The determinants of government bond yields: A comparative analysis of African, emerging and developed countries

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Abstract

Debt is a critical source of finance for countries to fund their budget deficits and development objectives. However, high yields discourage the issuance of bonds by African economies and impose financial difficulties, thus hindering the necessary development of the continent. This study examines the determinants of government bond yields in Africa and provides a comparative analysis against other emerging and advanced countries. The 10-year government bond is used as a proxy for the bond yield and its determinants are examined over the period 2010 – 2019. The Fixed Effects panel data model with an adjustment for heteroskedasticity and cross-sectional dependence is used. The findings show that Gross Domestic Product (GDP) growth, government debt and the Federal Reserve fund rate have a significant impact on African government bond yields. In contrast, for other emerging and advanced economies, additional factors affect government bond yields including the current account balance, exchange rate, inflation and volatility. The results of this study have important policy implications for governments in Africa as increased knowledge of the determinants of government bond yields provides direction as to what policies they can focus on to aid in lowering yields. For example, given that GDP growth is found to be a significant determinant of African government bond yields, this means that governments must focus on building industries so that they produce more finished goods. Intra-Africa trade must be expedited to foster self-sufficiency of Africa and reduce reliance on trade with the big economies. These results also serve to raise awareness and entice global investors towards holding African country bonds.

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CHAPTER 1: INTRODUCTION

1.1 Background

Emerging and frontier markets in Africa present an exciting opportunity for international finance and foreign investment because of the potential for high returns although with substantial risk. There is no single definition of emerging markets established as it differs across institutions, but some of the factors used as indicators are; political stability, economic stability, local market access, low labour costs, transparency, legal framework, skilled labour, infrastructure, quality of life, and government agency support (Kehl, 2007). Emerging markets can be defined as countries that are transitioning from a "developing" economy into a "developed" economy (IGI Global, 2020). According to the Corporate Finance Institute (2020), an emerging market refers to an economy that experiences considerable economic growth and possesses some characteristics of a developed economy. The Economist (2017) defines an emerging market as an economy that is not too rich, not too poor and not too closed to foreign capital. According to Mody (2004), emerging markets are identified by four characteristics. First, by their high market volatility and transitional nature occurring in their economic, political, social and demographic dimensions. Second, their high volatility and transitional nature contribute to a particularly acute trade-off between commitment and flexibility in policymaking. Third, there exists an underlying commitment to disciplined behaviour in emerging markets through institutions that set the boundaries of policy decision making. Fourth, there are lessons gained by policymakers to create neat solutions to problems as they evolve.

Frontier markets are more risky than emerging markets. Frontier markets are the furthest edge of acceptable investments, beyond which markets are underdeveloped and not suitable for investment (Uludag & Ezzat, 2016). They are more established than the least developed markets but are still less established compared to emerging markets (Chen, 2019). Frontier economies experience more domestic shocks than emerging markets because of poor policy decisions, weak institutions, lack of economic diversification and dependence on food and energy imports (Musaccio & Werker, 2016). Greater integration into the global economy has been an integral aspect of the development of the frontier economies, but has exposed these countries to shocks from global financial and goods markets (Zhu & Jahan, 2015). Frontier markets do not meet the criteria of fully-fledged emerging economies and are viewed as the "pre-emerging markets" (Schipke, 2015). Both frontier and emerging countries are viewed as having the potential to continue to grow in the future and have more impact on global trade and economics.

According to the Overseas Development Institute (ODI) (2018), Africa is the second fastest growing economic region, experiencing annual average Gross Domestic Product (GDP) growth of 4.6% for the period 2000 to 2016. In fact, Africa and Asia (excluding Japan) were the only continents that grew during the global financial crisis of 2007-2008 (Chironga et al., 2011). As of 2018, the continent’s real GDP is projected to grow 3.9% annually for the five-year period until 2022. Africa achieved economic growth of 3.4% in 2019 and, for the first-time, investment accounted for more than half the continent’s growth, with private consumption accounting for less than one third (Africa Development Bank, 2020). Africa’s top five fastest-growing economies are Ethiopia, Côte d'Ivoire, Senegal, Tanzania and Ghana (Gray, 2018). Growth in Africa has been driven by the steady rebound of commodity prices, an improvement in the global economy and improved capital market access after several countries have made valiant attempts to get their fiscal books in order (Adegoke, 2019). The population in Africa was 1.3 billion people as of 2019 and it is expected to double by 2050 (Ezeh & Feyissa, 2019). Emerging markets in Africa are recognised by their quickly improving political and legal environments and a growing need for more local business (Africa Growth Initiative, 2018).

According to the Harvard Business Review (2011), Africa has an abundance of riches, including 10% of the world’s oil reserves, 40% of its gold ore, and 80% to 90% of its deposits of chromium and platinum group metals. Africa could also provide at least 20% of global natural gas needs by 2025 given the discoveries made over the past decade in Mozambique, Tanzania, Senegal and Mauritania (Monnet, 2019). Africa has recently increased its trade with newly established partners, such as Russia and Turkey which have doubled and tripled respectively, while trade between the markets and the United States (US) has decreased by almost 66%. The implementation of the African Continental Free Trade Area (AfCTA) will support further trade within the continent, with enhanced market access supporting growth for many countries. Countries such as China, India and the United Arab Emirates have strong interest in investing in the Sub-Saharan Africa region and this further adds value to Africa’s foreign relations (Freund & Zeufack, 2020).

Although Africa has substantial growth prospects, it is not without challenges. It is acknowledged that the economic problems and injustice stems from the history of colonisation of the continent where by 1900 Africa had been colonised by mainly seven European powers – Britain, France, Germany, Belgium, Spain, Portugal and Italy – whose ideologies were racist and devoted to the exploitation of the colonised society (SAHO, 2015). Recently, the political turmoil in countries such as Algeria, Egypt, Libya, Morocco and Tunisia and the second civil war in Ivory Coast between 2010 and 2011 have hindered progress and companies have been slow to enter Africa for business. In addition to this, Africa still lacks proper infrastructure to foster development within the continent (Chironga et al., 2011). Historically, the railway infrastructure in Africa was created by European colonial powers to ensure military support and movement of goods to the ports to be shipped overseas (ADB, 2015). Largely, these have not been upgraded and by today's standards, they are in poor condition, thus they cannot carry heavy load of goods and are generally lightly loaded. This affects movement of goods within the countries and thus affects development or establishment of businesses in the continent (Bullock, 2009).

Additionally, while African countries have made progress in improving their socio-economic conditions, they still lag far behind countries in other parts of the world. As an example, based on the Human Development Index score, which quantifies a country's human development with respect to healthcare, education and life expectancy, Seychelles is the highest ranked country in Africa, but is only 62nd globally, followed by Mauritius (65th) and Algeria (83rd) (World Population Review, 2020). There is also huge income inequality in Africa; of the 10 most unequal countries in the world today, seven are in Africa (Children International, 2020). Of the 55 countries on the African continent, 33 of these are classified as Least Developed Countries (LCDs) by the United Nations (2019). These 33 countries are identified based on the per capita income of less than $1230, human assets and economic vulnerability.

Governments have a mandate to foster development and better the lives of its citizens, hence they need to finance development-related projects such as roads, power stations, hospitals, schools and many other tasks that are their primary responsibility. This need is clearly seen in Africa where such infrastructure and services are critical to improve the livelihoods of people. Governments generate funds from tax collection to support such efforts, with increased economic growth generating additional revenue for governments. However, if these funds are insufficient to cover expenses, governments are forced to raise debts to fund the shortfall, either from financial institutions or selling government bonds. Despite the growth on the continent in recent years and the vast resources many countries are endowed with, governments have been forced to borrow to support budget deficits and fund developmental projects. In fact, the total value of Eurobonds raised between 2018 and 2019 was more than the value of all bonds sold between 2003 and 2016 (Mutize, 2020b). The average debt-to-GDP ratio was 57% in 2017, with the ratio exceeding 100% for several countries including Cape Verde, Eritrea, Democratic Republic of Congo and Mozambique (Adegoke, 2019).

Most African bond markets are underdeveloped, with inactive and illiquid secondary markets, thus it is challenging for governments to borrow locally. Consequently, African governments borrow internationally through foreign currency bonds usually in the form of Eurobonds (Mutize, 2020a). Approximately 70% of Africa's foreign debt is denominated in dollars or euros. Foreign currency denominated debt poses extra risk as local currency depreciation increases the nominal value of the loans and interest repayments (Songwe, 2018). In addition, borrowing internationally imposes additional costs for African governments because of the additional premium due to perceived risk, badly informed rating agencies and biased behaviour of the issuers (Mutize, 2020b). Such costs and risks thus hinder the ability of governments to achieve their developmental objectives.

The International Monetary Fund (IMF) is concerned about the African countries which are piling on debt without evaluating the exchange rate risk and the real costs of repaying the debts (Mutize, 2020a). In addition to the costs of borrowing and the associated risks, several governments have allocated the funds raised through debt to failing projects, such as the Kuraz mega super project in Ethiopia and the Kenyan Standard Gauge Railway. This means that governments could borrow and spend the funds to achieve more. However huge amounts of debt curtail economic growth, reduce job creation and may lead to political unrest, thus resulting in a renewed rise in conflict across the continent (Songwe, 2018).

1.2 Problem statement

Debt financing is necessary to support development and eradicate poverty on the African continent, but unsustainable debt levels have made the continent to be more vulnerable (Lusigi, 2018). The cost of borrowing is a significant factor in determining the amount of debt that African countries can afford to borrow. Understanding the factors that influence sovereign yields is thus critical to enable governments to implement appropriate policies to improve these determinants, if possible, and thus lower the yield. They can also be better prepared by understanding what non-controllable factors may influence yields.

Several studies have analysed possible determinants of sovereign bond yields but with most of the literature focusing on developed countries or emerging markets, with little direct attention on Africa. For example, Vargas (2005) determined factors that influence the sovereign yield in Philippines such as monetary policy, the exchange rate, budget deficit, fiscal policy and real activity, with the effects of these varying depending on the maturity horizon of the yield. Poghosyan (2014) analysed determinants of sovereign bond yields in 22 advanced economies over the period 1980-2010 using panel cointegration techniques. Results show that one of the key determinants of sovereign yields is the government debt level; when this rises it results in an increase in the risk of default, monetisation-driven depreciation and inflation. Thus, investors require compensation for this which contributes to an increase in the yield. The study also finds that there is a difference in the way government bond yields change in the short- and the long-run. More recently, Yieand and Chen (2019) identified factors such as the exchange rate, foreign interest rate and GDP growth rate to be significant in determining Malaysian government bond yields while the current account balance- to- GDP ratio was not significant.

Mutize and Nkhalamba (2020a) conducted an analysis of economic growth as a determinant of sovereign credit ratings in 30 countries in Africa, Europe, Asia and Latin America from 2010 to 2018. The study found that economic growth has only a small impact on African countries compared to other developing countries. This implies that an increase in economic growth does not significantly increase the likelihood of a credit rating upgrade in Africa compared to developing economies on other continents. The results of this study thus suggest that determinants of African government bond yields may also differ from those of other developed countries.

Olabisi and Stein (2015) identified that there is an unexplained “Africa premium” of 2.9% on sovereign bonds issued by governments in sub-Saharan Africa between 2006 and 2014, after controlling for some possible factors such as credit ratings and macro-economic fundamentals. According to the authors, the higher coupon may only be explained as the penalty on African governments due to investor bias. However, Olabisi and Stein’s (2015) study did not consider African countries outside of sub-Saharan Africa such as Egypt and Morocco, which are some of the biggest economies on the continent (Statista, 2021). Moreover, while Olabisi and Stein (2015) did examine common determinants of bond yields such as the debt-to-GDP ratio and sovereign credit ratings, they did not evaluate a comprehensive set of factors that could explain bond yields such as Federal Reserve Interest Rate, World Governance Indicators and volatility, to name a few. As such, knowledge of the factors influencing the cost of borrowing among African countries over time is still nascent and, the inclusion of a wider set of factors, may provide further insight.

This study thus seeks to address this problem. Such research is of critical importance to African governments to assist in deciding whether to raise debt in order to fund development and will help governments to implement policies that will reduce yields on sovereign bonds and thus allow for more borrowing to further their development objectives. It will also be of interest to scholars as they seek to better understand socio-economic drivers of change on the continent. Making comparisons as to the impact of various determinants on government bond yields across different economies will give insights not only as to what factors are germane to all economies, but also what factors are unique to African sovereign yields, and what factors do not impact African sovereign yields. This will help in better understanding the determinants of African bond yields. Although other studies can be examined to find out what determinants affect the government bond yields of various economies, literature has shown that these factors change over time (and across some countries) and thus to provide an evaluation and understanding of what factors determine African sovereign bond yields and whether these factors differ from those in other countries, it is imperative to make a comparison by looking at the different countries over the same periods of time and with the same factors. In this way, this study is similar to that of Mutize and Nkhalamba (2020a) who examined the different role of economic growth as a determinant of sovereign credit ratings in Africa compared to other developed and developing countries.

1.3 Research questions and objectives

The research question which thus underpins this study is as follow: What are the key determinants of government bond yields in frontier and emerging African countries and are these similar/different to the determinants for other emerging and advanced countries?

This research question is addressed through the following research objectives:

- to analyse the determinants of yields on government bonds across a wide sample of countries;
- to examine the determinants of yields on government bonds in all frontier/emerging economies;
- to identify the determinants of yields on government bonds in frontier and emerging African countries;
- to identify the determinants of yields on government bonds in other emerging economies;
- to analyse the determinants of government bond yields in advanced economies;

- to compare the determinants across African frontier and emerging economies to those in other emerging and advanced economies; and
- to provide recommendations on how frontier and emerging economies in Africa can reduce the yield on government bonds to support development.

