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TOPIC

THE IMPACT OF SOVEREIGN RATINGS ON RESEARCH & DEVELOPMENT IN DEVELOPING COUNTRIES

NAME:

MAKHALA TSUNYANE – 1710274

SUPERVISOR:

DR THANTI MTHANTI

DECLARATION

I, Makhala Tsunyane, declare that the research work reported is my own, except where otherwise indicated and acknowledged. It is submitted to fulfil the requirements for the Masters of Management in Finance and Investment Degree at the University of Witwatersrand. It has not, either in whole or in part, been submitted for any other degree or diploma to any other university or institution.

_____ _____

Makhala Tsunyane Date

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ABSTRACT

Sovereign credit ratings are considered imperative in assessing the value and worth of a nation's economy, modern theory stresses the accumulation of knowledge as one of the critical factors for economic growth and productivity. One aspect of accumulating knowledge is through Research and Development (R&D). The aim of this paper is to analyse if credit ratings are robust determinants of R&D and various economic variables that have been suggested in the literature as influencing R&D, such as the number of researchers, tertiary school enrolment, financial development, the rule of law, and foreign direct investment as robust determinants of R&D performed in developing countries.

Through the use of an Extreme Bounds Analysis (EBA), the study covers 30 middle-income countries from 2002 to 2017. The study's estimations provide evidence that credit ratings, the number of researchers, tertiary school enrolment, financial development, the rule of law, and foreign direct investment, are robust determinants of R&D. However, the results demonstrated trade openness to be fragile in determining R&D. When it comes to ratings, the study reveals that a change in the credit rating is asymmetric, because a downgrade was robust and had a significant impact on R&D, while an upgrade found to be fragile and insignificant.

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LIST OF ABBREVIATIONS & ACRONYMS

BIS	Bank for International Settlements
CDF	Cumulative Density Function
CR	Credit ratings
CRAs	Credit Ratings Agencies
EBA	Extreme Bounds Analysis
FDI	Foreign Direct Investment
FMD	Financial Market Development
GDP	Gross Domestic Product Growth
GERD	National R&D
GNI	Gross National Income
GOVR	Government Revenue
HDI	The Human Development Index
INF	Inflation
IPRs	Intellectual property rights
LDC	Least Developed Countries
LI	Lower Income
MAX	Maximum
OBS	Observations
OECD	Organisation for Economic Co-operation Development
PopD	Population Density
R&D	Research and Development
RE	Researchers
REBA	Restricted Extreme Bounds Analysis (REBA).
RoL	Rule of Law
SD	Standard Deviation
SE	Standard Error
TRO	Trade openness
TSE	Tertiary School Enrolment
UMI	Upper Middle Income
VIF	Variance Inflation Factor

CHAPTER 1: INTRODUCTION

1.1 Background

Theories of development attempt to explain the conditions that are necessary for economic development to occur, and to weigh the relative importance of those conditions. New growth theorists such as Romer & Solow (1986; 1990) advocate the development of knowledge as a fundamental driver of economic development. The central proposition of new growth theory is that, unlike land and capital, knowledge is not subject to diminishing returns. They posit innovation to be a key driver of long-term productivity growth, as it increases the possibility of achieving a higher standard of technology in firms and regions. In return, this would then allow the introduction of new and superior products and processes, thereby resulting in higher levels of income and growth.

For that reason, it is imperative for developing countries, including least developed countries (LDCs), to build their innovation capacities, without which they are likely to miss opportunities to upgrade their technologies, move up the development ladder and, catch up with developed countries (United Nations, 2006). In order to get closer to the technological frontier Shiozawa (2016) suggests governments need to be in the forefront of building innovation. This entails funding the education system, improving their infrastructure and implementing policies that encourage innovation. Developed countries such as members of the Organisation for Economic Co-operation Development (OECD) have put in place strategies on how to improve innovation in their respective countries.

In his paper of creative destruction, Schumpeterian 's (1934) main idea is that long-run growth results from innovations and new inventions replace old technologies (hence creative destruction). The practical application of Schumpeterian’s growth theory can be seen in the late nineteenth century in inventions such as electricity and combustion engines. These inventions laid the foundation for a golden age of productivity growth in the mid-twentieth century and breakthroughs in information technology have also driven productivity surges in recent decades Guellec and Potterie (2003). Anticipated technologies such as three-dimensional printing, big data, self-driving cars, and artificial intelligence are paving the way for a fourth industrial revolution in the years to come. According to Guellec and Potterie (2003) R&D performed by business usually results in new goods and services, higher quality of output, and new production processes for the industry it operates in.

According to Shiozawa (2016), countries should move away from exclusive reliance on physical resources in order to be closer to the technological frontier, and instead, move towards expanding their knowledge base and support institutions that help develop and share knowledge. One avenue that can be used to accumulate knowledge is research and development (R&D). R&D is defined in the Frascati Manual OECD (2015) to be creative work undertaken on a systematic basis in order to increase the stock of knowledge. R&D investment is one of the essential elements in advancing knowledge, increasing productivity, and promoting growth. Institutes and universities mostly perform Government-supported research, which is mainly referred to as generic or basic research.

According to Sameti, Ranjbar, and Anousheh (2010), countries that invest sufficient resources in R&D activities, and engage in R&D efficiently, have the potential to achieve a desirable growth target resulting from R&D. This is why modern economies increasingly support R&D investment. The OECD (2009) and European Commission (2000, 2010) document the level of innovation in developing countries to be, on average, fourfold lower than that of advanced countries, despite various international activities aimed at increasing the level of R&D activity in these countries. The average share of total expenditure on R&D as a percentage of gross domestic product (GDP), as shown in Figure 1., is typically much higher in advanced economies (2% of GDP) than in emerging market and middle-income economies (0,65% of GDP) and low-income developing countries (0,15% of GDP).

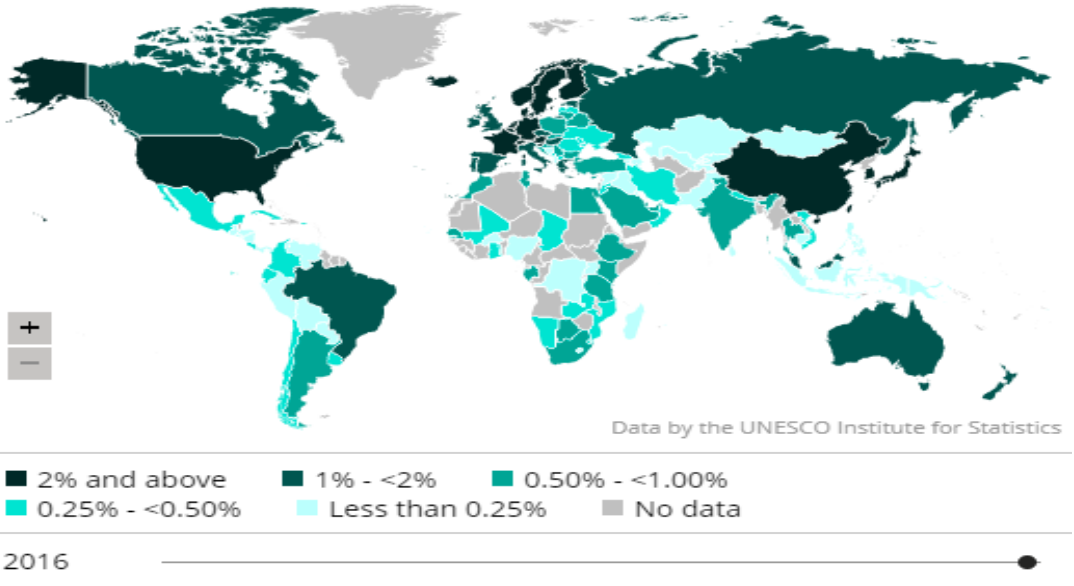

Figure 1. Research and development as a proportion of GDP 2016. (Source: UNESCO website)

Lack of capital is one of the factors that can limit a country from engaging in extensive R&D, for example, a country's primary source of revenue is generated mainly through taxes. This income is usually never enough to meet the government's financial needs, especially in developing countries. Countries are faced with various competing demands for public funding in areas such as health, education, infrastructure, and many other factors that may require government funding. Resultantly, government funding becomes an increasingly scarce resource, especially in times of financial crisis and economic austerity. This means governments and institutions within the country may need to find external investor to finance R&D activities. In order to enhance the probability of securing external funding or investors, one of the strategies of R&D that governments can employ is obtaining a sovereign credit rating.

The advantages of having a rating is that; it exposes a country to numerous opportunities such as gaining access to capital markets, and an increased pool of investors. This is because, in the absence of a rating, it becomes a hurdle for investors to decide on whether to invest or not with the corporate/country. Resultantly making it harder for a country to fund its current account deficit, and it also affects the borrowing costs. The reason investors rely on a sovereign credit rating to assess the creditworthiness of a country (despite CRAs having explicitly stated that their ratings are their independent opinion on default risk and cannot be sorely relied on Kaminsky and Schmukler (1999)) is that these ratings are believed to also indicate the nation's economic status in their evolution. The reliance on ratings issued by CRAs is such that it is no longer limited to investors but bank regulators also "consume" credit ratings and use them to set capital standards for regulated institutions under the Basel Committee Capital Accord Recommendations and this additional role has magnified the importance of CRAs[1].

1.2 Objective of the study

The ability for a country to develop, adapt, and harness its innovative potential is critical in terms of long term economic growth and competitiveness (Petrariu, Bumbac, and Ciobanu, 2013). This means all factors that can have any impact on innovation need to be explored and understood. In their study of the relation between sovereign credit rating revisions and economic growth (Chen et al. 2016), finds a country's economic growth exhibits a significant response to sovereign rating changes: a one-notch

[1] For regulatory purposes CRAs fall into two categories, recognized and non-recognized see Elkhoury (2009).

upgrade (downgrade) causes an increase (decline) in re-rated countries' five-year average annual growth rates. The study does not take into account the transmission of rating change on research and development. One study that investigated the manner in which credit ratings affect innovation has been undertaken by (Wang, 2017). However, the study's emphasis was on the impact on firm innovation and not so much on sovereign innovation.

