



Norges miljø- og  
biovitenskapelige  
universitet

Master's Thesis 2017 30 ECTS  
School of Economics and Business  
Department of Economics

## **Risks and Returns of Green Bonds**

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## Acknowledgement

This is a declaration for the completion of Master of Science (MSc) in Economics under Financial Economics specialization in Norwegian University of Life Sciences (NMBU), Ås, Norway.

The first and foremost my deepest gratitude is for the Almighty God (Trinity) for the unreserved gifts of alive healthy and the mother of the Son, St. Virgin Merry, for the overwhelming gifts of love, forgiveness, and generosity.

This thesis work would not have been as colorful as possible without the support of many people. My sincere gratitude goes to my supervisor Associate Professor Olvar Bergland for his guidance and valuable comments. Olvar is friendly and guides me to do my thesis as independent as possible.

My acknowledgement extends to the Standard and Poor's Financial Services LLC (S&P) and the Federal Reserve Economic Data (FRED) for making their data base freely available online. My gratitude goes to Professor Ole Gjølberg: without him my Financial Economics specialization dream would have not been realized. I also extend my appreciation to the Department student advisor, Kateryna Krutskykh for her unreserved support and service in connection with my study in NMBU.

I am indebted to my friends; Mr. Fesseha Abadi and Mr. Tewelde Tesfay for their contribution in editing and commenting the paper. My gratitude goes to my friend Yemane K. for his encouragement and helping me printing the thesis. I would also like to express my special thanks to my friends: Girma B., Mebrahtu B., Abinet T., and Sahle S. who made my stay in Norway pleasant and memorable.

Finally, I am grateful to my family: father Nigus Deribew and mom Hiray Hagos who have brought me up with special love and made me strong to face challenges. I am also indebted to my brothers and sisters: Solomon, Enbetu, Hilary, Alemash, and Getachew for their patience and love. My deepest gratitude goes to my wife Emebet Fantaye, for her tireless effort, patience, and encouragement. My special thanks go to my daughter Feven and son Natnael for their love, tolerance and long awaiting while I am away from home.

Habtu Nigus Deribew

May 2017

## **Abstract**

*This study examines the risks and returns of Green Bond (labeled as "Green" by issuers) in relation to other traditional bonds (S&P500 bond, Developed bond and EU bond) and stock (S&P500 stock) over a period of December 2008 to December 2016. It deals with investigating the relationship between bonds and stocks. In doing so, the source of the data set for this study is Standard and Poor's Financial Services LLC (S&P) Dow Jones Indices and the Federal Reserve Economic Data (FRED). S&P500 bond and stock are used as market benchmarks. The study employs the variance risk measure, Capital Asset Pricing Model and Autoregressive Distributive Lag Model in the analysis. Green Bond grows overtime next to S&P500 bond compared to bond market. However, stocks are growing faster and yields higher return than bonds. The finding of the study shows that Green Bond has positively and statistically significant relationship with S&P500 bond and S&P500 stocks in both CAPM and ARDL models. When corporate bonds and stocks increased by 100%, this leads Green Bond to increase by 91% and 45%, respectively in CAPM. The ARDL model confirms this finding that Green Bond grows by 98% in relation to bond and 43% in relation to stock. However, the systematic risk of Green Bond and the market (S&P500 bond) are equally volatile in CAPM and ARDL models unlike the mean-variance measure of risk. On the other hand, there is a statistically significant difference on the systematic risk of Green Bond and S&P500 stock. Thus, Green Bond has less systematic risk and is less volatile than S&P500 stock.*

**Key words:** *Green Bond, S&P500, bond, stock, CAPM, ARDL, and benchmark*



# Chapter One: Introduction

## 1.1. Description and Background of Green Bonds

Bonds are issued for raising capital to fund projects, assets or business activities. Hence, bonds are the widely used financial instruments in the market. Bonds can be federal government bonds, municipal bonds, and corporate bonds. Bonds can also be classified according to their function such as climate bonds, environmental, social and governance (ESG), Green Bonds etc.