1.4 Structure of the study

The remainder of the study is structured as follows: Chapter 2 presents a review of the literature on the determinants of government bond yields from a theoretical perspective and the findings of empirical studies on this subject. Chapter 3 describes the methodology and data that are used to answer the research objectives related to the determinants of the yield on government securities. In chapter 4, results are presented and discussed. Finally, chapter 5 contains the conclusion, policy recommendations and suggestions for future research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter comprises two sections: the theoretical framework (section 2.2), the empirical review (section 2.3) and the chapter summary (section 2.4). The theoretical framework examines the theory on the determinants of government bond yields while the empirical review analyses the findings of empirical studies that have sought to test the theoretical relationships that are explained in section 2.2.

2.2. Theoretical Framework

In economic theory, the long run real government bond yields depend on two main determinants, namely, potential growth in output and government debt. The Ramsey (1928) model of optimal growth is an economic theory that explains the determinants of long-term interest rates. The model explains that given a representative household preference described by the Constant Elasticity of Substitution (CES) utility function and the production process described by the Cobb-Douglas function, then the deterministic steady state of the real bond yield is determined by

$$r = \sigma g + \theta \tag{1}$$

where g is the net growth rate of per capita consumption, σ is the inverse of the intertemporal elasticity of substitution, θ is the household's rate of time preference and r is the real bond yield (Laubach, 2007).

According to Laubach (2007), there are three issues that should be addressed in modifying equation (1) above to a regression of treasury yields on fiscal variables. The first of these issues is fiscal variables not appearing, such as government spending that affect the interest rate and households must have a consumption profile that is a function of time. The second issue is that the equation provides an expression for the return on capital, which is more applicable for stocks than treasury bonds. The third issue is a problem of endogeneity whereby explanatory variables are correlated with an error term. In addressing this, it is known that in neoclassical models with nominal rigidities, the short-term real interest rate $r_t = i_t - E_t * \pi_t + 1$, where i is the nominal interest rate and $E_t* \pi_t+1$ is the expected rate of inflation, can deviate from the "natural" interest r^*_t , which is the real interest rate that would prevail without nominal rigidities. A comprehensive description of this idea was given by Woodford (2003). r^*_t is defined as;

$$r^*_t = \alpha + \beta f_t + u_t \tag{2}$$

where f_t is the measure of fiscal policy. Fiscal policy is the use of government spending and tax policies to influence economic conditions (Boyle, 2021). u_t denotes other factors affecting the natural rate like those in (1). Therefore, the real short-term interest rate can be written as;

$$r_t = \alpha + \beta f_t + u_t + (r_t - r^*_t) \quad (3)$$

where the real rate gap $r_t - r^*_t$ is not observed, but instead is subsumed in the residual of a regression of the current interest rate on fiscal factors (Laubach, 2007). The endogeneity problem arises when the real rate gap varies over time. However, since nominal rigidities are temporary in nature, then for a long horizon, the real rate gap vanish in expectation, i.e. $E_t - k(r_t - r^*_t) = 0$. Therefore, the economic model derived is:

$$E_t i_{t+k} = \beta_0 + \beta_1 E_t \pi_{t+k} + \beta_2 E_t f_{t+k} + \beta_3 E_t u_{t+k} + \epsilon_t \quad (4)$$

where $E_t i_{t+k}$ is the long-term nominal interest rate expected to prevail in k periods and the coefficient β_1 on expected inflation can be different from one, and u_t denotes additional regressors such as the growth rate of real Gross National Product (GNP) or GDP and the output gap. The main interest is in the magnitude and statistical significance of β_2. Inclusion of the fiscal variables and proxies for time variation in risk aversion resolves the first and second issues highlighted above (Laubach, 2007).

The Expectations theory put forward to explain the determinants of interest rates by John Maynard Keynes (1930) is based on the view that the central bank's actions determine the long-term interest rates and that the long-term government bond yield is a function of short-term interest rates (Alexopoulou et al., 2009). Effectively, Keynes suggests that the key drivers of the long-term interests on government bonds are various monetary policy measures and short-term interest rates. The central bank sets the risk-free short-term interest rates which, in turn, influences long-term interest rates. Keynes further argues that the investors tend to extrapolate the present and past in developing their view of the long-term outlook rather than mathematical expectations of an uncertain future. The investor takes hints about long-term interest rates from current conditions and the near-term outlook. Keynes's arguments on the drivers of long-term interest rates were developed in the context of advanced economies (Akram & Das, 2015). The expectations theory explains the monetary transmission mechanism where the long-term rates are an average of current short-term rates and expected future short-term rates (Roley & Sellon, 1995). This predicts what the short-term interest rates will be in the future based on current long-term interest rates (Murphy & Kelly, 2020). An increase (decrease) in the desired level of policy interest rates increases (decreases) current and expected future short-term rates (Roley & Sellon, 1995).

Effectively, Ramsey's (1928) model of optimal growth is an economic theory that explains the determinants of long-term interest rates from the perspective of economic variables such as inflation, per capita consumption and economic growth whereas the Keynes's Expectations theory explains the determinants of long-term interest rates from the perspective of monetary transmission mechanism. Keynes' Expectation theory further states that future short-term rates are derived from current long-term interest rates. Keynes also stated that monetary policy is not enough to induce economic growth, but the intervention of government through fiscal policy helps steer the economy as well (Schmidt, 2018). Governments make use of debt, amongst other streams of revenue, to steer the economy and this results in increase in sovereign debt. An increase in sovereign debt increases the default risk premium required by investors, thus increasing the bond yield. Increases in default risk are linked to the ratio of debt to the government's income streams (Poghosyan, 2012).

2.3 Empirical Review

Some studies focus on analysing the determinants of government bond yields, while others focus on the determinants of yield spreads. There is an overlap between these two because the yield spread is the difference in yield between two bonds, i.e. bond yield is measured relative to another bond (Kenny & Boyar, 2020). The following two sub-sections discuss the determinants of government bond yields in advanced and emerging economies.

2.3.1 Determinants in advanced economies

Poghosyan (2012) analysed the determinants of bond yields in 22 advanced economies over the period 1980 to 2010. The panel cointegration technique was used and this allowed for a distinction between long-run (the debt-to-GDP ratio and potential growth) and short-run (inflation, changes in the debt-to-GDP ratio, monetary policy, short-term fiscal policy and cyclical fluctuations) determinants of sovereign borrowing costs. It was found that a one percentage point increase in the debt-to-GDP and potential growth rate results in government bond yields increasing by two basis points and 45 basis points respectively. Secondly, the sovereign bond yields in the short-run deviate from the level determined by the long-run fundamentals, although about half of these deviations adjust in one year.

Poghosyan (2012) also explains how sudden events can cause breaks in economic data such as structural breaks in the government bond yield caused by economic crisis. In other words, the long run relationship can break down in the short run. An example of this occurred during the financial crisis, where the US government increased debt but the yield continued on a downward trend. This occurred because the upward pressure on the government bond yield due to the increase in the debt-to-GDP ratio was more than offset by the foreign inflows triggered by “safe-haven” considerations. This anomaly is corrected in the long run, as the yield would increase with debt-to-GDP ratio as expected. The introduction of a new law in capital markets could have a similar effect. It also happens that some countries with high levels of debt have had a low yield as seen with the yield on bonds issued by Spain as compared to the yield on bonds issued by the United Kingdom (UK). The UK has a higher debt-to-GDP ratio, but still pays low interest on government bonds (Poghosyan, 2012).

Chinn and Frankel (2003), covering the period from 1988 to 2003, found that short and long-term interest rates in the US influences those in the Euro area. Linde (2001), in a country-specific study on Sweden, found that higher budget deficits induce higher sovereign bond yields. Baldacci and Kumar (2010) also studied a sample of advanced economies over the period 1980 – 2008, analysing the impact of fiscal deficits and public debts on long-term interest rates. They found that increase deficits and public debts lead to increase in long-term interest rates. Afonso et al. (2015) studied the determinants of sovereign bond yield in the 10 advanced economies in the European Monetary Union (EMU) over the period 1999 - 2010. They investigated various potential determinants of bond yields namely, macroeconomic and expected fiscal fundamentals, international risk, liquidity conditions and sovereign credit ratings. The findings were that the determinants of government bonds change over time and sensitivity level of bond prices to fundamentals change over the financial crisis period. During the pre-crisis period, macro and fiscal fundamentals were generally not significant in explaining the spread, but since the dawn of the crisis the explained the movements well and was consistent with theoretical expectations. It is also found that sovereign credit ratings are significant in explaining the spread.

Another study by Akram and Das (2017) studied the determinants of government bond yields in 11 advanced eurozone countries from 2000 to 2015. The results from this study showed that short-term interest rates strongly influence the long-term interest rates on government bonds, which supports Keynes’ Expectation theory (1930). This finding was relevant to the countries in the eurozone as these are member countries of the EMU, and these countries lack monetary sovereignty and these findings helps assessing efficacy of the European Central Bank’s monetary policy. Giordano et al. (2012) analysed the determinants of sovereign spread in the ten advanced Euro area countries from 2002 to 2012. This disentangled the role of country-specific fundamentals driven by fiscal and macroeconomic fundamentals in explaining the 10-year yield spreads relative to Germany. The countries' spread show a time dependent contagion effect where they benefit from flight-to-quality effects (where investors choose to invest in bonds with good quality/credit rating in the case of economic shrinkage or debt crisis since the 2007/2008 financial crisis and then in 2010 when irregularities in Greece's budget were disclosed. This results in the yield spread being higher than justified by macroeconomic and fiscal fundamentals.

2.3.2 Determinants in emerging economies

A theory of sovereign risk based on adjusted version of the growth-indebtedness model was presented by Kharas (1984). This model introduced the use of sovereign spreads, it split the variables into permanent and transitory components and the global risk aversion and contagion variables were the determinants of spread. Dynamic econometrics were used to estimate the short and long run impacts of the explanatory variables on sovereign spreads. Largest variations on sovereign spreads in Argentina, Brazil and Mexico were explained by macroeconomic fundamentals, namely real GDP growth, gross capital inflows and debt service burden (as a percentage of GDP). However, it was found that the effect on US real interest rates had mixed to insignificant impact on the sovereign yield of the countries. One of the empirical findings was that reducing the debt service burden in GDP terms helps decrease the sovereign spreads and achieves lower cost of capital in Latin America (but also in other emerging economies) and the spread of market disturbances from one country to another, i.e. financial contagion or global risk-aversion help account for the variability in sovereign risk (Grandes, 2007).

Naidu et al. (2016) studied the determinants of government bond yields in twelve emerging countries, namely India, Mexico, Morocco, South Korea, Pakistan, Philippines, Russia, Seychelles, South Africa, Thailand, Turkey and Venezuela over the period 1980 - 2013. The determinants included the US 10-year benchmark bond yield, the government debt-to-GDP ratio, inflation, real interest rate, federal reserve rate, oil price and the volatility index. Generally, the challenges faced by emerging economies are higher borrowing costs, shorter maturity and less liquidity in the market. These difficulties are amplified by monetary policies pursued by advanced economies which destabilise the international debt markets. Changes in US interest rates are generally accompanied by parallel shifts in interest rates in the G-7 economies which, in turn, affect the movement in world interest rates. Thus, the movement in the interest rates of emerging economies are sensitive to changes in the US bond yields. In emerging economies, the long-term government bond yield has become increasingly dependent on global economic conditions, hence the study sought to determine the significance of these variables (Naidu et al., 2016).

Firstly, Naidu et al. (2016) conducted six panel unit root tests and found that the series were non-stationary in levels but stationary in first differences. Secondly, the Pedroni panel cointegration tests were conducted to test for the existence of a long run relationship between the domestic yield and the various debt, macro and global factors. Naidu et al. (2016) found a long run relationship between the domestic bond yields and these explanatory variables. Considering the finding of cointegration, Naidu et al. (2016) proceed to estimate the dynamic ordinary lease squares (DOLS) regression model to capture the long run coefficients of the cointegrating variables. It was found that there exists a long run relationship between the domestic yields, the US 10-year benchmark bond yield, government debt-to-GDP ratio, the federal reserve rate, oil price, real interest rates and volatility index. One of the key empirical observations include that one percent increase in the US bond yields will increase the bond yields of the emerging economies by about by ten percent. Naidu et al. (2016) assert that increasing globalisation and the integration of financial markets has made emerging markets more vulnerable to exogeneous shocks such as movements in interest rate in the advanced economies. The study also found that a one percentage point increase in the government debt to GDP raises the domestic bond yields by about two percentage points. In contrast to the findings by Poghosyan (2012) mentioned in the previous sub section, it is determined that the impact of increase in the debt-to-GDP on yields in the emerging markets is much higher than in advanced economies.

Žaja et al. (2018) studied the determinants of government bond yields in one of the newest EMU countries, that of Croatia, covering the period from 2001 to 2017. The study utilised 19 variables that cover macroeconomic, financial, fiscal and political indicators. The macroeconomic variables include the following: GDP, harmonized index of consumer prices (HICP), unemployment and foreign direct investment (FDI). The financial variables are the Zagreb Stock Exchange equity index CROBEX, the HRK/EUR exchange rate taken as the middle rate of the Croatian National Bank rate, monetary aggregate M1, the country’s credit rating and the reference interest rate EURIBOR. Fiscal variables include operating balance, domestic debt/public debt, domestic debt/GDP, external debt and public debt/GDP. Finally, the political variables are election period, government change, the appointment of a new finance minister and political option (right-wing) which are represented as dummies. Žaja et al. (2018) found that before the global financial crisis, most macroeconomic and fiscal variables had considerable influence on the sovereign yield. During the crisis, the country's credit rating, a financial variable, also had an impact. In the second period of the crisis the financial and political variables had a significant effect on the sovereign yield and in the recovery phase the macroeconomic variables became more important.

Vargas (2005) studied macroeconomic determinants of the movement of the yield curve in the Philippines, an emerging market. The macroeconomic variables used in the study are the Consumer Price Index, overnight lending rate, value of production index of key manufacturing enterprises, peso-dollar exchange rate, the government's budget deficit, non-performing loans of the banking industry and the federal funds rate of the US. The treasury yields with a term structure ranging from 3 to 120 months were used. The period covered was from January 1999 to November 2004. It was found that monetary policy has a significant effect on long-term interest rates and at the same time shocks to inflation and monetary policy have the largest impact on the volatility of long-term interest rates. The shocks to the exchange rate and budget deficits have the strongest effect on the volatility of short-term interest rates. Inflation, the exchange rate and non-performing loans significantly drive medium-term interest rates and shocks from these three are the largest source of volatility for medium-term interest rates.