The interest to study the relation between credit ratings and national innovation, especially in developing countries, stems from the belief that the CRAs played a significant role in the 2008 financial crisis in the United States, and the recent European Union crises (Seetharaman et al., 2017). It has also been argued widely that an unfavourable rating announcement can trigger a chain reaction, thus worsening the fundamentals of the country and causing subsequent rating downgrades (Kirikkaleli and Gokmenoglu, 2020). This has resulted in a lot of studies focusing on the impact of sovereign downgrades and upgrades in the political and economic sphere. Unfortunately, these studies have rarely translated to how these downgrades/upgrades can affect a country's development with regards to innovation.

The relationship between sovereign ratings and R&D in developing countries needs to be explored to determine whether credit worthiness of the sovereign has any impact on the development activities of a nation. Several studies relating to drivers of national innovation such as (Gumus and Celikay, 2015); (Wang 2010); (Bebczuk 2002); (Clarke, 2001); and (Sameti, Ranjbar, and Anousheh 2010) have not taken into account the impact that credit ratings can have on national R&D. This study shall, therefore, attempt to bridge this gap by studying the said relationship.

The study also considers whether having a developed financial market contributes to R&D intensity amongst other factors such as, trade openness, foreign development investment, intellectual property rights (IPRs) and foreign direct investment (FDI) are some of the channels for acquiring knowledge, especially in developing countries (World Bank, 1998). Therefore, there is a need to undertake studies and investigate how credit ratings can influence R&D in developing countries and other macroeconomic factors.

Additionally, the World Bank (1998) Development Report, emphasizes the importance of trade openness, strong intellectual property rights (IPRs) and foreign direct investment (FDI) as important channels through which knowledge can be acquired, especially for developing countries (Schneider, 2005). Resultantly, there is a need to undertake empirical analysis to investigate factors that can

influence R&D in developing countries. This is so that developing countries can adopt and implement policies that allow them to be well positioned with regards to their innovation systems.

1.3 Research questions

The purpose of this study is to apply regression analysis to test whether the sovereign credit ratings issued by S&P, Fitch and Moody's have a long-term structural influence on emerging markets' innovation by explicitly looking at the Research and Development expenditure undertaken by the government and the business sector. The research questions are as follows:

1) What are the determinants of R&D intensity?
2) Is there a statistically significant relationship between credit rating changes and R&D intensity?

1.4 Significance of the study

Developing countries are in a transitional state, ("emerging" from a less developed status and joining the group of developed countries) and this transition has resulted in governments developing and adapting policies that favour economic liberalisation and adopting free-market systems. This study intends to aid policy makers when developing innovation policies to consider how the perception of its ability to honour debt obligations impacts on their innovation ability. Elkhoury (2009) says that although precise information is not available on the way in which macroeconomic policies are taken into consideration by CRAs in establishing sovereign ratings, most analysts assume that orthodox policies focusing on the reduction of inflation and government budget deficits are favoured. In order to avoid rating downgrades, borrowing countries adopt policies that address the short-term concerns of investors, even when they are in conflict with long-term development needs of a country. When countries pursue short term development needs, R&D is overlooked.

Secondly, the study contributes to the literature in the following aspects; it provides new insights into the effects of credit ratings and extends the literature on credit ratings by showing robust evidence that rating downgrades can impede innovation. The study varies from prior studies such as Kisgen, (2006); Sufi (2009); Harford and Uysal, (2014) who document the impact of ratings on firm decisions by

specifically looking at the impact it can have on sovereign R&D. The study is also related to studies on determinants of national R&D such as Wang (2010), Sameti, Ranjbar, and Anousheh (2010), Bebczuk (2002), and Clarke (2001), differing in that it highlights the impact credit ratings can have on R&D as an important catalyst for economic growth. The study identifies a specific channel through which actual changes in credit ratings can affect economic development.

Thirdly, from an international perspective, this paper adds to the innovation literature by showing how market players affect corporate patenting activities. For example, He and Tian (2013) find that analyst coverage hinders corporate innovation by exerting excessive pressure on managers to meet short-term earnings targets. Findings in this paper suggest that intensified creditor intervention may be an underlying mechanism that reduces innovation when ratings deteriorate. Finally, investors and prospective investors may find this research beneficial.

1.5 Research Outline

The research is structured into five chapters. The first chapter introduces the research topic and a brief background on innovation and credit ratings. The second chapter provides a detailed literature review on R&D expenditure, credit ratings, and how ratings can affect innovation. The third chapter provides the research methodology and defines the analytical framework for the impact of long-term foreign currency sovereign credit ratings on R&D. It will also include an analysis of the data of the study. Chapter four comprises a presentation of the findings and an interpretation of the results, while chapter five being the last chapter, summarises critical findings, and offers recommendations on the findings from the empirical analysis before concluding.

CHAPTER 2: LITERATURE REVIEW

Introduction

The purpose of this chapter is mainly to review the literature, by first discussing the underlying theory before discussing factors that can affect R&D in section 2.2 and 2.3 respectively. Economic literature around credit ratings is centred around two themes, the first being on the rating process and factors considered by CRAs in assigning a rating. The second is on the impact that credit ratings have in decision making, especially for investors. This chapter also reviews the impact of credit ratings in section 2.4. Section 2.5 will then draw conclusions from the different studies.

2.1 Growth Theories

Economists have attempted to model economic growth and explain conditions that are necessary for growth to occur. This has resulted in the development of several theories, explanations, and arguments, such that two prominent theories evolved namely, the exogenous and the endogenous growth theories. To put the current study into context, it is imperative that an understanding of the underlying theories is obtained. Thus, the two theories will be divulged in the following sections beginning with the exogenous growth theory in section 2.1.1, and followed by the endogenous growth theory under section and 2.1.2.

2.1.1 Neoclassical theory of economic growth

The most discussed model presenting the neoclassical exogenous growth theory is the economic growth model that was developed by Solow. From its inception The Solow Growth Model, is based upon five factors or variables, which are the aggregate function product known as (Y); capital accumulation known as (K); labour known as (L); technology or knowledge or the multiply factor known as (A); and time which is known as (t). It follows then by this formal linear equation:

$$Y(t) = K(t)\,[A(t), L(t)]$$

The model attempts to explain the dynamics of long-run economic growth, as a result of investment capital accumulation (K), labour or population growth (L), which are argued to drive every economy (Solow, 1956). The "Solow" model is criticized on; is its inability to account for technological progress

in economic growth. Solow contemplates that technology has no impact on economic growth in the long run and asserts that technology cannot influence economic growth but is instead a determinant outside the model and is regular overtime.

2.1.2 Endogenous growth theories

In an attempt to improve on Solow's model, it was Paul Romer and Robert Lucas who gave rise to the 'endogenous' or 'new growth' theory, by assuming "knowledge" to be a capital good which is an input in production. The assumption further indicated that knowledge is a public good, with both public and private good characteristics (Inglesi-lotz 2014). of the R&D investment function. and had four primary inputs in this model. In its simplest form, the model can be expressed as

$$Y(t) = AK(t)$$

Here, A should again be understood as an expression representing factors that affect technology, while K includes both human and physical capital. The theory also advocates for the development of workers through education and training, because substantial advances in technology cannot occur without work undertaken on a systematic basis. This theory has brought about the necessity to rethink the manner in which to include technology in growth models and It is in this context that central governments introduced policies that encourage the development of R&D[2] activity. This include policies providing tax incentives and easy access to credit for firms performing R&D. Patent laws that favour R&D were developed, and universities are given grants to perform R&D (Hryckiewicz, 2014).

2.2 Empirical Literature

The literature review highlights the determinants of R&D investment at the national level with an emphasis on economic variables that have been put forward in explaining R&D intensity by various studies, which are discussed in detail in the following paragraphs.

[2] R&D is defined in the Frascati Manual (OECD 2015) to be creative work undertaken on a systematic basis in order to increase the stock of knowledge.

In assessing the determinants of national R&D, Wang (2010) uses EBA as a methodology to investigate the determinants of R&D investment at the national level, and his emphasis is on the role of patent rights protection in determining R&D. The results of the EBA tests performed on data from 26 OECD countries commencing in 1996 to 2006, showed patent rights protection and the income growth rate were fragile determinants of R&D investment, but, tertiary education and the proportion of scientific researchers in a country were robust determinants that had positive effects on R&D intensity. The EBA results further indicate that foreign technology inflows had a robust but negative impact on domestic R&D.

In a similar study relating to determinants of national R&D, Sameti, Ranjbar, and Anousheh (2010) used panel data to model 30 OECD countries over the period 1996 to 2008, with an emphasis on openness of trade. The study concludes that, trade openness, GDP growth and government R&D expenditures have a positive impact on R&D intensity. Likewise, Bebczuk (2002) investigated the determinants of R&D expenditures for 88 countries over the 1980s, using pooled ordinary least squares, concluding that foreign direct investment has a positive effect on protection of property rights and tertiary school enrolment. In the sections that follow, the study briefly examines these various determents of R&D in detail.

2.2.1 Human Capital

The capacity to absorb knowledge and technology, especially through foreign direct investment and its assimilation by qualified human capital are drivers of innovation and increased productivity (Elj, Moez El, 2014). R&D centres on three main activities[3]: basic research, applied research, and experimental development. The use of this stock of knowledge is to devise new applications or methodologies to enhance skills. Clarke (2001) points out that such skills can also help improve the ability to absorb new technologies coming from other countries[4].

[3]Basic research is an original experimental work with no specific commercial purpose and is carried out mostly in universities. While applied research has a specific aim as an original experimental work. Product development is concerned with the improvement and extension of existing products, while the generation of new or improved processes is process development (UNCTAD, 2005).

[4] See also empirical work by Goedhuys (2007b), Dabla-Norris E., Kersting E., and Verdier, G. (2010)).

The reason R&D uses highly trained individuals, is because researchers build on previous knowledge to create new ones. Therefore, the educational ability of the populace is amongst factors that can impact technological capability and R&D expenditures of a country's innovation (Clark, 2001). Furthermore, a large share of R&D expenditure relates to the salaries of researchers. Thirdly, having high levels of human capital might have an advantage. Bebczuk (2002) finds tertiary school enrolment has a positive influence on R&D, although its effect was significant at a 10% confidence level.

