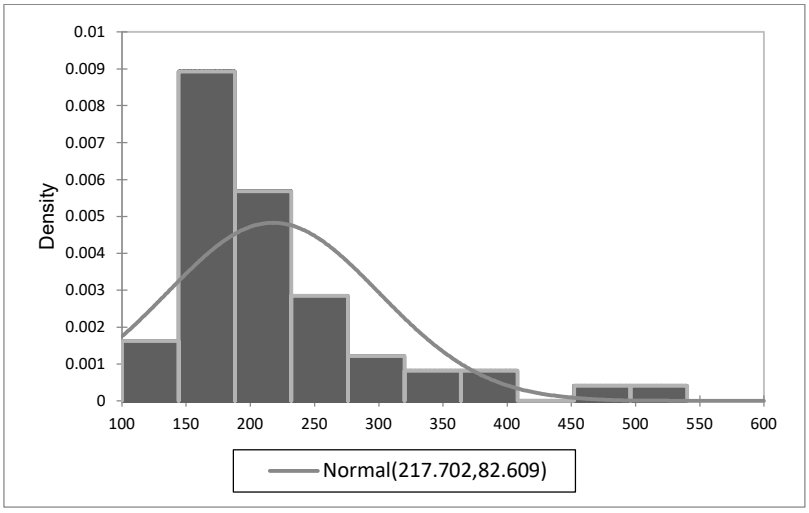


Figure 6A: Histogram (Std Dev of bp EMBIG-Spread Colombia)

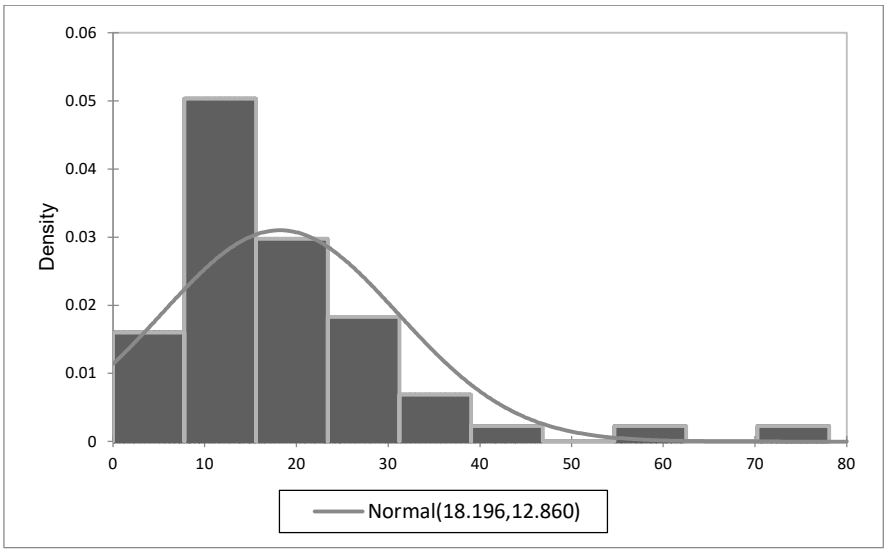


Table 5A
Ecuador All Variations of Independent Variable EMBI Spread

Variable	Observations	Min.	Max.	Mean	Std. deviation
End of Quarter EMBIG	76	376	4,731	1,038	744
AVG. EMBIG - Spread	76	393	3,944	1,059	756
Std Dev of bp EMBIG-Spread	76	0	1,195	108	192

Figure 7A: Histogram (End of Quarter EMBIG Ecuador)

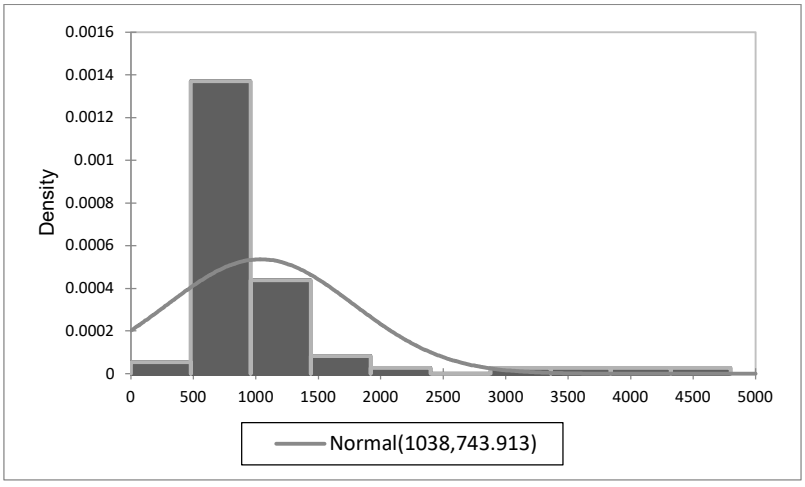


Figure 8A: Histogram (AVG. EMBIG - Spread - Ecuador)

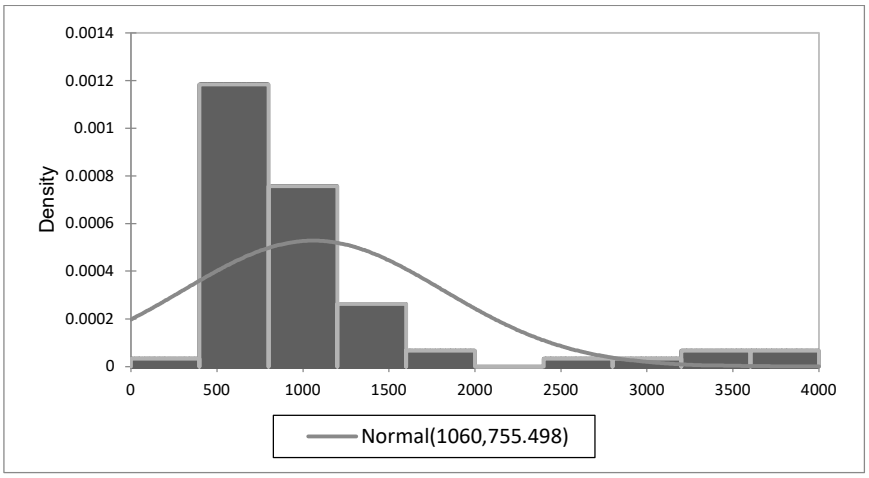


Figure 9A: Histogram (Std Dev of bp EMBIG-Spread Ecuador)

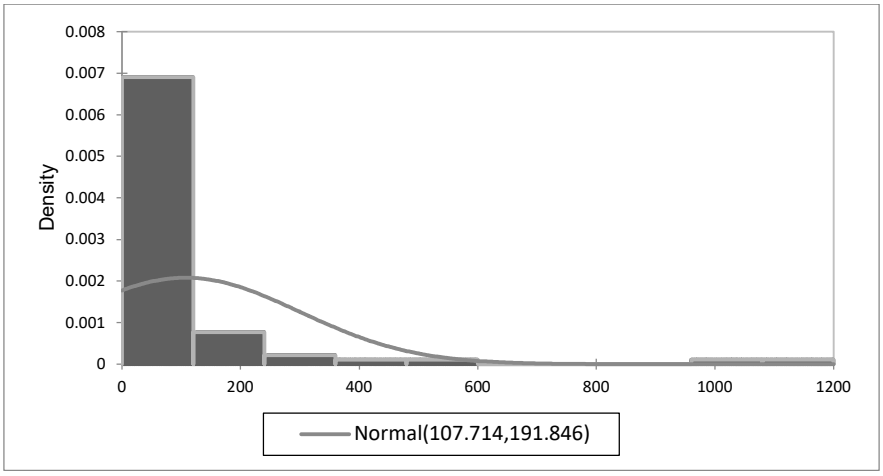


Table 6A
Summary statistics: Peru All Variations of Independent Variable EMBI Spread

Variable	Observations	Min.	Max.	Mean	Std. deviation
End of Quarter EMBIG	48	97	560	192	75
AVG. EMBIG - Spread	48	118	470	186	69
Std Dev of bp EMBIG-Spread	48	4	130	19	19

Figure 10A: Histogram (End of Quarter EMBIG Peru)