2.4 Chapter Summary

The theoretical framework underpinning the determinants of sovereign bond yields was presented in this chapter, followed by a review of empirical tests on this relationship in both developed and emerging markets. These studies on the determinants of government bond yields in advanced and emerging economies, however, have had little focus on African economies, and thus there is a lack of knowledge in this area. As such, this necessitates further research of the determinants of government bond yields in African economies. The methodology and data to be used in addressing this research question is discussed in Chapter 3.

CHAPTER 3: DATA AND METHOD

3.1 Introduction

In this chapter, the data collected, and the method employed to answer the research objectives is described. The research objectives, as explained in chapter 1, are to examine the determinants of government bonds in Africa and conduct a comparative analysis to emerging and developed countries. The chapter comprises the following: the sample (section 3.2), methodology (section 3.3), and finally, the chapter summary (section 3.4). The sample provides a detailed account of the data collected and its sources. The methodology outlines the contextual framework and provides an explanation for the model choice. A suitable model(s) is chosen and a detailed account of the model(s) using mathematical concepts is given. Lastly, additional considerations are made to improve the model such as accounting for heteroskedasticity and cross-sectional dependence.

3.2 Sample

The time period of the study spans from 2010 to 2019, with annual data collected. For the sample of countries, 30 advanced economies, nine African countries that are either frontier or emerging economies, and lastly, 19 emerging economies from other continents were selected. The list of countries in each category are shown in Table 1.

Table 1: Countries included in the sample

Advanced economies		**African frontier/emerging economies**	**Other emerging economies**	
Canada	Ireland	South Africa	Brazil	Romania
France	Israel	Egypt	Russia	Saudi Arabia
Germany	Lithuania	Morocco	India	Thailand
Italy	Malta	Nigeria	China	Turkey
Japan	Netherlands	Kenya	Bulgaria	Vietnam
United Kingdom	New Zealand	Ghana	Czech Republic	
United States	Norway	Botswana	Indonesia	
Denmark	Poland	Namibia	Colombia	
Sweden	Portugal	Uganda	Mexico	
Switzerland	Singapore		Chile	
Australia	Slovak Republic		Croatia	
Austria	Slovenia		Hungary	
Belgium	Korea		Pakistan	
Finland	Spain		Philippines	
Iceland	Taiwan			

The choice of countries in Africa and time period was limited by the availability of data. The sample has missing observations in some years: Uganda (2011), Botswana (2018-2019), Namibia (2010 – 2013) and Morocco (2010 – 2011).

Given the data from advanced, African frontier/emerging and other emerging economies, several analyses are conducted. Firstly, all economies are analysed together to ascertain the primary determinants of government bond yields globally. Secondly, all the frontier/emerging economies, i.e. all African frontier/emerging and other emerging economies, are examined as one grouping and lastly, the determinants of sovereign bond yields on each subset of countries is studied i.e. advanced economies, other emerging economies and African economies. Model selection is done for each subset.

3.3 Variable description

The 10-year government bond yield is considered the best measure to quantify overall changes in governments' cost of borrowing (Naidu et al., 2016). 10-year government bonds are typically used as a benchmark for the movement in the government bond yield. For example, in the US, the 10-year Treasury note is used as a benchmark for other interest rates such as Treasury bonds and mortgage rates (CFI, 2020).

A study by Afonso and Nunes (2013) analysed the ability of economic forecasts (forward looking) to explain changes in the sovereign yield. In contrast, this study assesses retrospectively the factors that influenced historical yields. Although it is acknowledged that forecasts can provide good prospects of yields, other studies have shown that examining historical trends is of value as many trends can give a reasonable indication for the things that are to happen in the future. For example, studies by Poghosyan (2014) and Naidu et al. (2016) used historical data for the period 1980 – 2010 and 1980 – 2013, respectively to examine the determinants of government bond yields in their sample of countries.

The variables are listed and defined in Table 2. Similar to the study by Naidu et al. (2016), the explanatory variables used in the analysis are GDP growth, current account as percentage of GDP, Gross National Savings (GNS) as a percentage of GDP, inflation, crude oil prices, nominal exchange rate, general government gross debt as percentage of GDP, inflation, the Chicago Board Options Exchange (CBOE) Volatility Index (VIX) and the Federal Reserve Interest Rate (fed fund rate). In addition, sovereign Credit Rating Score and World Governance Indicator (WGI) Score were also included. This is similar to the research by Mutize and Nkhalamba (2020b) who investigated the impact of long-term foreign currency sovereign credit ratings changes on 30-year sovereign bond yields for South Africa. The WGI was also used by Eichler and Plaga (2017) to analyse the link between political factors and sovereign bond holdings of US investors. The data was collected from various sources, as indicated in Table 2. The sources were the CBOE Global Markets website, Datastream, Federal Reserve Economic Data (FRED) website, IMF's World Economic Outlook (WEO) database, Investing.com, Knoema, Oxford Economics Global Data Workstation, Our World in Data (OWD) and the World Bank database.

Table 2: Description of data variables

Variable	Description	Source(s)
ygd	10-year government bond yield for the respective country	Datastream, Investing.com and knoema
gdpchange	GDP, constant prices percent change	WEO
currentaccountgdp	Current account balance percent of GDP	WEO
Gnsgdp	Gross national savings percent of GDP	WEO
exchangerate	Nominal exchange rate (average)	WEO
govdebtgdp	General government gross debt percent of GDP	WEO
Inflation	Inflation, average consumer prices percent change	WEO
crudeoilprices	Average Crude Oil Prices in US Dollars	OWD
Wgiscore	World Governance Indicator Score	World Bank Database
Vix	Chicago Board Options Exchange Volatility Index	CBOE Global Markets website
fedfundrate	Federal Reserve Interest Rate	FRED website
creditratingscore	Average Credit Rating Score	Oxford Economics Global Data
economy	Dummy variable, 1 - 3 to denotes advanced, Africa and other emerging economies.	

All variables represented in percentage form are not strictly positive numbers, (this includes all variables except crude oil prices, WGI and VIX) and hence are first linearly transformed by adding one and then the natural log transformation performed, i.e. variable x is replaced with ln(x+1), where ln is the natural log. Adding one enables the log transformation of a variable that could have otherwise been negative to be conducted. The natural log transformation is done on crude oil prices, WGI and VIX, i.e. variable x is replaced with ln(x). A log transformation aids in reducing skewness of data that could potentially be skewed and de-emphasizes outliers, hence potentially restoring symmetry to the data (Sauro & Lewis, 2016).

The first explanatory variable – the percentage change in GDP in constant prices – is an inflation-adjusted measure that reflects the real value of all goods and services produced by an economy. When there is economic growth i.e., GDP growth, the demand for money is higher, since greater spending activity means that there is a greater need for cash to finance projects. Higher currency demand causes inflation, which is the reduction of a currency's purchasing power. The central bank in response increase the interest rates to combat inflation. This results in investors choosing to inject money into the economy by being interested in stocks, and thus less demand for government bonds. Bond yields rise and fall with central bank interest rates (Kenny & Scott, 2021). Similarly, when there is negative or no economic growth, there is no demand for money, thus government bonds are viewed as a haven, which increases their demand resulting in a decrease in yield. Kapingura and Makhetha-Kosi (2014) examined the causal relationship between bond market development and economic growth in Africa. The study revealed that there is a positive relationship between economic activity (measured by GDP growth) and bond market capitalisation (which indicates activity in the bond market and in turn affects the yield). The positive relationship established was bi-directional in the sense that the real economic activity is also influenced by development of the bond market.

In the same breadth, GDP growth could also result in a reduction in sovereign bond yields. GDP growth affects revenues raised through taxes which is used to service government debt. The growth in GDP results in growth of revenue from taxes, hence, decreasing the likelihood of a bond default. Thus, investor would accept a lower yield for the risk taken. How the government bond yield change in respect to change in GDP growth is dependent on the nature of the economy. The decrease in yield due to an increase in GDP growth is likely to occur with high yield bonds, which are usually those of emerging markets, where an increase in GDP growth may imply a significant decrease in default risk. It is not always clear as to how the yield may respond to changes in GDP growth, but overall it is an aggregate response to decreasing demand of government bonds (which results in increase in the yield) against a decrease in yield due to investors accepting a lower yield as a compensation for reduced risk (Kenny & Scott, 2021).

A country's current account indicates the nation's transactions with the rest of the world, specifically its net trade in goods and services, its net earnings on cross-border investments, and its net transfer payments over a defined period (Tuovila & Drury, 2020). The current account is equal to the difference between savings and investment (Pettinger, 2017a). It is further stated that a positive (negative) current account balance indicates that a country is a net lender (borrower) to the rest of the world. The current account balance has an impact on sovereign yields (Afonso & Nunes, 2013). Increasing current account balances, with constant budget deficits, enhance liquidity in domestic financial markets and tend to lower domestic interest rates (Dombrecht & Wouters, 2020). For example, when the US is in deficit with some of its imports coming from China. It implies that China holds a lot of Dollar currency which needs to be exchanged to Renminbi. However, having to exchange the Dollar for Renminbi could result in appreciation of the latter currency and negatively affect its exports, hence China decides to buy US government bonds and invest in Dollars instead. This results in increase in demand for the US government bonds, hence a decrease in the yield (Rimkus, 2012).

The current account also interacts with GNS in that sustained low savings relative to investment translates into a persistent current account deficit and a deteriorating international investment position (SESRIC, 2011). GNS is GDP minus final consumption expenditure (Economic Times, 2021). It measures the amount of income that households, businesses, and governments save (Kagan, 2020). An increase in savings means there is strong demand for governments bonds, thus reducing their yields. For example, Japan has government debt that is at least 230% of GDP, and yet they have low bond yield (close to 0% in 2019) due to high level of domestic savings (Pettinger, 2017b).

There is also interaction between the current account balance and the exchange rate. The increase in current account deficit increases a country's vulnerability as it signals reliance on foreign financing, hence influencing the exchange rate (SESRIC, 2011). The larger the current account deficit, implies that the country has spends more on imports than it receives on exports (Maverick, 2019). This results in trade deficit which leads to depreciation of the domestic currency (Kenton & Boyle, 2020). The exchange rate is an important factor in determining bond yields because government debt issuance attracts foreign investors and their return on investment is dependent on the prevailing exchange rate. If the currency in which they invest their funds depreciates quicker, then it would be that, although the nominal amount may remain the same, the purchasing power of the returns would decrease as they would be converting from an already depreciated currency (Ingram, 2019). This then implies that for foreign investors to buy another country's bond, they would need to be compensated for exchange rate risk, hence an increase in exchange rate would imply increase in government bond yield.

If government borrowing increases, it is expected to result in higher bond yields. Increasing debt levels result in investors demanding a higher premium to compensate for the risk of debt default (Pettinger, 2018). Government debt to GDP is an important factor because a high debt ratio can make it difficult for a nation to access capital markets. Lenders will fear that they will not be repaid when they lend money to the country high in debt, thus they charge high rates to compensate for the risk or they may refuse to lend to the country entirely (NBER, 2019). If a government borrows too much, the government may be tempted to deal with the debt by increasing the money supply (printing money) and paying off the debt through inflation. Inflation causes bonds to fall in value because it reduces purchasing power of a currency, hence bonds will be purchased as lower price, which implies an increase in bond yields. Higher inflation will lead to higher bond yields as investors demand higher interest rates to protect against the falling value of nominal bonds (Pettinger, 2018).

Crude oil is an important commodity as it is a crucial input in the transportation of goods. The decline in crude oil prices will have negative impact on oil producing countries as it would imply less revenue from taxes, but for countries which are oil importers, this will give a boost to the economy as it is now cheaper to transport. Falling oil price tends to reduce bond yields in oil consumers, both because of declines in inflation and improving government finances (Cosgrave, 2014). In similar logic, it means that for the oil exporters, there will be reduced revenue, thus their government bond yield will increase.

The WGI project reports aggregate and individual governance indicators for over 200 countries and territories since 1996 for six dimensions of governance: voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law and control of corruption (World Bank, 2021). This measures quality of governance and is an important factor because when there is poor governance, countries could have a less functional economy, corruption and be unable to collect taxes effectively, hence affecting the country’s ability to service its debt. Thus, it is expected that when there is a low WGI score, there is institutional weakness which can lead to unsustainable debt levels, thus increasing the risk of default (Fournier & Bétin, 2018). Hence investors would want to be compensated for the additional risk, thus increasing the government bond yield.

The implied volatility of S&P index options measured by the VIX is used as a proxy for global risk appetite (Naidu et al., 2016). Trading volume in this market is dominated by investors seeking to purchase portfolio insurance (buying put options), which tends to increase as stock markets decline. The VIX is calculated using the prices of SPX index options, a stock index based on the 500 largest companies listed on the New York Stock Exchange (NYSE) and

Nasdaq (Wohlner & Wolfinger, 2020). VIX is one of the most popular derivative-implied risk measures and is frequently used by researchers and market participants to gauge fear or uncertainty with respect to the US equity market and even with respect to global equity markets (Datta et al., 2017). These options are very liquid with high trading volume and are thus able to show investor risk appetite and given that they are traded in one of the world's largest economies, the US, they can be seen as a good "investor fear gauge". Investors consider change in equity volatility when making investment decisions. When perceived market-wide risk increases, investors buy bonds that they deem to be safer. Thus, an increase in implied volatility results in decrease in yields for US treasuries and high-quality corporate bonds (Jubinski & Lipton, 2012).

The US is one of the world's largest economies and most established financial markets, and policy decisions in that country impact other countries (Smales, 2019). The federal fund rate is the interest rate at which depository institutions trade federal funds (balances held at Federal Reserve Banks) with each other overnight (FRED, 2021). The fed rate is used as a proxy for the world interest rate since the US is the second largest economy and its movements in interest rate impact on emerging economies capital markets. In response to monetary tightening, the prime rate increases and results in a decrease in the supply of money (Hayes & Kelly, 2020). This has a ripple effect to other economies given how enormous the US economy is and this has effects in personal and business environments.