Green Bonds are bonds in the financial sector in which a debt instrument is issued for green investment and sustainable activities by an entity. This is done to raise funds from investors and public organizations. It is a tax-free bond which is issued by state organizations and/or investors for the development of green projects (environmentally-friendly). These projects can be renewable energy; low-carbon transport, etc. are also known as Green Project Bonds. Generally, green projects often contain low levels of pollution. Green Bonds are equivalent to climate bonds since it is fixed-income instrument raised for climate change solutions.

There seems no universally accepted definition of Green Bond. However, KPMG International (2015) states a comprehensive definition, i.e. *Green bond is, like any other bond, a fixed-income financial instrument for raising capital through the debt capital market. The bond issuer raises a fixed amount of capital from investors over a set of time period, repaying the capital when the bond matures and paying an agreed amount of interest (coupons) along the way.*

The difference between Green Bond and regular bonds is on the destination of investments. The issuer of Green Bond publicly states that the capital raised is to fund 'green' projects, assets or business activities with an environmental benefit, such as renewable energy, low-carbon transport or forestry projects (Ibid). However, the issuer of normal bonds states where the fund is going and specifies the feasibility of the project, but are not obliged to specify about the greenness of the project.

According to Romani on Eurosif (2015) Green Bond seminar, Green Bonds are initially driven by issuers, in particular multilateral development banks (MDBs). This is to collect more funds using different strategies. Green Bond market has now

reached a new level of maturity where investors and policy makers play a key role. The first Green Bond was issued in 2007 by European Investment Bank (EIB) and the EU bank with a transparent allocation of proceeds to climate action. Nowadays, EIB is becoming the largest Green Bond issuer and its main target is on renewable energy and energy efficiency.

Currently, Green Bonds are increasingly attractive mechanisms for both private and public sector organizations to raise capital for projects, assets or other activities that benefit the economy, environment, and the society. The global Green Bond market is growing rapidly. Eight years ago, Green Bonds did not exist. However, after 2014 value of Green Bonds stood at over \$ 53 billion outstanding (Climate Bonds Initiative, 2016).

As depicted in the Figure 1.1, the market for Green Bonds shows a growing trend and hits at around \$ 36.6, and \$ 42 billion in 2014 and 2015, respectively (Climate Bonds Initiative, 2016). Climate initiative companies expects prior to the actual issuance for 2016. Accordingly, Moody's Investor Service expected to surpass \$ 50 billion and Hong Kong and Shanghai Banking Corporation (HSBC) to hit \$ 80 billion (World Economic Forum, 2016). Meanwhile, the actual issuance of Green Bond hit \$ 93.4 billion for 2016.