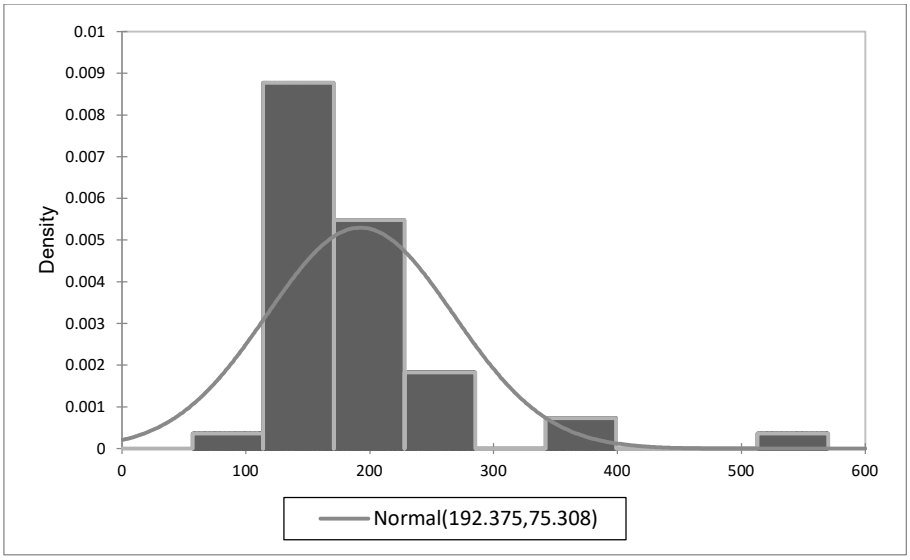


Figure 11A: Histogram (AVG. EMBIG - Spread – Peru)

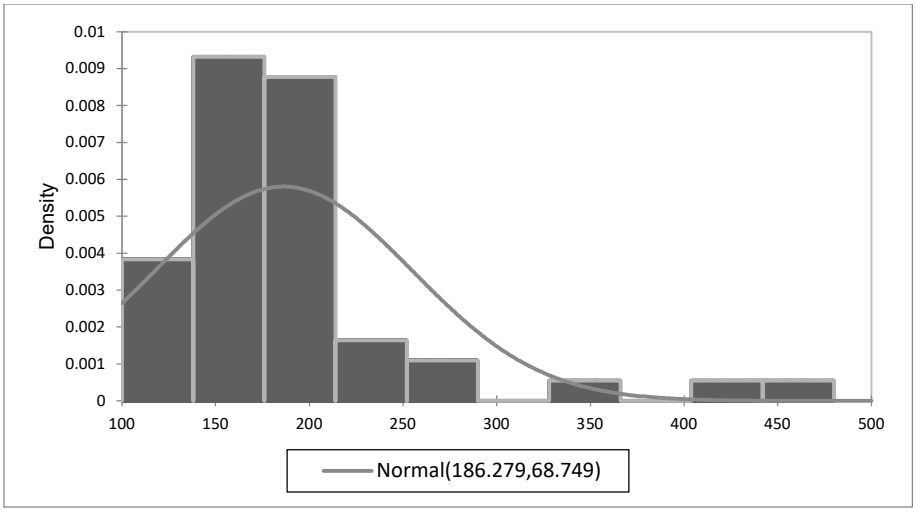
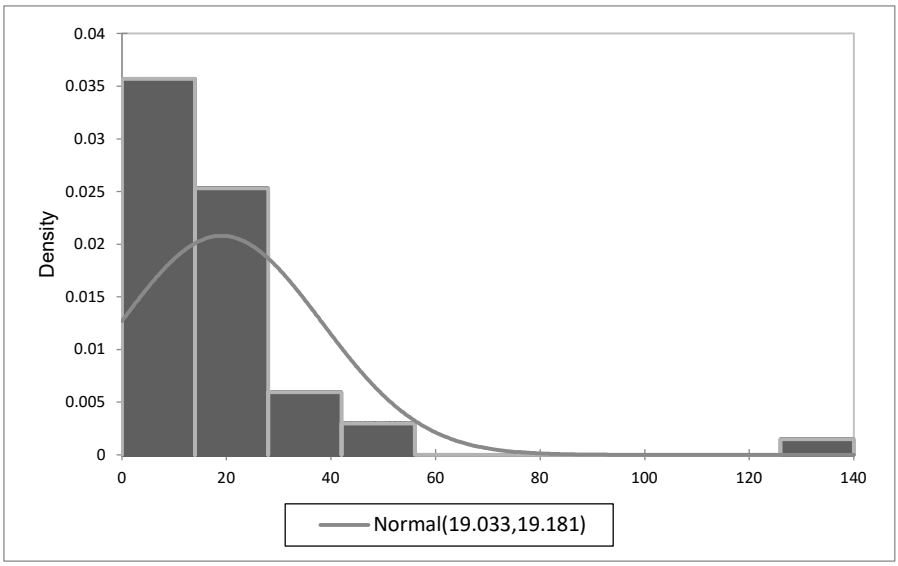


Figure 12A: Histogram (Std Dev of bp EMBIG-Spread Peru)



When comparing the complete data set of the EMBI Spread variable to the three variations computed to coincide with the quarterly macroeconomic data, the following preliminary conclusions can be drawn:

1. The skewness remains positive for the quarterly variations of the EMBI Spread for all three countries akin to the complete data set of EMBI Spread.
2. The skewness is markedly higher for the Ecuador in the quarterly data, akin to the complete data set of EMBI Spread.
3. The Standard Deviation of the EMBI Spread for the quarterly periods maintains the same patters as the complete data set of EMBI Spreads for all three countries.

These preliminary findings about the dependent variable should be of no surprise since the samples of means drawn from a population are in effect an unbiased

estimator of the population mean, otherwise said, the expected value of the sample mean is equal to the population mean. This provided reassurance about the multiple regressions analyses performed with the quarterly data, whose results are described further ahead (Section 6.5), since the basic descriptive statistics of the quarterly period EMBI Spreads were confirmed to be in line with the complete data set of the daily EMBI Spread variable. This engrained attribute of the quarterly statistics allowed for pairing macroeconomic data, regardless of its periodicity, with the end of quarter, average for the quarter or standard deviation of the quarter of the EMBI Spread in order to determine causality, in a similar fashion as Edwards (1983-1986) did with macroeconomic variables in his seminal work about the determinants of borrowing spreads.

INDEPENDENT QUANTITATIVE VARIABLES

ALL TWEETS AND FIN TWEETS: This variable refers to the impact generated by the Tweet activity from analyzing the hashtag term for all three countries (#Ecuador, # Colombia, #Peru) for the quarterly periods to coincide – when possible since hashtag (#) activity tracking only began in 2007 on Twitter social medium—with the macroeconomic data retrieved for each country.

Table 7A
Summary statistics: Colombia Tweet Variables

Variable	Observations	Minimum	Maximum	Mean	Std. deviation
Colombia ALL Tweets	47	0	2.05	0.37	0.49
Colombia FIN Tweets	47	0	0.57	0.15	0.16

Figure 13A: Histogram (Colombia ALL Tweets)

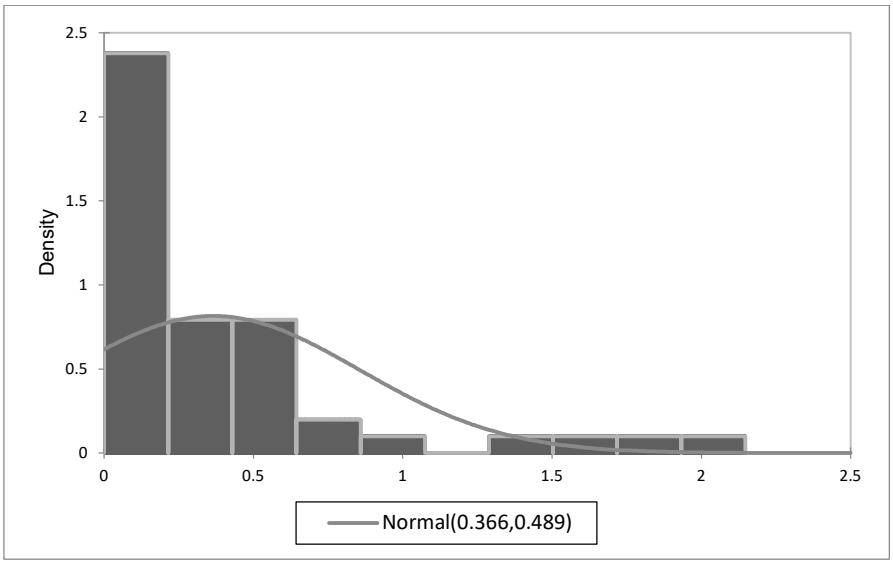


Figure 14A: Histogram (Colombia FIN Tweets)