Investors rely on credit ratings to determine the quality of bond, i.e. scaling the probability of default from low to high (AAII, 2021). Investors would require to be compensated more as probability of default increases. Hence, generally the relationship between bond yields and credit ratings is negative (Mutize & Nkhalamba, 2020b). Mutize and Nkhalamba (2020b) investigated the impact of credit ratings on 30-year sovereign bond yields for South Africa and found asymmetry in the response of the government bond yields to changes in credit ratings. That is, there is loss aversion where investors are less sensitive to an impact of an upgrade in credit rating than they are to a downgrade in credit rating. This is consistent with Prospect Theory devised by Tversky and Kahneman (1979) that explains the tendency of people to strongly prefer avoiding losses than acquiring gains.

3.4 Methodology

3.4.1 Panel Data Models

The dataset used in this study comprises 58 countries spanning the period 2010 to 2019 with 12 variables (11 explanatory variables). This is panel data because the dataset involves cross-sectional (country, denoted by “N”) and time-series (year, denoted by “T”) observations for analysis. More specifically, this is a micro panel dataset because the number of time observations is relatively small (Moffatt, 2019). Panel data increases the total number of observations and reduces the noise arising from individual time series, thus minimising the problem of heteroskedasticity (Adeleye, 2018b). Another advantage of panel data is that it resolves difficulties involved in interpreting the partial regression coefficients in the framework of a cross-section only or time series only multiple regression. The larger sample results in more degrees of freedom for the analysis, hence more variability and less multicollinearity among the variables (Vijayamohanan, 2016).

Past research examining the determinants of government bond yields and studies utilising panel datasets in general was reviewed to consider what models could be used in analysing panel data. Poghosyan (2012) applied the pooled mean group (PMG) estimator of Pesaran et al. (1999), which is a panel data version of the error-correction model. The advantages of using this model are that (i) it differentiates between long- and short-run determinants of bond yields; (ii) it pools long-run coefficients to improve efficiency and comply with theoretical predictions, while maintaining flexibility in allowing country-specific variation of short-run coefficients; and (iii) it allows testing for coefficient poolability (Poghosyan, 2012). The disadvantage of this model is that it assumes that the bond yields in all countries included in the panel respond to changes in economic fundamentals similarly, i.e. it assumes homogeneity and all variables must be non-stationary and with the same level of integration (Poghosyan, 2012). Moreover, the PMG method is used for estimating nonstationary heterogeneous panels in which both N and T are large (Blackburne & Frank, 2007).

Naidu et al. (2016) used the panel cointegration methodology. This method first determines the order of integration of each data series using panel unit root tests. If variables are found to have the same order of integration, i.e. all non-stationary at order one, then the cointegration technique developed by Pedroni (1999; 2004) is used to test for the existence of a long-run relationship between the variables. Lastly, should cointegration be found, then the long-run relationship among the variables is estimated by the DOLS method developed by Pedroni (2001). The advantage of the cointegration approach is that it allows modelling of variables that are non-stationary, as long as they have the same order of integration and are cointegrated (Naidu et al., 2016). The disadvantage of the model is that it requires sufficiently large time-series observations in the panel dataset and the model cannot be applied when the requirements of cointegration are not met. Another disadvantage is that in general unit root tests have low power (tests with low power may fail to reject the null hypothesis when it should be rejected), leading to a type II error, and thus multiple tests for stationarity must be conducted to ensure reliable results (Adeleye, 2018a).

The order of integration of the variables was examined to determine if either the PMG or the Pedroni (1999, 2004) cointegration test could be used. The unit root tests conducted included Breitung, Fisher-type tests, Harris-Tzavalis, Im-Pesaran-Shin, Levin-Lin-Chu test and Hadri Lagrange multiplier unit root tests. The pre-testing of all the variables revealed that the dataset comprises a mix of stationary and non-stationary variables and thus neither the PMG method nor Pedroni's cointegration test could be used. This is consistent with the recommendation that such models are best suited for panels with many time-series observations. The dataset of Naidu et al. (2016), for example, who employed Pedroni's approach, covered the period 1980 to 2013, i.e. 34 years of data compared to only 10 years in this sample.

In the circumstance where variables have different order of integration, but are all either of order zero or one (I(0) or I(1)) meaning stationary at levels and stationary at first differences respectively, then the panel autoregressive distributed lag model (ARDL) can be used to estimate the relationship and test for possible convergence in the long-run (Bardi et al., 2019). Bardi et al. (2019) used this methodology to analyse long-run interactions between structural policies and economic growth. The disadvantage is that this approach is a heterogeneous dynamic panel data modelling which means the model works well when there is large N or small N and large T, where $N < T$ (Adeleye, 2018b). This is restrictive in the sense that it cannot be used in a panel where there is small T or small N and T. Accordingly, the ARDL model was not deemed appropriate for this study due to the small value of T and the fact that in the smaller subsets of countries, N is also small (e.g. in the Africa group, N is only 9).

There are other modelling techniques that can be considered that have less stringent requirements for a panel dataset compared to the aforementioned techniques. These include: (1) the constant coefficients regression model, also known as pooled ordinary least squares (OLS); (2) the fixed effects model (FE); and (3) the random effects model (RE). The main advantage of these three models is that they are not strict on their requirements of the structure of the panel data. The disadvantage of the pooled regression model is that it assumes that there is neither a significant cross sectional (N) nor temporal effect (T). This results in a loss of information that could have aided in better understanding the impact of the explanatory variables (Vijayamohanan, 2016). The FE and the RE are based on assumptions regarding the error component. The main problem with the FE model is that the specification relies on too many parameters, resulting in a heavy loss of degrees of freedom compared to the Random Effects model which assumes that individual/time error components are random (Vijayamohanan, 2016).

The FE model assumes that either spatial (cross-section) units, temporal (time) or both spatial and temporal have different intercepts, whilst the RE model assumes different disturbances for either spatial, time or both spatial and time. If an assumption is made with respect to the existence of either spatial or temporal elements, a one-way FE or RE is estimated while if an assumption is made with respect to both elements then a two-way FE or RE is estimated (Vijayamohanan, 2016). One model must be selected from this, over and above proving that they are individually superior to the pooled OLS. In other words, the first step is to decide whether the models should he a one-way specification or a two-way specification.

Deciding between the one-way and two-way models can be motivated by the research question at hand and/or the interpretability of the results from that model. For example, the interpretation of a time FE model corresponds to a research question that involves cross-sectional comparisons, and the interpretation of a cross-section FE model corresponds to a research question that involves comparisons over time (Kropko & Kubinec, 2020). If the research intends to compare one cross section unit to itself over time, then it is appropriate to examine time series and to use cross section unit fixed effects. If the intention is to assess how the dependent variable between the cross-sectional units changes as a result of changes between their respective explanatory variables, then time fixed effects should be used (Kropko & Kubinec, 2020). Cross section fixed-effects coefficients can be interpreted as the average change in the dependent variable for each one-unit increase in the explanatory variable over time. Time point fixed-effects coefficients can be interpreted as the average change in the dependent variable for each one-unit increase in the explanatory variable between cases. Two-way fixed-effects coefficients can be interpreted as the average difference in intra-unit changes in the dependent variable at time point *t* for each one-unit intra-unit increase in the explanatory variable at time point *t*, averaged across time points. This means that the two-way FE measures a change in the difference of the dependent variable between two units as a response to changes in the difference between their respective explanatory variables (Terrence et al., 2019).

In FE, the primary interest is in the means of the factor levels (and the differences between them) whereas with random effects, the primary focus is on their variances. For the purposes of this research a one-way model was deemed appropriate because the interest is in the impact of explanatory variables (e.g. GDP growth) on the dependent variable (government bond yield) over a period of time and not necessarily a comparison between the countries nor their intra-unit changes in the government bond yield as a result of intra-unit change in the explanatory variable. Thus, going forward, the FE and RE models are discussed in the context of a one-way model. The best model between the pooled OLS, FE and RE need to be chosen in this context. Several tests are conducted in order to select the most suitable model. The F-test (Wald test) is used to compare the FE against the pooled regression and Breusch-Pagan Lagrange Multiplier (LM) test is used to compare RE against the pooled regression. Then, to compare FE against RE, the Hausman test is needed with the null hypothesis that the RE is the preferred model. If the null is rejected, then use the FE model, otherwise use the RE model (Park, 2010).

In the context of panel data, the unobserved heterogeneity is addressed by the within (demeaning) transformation, as in one-way FE model, or by taking first differences if the second dimension of the panel is a proper time series. Nickell (1981) showed that this process of within transformations results in a difficulty, e.g. in the context of a one-way fixed effects model, the demeaning process which subtracts the individual's mean value of y and each X from the respective variable creates a correlation between the regressor and error term. The resulting correlation creates a bias in the estimate of the coefficient of the lagged dependent variable and this problem is not corrected even by increasing the number of cross-sectional units, N, nor by inclusion of additional regressors. If the regressors are correlated with the lagged dependent variable to some degree, their coefficients may be biased as well. This problem similarly affects the one-way random effects model (Baum, 2013).

A solution to this was created by taking differences of the original model, however this resulted in correlation between the differenced lagged dependent variable and the error process, which now becomes a moving average of order 1, i.e. MA(1). The Anderson–Hsiao (AH) estimator was created to attend to this problem (Baum, 2013). Generalised method of moments (GMM) is another approach used to attend to the problems of the FE and RE models. GMM is a generic method for estimating parameters in statistical models and it uses moments conditions that are functions of the model parameters and data such that their expectations are all zero at the parameters' true values (Adeleye, 2018c). This is a dynamic panel data estimator that controls for endogeneity of the lagged dependent variable where there is a correlation between the explanatory variables and the error term in a model (Baum, 2013). It also controls for omitted variables, unobserved panel heterogeneity and measurement errors in the model. Upon further research Arellano and Bond (AB) argue that the Anderson–Hsiao estimator, while consistent, fails to take all the potential orthogonality conditions into account. The AB approach was extended into the system GMM context, of which the latter is more robust (Baum, 2013). Hence, under the GMM, there are two types of estimators, difference GMM and system GMM (Adeleye, 2018c).

The system GMM method works best in the following situations: A panel with 'small T, large N', a linear functional relationship, dependent variable that is dynamic and is a lagged variable (i.e. depending on its past information), the explanatory variables are not strictly exogenous, i.e. they could be correlated with past and possibly current realisations of the error fixed individual effects, fixed individual effects , implying unobserved heterogeneity, heteroskedasticity and autocorrelation within individual units' errors (Baum, 2013). Chronopoulos et al. (2020) analysed the determinants of bank holdings of domestic sovereign debt using the two-step system GMM while Mu et al. (2013) applied the system GMM model to analyse the key determinants of African government securities' markets and corporate bond market capitalisation.

Although the GMM method attends to some of the challenges faced by the FE and RE model, it is not without its challenges. The problem with the difference and system GMM is that they are complicated and so can easily generate invalid estimates (Roodman, 2009). GMM codes in Stata can be easily manipulated to yield different results. It also does not account for cross-sectional dependence and structural breaks. They are also not suitable for panel with long time-series. The model defines some variables as instruments, and it is susceptible to error as too many instruments weakens the Sargan and Hansen tests which test for the validity of this instruments. The results are also biased if instruments outnumber individual cross-sectional units and given the current literature there is still no defined optimal number of instruments required to make the model robust (Adeleye, 2018c).

The system GMM model is superior to the FE and RE models, and the latter two are generally better than the pooled regression. However, in this study, the system GMM, which is designed for situations with 'small T, large N' panels, could not be used because when running the model on the subset of African markets, T is too small to allow a robust model to be developed and N is not large enough when considering the different subsets of countries (for Africa N = 9 and T = 10). In addition, GMM does not account for cross-sectional dependence (in contrast, the FE model is able to account for this factor).

Accordingly, the pooled regression, FE and RE models are considered appropriate for the estimation of the regression model in this study. Further details about these three approaches and the tests used to determine the appropriate model between them are discussed in the following section.

3.4.2 Pooled OLS and the FE and RE models

The cross-sectional multiple regression model is of the form:

$$y_i = \alpha + \sum_{j=1}^{K}(\beta_j x_{ij}) + u_i \; ; \; i = 1, 2, \ldots, N, \; j = 1, 2, \ldots, K \quad (5)$$

where i is the cross-section unit, j is the explanatory variable and y_i is the dependent variable. The time series multiple regression is of the form:

$$y_t = \alpha + \sum_{j=1}^{K}(\beta_j x_{jt}) + u_t \; ; \; t = 1, 2, \ldots, T, \; j = 1, 2, \ldots, K \quad (6)$$

where t is the time period (Vijayamohanan, 2016). By combining equations (5) and (6), the following panel regression is obtained:

$$y_{it} = \alpha + \sum_{j=1}^{K}(\beta_j x_{jit}) + u_{it} \; ; \; i = 1, 2, \ldots, N, \; t = 1, 2, \ldots, T, \; j = 1, 2, \ldots, K \quad (7)$$

where the component assumption for the disturbances, u_{it}, is defined as

$$u_{it} = \mu_i + \lambda_t + v_{it} \quad (8)$$

where μ_i represents the unobservable individual (cross-section) heterogeneity, λ_t denotes the unobservable time heterogeneity and v_{it} is the remaining random error term where $v_{it} \sim$ IID $(0, \sigma_v^2)$. The first two components (μ_i and λ_t) are also called the 'within component' and the last component (v_{it}), the 'panel or between component' (Vijayamohanan, 2016).

If there is no importance of cross-section (country) and temporal effect (time), then the data can be pooled together and an OLS regression model is a special case of equation (7) where $u_{it} \sim$ IIN$(0, \sigma_u^2)$. The assumptions made regarding the error component of the panel data model determine whether the fixed or random effects model is appropriate. For the one-way error component model (either μ_i or λ_t) is random or fixed, i.e. either $\mu_i \sim$ IID$(0, \sigma_\mu^2)$ or is fixed or

$\lambda_t \sim IID(0, \sigma_\lambda^2)$ or is fixed, then the model is regarded as either a FE or RE (Vijayamohanan, 2016).