2.2.2 Foreign Direct Investment

The dissemination of new technology around the world can also take place through Foreign Direct Investment (FDI) and affect the decisions of domestic R&D investment. The channel through which FDI transfers technology is through multinational firms. These firms can transfer their technology through interactions between the multinational affiliate and domestics firms. Domestic companies can also buy patents, licences, or know-how from foreign firms. Havranek and Irsova (2013) conclude spillovers from FDI are more prevalent in countries that pay attention to education and R&D because learning to use and adapt technologies to local circumstances and replicating existing products and processes takes considerable effort.

This conclusion was also reached by Clarke (2001), that having an educated populace makes it easier to digest new knowledge brought about by FDI. Bebczuk (2002) and Guellec (2004) also determine FDI to have a positive effect on R&D intensity and does not substitute for domestic R&D. In contrast to the hypothesis of FDI having a positive impact on R&D, Clarke (2001) finds FDI is negatively correlated with R&D expenditure and, Elj, Moez El (2014) show that policy of opening up to trade and foreign direct investment for North African countries, has not had the expected impact in terms of technological transfers and innovation.

2.2.3 Financial Development

The financing of R&D activities is an important factor, especially in corporate innovation decisions because R&D projects require large amounts of money in order to be undertaken, and anticipated revenues are likely to be raised after a rather long period. The difficulty of forecasting future cash flows of R&D projects and control the use of funds make access to outside funding even harder. This is why firms around the world typically finance a small portion of their investments with external sources of funds, relying instead on internal funds (Bebczuk, 2002). However, the development of financial markets may encourage R&D not only via direct financing, but also when projects are self-financed, unexpected expenses might appear during its life, and access to credit may be necessary. Hsu, Tian, & Xu (2014) suggest that a well-functioning financial market plays a critical role when it comes to reducing financing costs, allocation of scarce resources, evaluation of projects, managing risk, and monitoring managers. Acharya and Xu (2017) provide evidence that publicly-traded firms in industries that are dependent on external finance generate more patents that are of higher quality and novelty than privately-held firms.

2.2.4 Trade Openness

Empirical evidence conveys that the size, depth, and liberalization of an economy's financial system can have a positive impact on its future growth in per capita, real income, entrepreneurship, employment, and output (P-H. Hsu, Tian, and Xu, 2014). The idea put forth is that; by opening up national markets, developing countries can draw additional domestic and foreign investments, thus increasing the rate of capital accumulation and returns on investments. The impression by Dang and Sui Pheng (2015) is that, imports bring innovations that are not available in the local economy, and local researchers may gain insights from these innovations. Therefore, by providing access to foreign innovations, trade openness can promote technological diffusion and international trade, economic and intellectual growth. Clark (2001) uses imports and exports as a share of GDP and the black market premium to measure trade openness and finds the two measures of openness to be uncorrelated with R&D expenditures. However, Wang (2010), finds the effect on R&D expenditures can be ambiguous, since openness may serve as a substitute for domestic innovation.

2.2.5 Patent/Property Rights

The protection of property rights is a vital issue in encouraging R&D, and the reasoning is that a deficient rule of law prevents the researcher from reaping the full benefit created by his invention. Clark (2001) finds that the risk of expropriation and the rule of law are correlated with R&D expenditures innovation. These results are similar to those found by Bebczuk (2002), who concludes the protection of property rights to be crucial to foster R&D. Schneider (2005) also finds patent rights affect domestic innovation in developed countries positively. However, concerning developing countries, IPRs had a negative effect on the rate of domestic innovation. According to Schneider (2005) a possible explanation for this negative relationship in developing countries was that the majority of innovations in developing countries may be imitation or adaptive. Other surveys of the patent system took a more nuanced position, arguing that often strong protections were not necessary to induce invention and that they entail significant costs (Wang, 2010).

2.2.6 Inflation and GDP

Macroeconomic factors, such as inflation and GDP, have been confirmed through econometric specifications to have an impact on R&D. For example Costamagna (2015), where he explored the relationship between R&D investment behaviour and inflation changes, confirms, the higher the inflation rate, the lower the R&D investment in the country. The impact was mostly prevalent in low and middle-income countries. In a similar manner as consumers grow prosperous, they tend to allocate a larger share of their income towards differentiated products, which are more R&D intensive. Hence the reason GDP growth rate and HDI are considered important as determinants of R&D.

2.2.7 Government funding

According to Sameti, Ranjbar, and Anousheh (2010), governments are the ones which provide R&D funding to universities and other research institutes in support of basic research. It is thus assumed that the government's surplus or deficit is very likely to affect national R&D investment intensity. Furthermore, in most countries, the public sector also performs the duty of engaging in R&D research directly by way of funding universities and other research institutes in support of basic research. The incentives to invest in R&D are also tied to the size of the economy; the bigger the economy, the stronger the incentives to conduct R&D, which in turn leads to faster growth.

As it stands, the innovation process is not only long and highly risky (mostly due to the high probability of unpredictability), it also requires a significant amount to finance it. In their discussion on whether the source of funds for R&D matter, Guellec and Potterie (2003), find there is a positive and significant effect of R&D expenditure on economic growth regardless of expenditure types, whether originating from the private, public, or foreign investment. However, the reality in most emerging economies is that external funding is crucial, thus obtaining a credit rating will be beneficial as it enhances their access to a broader pool of investors and allows them to gain access to global capital markets (Alsakka, R., ap Gwilym, O., and Vu, T. N., 2014).

2.3 Overview of Credit Rating

The historical logic underlying the existence of CRA resides within a basic problem of finance; how do lenders determine the creditworthiness of potential borrowers and assure themselves of the continued soundness of borrowers after a loan has been extended? The role of credit ratings has been to assist investors in evaluating credit worthiness and help pierce the fog of information asymmetry that surrounds the lending relationship (White, 2001). Rating agencies can either downgrade a country in times of difficulty or they can upgrade in the good times. A change in either direction can communicate new information about a particular country (Manungo 2017).

However, this role has since progressed to also be regulatory in nature since June 1999, when the Bank for International Settlements (BIS) Basel Committee on Banking Supervision proposed a revision to the international capital accord. Under the Committee's proposal, the amount of capital required for loans would vary depending on the credit rating of the issuer[5].

As stated earlier, the traditional sovereign credit rating is an analysis of the creditworthiness of a country, and the grading system by CRAs is such that they assign an ordinal symbol indicating the rating grade allocated. The categories of ratings are indicated in table 3 and can be divided into two; 1) the investment grade which ranges from AAA to BBB; and 2) the speculative grade which ranges from BB to D. An issuer assigned a rating of AAA shows a very strong ability to repay the principal and interest, while the

[5] For a complete discussions on the Basel Committee's reliance on CRAs see Coen and Packer (2000), Mulder (2000), Jackson (2005), and Elkhoury (2009), Dănilă (2012).

lower rating CCC, shows there is a strong vulnerability on the repayment of principal, including the interest rate (Alagidede and T.V.K Manungo 2017). A plus (+) or minus (-) modifier may be appended to the long-term rating category between AAA to D, to indicate their relative status within the category. These symbols are set such that there is an equivalent symbol in the other agencies in order to make comparisons across ratings issued by agencies.

The processes followed by CRAs to evaluate credit worthiness, are both qualitative and quantitative and differ across all agencies. However, CRAs have often been criticized for the lack of transparency in their rating process, nonetheless, studies[6] have been able to decipher variables that CRAs consider when assigning a rating. A more recent study is one by, Elkhoury (2009) in assessing the impact of credit ratings in developing countries. He posits sovereign risk, assigned by CRAs, also highlights several risk parameters of a country. He goes further to say these risk parameters can be dived into (i) economic; (ii) political; (iii) fiscal and monetary flexibility; and (iv) the debt burden risks.

Similarly, Montes et al. (2016), who carried out tests on the determinants of sovereign ratings in 40 developing countries found that if a country wants to improve on its sovereign rating, it should focus on the unemployment rate, foreign reserves, external debt, budget balance, inflation rate and GDP growth rate. Financial openness and inflation targeting were also seen as relevant factors for the developing economies. A less corrupt government and a democratic system that has law and order are also ways of improving sovereign ratings for emerging economies.

2.3.1 Impact on innovation

A study on patent information and corporate credit rating found patents to have a significant and positive effect on credit ratings, and companies which filed a comparatively high number of yearly patent applications received a better credit rating than their respective counterparts with lower patenting activity (Neuhäusler, Frey, and Blind, 2011; Wang & Yang, 2017). The results suggest that firms become less innovative in terms of both quantity and quality when they experience an exogenous deterioration in

[6] Such as those performed by Cantor & Packer, (1996a); Mora, (2006); Poon (2003); Ratha, De & Mohapatra, (2000) a general view from their assessments is that ratings encapsulate a number of macroeconomic factors, such as the country's economic growth, income per capita, inflation, external indebtedness, and economic development.

credit ratings. They also find there is a reduction in innovative activities following a sovereign downgrade. The reduction was found to be more pronounced in firms that were more dependent on external financing to fund their investments.

2.4 Concluding Remarks

The preceding literature review points out the importance of innovation in economic growth and posits that innovation is obtained as a result of a complex set of relationships among actors in the system such as the education system, the legal system as well as the impact of foreign policy (FDI and trade openness) can have on R&D. The literature also highlights the importance of sovereign credit ratings in an economy, as they are a crucial determinant of the interest rates a country faces. Secondly, rating effects are asymmetric. That is to say, positive rating events have no discernible impact on sovereign spreads, whereas negative rating events are associated with an increase in spreads (Gande & Parsley, 2005). However, it is not easy to outline the direct link between innovation and credit ratings and the impact that ratings would have on R&D.

CHAPTER 3: METHODOLOGY

Introduction

This chapter presents the model to be estimated and the variables to be included based on the literature review. The section also discusses the empirical model in detail and the methodology of the Extreme

Bounds Analysis (EBA) technique [7], explains the data sources and measures used as variables of interest. The model is estimated using the Extreme Bounds package in RStudio.