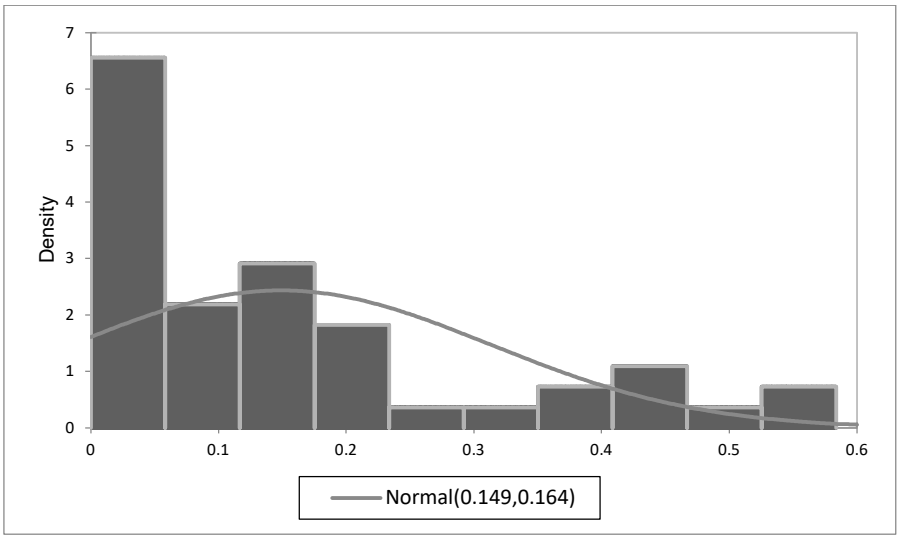


Table 8A
Summary statistics: Ecuador Tweet Variables

Variable	Observations	Minimum	Maximum	Mean	Std. deviation
Ecuador ALL Tweets	45	0	5.6	0.38	0.91
Ecuador FIN Tweets	45	0	0.24	0.05	0.07

Figure 15A: Histogram (Ecuador ALL Tweets)

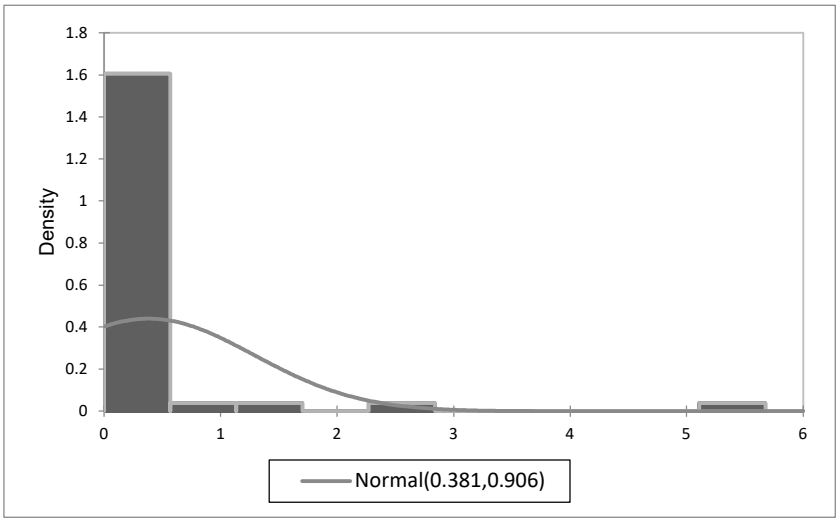


Figure 16A: Histogram (Ecuador FIN Tweets)

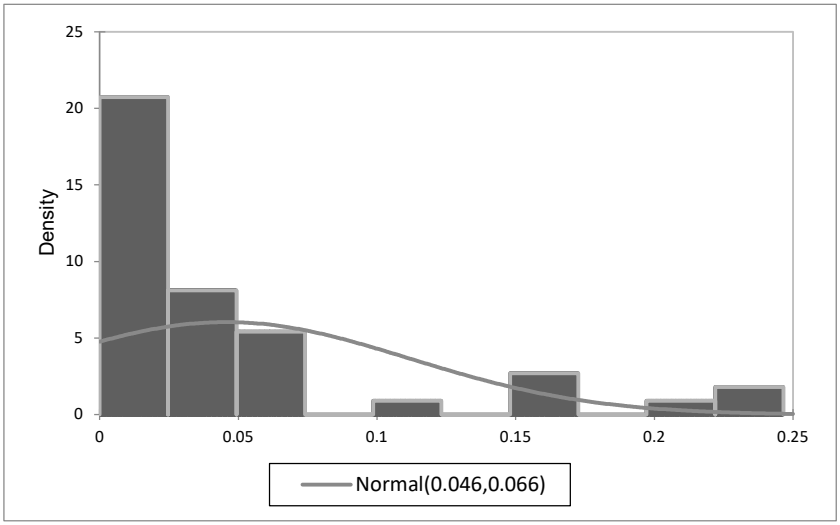


Table 9A

Summary statistics: Peru Tweet Variables

Variable	Observations	Minimum	Maximum	Mean	Std. deviation
Peru ALL Tweets	43	0	1.19	0.34	0.31
Peru FIN Tweets	43	0	0.41	0.09	0.09

Figure 17A: Histogram (Peru ALL Tweets)

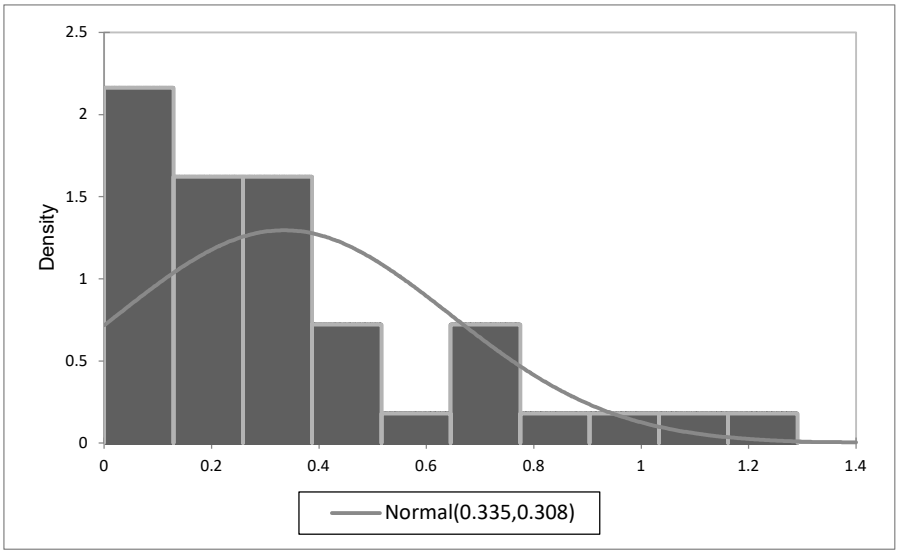
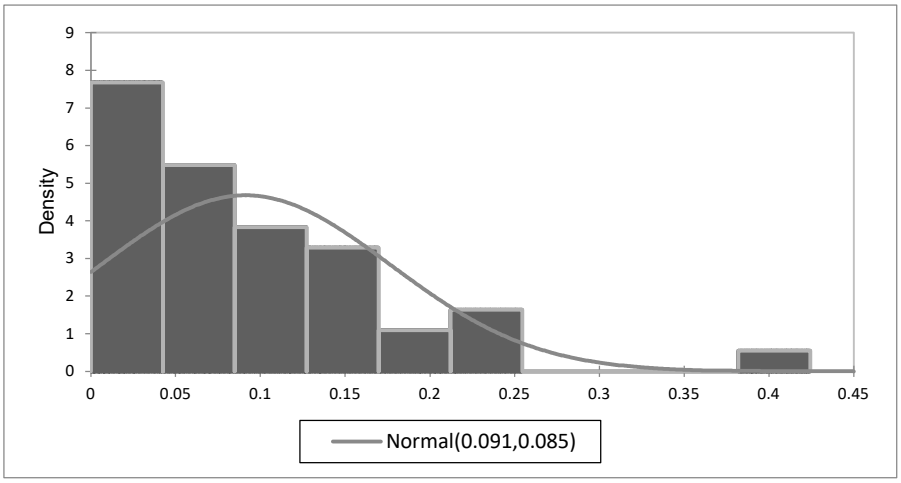


Figure 18A: Histogram (Peru FIN Tweets)



Std. Dev. = Endogenous Risk: This variable captures one of the core motivations behind the investigation. The Endogenous Risk measures results from the computation of quarterly economic activity changes for each one of the countries of the research. For this reason, the number of observations for this statistic depends on the available quarterly industrial economic data for each country. What is evident of this variable from observing the histograms is that the skewness of the data is not pervasive as in the previous variables studied and for this reason the benefits from a logarithmic transformation, with the specific purpose of ridding the data of heteroscedasticity, are limited. The reason for the normal distribution of this data rests on the fact that the Endogenous Risk is in effect and average of sorts and, as such, the data would be normally distributed because of the Central Limit Theorem.[13]

Table 9A
Summary statistics: Endogenous Risk

Variable	Observations	Minimum	Maximum	Mean	Std. deviation
Colombia Endogenous Risk	60	11%	13%	12%	6%
Ecuador Endogenous Risk	79	3.1%	4.9%	4.4%	0.2%
Peru Endogenous Risk	52	6.7%	8.5%	7.4%	0.4%

[13] This theorem states that even if data is not normally distributed, a sufficiently large sample from the data would be normally distributed.