Secondly, if there is a significant cross sectional or temporal effect, then we have the one-way component models, but if the errors are assumed to be constant, then we can have the FE model:

$$y_{it} = \sum_{j=1}^{K}(\beta_j x_{jit}) + u_{it}\ ;\ i = 1, 2,\ldots, N,\ t = 1, 2,\ldots, T,\ j = 1, 2,\ldots, K \quad (9)$$

where $u_{it} = \mu i + \lambda t + vit$, or $u_{it} = \mu i + vit$, or $u_{it} = \lambda t + vit$, and $vit \sim IIN(0, \sigma_v^2)$

The model above does not have a constant intercept because there are effects that are specific to a cross section unit or time. This model is also called the analysis of covariance (ANCOVA). The fixed effects can be discussed under two assumptions: (i) heterogeneous intercept (cross-section and time parameters) and homogeneous slope (beta coefficients) and (ii) heterogeneous intercepts and slopes. Cross section and time heterogeneity in model (5) above apply to intercepts, not slopes, i.e. the beta coefficients will be common across all units.

The FE model can be estimated using one of two methods, (i) the least squares dummy variable model (LSDV) or (ii) the within-groups regression model. The drawback of the former is that it has too many regressors, because a separate dummy variable is included for each cross-section or time series unit, and has the problem of multicollinearity (Nwakuya, 2019). As the number of regressors increase, the degrees of freedom fall, thus error variances rise, leading to Type 2 error in inference, i.e. not rejecting the false null hypothesis. This model is also unable to identify the time-invariant variables. A way to estimate the fixed effects model without using dummy variables is the within-groups regression model. This model eliminates the fixed effect, by expressing the values of the dependent and explanatory variables for each observation as deviations from their respective mean values (Gujarati & Porter, 2009). In developing this model, consider the following one-way error component model:

$$y_{it} = \alpha_i + \beta X_{it} + v_{it};\ i = 1, 2,\ldots, N,\ t = 1, 2,\ldots, T \quad (10)$$

and $v_{it} \sim IID(0, \sigma_v^{\ 2})$ and $Cov(x_{it}, v_{it}) = 0$, i.e. v_{it} independent of the explanatory variables. Then, averaging the regression over time, the following is obtained:

$$\bar{y}_{i.} = \alpha_i + \beta \bar{X}_i + \bar{v}_i \quad (11)$$

where $\bar{v}_{i.} = \sum_{j=1}^{T}(v_{it})/T$, $\bar{y}_{i.} = \sum_{j=1}^{T}(y_{it})/T$ and $\bar{X}_{i.} = \sum_{j=1}^{T}(X_{it})/T$. Now, subtracting (7) and (8) yields the following:

$$y_{it} - \bar{y}_i = \beta(X_{it} - \bar{X}_i) + (v_{it} - \bar{v}_i) \tag{12}$$

This deviations from the mean model is referred to as the Q transformation (Vijayamohanan, 2016). The OLS estimator for β from this transformed model is called the within-groups fixed effects estimator, or simply the 'within estimator', as it is based only on the variation within each company; this is identical to the LSDV estimator.

The individual-specific intercepts are estimated unbiasedly as:

$$\widehat{\alpha}_i = \bar{y}_{i.} - \hat{\beta}\bar{X}_{i.}\ ,\ i = 1, \ldots, N$$

(Vijayamohanan, 2016).

The xtreg command in Stata was used to compute the within-groups regression model. Stata's xtreg code for the FE model has built in F-test also for poolability with the null of no unit heterogeneity. This was used to determine the preferred model between the pooled regression and the within-group FE model. The challenge with the FE model is that it has specifications with many parameters, resulting in loss of degrees of freedom. So, alternatively the RE model can be used where the μ_is are assumed to be random. This gives us the model with:

$$\mu_i \sim IID(0, \sigma_\mu^2), \text{ and } v_{it} \sim IID(0, \sigma_v^2)$$

$$Cov(v_{it}, \mu_i) = 0\ Cov(v_{it}, X_{it}) = 0 \text{ and } Cov(X_{it}, \mu_i) = 0 \tag{13}$$

i.e. individual error components are not correlated with each other, and not autocorrelated across both cross-section and time series units (Vijayamohanan, 2016).

The RE model was compared against the pooled regression using the Breusch-Pagan Lagrangian multiplier poolability test with the null of $\sigma_\mu^2 = 0$, i.e. that the data can be pooled. This is a Lagrange multiplier test for RE model, and if the null is not rejected then it would mean that the component assumed to be random is in fact not random as the variance would be equal to zero (Stata, 2019).

If the pooled regression is favoured against the RE model but was not favoured against the FE model, then the FE model was used. If the pooled regression is not favoured against the RE model, then it becomes necessary to compare the FE model against the RE model. The Hausman test can be used with the null hypothesis that RE model would be consistent and efficient. Also, Judge et al. (1988) proposed the following simple rule, amongst others, that if N is large and T is small, the two methods differ and cross-sectional units in the sample are random drawings from a larger sample, then the RE model is appropriate; otherwise use the fixed effects model. In this study, the units are not random drawings, so one-way FE model is applicable, but for sake of completeness, the Hausman test was performed (Vijayamohanan, 2016).

3.4.3. Heteroskedasticity and cross-sectional dependence

Upon choosing the best model from the three, further checks were then performed to ensure the model used accounts for heteroskedasticity and cross-sectional dependence (CSD). The measure of spread is the variance, hence if the data is heteroskedastic then it implies that the variance of the error term differs across observations in the model. This variation of the error term can be caused by factors such as a poor method of data sampling, poor data transformation, wrong model specifications, the presence of outliers and/or skewness of one or more regressors (Adeleye, 2019). In the presence of heteroskedasticity, OLS estimators are still unbiased and consistent but are inefficient in the class of minimum variance estimators. Hence, the regression estimates cannot be used to construct confidence intervals or used for inference. Heteroskedasticity might lead to a type 1 error, i.e. rejection of the true null hypothesis (Adeleye, 2019). If the model decided upon is the OLS regression, then the Breusch-Pagan / Cook-Weisberg test for heteroskedasticity with the null of hypothesis of constant variance is conducted using the *xttest3* command in Stata. If the FE model is chosen, then the Modified Wald test for groupwise heteroskedasticity is performed. In the RE model, the panel groupwise heteroskedasticity test is done with a null hypothesis of homoskedasticity. In the pooled regression and FE models, the *vce (robust)* option command is used to control for the presence of heteroskedasticity (Stata, 2019). The *xtgls* with *panels(hetero)* option command is used when accounting for heteroskedasticity in the RE model. The *xtgls* also accounts for CSD (Hoechle, 2007).

CSD occurs where the units in the same cross section are correlated due to an unobserved common factor. This occurs when there are common factors that are omitted from the model, but are correlated with the explanatory variables (Arouri & Rault, 2014). Spatial correlation can arise because some social norms, psychological behavioural patterns and herd behaviour enter the panel regression as unobserved common factors (Hoechle, 2007). The CSD test is used with cross-section time-series data, hence it would not be tested when doing pooled regression model (Stata, 2019). The *xtcsd* command in Stata was performed, which is the Pesaran test for CSD, with the null hypothesis of cross-sectional independence. If the data is found to be heteroskedastic and cross-sectionally dependent, and the FE model is assumed, then the *xtscc* (instead of *xtreg* with *vce(robust)*) Stata command for regression with Driscoll-

Kraay standard errors is used (De Hoyos & Sarafidis, 2006). These standard errors are robust to CSD (Stata, 2019).

3.5 Chapter summary

In this chapter, the description of the sample and variables was provided. The dependent and explanatory variables were defined and the reasons for choosing them were outlined. A variety of models were compared, and the best model was chosen after assessing their relative strengths with regards to the dataset collected. A mathematical expression and detailed explanation of the best model was given. The results of the analysis are presented and discussed in Chapter 4.

CHAPTER 4: EMPIRICAL RESULTS

4.1. Introduction

This chapter presents the results of the empirical analysis, described in the preceding chapter, on the samples of all frontier/emerging, Africa frontier/emerging, other emerging and advanced countries. Section 4.2 presents the descriptive statistics that quantitatively summarise features from the data collected. In section 4.3, the output from the pooled OLS, one-way FE and one-way RE models is presented. The best model of these three is then chosen based upon the results of several tests such as the F-test and the Hausman test. Further considerations are also made to determine how the chosen model could be improved. Thereafter, the results from the best model for all the frontier, emerging and advanced economy subsets are reviewed and compared to theory and prior empirical studies. In section 4.4, the results across all the subsets are compared and lastly, in section 4.5, the chapter summary is presented.

4.2. Descriptive statistics

The dataset comprises 58 economies for the period 2010 to 2019. The descriptive statistics for the dataset are presented in Table 3 below.

Table 3: Descriptive statistics

Variable	Observations	Mean	Std. Dev.*	Minimum	Maximum
Ygd	571	0.0492	0.0448	-0.0047	0.2440
Gdpgrowth	571	0.0320	0.0272	-0.0406	0.2538
Currentaccountgdp	571	0.0085	0.0554	-0.1567	0.2363
Gnsgdp	571	0.2445	0.0796	0.0529	0.5091
Exchangerate	571	729.12	3241.3	0.6074	23227
Govdebtgdp	571	0.5935	0.3633	0.0156	2.3796
Inflation	571	0.0318	0.0346	-0.0209	0.2353
Crudeoilprices	10	79.5859	26.3043	43.7342	111.6697
Wgiscore	571	0.6243	0.1746	0.2417	0.8981
Vix	10	16.8572	3.9143	11.0902	24.2026
Fedfundrate	10	0.0061	0.0078	0.0009	0.0216
Creditratingscore	571	14.1497	4.4755	4.5	20

Note: Std. Dev.* refers to standard deviation.

There are 10 observations each for the crude oil prices, fed fund rate and VIX because these variables are only measured over time, not across countries. The mean government bond yield for all countries in the study is 4.92%, with a maximum of 24.40% (Ghana in 2016) and minimum of -0.47% (Switzerland in 2019). This shows that there is a 4.92% average return earned when investing in 10-year government bonds around the world, which is 1.74% above the average inflation rate (3.18%). The average GDP growth rate for the period 2010 to 2019 is 3.20%. Ireland achieved the highest annual GDP growth of 25.38% in 2015, whereas

Portugal's GDP shrunk by 4.06% in 2012. The average value of the current account as a percentage of GDP is below one percent (0.85%) which reflects that the current account across the countries in the sample are neither in substantial deficit nor surplus compared to the rest of the world. The minimum value is negative which means some countries are net borrowers. The average value of GNS as a percentage of GDP is 24.45% revealing that these countries, on average, spend 24.45% less income than they earn. The emerging economies have the highest savings rate of 25.67%, followed by advanced economies at 24.90% and Africa at 19.95% (Appendix table A1 to table A3).

The average nominal exchange rate is 729 and it means that one US dollar buys 729 units of foreign currency. The average crude oil price is $79.35, and the standard deviation is $24.99. Hence, using the standard deviation empirical rule, this means that 68% of the crude oil prices are within the interval ($54.36, $104.34) which confirms that crude oil prices have fluctuated substantially over the period, with a minimum of $43.73 (2016) and maximum of $111.67 (2012). WGI scores range from 0 to 100%. The average WGI score is 64% and it shows an above the mid-point average quality of governance, although with room for improvement amongst these countries. The highest WGI score is 89.81% (Singapore in 2019) and the lowest score is 24.17% (Nigeria in 2014). The VIX average is 16.86, with a minimum of 11.09 in 2017 and maximum of 24.20 in 2011. A graphical representation (see Figure A1) of the VIX data shows that it has fluctuated over the sample period, hence confirming that global risk appetite varied from year to year depending on changes in economic fundamentals. The average Fed fund rate is 0.61%. The average credit rating score is 14, with the score of the best rated government bond, AAA, 20. Canada and Switzerland are consistently amongst the countries with the highest score of 20.

The average government bond yield is 11.95% for the African frontier/emerging economies, 6.14% for other emerging economies and 2.26% for the advanced economies. This demonstrates that African economies pays at least four times more interest on government bonds compared to the advanced economies and almost double that of emerging countries in other continents (see Appendix table A1 to table A3). The average inflation rate is higher in Africa economies (7.50%), followed by other emerging economies (4.02%) with advanced economies (1.48%) having the lowest inflation. The advanced economies have the highest average government debt as percentage of GDP at 73.54%, whilst the average for African countries and other emerging economies are lower but similar in magnitude at 45.41% and 42.87%, respectively. Africa has the highest GDP growth (4.21%), followed by emerging economies (3.93%) and lastly, the advanced economies (2.47%). The emerging economies has the highest savings rate of 25.67%, followed by advanced economies at 24.90% and Africa at 19.95% (Appendix table A1 to table A3). When it comes to governance, the WGI score indicates both Africa frontier/emerging economies and other emerging economies scores are below 50%, with values of 43.68% and 48.71%, respectively.

4.3. Empirical results

4.3.1 Pooled OLS vs one-way FE model vs one-way RE model

Equation (7), with its respective assumptions for the pooled OLS regression, FE and RE, with N = 58 and T = 10 (including all countries), was estimated in Stata. Table 4 presents the coefficients and standard errors for each model.