3.1 Data and Sample

The data in this study is based on a balanced annual panel dataset running for a period of 16 years, from 2002 to 2017. As at 2017, there were 120 countries that were classified as emerging income countries[8]. However, due to the shortage or unavailability of data for all variables, only 30 out of 120 emerging market economies had sufficient data for all variables of interest. Figure 4 in the appendix shows the list of countries used in the study and their respective economic classification. The R&D and RE data was sourced from the UNESCO website, while the rest of the explanatory variables were sourced from the World Bank data bank[9].

The credit rating changes on the other hand were extracted from Bloomberg. As previously highlighted, firms which dominate the rating industry are Standard & Poor's (S&P), Moodys and Fitch Ratings and together they cover approximately 80% of sovereign credit ratings (Bales, 2020). The study therefore uses ratings from these agencies. All the data was selected based on its relevance, suitability for the set objectives, and its significance to the study.

3.2 Empirical Model

In order to study variables which are robustly related to our dependent variable, the study uses the EBA formula as set out in equation one (1).

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[7] The EBA method has been widely used by economists such as Levine and Renelt (1992); Sala-i-Martin (1997); Miller & Upadhyay (2000); Clarke (2001), Hwang & Wang (2004) Sturm, Berger, and de Haan (2005), Moosa & Cardak (2006), and Reed (2009).

[8]. The study defines emerging markets to be the upper and lower middle -income countries as determined by the World Bank as of 2017. Included in the lower-middle-income, are countries with a gross national income per capita (GNI) is between $996 - $3,895 while in the upper-middle-income the GNI is $3,896–12,055.

[9] Missing observations on some of the variables for some countries were interpolated using Eviews.

$$\mathbf{R_d} = \beta_i \mathbf{I} + \beta_m \mathbf{M} + \beta_z \mathbf{Z} + \mu \quad \textbf{(1)}$$

The common way of conducting the EBA formula is by dividing the variables into groups as expressed in equation (1). The first is the dependent variable being the R&D (GERD) investment of the country and is denoted as $\mathbf{R_d}$. The second group shown as **I**, and includes explanatory variables that are considered to be core in explaining the dependent variable, and are therefore included in every single regression (including a constant). The third is **M** (focus variables), and included in this group are variables of interest, these are variables that will assess if they are robust in explaining the dependent variable. The fourth is **Z**, a vector of exactly three possible additional control variables chosen from the pool of explanatory variables. The study also follows (Clarke 2001) by including fixed country effects in all regressions in addition to the **Z** variables.

$$\mathbf{R_d} = \beta_i \mathbf{I} + \beta_k \mathbf{k} + \beta_z \mathbf{Z} + \mu \quad \textbf{(2)}$$

Essentially, the difference between equation one (1) and equation two (2) is minimal in that all variables are still consistent with those in equation one (1) with the exception of the focus variables, which are denoted as **K** in equation two (2). Equation two is mainly used to determine whether rating changes (upgrades and downgrades) can be considered as robust determinants of R&D. For equation two (2). In the case of equation two (2), the focus variables are the dummy variables **up** and **dw**. This is done to differentiate the numerical scale that is used in equation one (1) from equation two (2). The "**up**" variable will be presented by one (1), while a negative one (-1) represents a down grade. As indicated in equation one (1), fixed effects will be included in addition to **Z** variables.

In addition, the fixed effects assist in controlling for omitted variables that are constant over the period and a fixed effect panel regression allows for the isolation of variables that are not common amongst countries, giving a true measure of statistical significance (Brooks, 2019). This is a common method used in the study of credit ratings and authors such as Erdem and Varli (2014), Montes et al. (2016), Chen et al. (2013), Li et al (2007), Gande (2005), Kaminsky and Schmukler (2002) all make use of a panel regressions.

3.3 Description of Variables

The dependent variable is actual R&D performed by the public and private sector in a country and referred to as GERD. The GERD is measured as a percentage of (GDP). The independent variables include the number of researchers in a country, these are measured as a proportion of the country's total population (RE) and the number of tertiary school enrolments (TSE). Both RE and TSE are expected to have a positive impact on R&D.

The second and third independent variables are trade openness (TRO) and foreign development investment (FDI), respectively. TRO is calculated as the ratio of a country's total trade, which is the sum of exports plus imports to the country's GDP, while the FDI indicator is the percentage of Foreign Direct Investments to GDP. Sameti, Ranjbar, and Anousheh (2010) indicate that cross-border technology flows may give rise to knowledge spillovers with a favourable impact on domestic R&D. Therefore, both FDI and TRO are expected to be positively correlated with R&D (Hammadou 2014). To test the impact that patent rights might have on (GERD) R&D, the researcher used the rule of law as taken from the IMF website. The rule of law is measured as the country's score on the aggregate indicator, in units of a standard normal distribution, ranging from approximately -2.5 (weak) to 2.5 (strong).

The rule of law proxy is intended to capture the extent to which agents have confidence in and abide by the rules of society, and in particular, the quality of contract enforcement, property rights, the police, and the courts' rule of law. The rule of law is anticipated to be positively correlated with R&D. The economic variables that are considered to likely impact on R&D intensity include Inflation (INF), which is measured as the country's CPI, the GDP growth, Population Density (PopD), and The Human Development Index (HDI).

Table 1: List of variables

Variable Name		Measurement	Definition	Data Sources
National R&D	GERD	R&D expenditure (% of GDP).	Gross domestic expenditures on R&D include both capital and current expenditures in the four main sectors: Business enterprise, Government, Higher education, and Private non-profit organisations. R&D covers basic research, applied research, and experimental development.	UNESCO
I Variables				
Researchers	RE	The ratio of researchers to the total population.	The number of professionals engaged in the conception or creation of new knowledge (who conduct research and improve or develop concepts, theories, models, techniques instrumentation, software, or operational methods).	UNESCO
Tertiary school enrolments	TSE	School enrolment, tertiary (% gross).	It is the ratio of total enrolments, regardless of age in tertiary institutions.	World bank
M Variables				
Credit ratings	CR	Ratings assigned by Moody's, S&P, and Fitch.	A sovereign credit rating is an evaluation made and issued by Credit Rating Agencies (CRAs), of the creditworthiness of an independent government of the nation's ability to pay back its debts and its likelihood of default.	Bloomberg
Financial Market Development	FMD	Financial Development Index.	It summarizes how developed financial institutions and financial markets are in terms of their depth (size & liquidity), access, and efficiency in an economy.	IMF

Variable Name		Measurement	Definition	Data Sources
Foreign direct investment	FDI	Foreign direct investment, net inflows (% of GDP).	Foreign direct investments are the net inflows of investments 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.	World Bank
Trade openness	TRO	The trade openness index is calculated as the ratio of the country's sum of exports and imports to the country's GDP.	It is access to foreign capital investment through capital goods imports and exports.	World Bank
Rule of Law	RoL	The country's score on the aggregate indicator, in units of the standard normal distribution, i.e., ranging from approximately -2.5 (weak) to 2.5 (strong).	Rule of Law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts.	IMF
Z Variables				
Gross Domestic Product Growth	GDP	The annual percentage growth rate of GDP.	GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.	World Bank
Inflation	INF	Average annual consumer price inflation rate.	The annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly.	World Bank

Variable Name		Measurement	Definition	Data Sources
Population Density	PopD	People per sq. km of land area.	Population density is population divided by land area in square kilometres. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.	World Bank
The Human Development Index	HDI	Combination of three indicators: life expectancy, expected mean of years of schooling and Gross National Income per capita.	HDI is a summary measure of average achievement in key dimensions of human development: a long and healthy life, the level of education attainment, and have a decent standard of living.	UNDP
Government Revenue	GOVR	Public Sector: Government finance: revenue or deficit.	Revenue is cash receipts from taxes, social contributions, and other revenues such as fines, fees, rent, and income from property or sales excluding grants.	World Bank

A numerical scaling is used in equation one (1) to determine if credit ratings are robust in in determining R&D. For credit ratings, the first step is to transform the ordinal scale to a numerical scale[10], starting from 1 to 20, with the highest rating allocated at 20. The second step is to assess if there were any variations between the rating agencies for each country and if any existed, then the lowest rating was allocated. To assess and determine the impact of rating changes, the country is allocated a dummy variable as shown in Table 2 below. The changes in the credit rating decision has been arranged into

[10] The method of transforming an ordinal rating scale to numerical scaling has been used by researchers such as Cantor & Packer (1996a), Grande & Parsley (2005), Antonio Afonso, Furceri, & Gomes (2011), Bozic(2013), and Ntswane (2014). However, Reisen & Maltzan (1999), and Afonso (2003) apply a logistic transformation. Afonso, Gomes and Rother (2011) confirm that such transformation provides little improvement over the linear one. (Bales 2020).

dummy variables whereby **"up"** is one (1), **"no change"** is zero (0), and **"down"** negative one (-1) is transformed into discrete dummy variables.

According to literature, Wang (Erik) & Yang, (2017) a sovereign downgrade leads to significant reductions in R&D expenditures, patent applications and citations in bound firms, relative to non-bound firms. A credit downgrade is expected to have a negative impact on R&D, while an upgrade should have a positive impact. In the case of FMD, the data is collected from the IMF website. It is intended to indicate whether having developed financial systems are required to undertake innovation or R&D activities.

Table 2: Foreign currency sovereign credit ratings.

	Rating Description	**S&P**	**Fitch**	**Moody's**	**Conversion**
	Equation 1 scale				
Investment grade	Prime	AAA	AAA	Aaa	20
	High grade	AA+	AA+	Aa1	19
		AA	AA	Aa2	18
		AA-	AA-	Aa3	17
	Upper medium grade	A+	A+	A1	16
		A	A	A2	15
		A-	A-	A3	14
	Lower medium grade	BBB+	BBB+	Baa1	13
		BBB	BBB	Baa2	12
		BBB-	BBB-	Baa3	11
Speculative	Non-investment grade speculative	BB+	BB+	Ba1	10
		BB	BB	Ba2	9
		BB-	BB-	Ba3	8
	Highly speculative	B+	B+	B1	7
		B	B	B2	6
		B-	B-	B3	5
	Substantial risks	CCC+	CCC+	Caa1	4
		CCC	CCC	Caa2	3

	Rating Description	S&P	Fitch	Moody's	Conversion
		CCC-	CCC-	Caa3	2
	Extremely speculative	CC	CC	Ca	1
	Default imminent	C	C	C	0
	In default	D	D		0
	Equation 2 Scale				
	Up				1
	No change				0
	Down				-1

3.4 Estimation Method

EBA is a global sensitivity test that determines which economic variables, as suggested by the literature, are robust or fragile determinants of the dependent variable. The EBA approach was theoretically developed by Leamer (1983). The procedure stemmed from the argument made by Cooley and LeRoy (1981), that economic theory ordinarily does not generate a complete specification of which variables are to be held constant when statistical tests are performed on the relation between the dependent variable and the independent variables of primary interest.