Figure 19A: Histogram (Colombia Endogenous Risk)

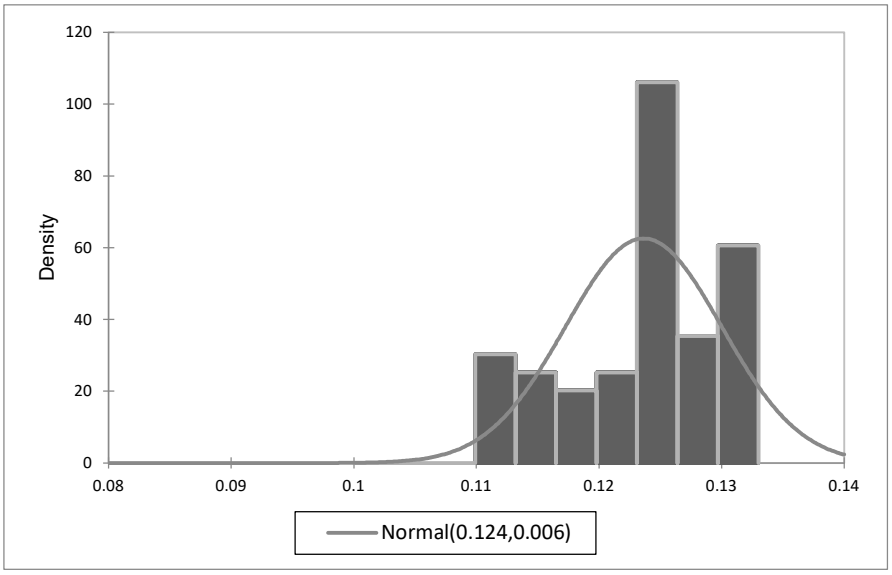


Figure 20A: Histogram (Ecuador Endogenous Risk)

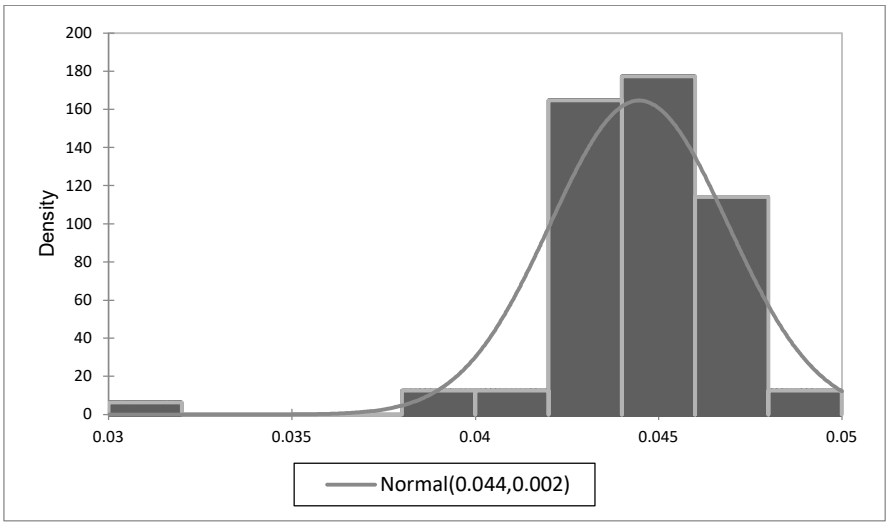
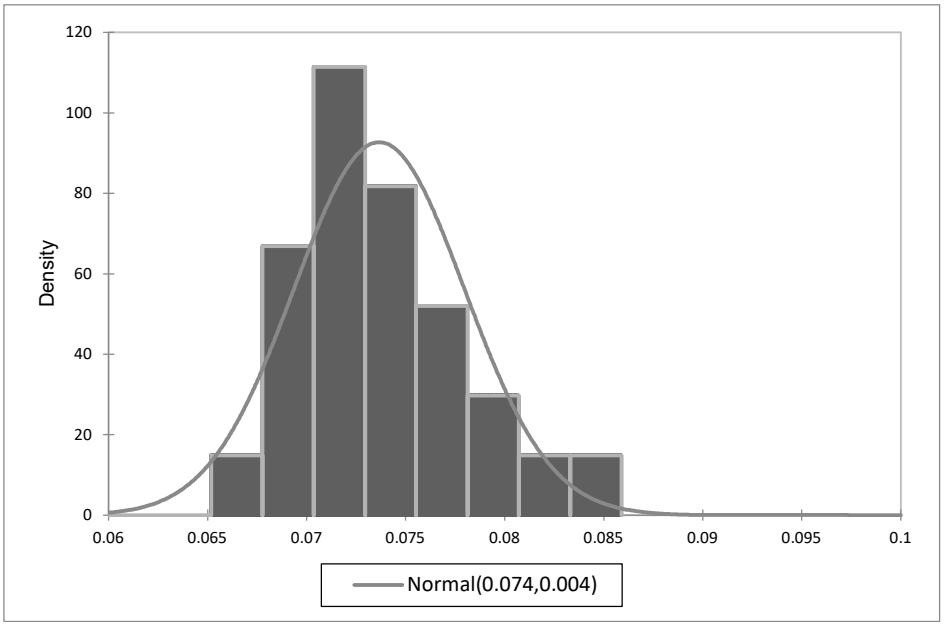


Figure 21A: Histogram (Peru Endogenous Risk)



The Endogenous Risk variable showed signs for the presence of a unit root or non-stationarity and was thus subjected to an Augmented Dickey-Fuller correction and test (Figures 4, 5, and 6). The differenced and lagged time series of this variable was stationary once corrected, yet the results of the regression proved only significant for the country of Ecuador and for the other two countries this independent regressor did not survive the elimination upon inspection of VIF (Variance Inflation Factor) multicollinearity.

SURVEY AND PERCEPTION INDICES AS INDEPENDENT VARIABLES

STARTING A BUSINESS: This index is the result of the yearly survey conducted by the World Bank (https://www.doingbusiness.org/en/methodology/starting-a-business).

The notion here is that the component values which comprise the Starting A Business indicator would have an impact on the EMBI Spread at the time of publication, which is a year ahead of the survey information year. The important event, the event that is researched to measure its hypothetical impact on EMBI Spreads is the publication of the report itself and the ensuing score for a country, not the actual timeframe for retrieval of the survey information. It merits noting the greater importance of the publication containing the index's score on the observed EMBI Spread rather than the actual timeframe of the retrieval of the data used for the report. As an example, the year 2020's Report whose publication occurred in the third quarter of 2019 would hypothetically have an impact on the observed EMBI Spread beginning in the third quarter of 2019 and beyond, but certainly not before that date (https://www.worldbank.org/en/news/feature/2019/10/24/doing-business-2020-sustaining-the-pace-of-reforms). The score was ranked, and the percentile data was used as an independent variable in the regression analyses.

Table 10A
Summary Statistics for STARTING A BUSINESS Percentile RANK

Variable	Observations	Min.	Max	Mean	Std. deviation
Percentile RANK Colombia	17	44.3%	66%	55.5%	6.1%
Percentile RANK Ecuador	17	6.8%	35.1%	20.2%	8.3%
Percentile RANK Peru	17	27.5%	42.6%	35.4%	5.3%