Table 4: All countries pooled OLS, FE and RE model results

Variable	Model (1) OLS	Model (2) FE	Model (3) RE	Model (4) Modified FE
ln(gdpgrowth+1)	-0.0547	-0.1386***	-0.1084***	-0.1386***
	(0.0341)	(0.0278)	(0.029)	(0.0208)
ln(currentaccountgdp+1)	-0.1198***	-0.0132	-0.0552**	-0.0132
	(0.021)	(0.0244)	(0.0237)	(0.0219)
ln(gnsgdp+1)	0.0237	-0.1128***	-0.0892***	-0.1128***
	(0.0207)	(0.0315)	(0.0269)	(0.0136)
ln(exchangerate)	0.0002	0.0207***	0.0014	0.0207***
	(0.0004)	(0.0048)	(0.0008)	(0.0064)
ln(govdebtgdp+1)	-0.0209***	-0.0036	-0.0218***	-0.0036
	(0.0044)	(0.0148)	(0.0084)	(0.0125)
ln(inflation+1)	0.5524***	0.2081***	0.3156***	0.2081***
	(0.0323)	(0.0327)	(0.0317)	(0.0409)
ln(crudeoilprices)	-0.0013	0.0073***	0.0016	0.0073***
	(0.0026)	(0.0021)	(0.0019)	(0.0018)
ln(wgiscore)	0.0012	-0.0233	-0.03***	-0.0233
	(0.0055)	(0.0184)	(0.0101)	(0.0242)
ln(vix)	0.0092**	0.0153***	0.0123***	0.0153**
	(0.0039)	(0.0027)	(0.0028)	(0.0059)
ln(fedfundrate+1)	-0.534***	-0.6272***	-0.4882***	-0.6272***
	(0.1111)	(0.0803)	(0.0803)	(0.1236)
ln(creditratingscore)	-0.0584***	0.0183**	-0.0304***	0.0183***
	(0.0045)	(0.0092)	(0.0069)	(0.0066)
economy	-0.0027**	0***	-0.0014	0***
	(0.0013)	(Omitted)	(0.0028)	(Omitted)
constant	0.1765***	-0.1046***	0.0951***	-0.1046***
	(0.0183)	(0.0388)	(0.0246)	(0.0302)

Model (1) is the pooled regression model, Model (2) is the fixed effects model, Model (3) is the random effects and Model (4) is the modified fixed effects model. Standard errors are presented in parentheses. ** and *** denote that the variable is significant at the 5% and 1% levels, respectively.

It is conventional to use p-value boundary of 5% so that if it is smaller than this level, then the null hypothesis is rejected (Underhill & Bradfield, 2013). The power of the test i.e., the ability to detect a false null hypothesis, increases with the sample size (Ramachandra & Tsokos, 2021). Model (1) shows that seven variables plus the constant are significant (two variables at 5% and five variables and the constant at the 1% significance level). The F-test for the model was also obtained, which has the null hypothesis that the model is not significant. The p-value (Table A4, Model (1)) for this test is equal to zero, hence the null hypothesis is rejected, and it can be concluded that this model is significant i.e. the independent variables can explain the dependent variable. The next task is to compare this model against the one-way (cross section) FE model, Model (2).

The FE model shows that eight variables plus the constant are significant (one variable at 5% and seven variables including the constant at the 1% significance level). The economy dummy variable was omitted because the FE model does not include time-invariant variables (Kropko & Kubinec, 2020). The poolability F-test was conducted (see appendix Table A4, Model (2)) with the null hypothesis of zero country heterogeneity. The F-test rejects the null hypothesis; thus, the FE model is better than the pooled regression model in this instance as it allows for country heterogeneity. As such, the FE model is then compared to the RE model.

The one-way (cross section) RE model, model (3), shows that nine variables plus the constant are significant (one variable at 5% and eight variables including the constant at 1% significance level). The economy dummy variable was included because, unlike the FE model, the REmodel does include time-invariant variables (Kropko & Kubinec, 2020). The Breusch-Pagan Lagrangian multiplier poolability test was conducted, with the null hypothesis of no random effects, i.e. $\sigma_{\mu}^2 = 0$ (see Table A5). The null hypothesis is rejected, and thus it can be concluded that data should not be pooled, hence the RE model is chosen. Consequently, it is necessary to compare the FE and RE models. As explained in the preceding chapter, the Hausman test is used for this purpose. The null hypothesis that the RE model is consistent and efficient, is tested by assessing whether differences in coefficients are systematic. The test (see Table A6) rejects the null hypothesis and therefore it can be concluded that the RE model is inconsistent and hence the FE model is chosen.

Using the FE model, the test for heteroscedasticity and CSD was then performed, as explained in chapter 3. The Modified Wald test with the null of hypothesis of constant variance is rejected and thus it can be concluded there is heteroscedasticity (appendix Table A7). Secondly, Pesaran's test of cross-sectional independence is performed. The results of this test (see appendix Table A8) result in the rejection of the null hypothesis. As such, there is evidence of CSD. As such, the *xtscc* command was used and the model was re-estimated with Driscoll-Kraay standard errors which are robust to general forms of CSD (Stata, 2019), with the results shown in Table 4 as Model (4).

In Model (4), eight variables are significant (one variable at 5% and seven variables at the 1% significance level), namely GDP growth, GNS as a percentage of GDP, exchange rate, inflation, crude oil price, VIX, fed fund rate and the credit rating score, and the constant (at 1%). The fed fund rate has the most impact in absolute terms on the government bond yield; an increase of 1% in the fed fund rate results in a 0.6272% decrease in the government bond yield. This variable being significant is consistent with Iacoviello and Gaston Navarro (2018) who stated that other economies (including the US) are influenced by the movement in the fed fund rate. Similarly, Naidu et al. (2016) found the fed fund rate has a negative impact on government bond yields in emerging economies. Given that there is increasing globalisation with the world becoming more financially integrated, and with the US being one of the major economies in the world, its monetary policies influence other economies (Beckworth & Crowe, 2017). An increase in the fed fund rate slows economic growth (Tarver, 2020). A fall in US GDP growth has a ripple effect on other economies GDP, which ultimately has an impact on their government bond yield.

The determinant with the second largest impact in absolute terms on government bond yields is inflation but, in contrast to the fed fund rate, inflation has a positive effect on the government bond yield, where a 1% increase in inflation causes the government bond yield to increase by 0.2081%. This conforms with the literature as Pettinger (2018) also stated that higher inflation leads to a higher bond yield. A 1% increase in GDP growth results in a 0.1386% decrease in the government bond yield. This shows that investors like countries which are growing and therefore require a lower risk premium. It is noticed that in this instance that GDP growth reduces the government bond yield, but in general, it is not always the case as Kenny & Scott (2021) stated that the impact may not always be clear.

The finding across all countries that an improvement in credit rating score results in an increase in the government bond yield is not consistent with literature. It is expected that a higher rating would translate into a lower cost of debt (Mutize & Nkhalamba, 2020b). However, in this instance, a unit increase in the credit rating score, results in 0.0183% increase in government bond yield. This may allude to the criticism of the rating agencies for being biased towards some countries. The study by Yaltaa and Yaltab (2018) indicated that the US, as well as those countries that have closer economic and military relations with the US, receive substantially higher credit ratings. The rating agencies have been accused of false ratings, flawed methodology and political bias (Mutize, 2019). This bias could be an "invisible hand" that causes an atheoretical relationship between credit ratings and government bond yields.

GNS as a percentage of GDP causes the government bond yield to move in the opposite direction, where a 1% increase in the former leads to 0.1128% decrease in the latter. This relationship is consistent with the findings by Pettinger (2017b) where in Japan, there is a strong demand for government bonds (hence low yield) due to high level of domestic savings. A unit increase in the exchange rate results in 0.0207% increase in the government bond yield. This is consistent with literature as government bonds attracts investors all around the world, so they would require to be compensated for exchange rate risk which is reflected by a depreciation in the domestic currency (as captured by an increase in the exchange rate). A 1% increase in crude oil prices results in a 0.0073% increase in the government bond yield. This is consistent with Cosgrave (2014) who stated that increasing oil prices tend to increase bond yields because it leads to increases in inflation. Investors expect to be compensated for inflation rate risk, thus bond yields increase (Pettinger, 2018). A 1% increase in VIX results in 0.0153% increase in government bond yield. This is not in conformity with findings by Jubinski & Lipton (2012) who mentioned that increase in volatility means that investors will require safer bonds, thus an increase in demand for government bonds, hence decreasing their yields. The current account as percentage of GDP, government debt as percentage of GDP and the WGI score are insignificant.

4.3.2 One-way FE model for all frontier/emerging, Africa frontier/emerging, other emerging and advanced economies.

The same methodology as elaborated above from Model (1) to Model (4) was repeated on all the data subsets, i.e. all frontier/emerging, Africa frontier/emerging, other emerging and advanced economies. The results are consistent in that the FE model is the preferred method of regression. The table on the next page shows results from regression performed on the subsets, i.e. all frontier/emerging, Africa frontier/emerging, other emerging and advanced economies. Additional regression results are included in the appendix Table A9.

Table 5: Economies comparison

Variable	Model (5) Modified FE All Frontier/ Emerging	Model (6) Modified FE Africa Frontier/ Emerging	Model (7) Modified FE Other Emerging	Model (8) Modified FE Advanced
ln(gdpgrowth+1)	-0.1672***	-0.1658˙	-0.1342**	-0.0732***
	(0.0343)	(0.0895)	(0.0578)	(0.0251)
ln(currentaccountgdp+1)	-0.057***	-0.0329	-0.0846**	0.0518**
	(0.0194)	(0.0424)	(0.0327)	(0.0243)
ln(gnsgdp+1)	-0.0307	0.0216	-0.0252	-0.2482***
	(0.0196)	(0.0295)	(0.0569)	(0.0252)
ln(exchangerate)	0.0205***	0.0096	0.0239***	-0.035***
	(0.0069)	(0.009)	(0.0075)	(0.0065)
ln(govdebtgdp+1)	0.0424**	0.2455***	-0.0028	-0.0519***
	(0.0179)	(0.0578)	(0.0187)	(0.0133)
ln(inflation+1)	0.2080***	0.1095	0.2472***	0.2191***
	(0.033)	(0.0682)	(0.0266)	(0.0355)
ln(crudeoilprices)	0.0068***	0.0102	0.0061	-0.0017
	(0.0015)	(0.0063)	(0.004)	(0.0024)
ln(wgiscore)	-0.0235	-0.0224	-0.0057	-0.0571***
	(0.0366)	(0.0558)	(0.0313)	(0.0191)
ln(vix)	0.0142**	0.0031	0.018**	0.0121**
	(0.0052)	(0.0104)	(0.0067)	(0.0057)
ln(fedfundrate+1)	-0.6253***	-1.1893***	-0.6229***	-0.5263***
	(0.1564)	(0.2562)	(0.1787)	(0.0622)
ln(creditratingscore)	0.0132	0.019	0.0233	0.0085
	(0.0127)	(0.0234)	(0.0113)	(0.0105)
economy	0***	0***	0***	0***
	(0)	(0)	(0)	(0)
constant	-0.1283***	-0.121	-0.1649***	0.0685
	(0.045)	(0.1296)	(0.0546)	(0.0415)

** and *** marks denote that the variable is significant at 5% and 1% level, respectively. ˙ See Model (6) comment in paragraphs that follows. FE means fixed effects model.

As with the model for all countries, Model (5) is the FE model that accounts for heteroskedasticity and CSD (see Table A10 – A14). The model shows that the fed fund rate and the inflation having the most impact on government bond yields in emerging and frontier markets. If the fed fund rate increases by 1%, then the government bond yield decreases by 0.6253% and if inflation increases by 1%, then the yield increases by 0.2080%. An increase in GDP growth and the current account as percentage of GDP result in the government bond yield moving in the opposite direction whereas an increase in the exchange rate (depreciation of domestic currency), government debt as percentage of GDP, crude oil prices and the VIX results in an increase in the government bond yield for emerging and frontier economies. The credit rating, WGI score and GNS as percentage of GDP are insignificant.

Model (6) shows the results for the Africa frontier/emerging economies. The suitable model for this subset was also the FE model that accounts only for heteroskedasticity as CSD was found to be insignificant. The Hausman test was also not necessary because the pooled regression model was preferred over the RE model, but the FE model was superior to the former (see Table A15 – A18). One of the determinants (GDP growth) has a p-value of 10.1% and, in this case, a less orthodox approach is taken to consider this factor to be significant. 10% is sometimes used as a slightly less stringent criterion of significance and the p-value of GDP growth is just at the periphery of this criterion. This decision is made because this regression is done on a small subset with only nine countries and secondly the p-value is not too far off. Government debt as percentage of GDP and the fed fund rate are the only other significant variables (at 1% significance level). All other variables are insignificant as they have a p-values ranging between 14.2% - 76.9%.

A 1% increase in GDP growth leads to a -0.1658% decrease in the government bond yield and this is consistent with Kenny and Scott’s (2021) assertion because greater growth results in a lower yield as investors do not seek as high a risk premium. A 1% increase in government debt as percentage of GDP results in a 0.2455% increase in the government bond yield. The direction of the impact (positive) is consistent with the findings by Poghosyan (2012) who examined its long-run impact in advanced economies. An increase in the fed fund rate has a negative impact on the government bond yield of African countries, where a 1% increase in the former results in a 1.1893% decrease in the latter. The results of the impact of fed fund rate are consistent as those found by Naidu et al. (2016) who studied the determinants of sovereign bond yields in 12 emerging economies.

With Model (7) is the FE model that accounts for heteroskedasticity and CSD (see Table A19 – A23), the results indicate that in other emerging markets GDP growth, current account as percentage of GDP, exchange rate, inflation, VIX and the fed fund rate are significant. However, GNS as percentage of GDP, government debt as percentage of GDP, crude oil price, WGI score and credit rating score are insignificant. A 1% increase in the fed fund rate results in a 0.6229% decrease in the government bond yield. If inflation increases by 1%, the government bond yield increases by 0.2472%. The results on inflation are not in conformity with the findings by Naidu et al. (2016). They could not validate the significance of inflation as a determinant of government bond yield and the reason provided was that it may be due to inflation being the norm rather than an exception in most emerging economies. The difference in this result may be due to difference in dataset used and/or model assumptions, but it can be acknowledged that in theory, as Pettinger (2018) also stated, high inflation leads to a higher bond yield.

Turning to Model (8), the FE model that accounts for heteroskedasticity and CSD (see Table A24 – A28) was used for the advanced economies. The following variables were found to be significant: current account as percentage of GDP, VIX, GDP growth, GNS as percentage of GDP, exchange rate, government debt, inflation, WGI score and fed fund rate. A 1% increase in the fed fund rate results in a 0.5263% decrease in the government bond yield. If inflation increases by 1%, the government bond yield increases by 0.2191%.