A selection of variables has been suggested as determinants of R&D in the literature review, however, there is little consensus in the literature as to which variables really matter. Secondly, most authors do not carefully examine the sensitivity of their findings. Thus, it is hard to tell whether the variables reported to be significant in a particular regression are really robustly related. This is why Extreme Bounds Analysis is useful for testing whether minor changes in the list of examined variables can fundamentally alter the conclusions of empirical research. This procedure assists in determining whether credit ratings and other economic variables as suggested are robust or fragile determinants of R&D.

As highlighted in the previous section, the EBA technique divides the variables into three groups; 1) *"free variables"* (**I)**, these are variables that are be included in each regression; 2) "*doubtful variables",* these variables are referred to as variables of interest (**M)**, and 3) **Z** variables, which are selected from the remaining variables. EBA works by running an exhaustive number of regressions whereby each regression contains the same core variables (**I**), a variable of interest (**M**) and a changing combination

of variables in **Z**. After running the regressions, the process is continued by finding the coefficient estimates and standard deviations of these estimates.

The next procedure is to scan the model specifications for the minimum and maximum value that the $\boldsymbol{\beta_m}$ parameter could take at the requested confidence level and use those values to compute the "extreme bounds". The lower bound is calculated by taking the lowest value for $\boldsymbol{\beta_m}$ minus two standard deviations while the upper bound is the highest value for $\boldsymbol{\beta_m}$ plus two standard deviations. The fragility test is then based on whether these extreme bounds have the same or opposite signs, if the signs are the same in all the models, then it is said to be robust, however, if there is an opposite sign in one model out of the number of models ran, then the $\boldsymbol{\beta_m}$ parameter is said to be fragile. Leamer's EBA has been criticised as being too stringent a test of robustness, in part because, under its criteria, a variable is considered "fragile" even if one regression out of many causes a change in the sign of a coefficient, and as a result, one may conclude either that no variables are robust as the robustness test is difficult to pass.

In response to the perceived criticism of Leamer's EBA, Sala-i-Martin (1997) refined the robustness criteria by focusing on the entire distribution of regression coefficients, and not just on its extreme bounds. Instead of applying a binary label of robust or fragile, Sala-i-Martin (1997) estimates the cumulative density function (CDF) from each regression model separately and assigns some level of confidence to the robustness of each of the variables. He argues that if; 90% of the density function for γ k lies on either side of zero, it is probably safe to conclude that I_k is robust.

Another criticism of the use of extreme bounds, is that the actual coefficients used may come from models that most economists would find unreasonable (Granger and Uhlig, 1990). In order to address this concern, it requires another refinement to Leamer's EBA, as suggested by Granger and Uhlig (1990), who propose eliminating models with poor goodness of fit by imposing a condition on the level of goodness of fit, such that all models with a very low R^2 are irrelevant for the calculation of extreme bounds.

To give the results more credibility, Levine and Renelt (1992) restrict their EBA by using three **Z** variables only, hence restricting the number of explanatory variables in each equation. Furthermore, regression is restricted such that the variance inflation factor (VIF) on the examined coefficient does not exceed two (2). This is done so as to alleviate concerns of multicollinearity. VIF quantifies how much the variance of estimated regression coefficients is increased due to regressor collinearity (Mansfield

and Helms, 1982). The above modifications result is what is referred to as restricted extreme bounds analysis (REBA).

The study adopted REBA by including up to three "doubtful variables" in each regression and imposed further restrictions, such as weighting results according to the goodness-of-fit of each regression by using adjusted R^2. A variable is regarded as robust if it passes Leamer's EBA test or if it's CDF (0) is not lower than 90 percent for Sala-i-Martin's (1997) EBA. This is a better procedure to study the determinants of R&D as it enables a researcher to enlarge their search and reports the most favourable and the least favourable outcomes.

CHAPTER 4: RESULTS AND DISCUSSION

Introduction

This chapter presents the model estimation results and provides discussions on which variables were found to be robust and which were found to be fragile in explaining R&D. The data analysis and empirical results are presented in section 4.1 to 4.4. The results of the prescribed model can be found in section 4.3. First, the results on the determinates of R&D are presented, followed by the results of the impact of credit ratings.

4.1 Descriptive Statistics

Before presenting the estimation results, an assessment of the data was carried out to mien the behavioural pattern of the data. Table 3 reports a summary of statistics of the variables used in the econometric estimation. The data is for thirty (30) countries for a period of sixteen (16) years, starting in 2002 to 2017. The average domestic expenditures on R&D (GERD) is reported to be 0,51% across the countries. The country with the highest GERD was China, while the lowest was Venezuela. In terms of the ratio of researchers engaged in innovation, the country with the highest number of researchers was Russia with 5,997 professionals engaged in R&D. Regarding government revenue, the average revenue for thirty (30) countries is 24% with Ecuador having the highest and Pakistan being the lowest. It is also worth noting that the highest rating that was allocated to a country was 17, which is equivalent to a credit rating of AA. On average, most developing countries were assigned a credit rating of 9, which is equivalent to a BB- credit rating.

Table 3: Descriptive Statistics

Sample: 30 Countries (2002 - 2017)										
	obs	**mean**	**sd**	**median**	**min**	**max**	**range**	**skew**	**kurtosis**	**se**
GERD	480	0.51	0.39	0.45	-0.2	2.16	2.36	1.18	1.91	0.02
RE	480	1182.22	1229.91	731.85	17.38	5997.99	5980.62	1.72	2.95	56.14
GDP	480	4.17	3.74	4.41	-19.6	18.29	37.89	-1.46	6.62	0.17

TRO	480	1.72	38.27	-2.04	-52.9	415.15	468.03	6.52	53.38	1.75
GOVR	480	24.42	7.98	24.57	7.53	42.35	34.82	-0.02	-0.92	0.36
FDI	480	3.44	3.04	2.83	-4.89	31.24	36.14	3.16	19.23	0.14
INF	480	8.06	22.46	5.03	-30.9	388.16	419.02	13.19	199.93	1.03
PopD	480	101.49	92.48	79.04	5.5	450.24	444.74	1.87	3.16	4.22
FMD	480	0.34	0.15	0.3	0.07	0.69	0.62	0.65	-0.5	0.01
TSE	480	38.49	19.44	35.23	2.04	112.06	110.01	0.75	0.31	0.89
RoL	480	-0.39	0.48	-0.37	-2.26	0.71	2.96	-0.43	0.89	0.02
GNI	480	10813.7	5338.6	9890	2340	29200	26860	0.86	0.46	243.67
HDI	480	0.7	0.07	0.71	0.46	0.82	0.35	-0.88	0.59	0
CR	480	9.34	2.91	9	0	17	17	0.06	-0.31	0.13

4.2 Correlation analysis

The correlations matrix, which denotes the degree of association between all variables, is reported in Table 4 below. An overview of the matrix indicates that most of the values were much closer to zero, indicating there is no significant association amongst the selected variables. However, there are variables whose relations were not very significant but moderate. An example of such would be the positive correlation between the number of researchers and the research expenditure. Another relation worth highlighting is the one between the number of researchers and tertiary school enrolment.

The results also indicate there is a moderate correlation and an increase in the number of tertiary enrolments will likely result in an increase in the number of researchers. Another relation that was observed to be moderately correlated was between the number of tertiary school enrolments and the gross national income. Figure 2 in the appendix is used to depict the correlation between the dependent and independent variables. The data was divided into Upper Middle Income (UMI) and Lower Income (LI) countries.

Table 4: Correlation Matrix

	GERD	**RE**	**GDP**	**TRO**	**GOVR**	**FDI**	**INF**	**PopD**	**FMD**	**TSE**	**RoL**	**GNI**
GERD	**1**											
RE	**0.666**	1										
GDP	**0.084**	-0.035	1									
TRO	**0.007**	-0.077	0.058	1								

GOVR	**0.031**	0.317	-0.177	-0.319	1							
FDI	**-0.042**	0.106	0.204	-0.163	0.22	1						
INF	**-0.106**	-0.061	-0.401	-0.066	-0.039	-0.04	1					
PopD	**-0.022**	-0.249	0.224	0.185	-0.428	-0.103	-0.069	1				
FMD	**0.597**	0.394	0.003	0.03	-0.172	-0.089	-0.06	0.007	1			
TSE	**0.177**	0.511	-0.215	-0.181	0.389	0.149	0.189	-0.386	0.074	1		
RoL	**0.31**	0.131	0.136	-0.107	0.07	0.159	-0.377	0.136	0.384	-0.165	1	
GNI	**0.293**	0.481	-0.201	-0.063	0.189	0.018	0.085	-0.454	0.421	0.607	0.165	1

Strength

1.0	0.8	0.6	0.4	0.2	0.0	-0.2	-0.4	-0.6	-0.8	-1.0

4.2 Regression Results

The regression results from the estimation of equation one (1) using the restricted EBA technique are listed in Tables 5 to 9, while results for the traditional EBA, which has no restrictions and includes all variables as focus variables, are listed in Table 10 of the appendix. The results shown in Table 10 are based on 1080 regressions that were ran in Rstudio and the total number of observation totalled to four hundred and eighty (480), while the results in Table 5 are from estimating nine hundred and thirty regression models (930). The free variables RE and TSE are included in all nine hundred and thirty regressions, while the focus variables are only included in two hundred and ninety-nine (299) regressions.