Figure 22A: Histogram Percentile RANK Colombia

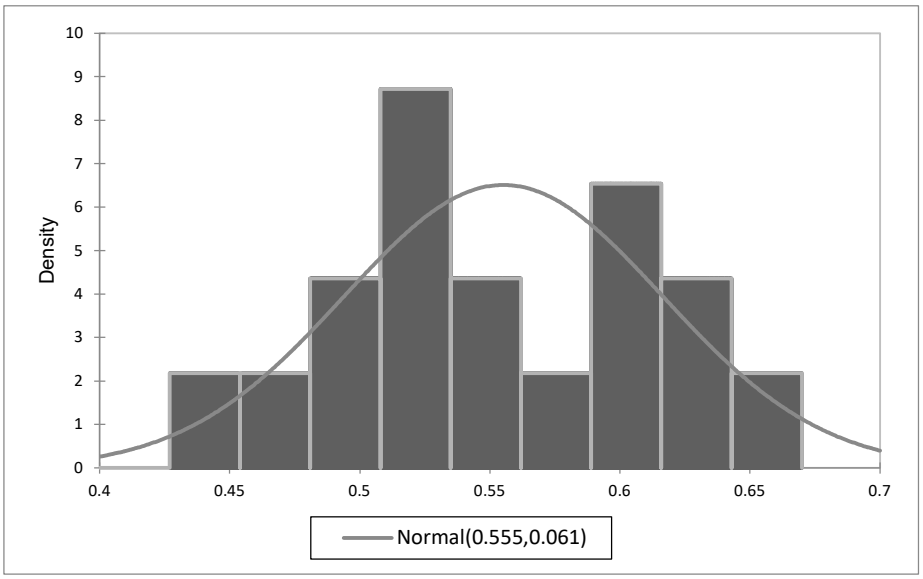


Figure 23A: Histogram Percentile RANK Colombia

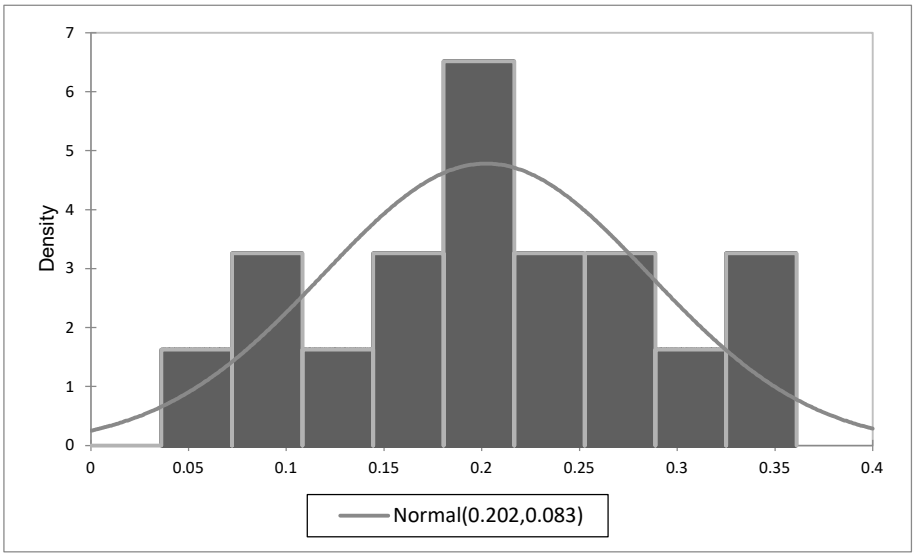
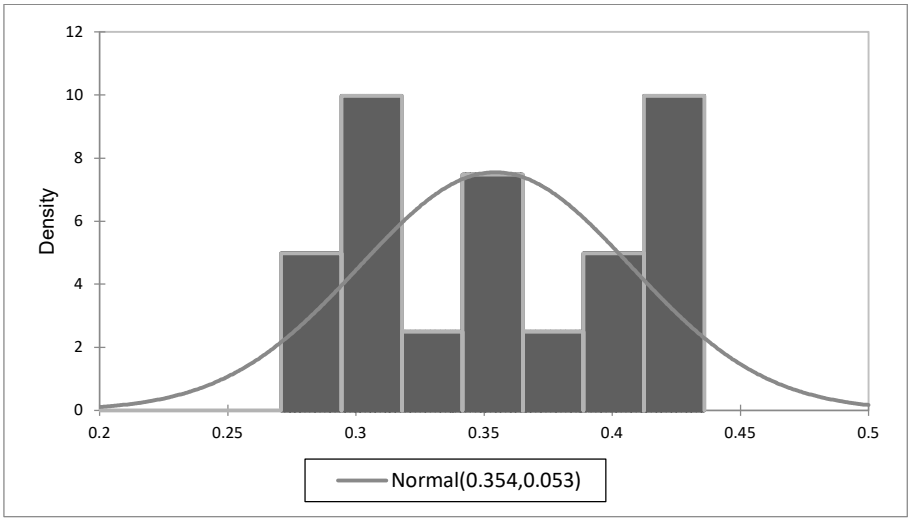


Figure 24A: Histogram Percentile RANK Peru



CORRUPTION: A percentile rank was computed from the original raw score of the publication. In a similar fashion to the comment about the previous index's impact, the Corruption Perception Index (CPI) yearly publication would presumably have an effect on the EMBI Spread on or after the time it is published (https://www.transparency.org/en/cpi#). The year 2019 score and rankings of the CPI according to the press release on their website (https://www.transparency.org/en/cpi/2019/press-and-downloads) became available on January 23, 2020 and would hypothetically have an effect on the EMBI Spread thereafter. To make the data wieldier it has been assumed that the year of the index (i.e., 2019) has an impact on the following year's EMBI Spread.

Table 11A
Summary statistics: CPI Percentile RANK

Variable	Observations	Min.	Max.	Mean	Std. deviation
CPI Percentile RANK Colombia	22	7.1%	65.4%	48.8%	13.3%

CPI Percentile RANK Ecuador	22	9.4%	48%	25.6%	11%
CPI Percentile RANK Peru	22	42.2%	60%	53.2%	5.4%

Figure 25A: Histogram (CPI Percentile RANK Colombia)

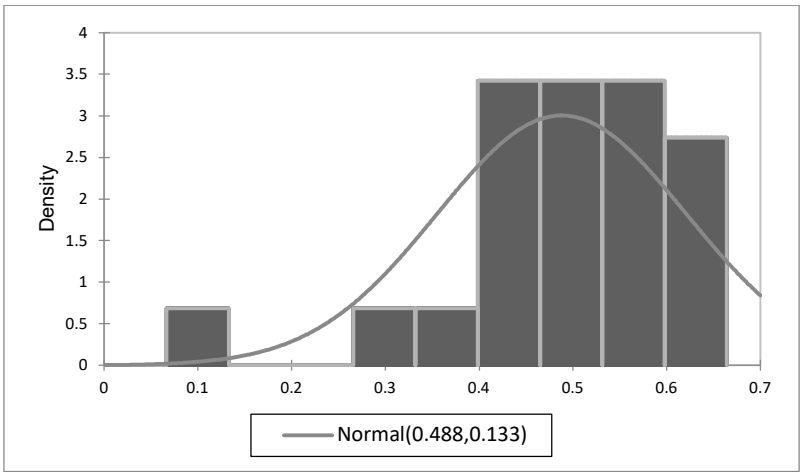


Figure 26A: Histogram (CPI Percentile RANK Ecuador)

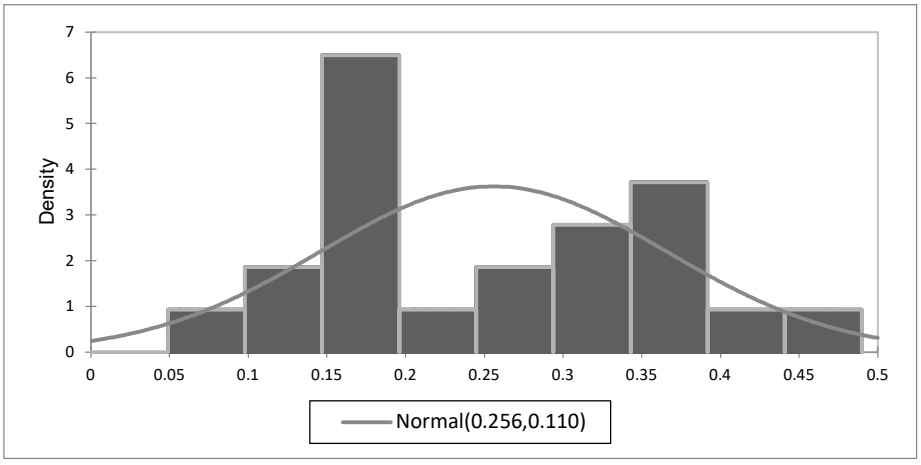
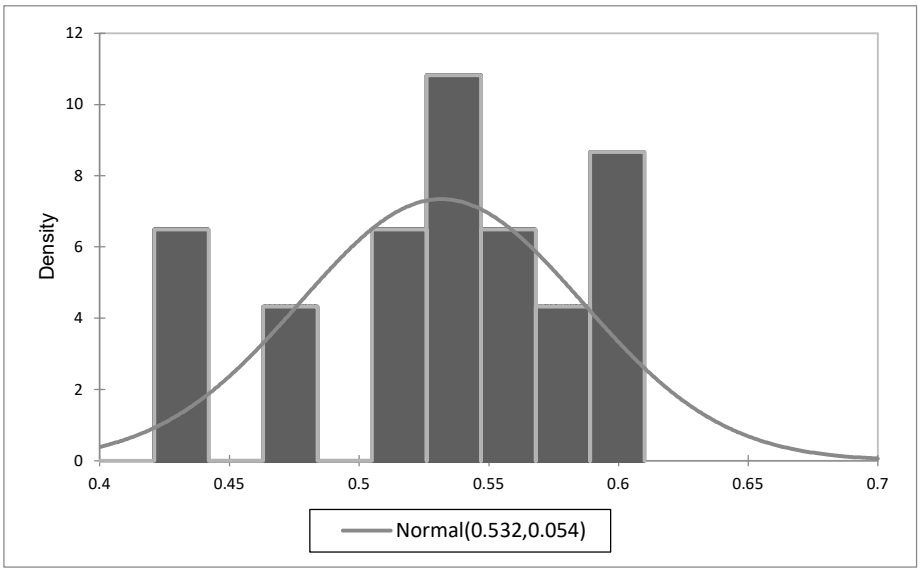


Figure 27A: Histogram (CPI Percentile RANK Peru)



Rank variables represent a report card on a country's standing in relation to others, and a such provide a periodic verdict on the merits that a country exhibits to garners the interest of investors and capital. From a pure equilibrium approach, demand for countries with a promising *score* attract more investors, hypothetically lowering their cost of access to capital and consequently the EMBI Spread. On the other hand, countries with derelict policies and corresponding poor *score* find themselves needing to pay a premium to attract those same investors and capital, hence their EMBI Spread would hypothetically be larger.