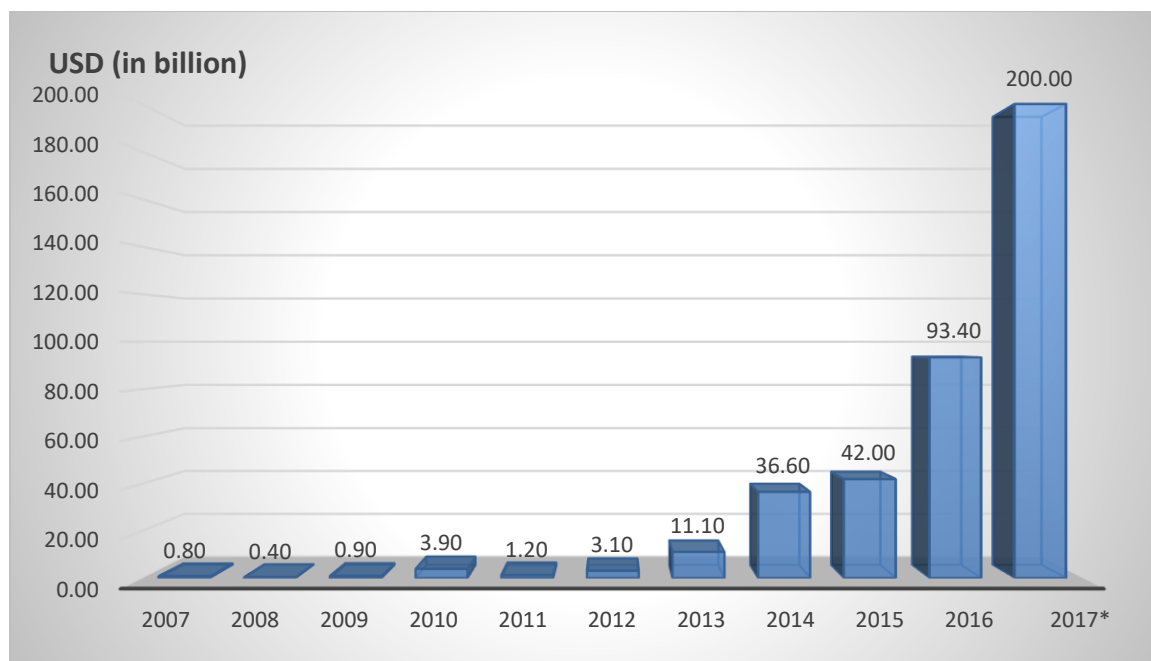


Figure 1.1: Issuance of Green Bond by year

\* is an "estimate"

Besides, according to Hong Kong based Reuters, Moody's expectation for Green Bond issuance at global level will cross \$200 billion in 2017 doubling the 2016 record (Moody's Investor Service, 2017).

## **1.2. Statement of the Problem**

According to different climate initiatives (such as Climate Bonds Initiative, Moody's Investor Service, HSBC), the demand for Green Bond is increasing from time to time since it benefits investors beyond sustainable environmental development. Issuers and Investors should carefully consider the potential risks and rewards of issuing Green Bonds by undertaking a cost-benefit analysis. Positive public relations, investors' diversification and Potential for pricing advantage/cost of funds are among money benefits of Green Bonds (Agarwal, 2015; Mark, 2015).

Green Bond market is a new financial instrument market. It is assumed to have a minimal risk of default since it is backed by governments. Green Bond appears to have limited literature. However, there are some reports on the growth of Green Bond issuance by Climate Bonds initiative, Moody's investor service (Moody's climate bonds initiative), Centre for International Climate and Environmental Research Oslo (CICERO), and other environmental related organizations.

According to Agarwal (2015) and Mark (2015), the primary benefit of Green Bond is to help in enhancing an issuer's reputation by marketing themselves as environmentally conscious, sustainable, and responsible. This is an effective way for an issuer to demonstrate its green credentials, particularly in the water, power, and transportation sectors. It displays the issuers' commitment towards the development and sustainability of the environment.

Due to global pool of capital, Green Bond also diversifies investor's base and improve market access. This source of capital focuses primarily on environmental, social and governance (ESG) related aspects of projects in which they intend to invest. Thus, Green Bond provides an issuer access to such investors who otherwise may not be able to tap with a regular bond.

Finally, the issuance of Green Bond attracts wider investor base and this may in turn benefit the issuers in terms of better pricing of their bonds vis-a-vis a regular bond.

However, there is limited evidence to suggest that governmental (municipal) Green Bonds offer any pricing benefits over traditional governmental (municipal) bonds. An argument in support of a pricing benefit for Green Bonds over traditional bonds is that over time, increased investor demand is likely to contribute to better pricing for the issuer. However, there are also potential costs as regards to issuing Green Bonds. Those costs include costs of issuance, administrative burden, and reputational risk (Mark, 2015).

Green Bonds are becoming useful instruments for development banks because investing the proceeds in environmentally beneficial projects serve their goals of sustainable economic development and social progress. On the other hand, other types of bond issuers get benefit from selling bonds beyond their traditional investor base to capture a broader and growing group of investors that want to engage on environmental and social issues (Falk et al., 2015). Issuers consider themselves as environmental friendly and pretending to be environmentally concerned bodies to get more funds. The idea behind Falk is that there seem to be a shift from traditional bond to Green Bonds.