The reason the focus variables are fewer is that, unlike the free variables, which are included in all regressions, focus variables are only included in fewer specifications regressions based on the methodology. Furthermore, the number of coefficients used to determine the upper and lower bounds were fewer, and not based on coefficients from all regressions. It uses coefficients that were observed to be reasonable based on the restrictions imposed in the regression.

For example, the variance inflation factor was set at two (2), therefore, coefficients which exceed the specified maximum of two (2), were not used. Also, only coefficients estimated from models with a goodness of fit based on adjusted R squared were used. For the free variable RE, the number of coefficients used were also less at 695 instead of 930, while TSE used 770 instead of 930. For the focus variables it is only in the case of TRO and FDI that the number of coefficients used is equal to the number

of regressions and ran as 299. For the rest of the focus variables the number comes to 232 except for CR, which was 290.

Table 5: Number of regressions estimated and coefficients used

	(Intercept)	RE	TSE	CR	TRO	FDI	FMD	RoL
Type		Free	Free	Focus	Focus	Focus	Focus	Focus
Nr of regressions by variable:	930	930	930	299	299	299	299	299
Nr of coeff used by variable:	930	695	770	290	299	299	232	232

4.2.1 Determinants of R&D

The results reproduced in Table 6 report the weighted means coefficients (weighted using adjusted R^2) and the standard errors. It also shows the minimum and maximum values of coefficient and standard errors undertaken by the variables across the estimated regression models. The results indicate the following variables to be positively correlated with research and development; number of researchers, credit ratings, financial development, trade openness, foreign direct investment and the rule of law. However, research and development expenditure is negatively correlated with tertiary school enrolments together with foreign direct investment.

The negative correlation clashes with the conventional wisdom that both tertiary enrolments and foreign direct investment are complementary inputs in R&D. Looking at the weighted mean coefficients, what is also striking about the results is that some of the variables, such as the number of researchers, tertiary enrolments, trade openness and foreign direct investment may not be distinguishable from zero in a statistically significant way. Both the maximum and minimum coefficients values are still significantly low.

However, credit ratings, financial development and rule of law appear to be statistically significant when compared to the rest of the variables. An improvement in the rating notch will actually cause a two percent increase in R&D, while an improvement in the legal system (proxied as the rule of law) will result in an incremental of twelve percent in R&D. Most notable, is the ninety-one percent increase in

R&D as a result of an improvement in financial development. These results are in line with the view that finance is essential to invest in R&D.

Table 6: Estimation results for equation 1

	Type	Coef (Wgt Mean)	Coef Min	Coef Max	SE (Wgt Mean)	SE (Min Coef)	SE (Max Coef)
(Intercept)	free	0.04865	-0.17679	0.47986	0.04323	0.04259	0.02894
RE	free	0.00021	0.00018	0.00025	0.00001	0.00001	0.00002
TSE	free	-0.00285	-0.0043	-0.0019	0.00084	0.00085	0.00084
CR	focus	0.02156	0.00081	0.03516	0.00556	0.00526	0.00518
TRO	focus	0.00026	-0.00002	0.00063	0.00027	0.00018	0.00032
FDI	focus	-0.0084	-0.02042	-0.00109	0.00275	0.00325	0.00207
FD	focus	0.91452	0.83968	0.96406	0.0923	0.09805	0.0874
ROL	focus	0.11571	0.05498	0.19684	0.02621	0.02395	0.02492

The EBA analysis in Table 7 shows results for Leamer and Sala-i-Martin's EBA. Leamer's EBA shows the lower and upper extreme bounds of regression coefficient estimates, and based on these bounds, the number of researchers, tertiary school enrolments, financial development and the rule of law are classified as robust. Trade openness, credit ratings and foreign direct investment are classified as fragile. According to Sala-i-Martin's EBA method, more variables are considered to be robustly associated with R&D than those identified by Leamer. Sala-i-Martin also considers CR and FDI as robust in addition to those by Leamer. The results of the two EBAs are set out in Table 7 below.

Table 7: Leamer and Sala-i-Martin's EBA results

	Type	Leamer's EBA			Sala-i-Martin's EBA			
		Lower Extreme	Upper Extreme	Robust/ Fragile	G: CDF (beta < = 0)	G: CDF (beta > 0)	Robust/ Fragile	Significance
RE	free	0.00016	0.00028	robust	0	100	robust	***
TSE	free	-0.00596	-0.00025	robust	99.8684	0.13161	robust	***

CR	focus	-0.01137	0.04531	fragile	9.15845	90.8416	robust	*
TRO	focus	-0.00061	0.00133	fragile	20.9623	79.0378	fragile	
FDI	focus	-0.02678	0.00297	fragile	92.9963	7.0037	robust	*
FMD	focus	0.64621	1.13535	robust	0	100	robust	***
RoL	focus	0.00112	0.24569	robust	0.2304	99.7696	robust	***
Significances level at 10% *, 5% and 1% *** **								

A graphical presentation of the above results for focus variables is displayed in Figure 2. The red line in the histograms also show EBA's null hypothesis which is set at zero. If the distribution curve of regression coefficients does not pass the null hypothesis value (i.e. zero), the variable is marked as robust and fragile should it pass. The grey bin's areas present the distribution of regression coefficients. When the bins are to the right of zero, a majority of the regression coefficients of the corresponding variables are positive. Conversely, if most of the bins' area lies to the left of zero, it means most values of the corresponding variables are negative.

The histograms depict tertiary school enrolment and foreign direct investment to be negative as the bins' area lies on the left side. While the number of researchers, credit ratings, financial development and rule of law are positive and lie to the right. The distribution of the regression coefficients in trade openness is bimodal, because it has coefficients that are both positive and negative, hence it was considered to be fragile by both EBAs.

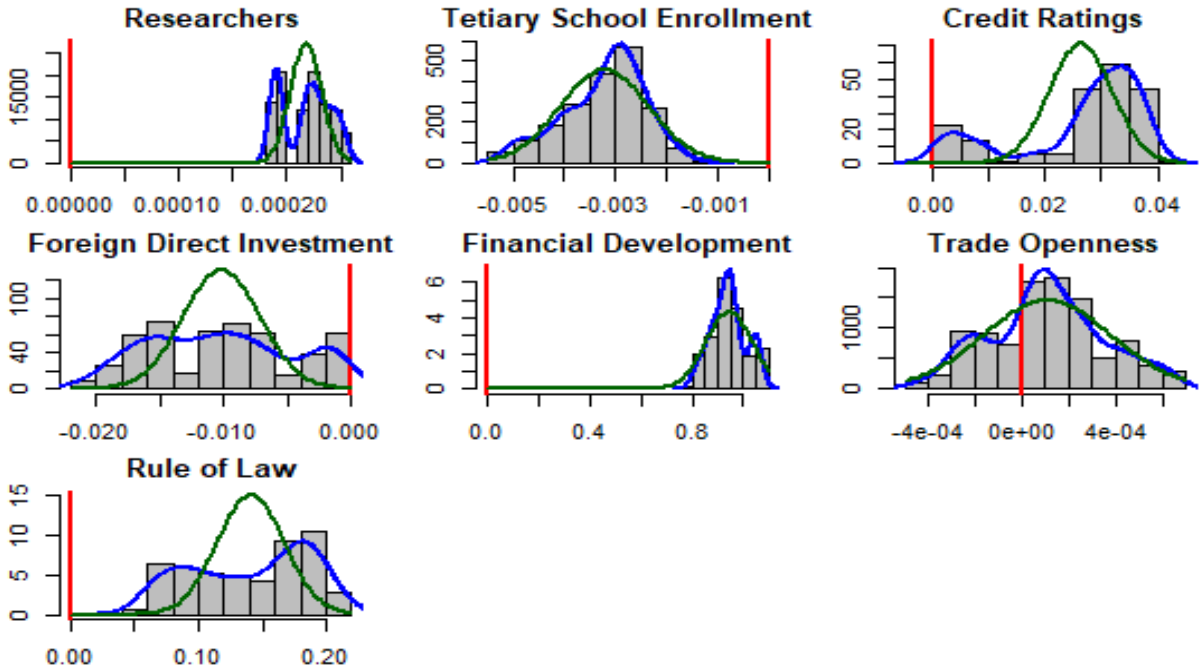

Figure 2. Histograms focus variables based on restricted EBA

Note: The magnitudes of regression coefficients are on the horizontal axis. The vertical axis indicates the corresponding probability density. The grey bins in the histogram contain the ordinary least squares (OLS) coefficients on each examined variable from all of the estimated regression models. The thick blue curve represents the corresponding kernel density and the green curve presents the normally distributed approximation. There is also a red vertical line at zero, the default coefficient value under the null hypothesis. The blue kernel density curve (a non-parametric approximation of the shape of each regression coefficient's distribution), and the green normally distributed approximation are quite different from each other. This lack of alignment suggests that regression coefficients are not normally distributed across model specifications.

4.2.2 Impact of rating changes on R&D

The results presented in Table 7 have shown credit ratings are robust determinates of R&D expenditure. In this section the impact and influence that credit ratings would have on R&D when there is an upgrade vs. a downgrade by estimating equation two (2) is investigated. A quick look at Tables 8-9 reveals the

results from this estimation. For equation two (2), free variables are still consistent with equation one (1) being; the number of researchers and tertiary school enrolments and the focus variables being the dummy variables **up** and **dw**. All other variables are included as **Z** variables and remain the same as in equation one (1). The results reveal 352 regressions were estimated, and the free variables are included in all 352 regressions while the **up** and **dw** were included in 172 regressions.

Table 8: Impact of rating changes

	Type	**Number of regressions by variable**	**Number of coefficients used by variable**	**Coef (Wgt Mean)**	**Min Coef**	**Max Coef**	**SE (Wgt Mean)**	**SE (Min Coef)**	**SE (Max Coef)**
RE	**free**	352	352	0.00023	0.00018	0.000026	0.00001	0.0000	0.00001
TSE	**free**	352	260	-0.00325	-0.00540	-0.00109	0.00048	0.0006	0.00057
up	**focus**	176	176	0.01008	-0.01572	0.03201	0.02387	0.0330	0.03188
Dw	**focus**	176	176	-0.05142	-0.11470	-0.01581	0.02939	0.0414	0.01766

The coefficient value suggests a sovereign downgrade will result in a 5,142% decrease in R&D, while an upgrade will only result in a 1,0008% increase in R&D. It can also be observed that **up** is fragile in explaining the impact of rating changes while **dw** is robust. A graphical presentation of the above results for focus variables is displayed in Figure 3. The results for the free variables are consistent with those found in equation one (1) and remain robust in explaining R&D.