MACROECONOMIC INDICES AS VARIABLES

Solvency, liquidity, and balance of payments indicators are the most used indicators (Rowland and Torres, 2004) and these fundamental macroeconomic measures are coupled with dummy or qualitative analyses variables to determine their predictive ability of the probability of default or cost of borrowing spread of sovereign

debt. Upon review of the literature about the study of the determinants of country risk and spread, the following macroeconomic time series are part and parcel used to prognosticate the corresponding spreads as a proxy of risk (Edwards, S. 1984, Grandes, M. 2007, García-Herrero, et al 2005). These variables have been grouped and identified as macroeconomic core variables for the purposes of the data used in the regression analyses.

Table 12A
Summary statistics: Core Macroeconomic indicators (quarterly)

Variable	Observations	Minimum	Maximum	Mean	Std. deviation
COL FDI/GDP	56	0.3%	5.0%	3.1%	1.1%
COL Debt Svce./GDP	56	1.1%	5.6%	2.4%	1.1%
COL Reserves/GDP	56	0.0%	2.9%	1.0%	0.8%
ECU FDI/GDP	76	-0.2%	2.9%	1.1%	0.8%
ECU Debt Svce./GDP	76	1.3%	15.3%	4.6%	3.0%
ECU Reserves/GDP	76	-37.3%	2.9%	-1.7%	7.3%
PER FDI/GDP	48	1.5%	7.5%	4.6%	1.5%
PER Debt Svce./GDP	48	1.0%	8.8%	2.4%	1.9%
PER Reserves/GDP	48	-1.9%	12.3%	2.8%	4.1%

Figure 28A: Histogram (COL FDI/GDP)

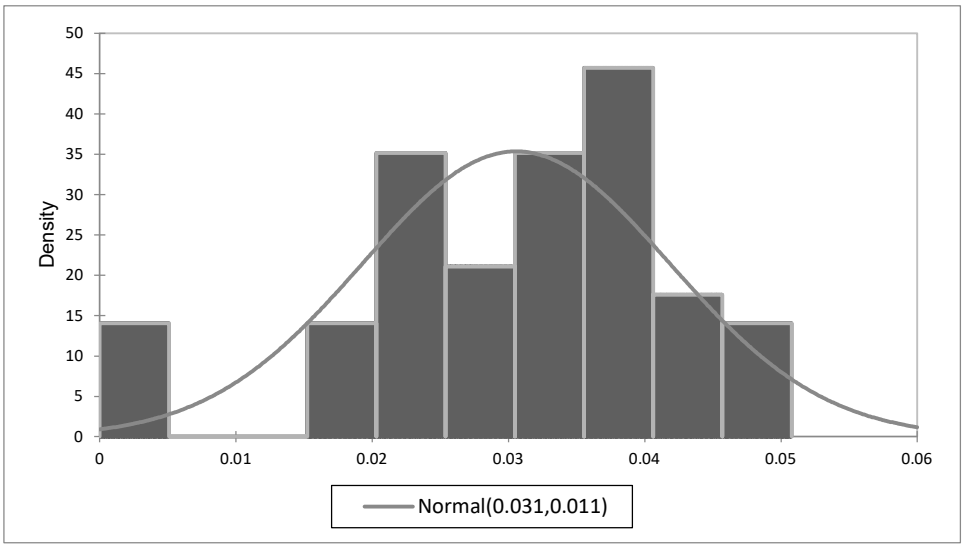


Figure 29A: Histogram (COL Debt Svce./GDP)

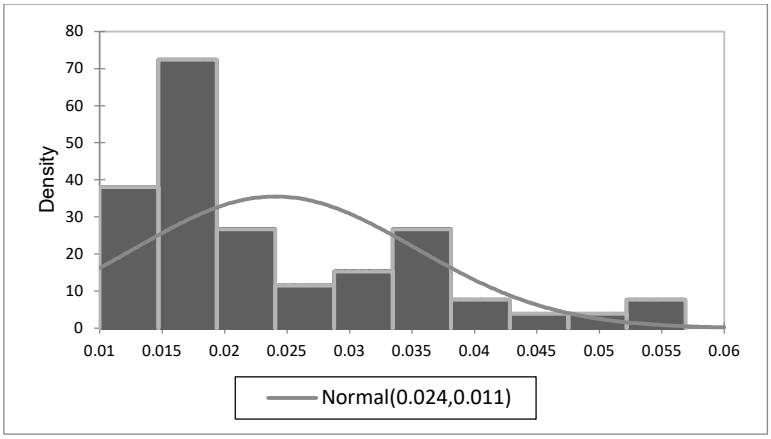


Figure 30A: Histogram (COL Reserves/GDP)

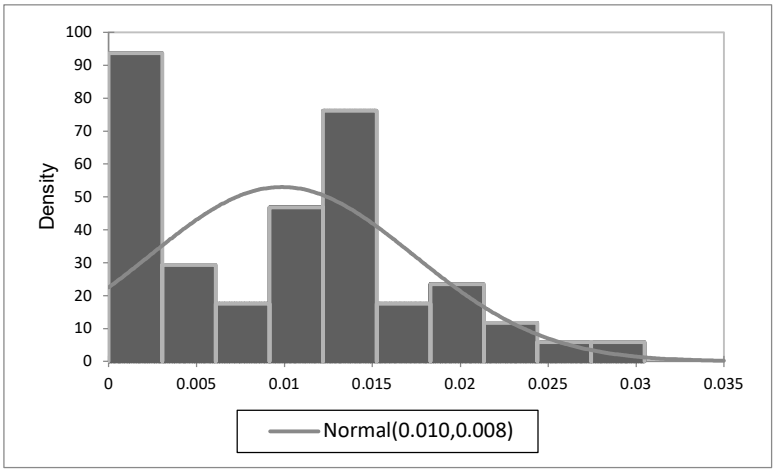


Figure 31A: Histogram (ECU FDI/GDP)

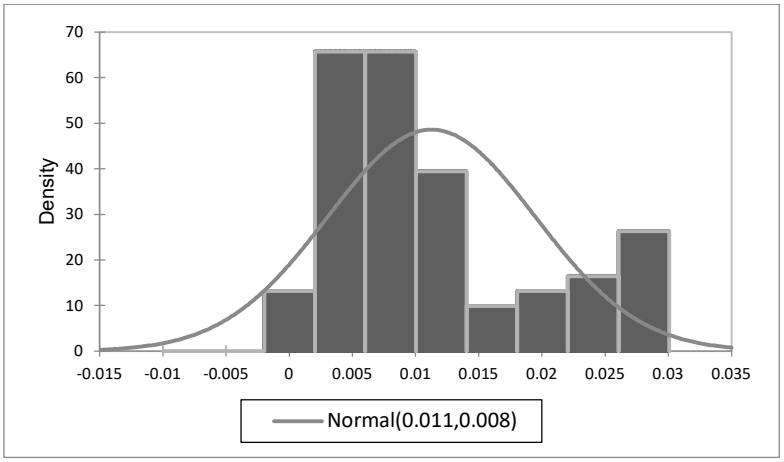


Figure 32A: Histogram (ECU Debt Svce./GDP)

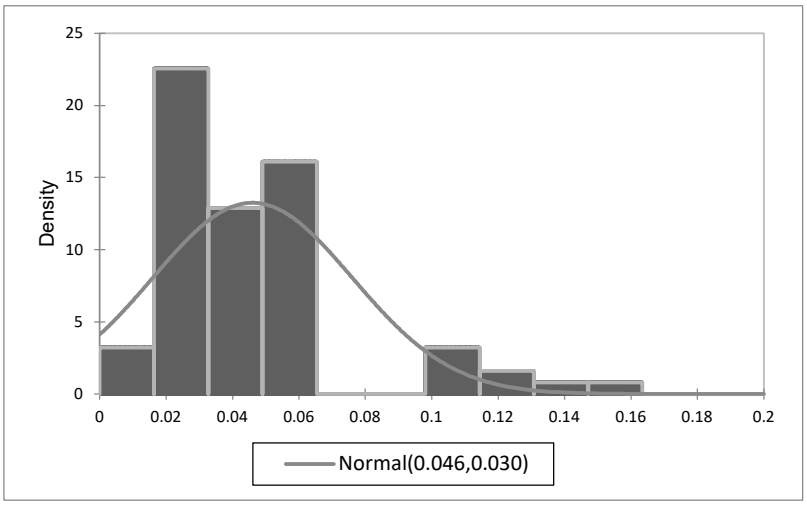


Figure 33A: Histogram (ECU Reserves/GDP)