Investors have shown their demand for Green Bonds (as evidenced on Figure 1.1). It might be due to these bonds are assumed to be safer and are supposed to have low risks of default. Comparing to other bonds, it is supposed to yield low return but governments encourage it by exempting tax. The reason is to motivate and inform investors that the goal of the finance is to make clean and low-carbon environment, and to achieve the low degree Celsius goal (i.e. 2°C). In most cases, it is believed that the systematic risk of corporate and government bonds is less than or equal 20 percent compared to the risk of the global stock market. This study attempts to look at the risk level of Green Bonds in relation to stock market.

Currently, Green Bond market has got a great attention. However, as the market is quite new, it demands more research. Investors and issuers demand for more precise information about the consequences of investing and issuing this bond in long run. On top of that, this area has a limited literature. Therefore, the results of this study may add more knowledge to the existing literature. It may also help to understand whether the bond market mobilize the fund from one market (such as

climate bond, Corporate bond or global bond) to Green Bond or not. This is an attempt to examine the relationship among bonds market.

Therefore, the root of the study is to examine how well is functioning the market for Green Bond in relation to other bonds and stocks. Hence, it tries to address the following research questions. Are Green Bonds riskier in relation to other traditional bonds? How is Green Bonds risk level compared with the risk of global stock market? Is there cause and effect relation between Green and global bonds over time? How is the relationship between Green Bond and stock market over time?

### **1.3. Objective of the Study**

The main objective of this study is to explore the relationship between Green Bond and different traditional bonds. The study tries to investigate the relationship between Green Bond and stocks.

#### **1.3.1. Specific Objectives**

The specific objectives of this study are:

1. To measure the risk and return of Green Bond in relation to traditional bonds (corporate, and government bonds) market
2. To examine the risk and return of Green Bond relative to global stock market
3. To explore the relationship between Green and corporate bond overtime
4. To analyze the relationship between Green Bond and stock markets over time

### **1.4. Organization of the Study**

The study is organized in to six chapters. Chapter one deals with introduction, statement of the problem and objectives of the study. Chapter two reviews the conceptual literatures on bonds specifically on Green Bonds. Chapter three presents methods and materials. It includes the types and nature of the data, and variable definitions and specifications. Chapter four presents data analysis; it goes from descriptive statistics through Capital Asset Pricing Model to time series econometric model specification specifically ARDL. Chapter five is the main body of the study that discusses major findings based on descriptive statistics and econometric model results. Finally, the conclusion is in chapter six.

## **Chapter Two: Review of Literature**

### **2.1. The Concept of Bonds**

Bonds are financial debt instruments in which an investor loans money to an entity (typically corporate or municipal or governmental) which borrows the funds for a defined period at a variable or fixed interest rate. Literally, it is a certificate that shows amount of money that governments or corporations have borrowed from investors. Companies, municipalities, states and sovereign governments can issue bonds to raise money and finance a variety of projects and activities (Investopedia, 2017).

Bonds are generic assets of a fixed income type because they generate a fixed amount of money when it matures. According to Brokamp (2017), there are four different types of bonds defined by who sells the debt: federal government bonds, other government agencies bonds (some government and quasi-government agencies), corporate bonds, and municipality (state and local governments) bonds. Bonds are also classified in to different types based on their investment destinations, such as traditional (Corporate and governments) bonds, Green Bonds, Climate bonds and so on.

There are four basic concepts of bonds. These are: par-value, coupon, maturity, and yield. Par-value (a face or principal value) is how much the bondholder will receive at maturity. Coupon (coupon rate) is the interest rate the bond pays. Maturity refers to the length of time before the par-value is returned to the bondholder. It may be as short as a few months (mostly 3 months), or as long as 50 years or more. Yield is an internal rate of return for bonds.

Bond yield could be nominal yield, current yield and yield to maturity. Nominal yield is the coupon or interest rate. Current yield is the coupon that considers the current market price of the bond, which may be different from the par-value and gives a different return. However, Current yield does not account for capital gains or losses on bonds bought at prices other than par-value. Yield to Maturity (YTM) is the most commonly used in the calculation of bonds rate. It considers the current market price,

the coupon rate, the time to maturity and assumes that interest payments are reinvested at the bond's coupon rate.