Table 9: Leamer and Sala-i-Martin's EBA results

	Type	**Leamer's Extreme Bound Analysis**			**Sala-i-Martin's Extreme Bounds Analysis (EBA)**			**Significance**
		Lower Extreme	**Upper Extreme**	**Robust/ Fragile**	**G: CDF (beta < = 0)**	**G: CDF (beta > 0)**	**Robust/ Fragile**	
RE	Free	0.00017	0.00027	**Robust**	0.0000	100.000	**Robust**	***
TSE	Free	-0.00652	0.00003	Fragile	99.96823	0.03177	**Robust**	**

up	Focus	-0.08038	0.10017	Fragile	32.69859	67.30141	Fragile	
down	Focus	-0.19592	0.03064	Fragile	94.08362	5.91638	**Robust**	*
Significances level at 1% *, 5%** and 10% ***								

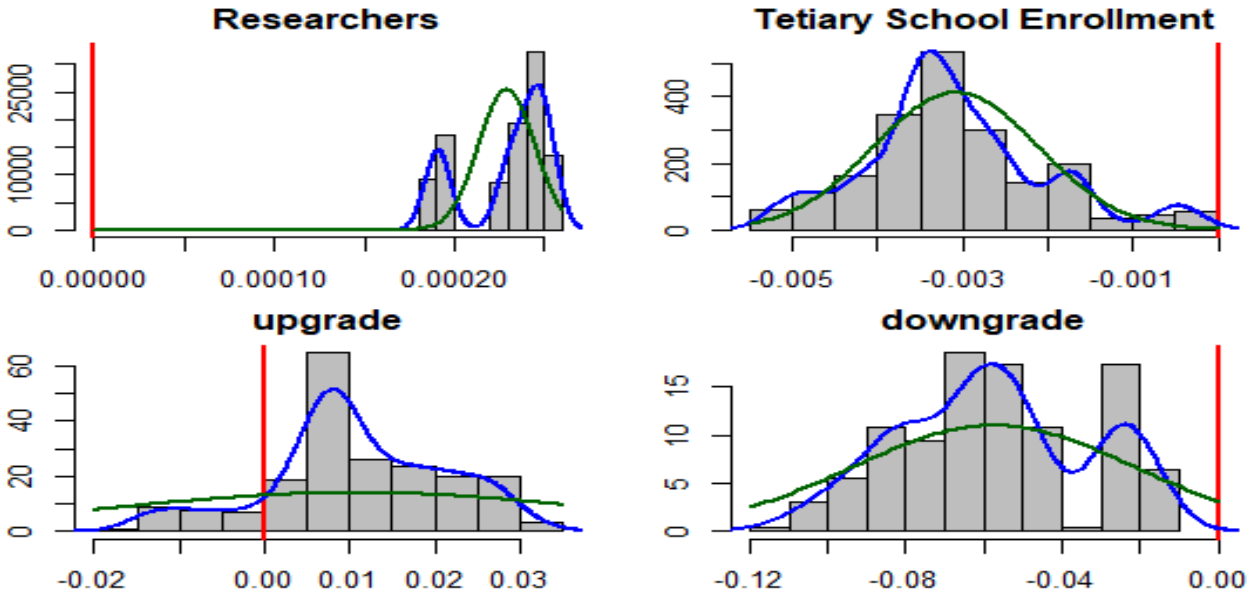

Figure 3: Histograms for rating changes

4.3 Concluding Remarks

This chapter presents the empirical results using the proposed methods discussed in Chapter 3. The results obtained from the EBA were both contrary to and in support of theory. The empirical results provide evidence that the number of researchers, tertiary school enrolments, credit ratings, financial development, the rule of law, and foreign direct investment, are robust determinants of R&D. The same conclusion of robustness also holds when it comes to the impact of a sovereign change relating to a downgrade. The results further demonstrate trade openness to be fragile in determining RD, as well as a sovereign upgrade. A summary of findings and recommendations for future research are presented in the next chapter.

CHAPTER 5: CONCLUSION

Introduction

The objectives of the study are to first examine the determinants of R&D intensity before going on to evaluate the impact of credit ratings on R&D. The study is unique in a sense that it looks at emerging markets, by using a sensitivity technique EBA. The results can be useful in guiding policy makers in emerging markets to develop approaches for enhancing innovative performance in the knowledge-based economies of today. This chapter is organised in the following manner: Section 5.2 gives a discussion around the study objectives and provides the conclusions drawn. Section 5.3 provides the recommendations based on the findings and the last section briefly highlights the study limitations.

5.1 Results

Objective 1: Determine the drivers of R&D intensity in emerging markets

The results as tabled out in chapter four indicate the number of researchers, tertiary enrolments, credit ratings, foreign direct investment, and financial development, are robust in determining the national R&D investment while trade-openness is fragile.

The proportion of scientific researchers being robust in determining R&D investment can be interpreted from the perspective of the production theory, whereby scientific researchers are regarded as a necessary input factor in R&D. The impact of qualified human resources appears to be insignificant, and perhaps, this points to the underutilisation and inefficient allocation of capital in these area. Authors such as Clarke (2001) and Wang (2010) find similar results.

Tertiary school enrolment, is observed to be significant, however, it is negatively correlated with R&D expenditures. The negative correlation clashes with the conventional wisdom that education should have a positive impact on R&D. This may indicate that tertiaries in developing countries do not put enough emphasis on scientific exploration, therefore, more resources need to be devoted to R&D activities at tertiary level and policies implemented encouraging the education sector to engage in R&D projects, such as the creation of R&D institutions or programs tying cooperation between the private and

education sectors. Ramzi and Salah (2018) find similar results when empirically assessing the determinants of innovation capacity in the less innovative countries in the Euro-Mediterranean region.

Another striking finding is that of foreign direct investment, although robust, it was negatively correlated with R&D. This rejects the hypothesis that foreign technology has a positive impact on national R&D. A plausible explanation for the negative correlation is that FDI uses similar inputs to R&D, such as the local labour force (e.g., experienced engineers and scientists) the findings are similar to those of Clarke (2001) and Wang (2010). On the other hand, trade openness is found to be fragile and not significant in determining R&D.

The empirical analysis carried out finds that trade openness is positively correlated with R&D; however, fragile as a determinant of R&D. The reason relates to the view that trade openness may serve as a substitute for domestic innovation. Similar results were also observed by Clark (2001) whose analysis found the impact of exports to be insignificant. His reasoning is that this could be as a result of the rigid structure in the countries and the concentration of exports being in sectors with little technological effort. Similar results were also observed by Elj, Moez El (2014) in their empirical study on innovation and productivity analysis for North African countries. while Bebczuk (2002) indicates openness reduces national R&D and this can deprive some countries from an R&D industry.

The Rule of Law, used as an indicator of a nation's patent rights protection effort, is a robust determinant of R&D and shows a positive correlation with R&D. This implies that a stronger patent protection system encourages more R&D investment, holding other variables constant. The result is consistent with the view that property rights are essential in providing investment incentives to innovators (Besley and Case, 1992). Financial development was robust and showed a positive correlation. This shows a country with well-functioning financial institutions and markets, engages more in R&D intensity, which also resonates with the view that most R&D requires financing before it can be undertaken.

Objective 2: Evaluate the impact of rating changes on R&D intensity.

When it comes to credit ratings, the first step determined the ratings to be robust, and positively associated with R&D, indicating the higher the sovereign rating, the higher the R&D. The reason may be that a good rating will encourage investors to invest funds in the country, while a low rating can discourage capital flows into the country. The second step was to assess the impact that a change in the rating would have on R&D. The EBA methodology indicates rating downgrades are robust and have a significant impact on R&D, while upgrades were fragile. The empirical analysis provided evidence that a change in the credit rating is asymmetric.

5.2 Recommendations

Ultimately, innovation holds the potential to address the most pressing social and human challenges in in emerging economies, a full understanding of how actors in the national innovation system relate to each other in the creation of national innovative capacity is necessary. This paper gives light into some of the factors emerging countries should look into when developing their national innovative capacity frameworks. These include the following areas:

- Policy makers need to consider the spillover effects of sovereign default risk when making key policy decisions, and implement policies that will assist in improving credit ratings as they can impede R&D.
- It is important to expand tertiary education and accumulate more human capital to engage in more innovative R&D.
- Policymakers should also focus on solutions that increase trade restrictions so as to decrease trade openness.
- Increased proactive measures, which can lessen the likelihood of a downgrade such as the adoption of inflation targeting, financial openness, democracy, law and order, and less corruption are important drivers to improve the sovereign rating of a developing nation.

5.3 Evaluation of the study

Limitations

The first and foremost limitations in carrying out the study were data limitations. Most emerging countries did not have data that was readily or publicly available, and this resulted in the analysis being performed on thirty countries out of one hundred and three countries, and these were especially African countries. The second limitation was the issue of few published studies on the subject, hence some of the references cited in the study are older than 10 years. Literature that exists on the effect of credit ratings mostly focus on developed countries and there is paucity of information on how credit ratings affect innovation. The scarcity was even greater when it came to their impact on innovation in developing countries.

Further study

The current study is solely focused on emerging markets and evaluating the impact that credit ratings could have on national R&D for a period of 17 years, therefore, recommendations for further study would be to increase the time period. There is also an opportunity that further studies can be performed on the impact of credit ratings to R&D performed specifically by government or R&D performed by the private sector. Alternatively, an analysis on whether a country's credit rating can improve based on its R&D expenditure can possibly be carried out. Again, the research does not cover other factors that could be influential such as the entrepreneurship "brain drain" and R&D tax incentives on R&D, which could potentially be relevant in explaining R&D.