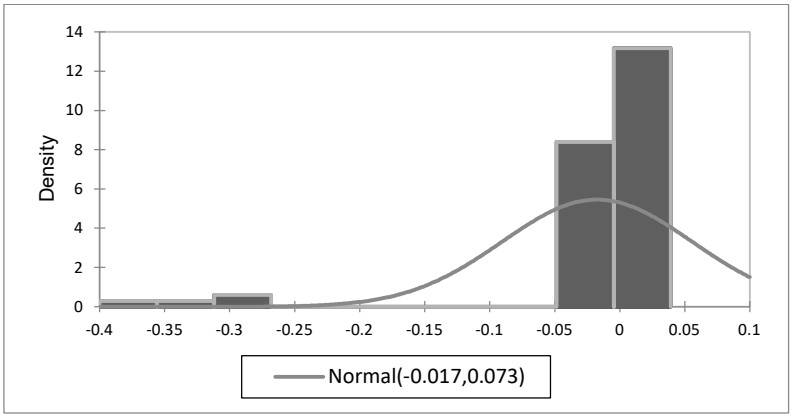


Figure 34A: Histogram (PER FDI/GDP)

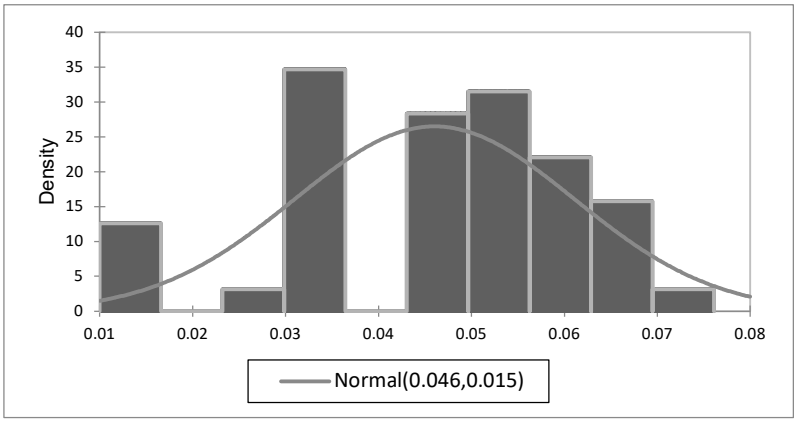


Figure 35A: Histogram (PER Debt Svce./GDP)

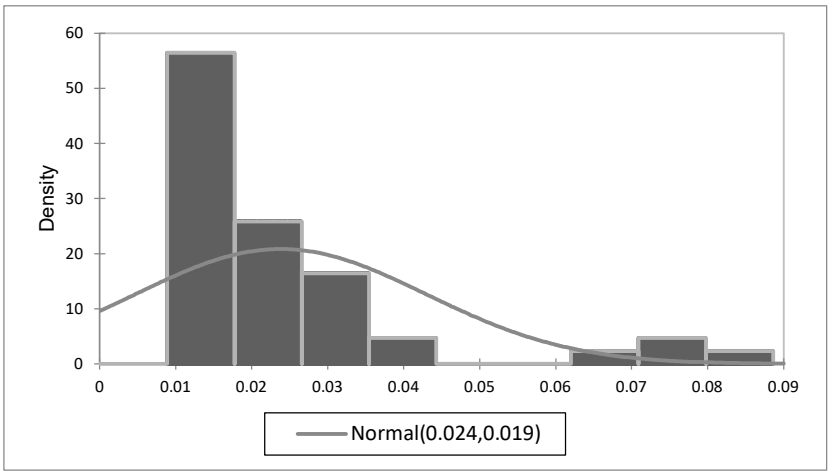
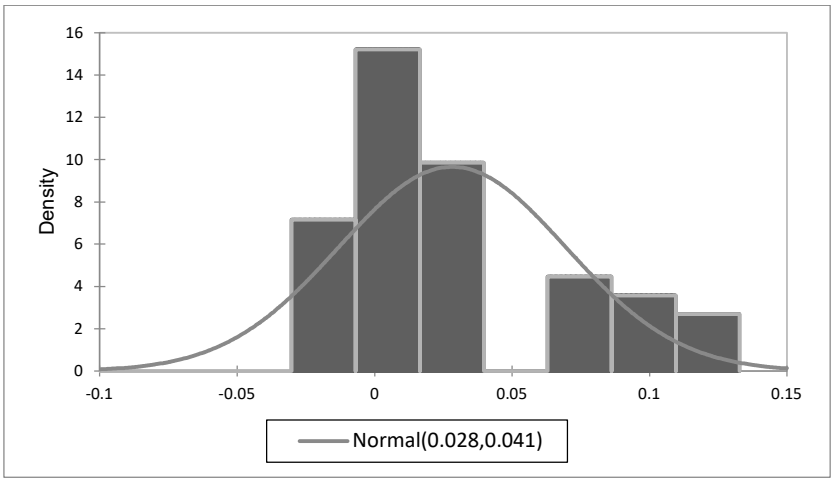


Figure 36A: Histogram (PER Reserves/GDP)



CAPITAL MARKETS DATA AS INDEPENDENT VARIABLES

The Bid-Ask Spread, a traded or non-traded sovereign issue and an Investment Grade credit rating, three independent variables associated with the capital markets are used as qualitative (dummy) independent variables for each quarterly period of activity analyzed. Also, the ensuing three quantitative variables from this field are used in the regression analyses: (1) the average credit score given to a sovereign issue from credit rating entities, (2) the appreciation or depreciation

percentage of the local currency against the US Dollar during the quarterly periods of analysis to correspond to macroeconomic activity, and (3), the standard deviation of the exchange rate of the local currency to the US Dollar for the quarterly period to coincide with the analysis of macroeconomic activity.[14]

Table 13A
Summary statistics: Colombia Bid-Ask Spread in Basis Points

Variable	Observations	Min.	Max	Mean	Std. deviation
Colombia Bid Ask Spread (Liquidity)	30	2	9	4	2

Table 14A
Summary statistics: Colombia Qualitative Variables

Variable	Categories	Counts	Frequencies	%
Colombia TRADED = 1 NON-TRADED=0	0	26	26	46.4
	1	30	30	53.6
Colombia AVG. Invest. Grd. (1) Or Not (0)	0	24	24	42.9
	1	32	32	57.1

Table 15A
Summary statistics: Colombia F/X Depreciation or Appreciation and Standard Deviation of quarterly F/X

Variable	Observations	Min.	Max.	Mean	Std. deviation
Colombia FX DepR_AppR	56	-17.2%	14.2%	-1.0%	6.8%
Colombia STD. DEV of F/X (in COP/USD)	56	7.7	166.3	56.3	38.8

[14] Ecuador uses the US Dollar as its official currency and thus does not have a local currency exchange rate.

Figure 37A: Histogram Colombia F/X Depreciation or Appreciation

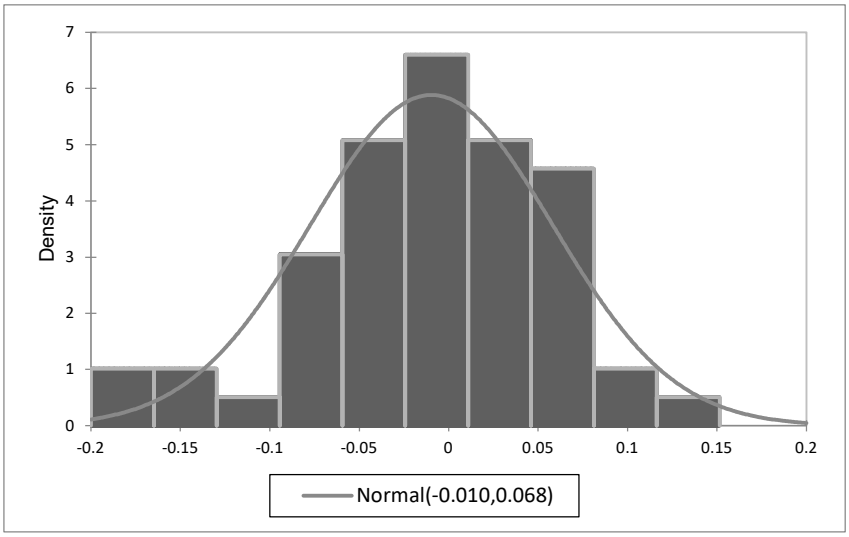


Figure 38A: Histogram Colombia Std.Dev. of F/X

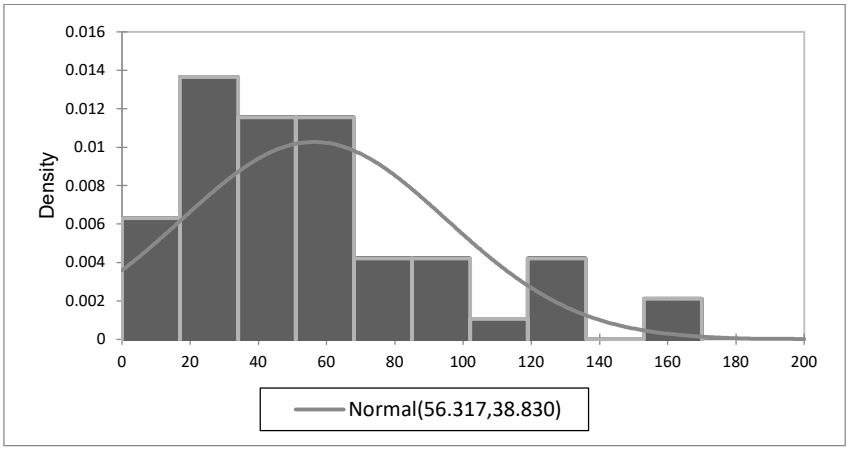


Table 16A
Summary statistics: Ecuador Bid-Ask Spread in Basis Points

Variable	Observations	Min.	Max.	Mean	Std. deviation
Ecuador Bid Ask Spread (Liquidity)	19	5	20	11	4