4.4 Comparison across all economies

A comparison across all the subsets of the samples yields several notable findings. GDP growth is significant across all subsets and has the greatest impact in African frontier/emerging markets where a 1% increase in GDP growth results in a 0.1658% decrease in the government bond yield, followed by other emerging economies with a 0.1342% decrease and lastly the advanced economies with a 0.0732% decrease. African economies are in developing phase and its GDP growth attracts more FDI through which new technology can be acquired (Ek, 2007). As Kenny and Scott (2021) elaborated, given the nature of these economies, the impact of growth will be more pronounced and with less stringent access to the markets, will result in a decrease in the risk of default, thus decreasing the yield. This impact would be greater on the African developing economies as compared to other economies who are relatively more established, implying that they have already gone past that phase of growth.

The current account as percentage of GDP is significant in other emerging economies and advanced economies, but not in African frontier/emerging economies. It has varying impact, where its increase leads to increase in government bond yield in advanced economies but a decrease in other emerging economies’ government bond yield. This discrepancy in response to changes in current account as percentage of GDP is created by the choice investors make given the nature of the economy in which they would like to keep most of their investments. In advanced economies, following the argument of Rimkus (2012), an increase in the current account implies that the countries are moving further from deficit (reducing deficit, if already in), meaning that the demand for their government bonds decrease, and hence yield increases.

On the other hand, in emerging economies, following the argument of Dombrecht and Wouters (2020), an increasing current account balance means the country has more exports than imports, which enhances liquidity, hence the demand for domestic government bonds increases, thus decreasing the yield.

GNS as percentage of GDP is only significant in advanced economies and has a negative impact on the government bond yield. An increase in GNS as percentage of GDP implies the country has increasing disposable income compared to its final consumption expenditure. The disposable income is used to invest in government bonds, which drives the demand for the government bonds up and hence yield decreases.

An increase in the exchange rate impacts the government bond yield positively in other emerging economies whereas it decreases the government bond yield in advanced economies. In emerging economies, this reflects that investors require compensation for the loss in purchasing power as a result of the depreciation in the domestic currency. The impact in advanced economies, in contrast, reflects that a depreciation in the domestic currency means the bonds in these economies are cheaper as it costs less per unit of domestic currency to buy other advanced economies currency. Bonds in advanced economies usually carry high credit rating and are considered safer given their low probability of default (Perry, 2020). This results in increased demand for those government bonds, thus their yield decreases.

Government debt as percentage of GDP positively impact the government bond yield in Africa frontier/emerging economies whereas it reduces the bond yield in advanced economies. An increase in government debt means that the country has increasing risk of default, thus investors would require an increase in the yield. The opposite of this is seen in advanced economies. This could be that advanced economies have established markets and they are in position to take advantage of leverage due to increasing demand for their bonds for safe-haven considerations in the short-run (Poghosyan, 2014). This means that the hike in yield expectation as a result of increasing debt is being offset and/or surpassed by the downward pressure in yield as a result of increase in demand for bonds. This trend is not sustainable because large debt build up can lead to diminished economic activity by crowding out investment or cause increase in taxes and reduce government spending in order to cover high interest payments (Yared, 2019). This results are not consistent with those of Baldacci and Kumar (2010) who found that an increase in the debt-to-GDP ratio results in increase in yield, but did mention that the impact of increase in debt-to-GDP depends on the initial fiscal position, institutional and other structural conditions, which is consistent with the evidence seen here. That is, the stronger fiscal position of advanced economies compared to African countries results in a different effect of an increase in the country's debt position on the government bond yield.

Inflation is significant in other emerging and advanced economies and impacts positively on government bond yield for both groupings. This is because inflation decreases the purchasing power of currency (Hayes & Boyle, 2020). Thus, investors would need to be compensated for this through an increase in the government bond yield. Similar to the reason given by Naidu et al. (2016), inflation is insignificant determinant among African countries because it is a usual occurrence than a unique attribute in African economies, so it is not useful in distinguishing differences in government bond yields. The crude oil price is significant for all countries, but not significant in the individual subsets. WGI is significant only in the model for advanced economies and negatively impacts the government bond yield. Increases in governance result in decreases in yield because an improving governance means better management of government resources, hence efficiencies in the ability to collect tax, generate additional streams of revenue and reduced corruption, which puts the government in a better position to services its government bond debt. In advanced economies with better governance, a slight improvement could be significant, ensure synergies in governance and reduce risk of default and hence, investors would require a lower risk premium. WGI may be insignificant in emerging and African economies because these subsets generally have a low score, both average below 50%, so a small difference is not seen to have a material impact as it does not sufficiently attend to fundamental structural issues.

VIX is significant in emerging and advanced economies and has a positive impact on government bond yield. An example of this is when equity market is doing well, but investors remain sceptical about how long they will do well. So, they end up diversifying their portfolio by continuing to put money in both bond and equity markets, hence experience a decrease in VIX concurrently with decrease of yield in the bond market. This can also occur when there is overall investor confidence in federal agencies and company performance, e.g. moving out of recession. This results in a decrease in VIX and a decrease in yield expected from the government bond. Also, in the presence of low inflation, government bonds are attractive because they beat inflation and simultaneously companies do not lose their profitability to inflation, and this results in stocks being attractive too. Another situation can be a case where there are generally low interest rates. Bonds retain their value and corporate bond and stocks remain attractive as interest is not eating away company profits (Johnston, 2021). This is likely the reason for this trend because, as Del Negro et al. (2018) stated, ten years after the financial crisis the world economy remains mired in a low interest rate environment. In this instance, there is less prevalence of pressure that results in flight-to-quality effect highlighted by Jubinski and Lipton (2012).

The fed fund rate negatively influences the government bond yield across all subsets and has the most impact in African frontier/emerging markets. As elaborated by Kenny and Scott (2021), this results in GDP in foreign economies falling, and investors looking for safer investments (bonds) and hence their yield decreases. This is in line with the findings by Naidu et al. (2016) that fed fund rate has a negative impact on the government bond yield and in agreement with Roley and Sellon (1995) that monetary policy has an impact both in the short-run and the long-run. The credit rating is significant in Model (4) for all countries, but not significant in the individual subsets. This may be due to the biases with the credit rating agencies as stated in section 4.3.2, hence it does not have a definite impact in the subset economies.

4.5 Chapter summary

In this chapter, the regression model was determined, and regression analysis was done on various economy subsets, i.e. all frontier/emerging, Africa frontier/emerging, other emerging and advanced economies. Comparisons were made amongst these economies to see how the government bond yield in each subset is influenced by the explanatory variables. Further explanations were given for any anomalies observed in the analysis. The findings of the study are summarised in the following chapter in line with the research objectives and thereafter policy recommendations and suggestions for further research are discussed.

CHAPTER 5: CONCLUSION

5.1 Introduction

This chapter provides a summary of the methodology and findings of the study in line with the research objectives. Thereafter policy recommendations are proposed in light of the findings and a discussion of some of the limitations of this research is also presented. Finally, recommendations for future research are given.

5.2 Summary of methodology

This research studied 58 countries, categorised either as Africa frontier and emerging markets, other emerging or advanced economies, using data for the period 2010 – 2019 to examine the determinants of government bond yields. The research objectives were to examine the determinants of government bonds yield in all countries in the study, and the categories such as African frontier/emerging countries etc. and then compare these to the determinants in other economies. The determinants examined were drawn from the literature and included GDP growth, current account as percentage of GDP, GNS as percentage of GDP, exchange rate, government debt as percentage of GDP, inflation, crude oil prices, WGI score, VIX, fed fund rate and credit rating score. Various econometric models were compared and given the structure of the data; the one-way FE model was determined to be appropriate to use in examining these determinants across all sub-samples.

5.3 Summary of findings

African countries pay an average government bond yield of 11.95% compared to 6.14% for other emerging economies and 2.25% for the advanced economies. From the research carried out, it was found that there is a varying impact of the determinants across the three groupings of countries and not all of them are significant. In African markets, GDP growth, government debt as percentage of GDP and the fed fund rate were the significant determinants of the government bond yield. A 1% increase in each of the variables results in a -0.1658%, 0.2455% and -1.1893% change in the government bond yield, respectively. This shows that the fed fund rate has a major impact on the African markets examined in the study, followed by government debt as percentage of GDP and lastly GDP growth.

This is similar to findings by Naidu et al. (2016), who studied a sample of emerging markets, where they also documented that for emerging markets the long-term government bond yield is increasingly dependent on global economic conditions, with the fed fund rate used in this study capturing the global environment given the US being one of the major economies. This indicates that monetary policies of the US have significant impact on African country government bond yield. Grandes (2007) also mentioned the influence of financial contagion, the spread of market disturbances from one country to another, with the importance of the fed fund rate consistent with this view. This is owing to fact that the US is one of Africa's biggest trading partners and as of 2017, it was Africa's third biggest trading partner after China and the European Union (Smith, 2019). Monetary tightening in the US through increasing the fed fund rate makes increasing savings more attractive and constricts spending in an economy (Hayes & Kelly, 2020). As a result of increase in savings rates and given that investors desire to diversify their portfolios by demanding more government bonds from various economies, then bond prices increase, hence yields decrease.

The current account as percentage of GDP was not significant in Africa but was significant in other economies where an increase leads to an increase in the government bond yield in advanced emerging although a decrease in other emerging economies. The exchange rate was not an important determinant for sovereign bond yields in African economies and had a varying impact on other economies. Its increase leads to an increase in government bond yield in other emerging economies, but a decrease in yield in advanced economies. Government debt as percentage of debt was significant in Africa and advanced economies, its increase leading to an increase in yield in Africa countries but a decrease in advanced economies. Inflation was significant in emerging and advanced economies, its increase leading to an increase in government bond yield. GDP growth and the fed fund rate were significant across all economies and their increase leads to a decrease in government bond yields. GNS as percentage of GDP and WGI score were significant only in advanced economies. VIX was found to be a significant determinant of government bond yields in emerging and advanced economies. The impact was positive suggesting that higher volatility contributes to higher government bond yields. Crude oil prices and the credit rating score were not significant in any of the three sub-sets of economies.

5.4 Policy recommendations

Africa has vast resources and can be considered one of the richest continents and yet it has one of the lowest GDP per capita (Ali, 2019). It is acknowledged that this injustice stems from the history of colonisation of the continent (SAHO, 2015). It is also noted that, although colonisation has effectively ended, the post-colonial economic development on the continent has resulted in combined and uneven development, and the continent is not integrated in a way that is favourable, but it is such that it ensures dependence on the advanced economies. For example, in Sub-Saharan Africa two-thirds of imports are finished goods (Schmieg, 2016). This means most of the value chain is allotted to other economies, only to receive goods for consumption.

This implies the continent experiences lower GDP growth than it should otherwise be experiencing. Given that GDP growth is a significant determinant of African government bond yields, then it means the government must focus on building industries so that they produce more finished goods and services and thus are less reliant on imports and even export such goods. This will create more income for the countries, thus increasing GDP growth, which will in turn reduce government bond yields. Intra-Africa trade was around 2% during the period 2015–2017 (UNCTAD, 2019). Intra-Africa trade must also be expedited through nurturing of and expanding the scope of initiatives such as the AfCTA that commenced in January 2021 (Baliño, 2021). This will foster self-sufficiency of Africa and reduce reliance on trade with the big economies and this will boost economic growth and create synergies that would nourish regional integration. This reduced dependence on advanced economies would result in less impact of the fed fund rate on the government bond yield. As a result, it is expected that the African countries will also be in position to borrow from each other as well, at potentially favourable interest rates.

In order to reduce the impact of US monetary policy on African government bond yields, Africa must diversify its trading partners, hence changes in US GDP growth in response to movement in fed fund rate would not have a highly significant impact on the continent’s GDP, which in turn affects their government bond yield. Further recommendations given by Vargas (2005) who studied determinants of government bond yield in the Philippines was that monetary policy must ensure exchange rates are kept at a manageable level and on the fiscal policy side, the government must improve its revenue collection. Although exchange rate was not a significant determinant of African governments bond yields, it may become increasingly important as time progresses, and continent become more globally integrated. Presbitero et al. (2016), who studied sovereign bonds in developing countries, also mentioned that it is important to ensure sound fiscal policy in order to attract foreign investors.

5.5 Limitations

There are some limitations to this study, one of them being availability of data for African countries. Data for only 9 of 54 African countries was available, due to most countries not having well established bond markets and having a short time series for the data currently available. This missing data reduces the extent to which this study could have explored other issues related to the determinants of government bond yields, such as distinguishing the determinants into short-run and long-run effects just as Poghosyan (2012) has done for advanced economies. There is a limited research done on this topic, thus this provides an opportunity to explore this area of work and contribute to the understanding of these determinants, thus help in giving recommendations to governments and contribute to literature on government bond yields in Africa.

5.6 Recommendations for future research

It was determined that African governments pay at least four times more than advanced economies and two times more than emerging markets to borrow funds. Further research is needed to dissect the intricacies that result in Africa paying much higher interest. This research indicated that bondholders weigh different factors when considering African economies bonds compared to other economies. Further research should control for factors than are significant to African economies and control for those that are significant to other economies to derive a portion left that is unexplained by any of the factors which may then reflect an African premium or plausibly, any factor not accounted for by the determinants identified. This will expand further on the research by Olabisi and Stein (2015) who identified an unexplained “Africa premium” on sovereign bonds issued by governments in sub-Saharan Africa between 2006 and 2014.

Further research should be done to determine ways in which the fed fund rate influences African economies. Presbitero et al. (2016) also mentioned that given the ongoing trend in sovereign bond issuance (SBI) by low-income developing countries, further analysis is needed to understand the real effect of SBIs on the scaling of debt sustainability. This study of the determinants of government bond yields should be extended to includes most countries and information on bonds that are not traded in the secondary market and loans from financial institutions as this will give indication of actual interest paid.