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APPENDIX

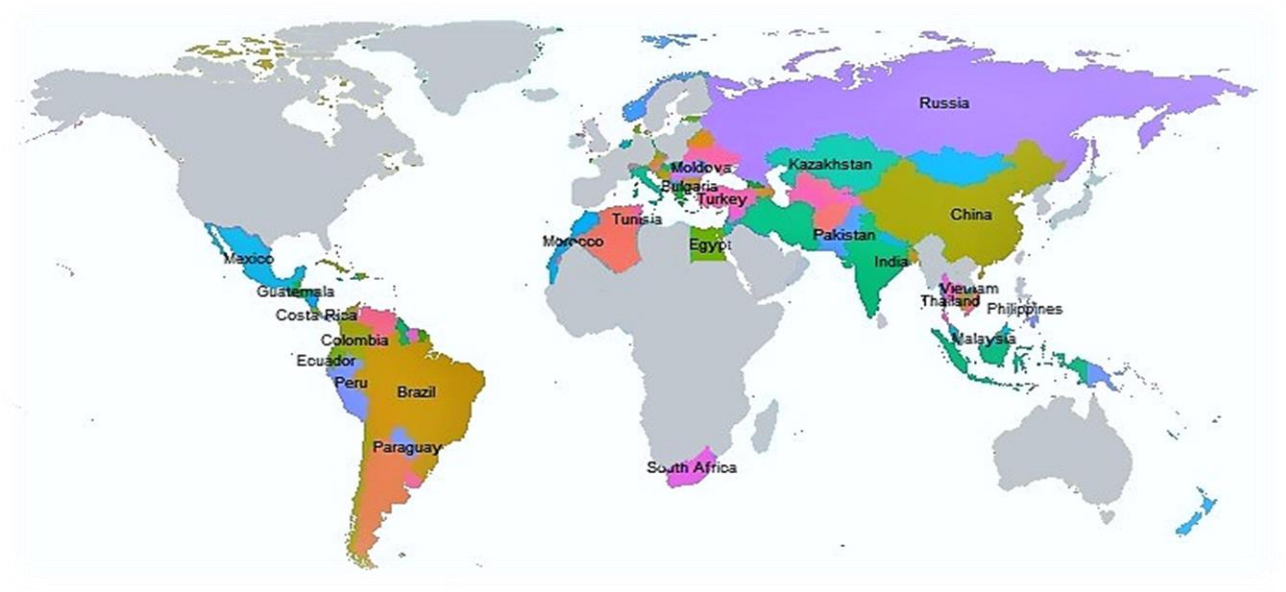

Figure 4: Countries used in the study

	COUNTRY	GRP
1	BOSNIA	UMI
2	BRAZIL	UMI
3	BULGARIA	UMI
4	CHINA	UMI
5	COLOMBIA	UMI
6	COSTA RICA	UMI
7	ECUADOR	UMI
8	EGYPT	LMI
9	GUATEMALA	UMI
10	INDIA	LMI
11	KAZAKHSTAN	UMI
12	MACEDONIA	UMI
13	MALAYSIA	UMI
14	MEXICO	UMI
15	MOLDOVA	LMI

	COUNTRY	GRP
16	MOROCCO	LMI
17	PAKISTAN	LMI
18	PARAGUAY	UMI
19	PERU	UMI
20	PHILIPPINES	LMI
21	ROMANIA	UMI
22	RUSSIA	UMI
23	SERBIA	UMI
24	SOUTH AFRICA	UMI
25	THAILAND	UMI
26	TUNISIA	LMI
27	TURKEY	UMI
28	UKRAINE	LMI
29	VENEZUELA	UMI
30	VIETNAM	LMI

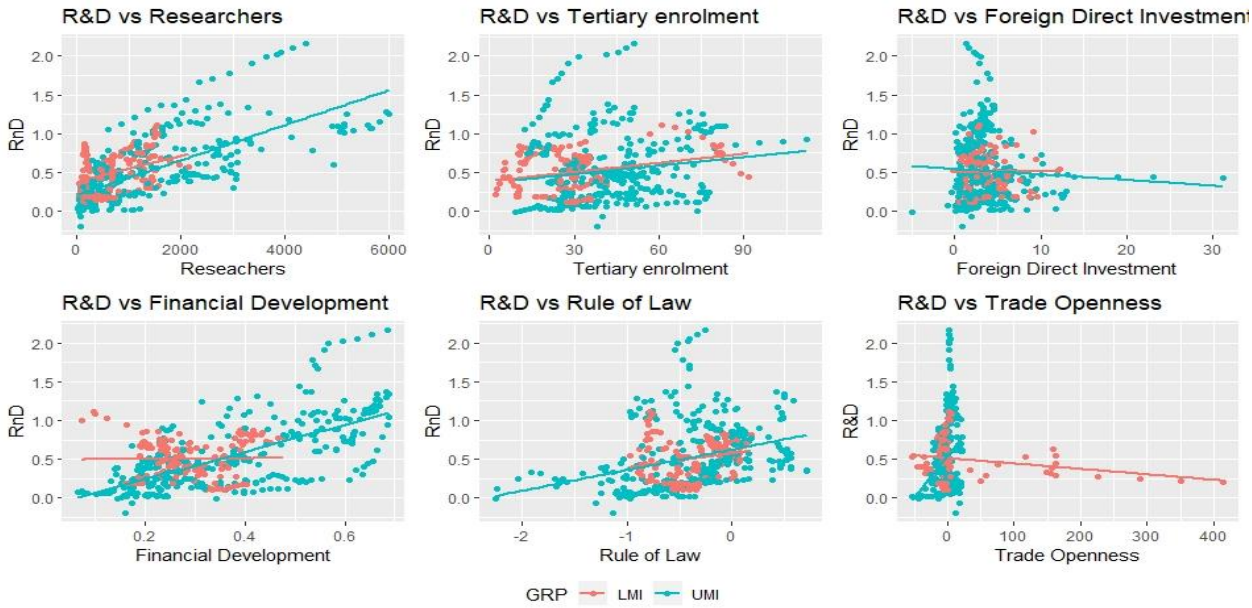

Figure 5: Correlation between R&D the dependent variable and independent variables

Table 10: Leamer and Sala-i- Martin' s results for all variables based on unrestricted EBA

	Type	Leamer's EBA			Sala-i-Martin's EBA			
		Lower Extreme	Upper Extreme	Robust/ Fragile	G: CDF (beta < = 0)	G: CDF (beta > 0)	Robust/ Fragile	
RE	free	0	0	**robust**	0	100	**robust**	***
TSE	free	-0.007	0.003	fragile	94.849	5.151	fragile	**
CR	focus	-0.014	0.05	fragile	5.559	94.441	fragile	**
FDI	focus	-0.029	0.003	fragile	98.603	1.397	**robust**	***
FMD	focus	0.584	1.249	**robust**	0	100	**robust**	***
RoL	focus	0.003	0.279	**robust**	0.136	99.864	fragile	***
TRO	focus	-0.001	0.001	fragile	38.514	61.486	fragile	
GDP	focus	-0.007	0.02	fragile	9.647	90.353	**robust**	*
HDI	focus	-2.533	0.865	fragile	88.09	11.91	fragile	
GNI	focus	0	0	fragile	46.357	53.643	fragile	
INF	focus	-0.002	0.003	fragile	45.367	54.633	fragile	
GOVR	focus	-0.012	0.005	fragile	91.446	8.554	**robust**	*
PopD	focus	0	0.001	fragile	3.83	96.17	**robust**	**
Significances level at 10% *, 5% and 1% ***								

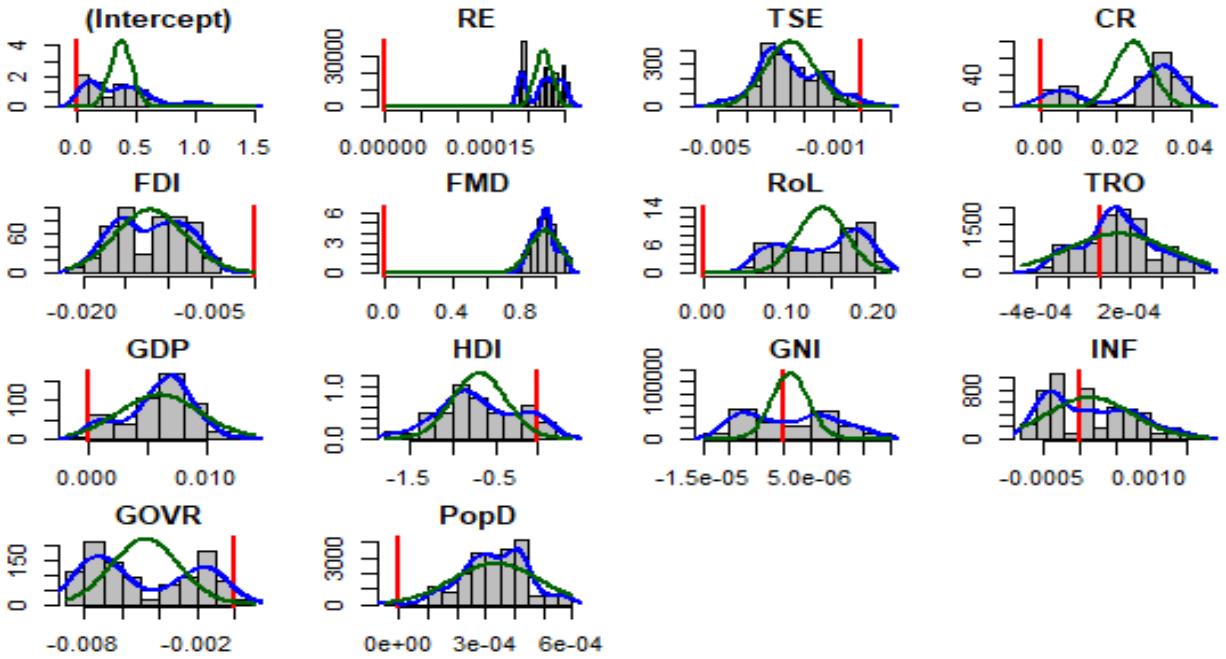

Figure 6: Histograms for all variables based on unrestricted EBA