Figure 39A: Histogram Ecuador Bid Ask Spread (Liquidity)

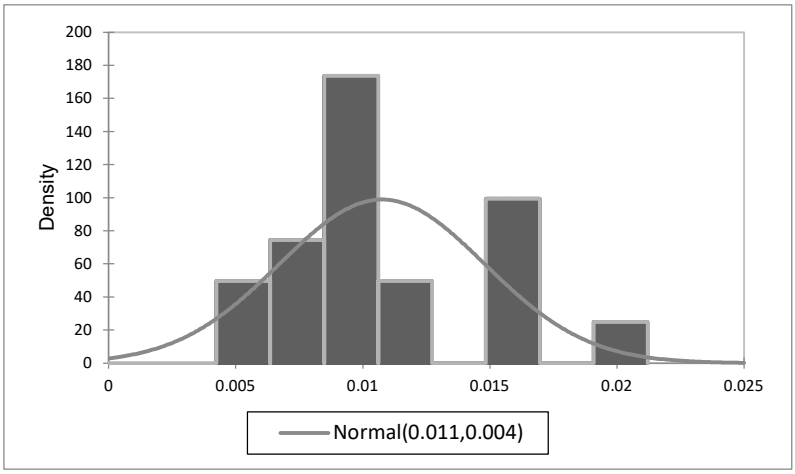


Table 17A
Summary statistics: Ecuador Qualitative Variables

Variable	Categories	Counts	Frequencies	%
Ecuador TRADED = 1 NON-TRADED=0	0	41	41	68.3
	1	19	19	31.7

Note. Ecuador has never been an Investment Grade issue sovereignty, thus that qualitative variable is not operational.

Table 18A
Summary statistics: Ecuador Average Period Credit Rating Score

Variable	Observations	Minimum	Maximum	Mean	Std. deviation
Ecuador AVERAGE PERIOD RATING	76	3.0	9.0	6.3	1.3

Figure 40A: Histogram Ecuador Average Credit Rating

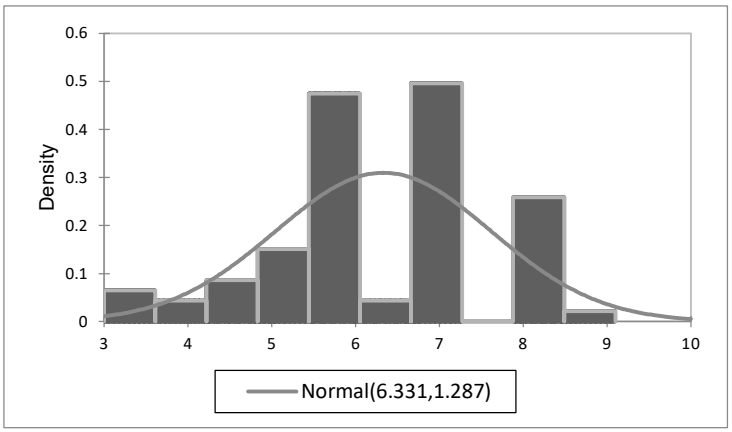


Table 19A
Summary statistics: Peru Bid Ask Spread in Basis Points and Average Credit Rating Score

Variable	Observations	Min.	Max.	Mean	Std. deviation
Peru Bid Ask Spread (Liquidity)	48	3	33	7	5
Peru AVERAGE PERIOD RATING	48	11	16	13.4	1.8

Figure 41A: Histogram Peru Bid-Ask Spread

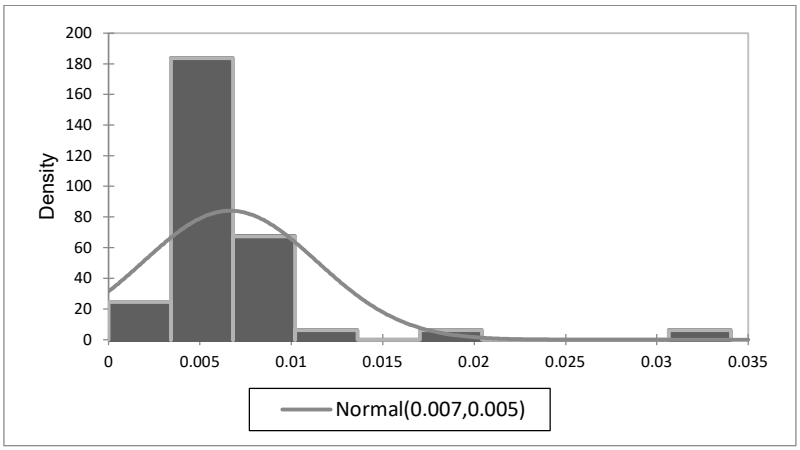


Figure 42A: Histogram Peru Average Credit Rating

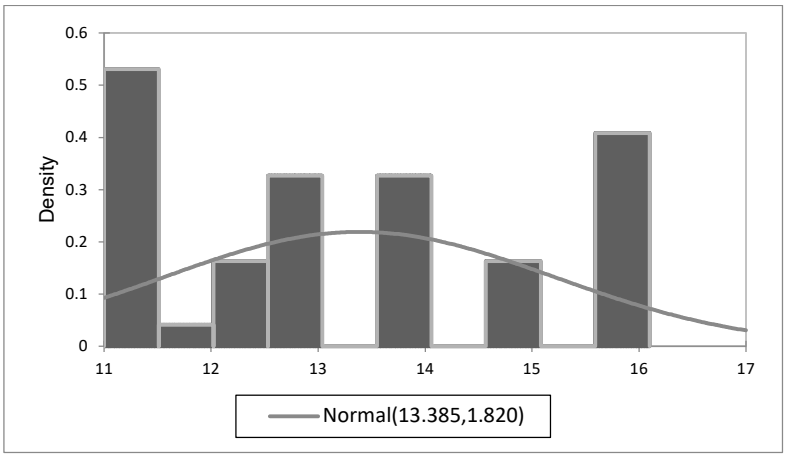


Table 20A
Summary statistics: Peru Qualitative Variable Investment Grade or Not

Variable	Categories	Counts	Frequencies	%
Peru AVG. Invest. Grd. (1) Or Not (0)	0	14	14	29.2
	1	34	34	70.8

Note. Peru issue studied has been traded throughout the quarterly periods analyzed, thus the ualitative variable Traded or Not-Traded not operational.

Table 21A
Summary statistics: Peru F/X Depreciation or Appreciation and Standard Deviation of quarterly F/X

Variable	Observations	Min.	Max.	Mean	Std. deviation
Peru FX DepR_AppR	48	-5.5%	8.8%	-0.2%	2.9%
Peru STD. DEV of F/X in PEN/USD	48	0.005	0.078	0.028	0.018

Figure 43A: Histogram Peru F/X Depreciation or Appreciation

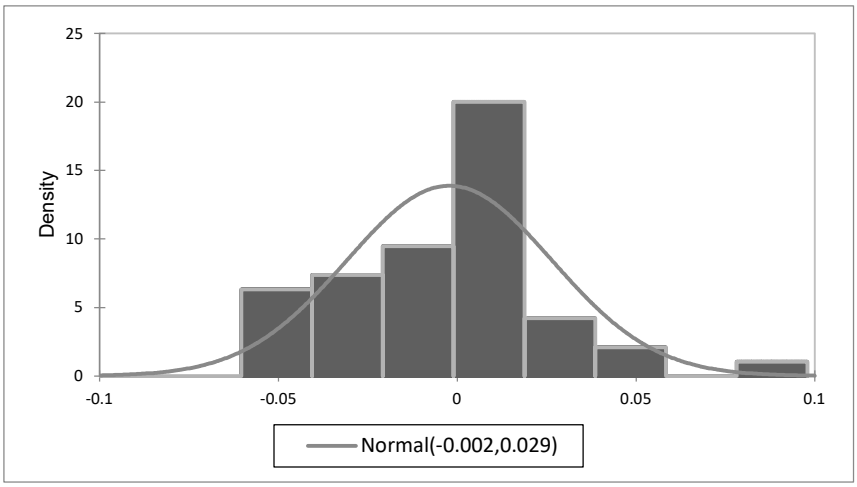


Figure 44A: Histogram Peru Std. Deviation of F/X