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APPENDICES

Table A1: Africa frontier/emerging economies descriptive statistics

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
Ygd	81	0.119508	0.0509	0.0280	0.2440
Gdpgrowth	81	0.0421	0.0292	-0.0170	0.1420
Currentaccountgdp	81	-0.0353	0.0488	-0.1567	0.1535
Gnsgdp	81	0.1995	0.0864	0.0529	0.4469
Exchangerate	81	391.8126	996.2507	1.4310	3781.1370
Govdebtgdp	81	0.4541	0.2191	0.0939	1.0316
Inflation	81	0.0750	0.0477	0.0024	0.2353
Wgiscore	81	0.4368	0.1126	0.2417	0.6517
Creditratingscore	81	8.6800	2.9663	4.6667	15.0000

Note: Std. dev. refers to standard deviation.

Table A2: Other emerging economies descriptive statistics

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
Ygd	190	0.0614	0.0321	0.0040	0.1649
Gdpgrowth	190	0.0393	0.0272	-0.0390	0.1120
Currentaccountgdp	190	0.0001	0.0442	-0.0887	0.2363
Gnsgdp	190	0.2567	0.0804	0.1075	0.5091
Exchangerate	190	1949.3730	5377.5100	1.4064	23227.3200
Govdebtgdp	190	0.4287	0.2104	0.0156	0.8947
Inflation	190	0.0402	0.0331	-0.0209	0.1868
Wgiscore	190	0.4871	0.1047	0.2504	0.7489
Creditratingscore	190	11.7040	3.0371	4.5000	17.3333

Note: Std. dev. refers to standard deviation.

Table A3: Advanced economies descriptive statistics

Variable	Observations	Mean	*Std. Dev.	Minimum	Maximum
Ygd	300	0.0226	0.0185	-0.0047	0.1356
Gdpgrowth	300	0.0247	0.0244	-0.0406	0.2538
Currentaccountgdp	300	0.0257	0.0558	-0.1135	0.2293
Gnsgdp	300	0.2490	0.0731	0.0751	0.5059
Exchangerate	300	47.3704	201.9976	0.6074	1165.3580
Govdebtgdp	300	0.7354	0.4099	0.2040	2.3796
Inflation	300	0.0148	0.0120	-0.0162	0.0540
Wgiscore	300	0.7618	0.0858	0.5729	0.8981
Creditratingscore	300	17.1755	2.9847	9.0000	20.0000

Note: * Std. dev. refers to standard deviation.

Table A4: Additional regression results for all countries pooled OLS, fixed effects and random effects model

Model (1)	Source	SS	df	MS	Number of obs	571
					F(12, 558)	215
	Model	0.8084	12	0.0674	Prob > F	0
	Residual	0.1746	558	0.0003	R-squared	0.8224
					Adj R-squared	0.8186
	Total	0.9830	570	0.0017	Root MSE	0

Model (2)	Fixed-effects (within) regression		Number of obs	571
	Group variable: country_id		Number of groups	58
	R-sq:		Obs per group:	
	within	0.4477	min	6
	between	0.2701	avg	10
	overall	0.2660	max	10
			F(11,502)	37
	corr(u_i, Xb)	-0.7333	Prob > F	0

Model (3)	Random-effects GLS regression		Number of obs	571
	Group variable: country_id		Number of groups	58
	R-sq:		Obs per group:	
	within	0.3912	min	6
	between	0.8304	avg	10
	overall	0.7734	max	10
			Wald chi2(12)	723
	corr(u_i, X)	0 (assumed)	Prob > chi2	0

Table A5: All countries Breusch and Pagan Lagrangian multiplier test for random effects

	Var	sd = sqrt(Var)
lnygb	0.0017245	0.0415274
e	0.0001335	0.0115528
u	0.0001247	0.0111685
Test: Var(u) = 0		
	chibar2(01) =	338.96
	Prob > chibar2 = 0	

Table A6: All countries Hausman test

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg
Test: Ho: difference in coefficients not systematic
chi2(11) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 104.27
Prob>chi2 = 0

Table A7: All countries Modified Wald test for groupwise heteroskedasticity

H0: sigma(i)^2 = sigma^2 for all i
chi2(58) = 1040.87
Prob>chi2 = 0

Table A8: All countries cross sectional dependence test

Pesaran's test of cross-sectional independence = 26.139, Pr = 0.0000

Table A9: Additional regression results for all frontier/emerging, Africa frontier/emerging, other emerging and advanced economies modified fixed effects model

Model (4)	Regression with Driscoll-Kraay standard errors	Number of obs	571
	Method: Fixed-effects regression	Number of groups	58
	Group variable (i): country_id	F (11,57)	1 984
	maximum lag: 2	Prob > F	0
		within R-squared	0

Model (5)	Regression with Driscoll-Kraay standard errors		271
	Method: Fixed-effects regression	Number of groups	28
	Group variable (i): country_id	F (11,27)	2 942
	maximum lag: 2	Prob > F	0
		within R-squared	0

Model (6)	Regression with Driscoll-Kraay standard errors	Number of obs	81
	Method: Fixed-effects regression	Number of groups	9
	Group variable (i): country_id	F (11,8)	48
	maximum lag: 2	Prob > F	0
		within R-squared	1

Model (7)	Regression with Driscoll-Kraay standard errors	Number of obs	190
	Method: Fixed-effects regression	Number of groups	19
	Group variable (i): country_id	F (11,8)	525
	maximum lag: 2	Prob > F	0
		within R-squared	0

Model (8)	Regression with Driscoll-Kraay standard errors	Number of obs	300
	Method: Fixed-effects regression	Number of groups	30
	Group variable (i): country_id	F (11,29)	790
	maximum lag: 2	Prob > F	0
		within R-squared	1

Table A10: Additional regression results for all frontier/emerging markets pooled OLS, fixed effects and random effects model

Model (1)	Source	SS	df	MS	Number of obs	271
					F(12, 258)	79
	Model	0.3869	12	0.0322	Prob > F	
	Residual	0.1053	258	0.0004	R-squared	0.7860
					Adj R-squared	0.7761
	Total	0.4922	270	0.0018	Root MSE	0.0202

Model (2)	Fixed-effects (within) regression		Number of obs	271
	Group variable: country_id		Number of groups	28
	R-sq:		Obs per group:	
	within	0.3967	min	6
	between	0.0499	avg	9.70
	overall	0.0566	max	10
			F(11,232)	13.87
	corr(u_i, Xb)	-0.7429	Prob > F	0

Model (3)	Random-effects GLS regression		Number of obs	271
	Group variable: country_id		Number of groups	28
	R-sq:		Obs per group:	
	within	0.3589	min	6
	between	0.7713	avg	9.70
	overall	0.7217	max	10
			Wald chi2(12)	230.97
	corr(u_i, X)	0 (assumed)	Prob > chi2	0

Model (4)	Regression with Driscoll-Kraay standard errors	Number of obs	271
	Method: Fixed-effects regression	Number of groups	28
	Group variable (i): country_id	F(11,57)	2 941.51
	maximum lag: 2	Prob > F	0
		within R-squared	0.3967

Table A11: All frontier/emerging markets Breusch and Pagan Lagrangian multiplier test for random effects

	Var	sd = sqrt(Var)
lnygb	0.0018229	0.0426952
e	0.0001695	0.0130174
u	0.0002637	0.0162379
Test: Var(u) = 0		
	chibar2(01) =	205.75
	Prob > chibar2 = 0	

Table A12: All frontier/emerging markets Hausman test

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg
Test: Ho: difference in coefficients not systematic
chi2(11) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 34.21
Prob>chi2 = 0.0003

Table A13: All frontier/emerging markets Modified Wald test for groupwise hetero-skedasticity

H: sigma(i)^2 = sigma^2 for all i
chi2(58) = 264.43
Prob>chi2 = 0

Table A14: All frontier/emerging markets cross sectional dependence test

Pesaran's test of cross-sectional independence = 4.902, Pr = 0.0000

Table A15: Additional regression results for African frontier/emerging markets pooled OLS, fixed effects and random effects model

	Source	SS	df	MS	Number of obs	81

Model (1)					F(11, 69)	37.45
	Model	0.1410	11	0.0128	Prob > F	0.0000
	Residual	0.0236	69	0.0003	R-squared	0.8565
					Adj R-squared	0.8337
	Total	0.1646	80	0.0021	Root MSE	0.0185

Model (2)	Fixed-effects (within) regression		Number of obs	81
	Group variable: country_id		Number of groups	9
	R-sq:		Obs per group:	
	within	0.5137	min	6
	between	0.0356	avg	9.0
	overall	0.0589	max	10
			F(11,61)	5.86
	corr(u_i, Xb)	-0.4373	Prob > F	0.0000

Model (3)	Random-effects GLS regression		Number of obs	81
	Group variable: country_id		Number of groups	9
	R-sq:		Obs per group:	
	within	0.1838	min	6
	between	0.9932	avg	9
	overall	0.8565	max	10
			Wald chi2(11)	411.94
	corr(u_i, X)	0 (assumed)	Prob > chi2	0

Model (4)	Regression with Driscoll-Kraay standard errors	Number of obs	81
	Method: Fixed-effects regression	Number of groups	9
	Group variable (i): country_id	F(11,8)	47.83
	maximum lag: 2	Prob > F	0
		within R-squared	0.5137

Table A16: African frontier/emerging markets Breusch and Pagan Lagrangian multiplier test for random effects

	Var	sd = sqrt(Var)
lnygb	0.0020573	0.0453577
e	0.0001672	0.0129319
u	0	0
Test: Var(u) = 0		
	chibar2(01) =	0
	Prob > chibar2 = 1	

Table A17: African frontier/emerging markets Modified Wald test for groupwise heteroskedasticity

H0: sigma(i)^2 = sigma^2 for all i
chi2(58) = 45.91
Prob>chi2 = 0

Table A18: African frontier/emerging markets cross sectional dependence test

Pesaran's test of cross-sectional independence = -1.820, Pr = 1.9313

Table A19: Additional regression results for emerging markets pooled OLS, fixed effects and random effects model

Model (1)	Source	SS	df	MS	Number of obs	190
					F(11, 178)	44.07
	Model	0.1240	11	0.0113	Prob > F	0
	Residual	0.0455	178	0.0003	R-squared	0.7314
					Adj R-squared	0.7148
	Total	0.1695	189	0.0009	Root MSE	0.01599

Model (2)	Fixed-effects (within) regression		Number of obs	190
	Group variable: country_id		Number of groups	19
	R-sq:		Obs per group:	
	within	0.4627	min	10
	between	0.0442	avg	10
	overall	0.0543	max	10
			F(11,160)	12.53
	corr(u_i, Xb)	-0.9106	Prob > F	0.0000

Model (3)	Random-effects GLS regression		Number of obs	190
	Group variable: country_id		Number of groups	19
	R-sq:		Obs per group:	
	within	0.4179	min	10
	between	0.8476	avg	10
	overall	0.7177	max	10
			Wald chi2(12)	204.64
	corr(u_i, X)	0 (assumed)	Prob > chi2	0

Model (4)	Regression with Driscoll-Kraay standard errors	Number of obs	190
	Method: Fixed-effects regression	Number of groups	19
	Group variable (i): country_id	F(11,57)	524.70
	maximum lag: 2	Prob > F	0.0000
		within R-squared	0.4627

Table A20: Emerging markets Breusch and Pagan Lagrangian multiplier test for random effects

	Var	sd = sqrt(Var)
lnygb	0.000897	0.02995
e	0.0001484	0.0121818

u	0.0000756	0.0086961
Test: Var(u) = 0		
	chibar2(01) =	60.4
	Prob > chibar2 = 0	

Table A21: Emerging markets Hausman test

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg
Test: Ho: difference in coefficients not systematic
chi2(11) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 28.93
Prob>chi2 = 0.0003

Table A22: Emerging markets Modified Wald test for groupwise heteroskedasticity

H0: sigma(i)^2 = sigma^2 for all i
chi2(58) = 198.94
Prob>chi2 = 0

Table A23: Emerging markets cross sectional dependence test

Pesaran's test of cross-sectional independence = 6.965, Pr = 0.0000

Table A24: Additional regression results for advanced markets pooled OLS, fixed effects and random effects model.

Model (1)	Source	SS	df	MS	Number of obs	300
					F(11, 288)	32.65
	Model	0.0528	11	0.0048	Prob > F	0.0000

	Residual	0.0423	288	0.0001	R-squared	0.5550
					Adj R-squared	0.5380
	Total	0.0951	299	0.0003	Root MSE	0.0121

Model (2)	Fixed-effects (within) regression		Number of obs	300
	Group variable: country_id		Number of groups	30
	R-sq:		Obs per group:	
	within	0.6130	min	10
	between	0.0000	avg	10
	overall	0.0083	max	10
			F(11,259)	37.29
	corr(u_i, Xb)	-0.9746	Prob > F	0.0000

Model (3)	Random-effects GLS regression		Number of obs	300
	Group variable: country_id		Number of groups	30
	R-sq:		Obs per group:	
	within	0.5589	min	10
	between	0.3974	avg	10
	overall	0.4907	max	10
			Wald chi2(12)	336.21
	corr(u_i, X)	0 (assumed)	Prob > chi2	0

Model (4)	Regression with Driscoll-Kraay standard errors	Number of obs	300
	Method: Fixed-effects regression	Number of groups	30
	Group variable (i): country_id	F(11,57)	790.20
	maximum lag: 2	Prob > F	0.0000
		within R-squared	0.6130

Table A25: Advanced markets Breusch and Pagan Lagrangian multiplier test for random effects

	Var	sd = sqrt(Var)
lnygb	0.0003179	0.0178307
e	0.0000839	0.009159
u	0.0000342	0.0058452
Test: Var(u) = 0		
	chibar2(01) =	70.31
	Prob > chibar2 = 0	

Table A26: Advanced markets Hausman test

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg
Test: Ho: difference in coefficients not systematic
chi2(11) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 58.23

Prob>chi2 = 0

Table A27: Advanced markets Modified Wald test for groupwise heteroskedasticity

H0: sigma(i)^2 = sigma^2 for all i
chi2(58) = 251.92
Prob>chi2 = 0

Table A28: Advanced markets cross sectional dependence test

Pesaran's test of cross-sectional independence = 17.388, Pr = 0.0000

Figure A1: Volatility index graph