Bonds can also be characterized as zero-coupon and coupon bonds according to their payment status. Zero-coupon (accrual) bonds are bonds that make only a single payment at their maturity date and do not pay interest payments (coupons). However, coupon bonds consider the start and end date of bond payments, the number and amount of payments, and the principal to include interest payments (McDonald, 2013).

## **2.2. Concepts of Green Bonds**

Green Bonds are types of bonds similar to the conventional bonds that exist in the market since 2007. The European Investment Bank took the initiative to issue Green Bonds, and followed by the World Bank. Later in 2013, corporates joined the market.

Green Bond is characterized by the project it finances. This made Green Bond different from other regular bonds. With the exception of the destination of the investment and tax-exempt, all other behaviors of Green Bond are similar to other bonds. The maturity period, the rate of return and the default risk are all the same. The issuer states that the aim is raising capital to fund 'green' projects, assets or business activities with an environmental benefit, such as renewable energy, low carbon transport or forestry projects.

The unique characteristics that Green Bonds have is that they are invested in environmentally-friendly projects, for instance investing in renewable energy, sustainable waste management, energy efficiency, clean water, low-carbon transportation, and biodiversity. In general, it is all about investing for green environment and climate. The investment on these brownfield sites made Green Bonds to be a sustainability element.

The main target and goal of Green Bond is implied on its name "Green". It is just keeping the environment green, clean and carbon free. According to Skandinaviska Enskilda Banken-SEB (2014), the nature of the Green Bond is to enable mainstream fixed income mandates to engage and access climate finance. The strength is that it

is enabling and engaging traditional bond mandates for climate finance, and thereby activates new pockets of money for Green investments.

Green Bond is to be used as an instrument for business leaders to transform their organizations to be more comprehensive and address society challenges through their existing infrastructure (Ibid). Green Bonds are also more attractive from an investor point of view since they are tax-exempted as compared to taxable bonds. However, Green Bonds are also characterized as lower interest rates that made the way easy for issuers to raise larger amounts of capital compared to the ordinary bonds issued by banks. This is not good for investors, but lower interest is a sign of safe investment that is associated with lower risk.

### **2.2.1.Types of Green Bonds**

Green Bonds undergo lots of updates from time to time. Now a day's, two categories of Green Bonds have emerged in the market. These are Green Bonds (certified as Green Labelled) and unlabeled Green Bonds for projects that produce environmental benefits (UNDP, 2016). According to Green Bond Principles (2014), Green Bonds are instruments in which the proceeds will be exclusively applied and further states that additional types of Green Bonds may emerge as the market develops.

Leadership in Energy and Environmental Design (LEED) Certification is one of the rating systems for labelled Green by the U.S. Green Building Council to measure the environmental impact of buildings, such as homes, commercial offices and schools. It evaluates buildings based on water and energy consumption and greenhouse gas emissions (Investopedia, 2017).

According to Climate Bonds Initiative (CBI) and Green Bond Principles (2014), there are four main types of Green Bonds: Green use of proceeds bond; Green use of proceeds revenue bond; Green project bond; and Green securitized bond.

Green use of Proceeds Bond is a standard recourse to the issuer debt obligation where the credit rating is the same for the issuer and the bond, for example the European Investment Bank's Climate Awareness Bonds.



Green use of Proceeds Revenue Bond is a non-recourse to the issuer debt obligation that is pledged to a revenue stream that is generated by fees, taxes, etc. The proceeds can be invested in related or unrelated green project(s), for example the Iowa Finance Authority bond where the proceeds will finance water and wastewater projects and the State of Hawaii's issuance of bond for Green Infrastructure Fee applied to the electricity bills.

Green Project Bond is a project bond for a single or multiple green project(s) for which the investor has direct exposure to the risk of the project(s) with or without recourse to the issuer, for instance OPIC and US development finance institution.

Green Securitized Bond is a bond collateralized by one or more specific projects, including covered bonds. The first source of repayment is generally the revenue generated by the assets. This type of bond covers, for example asset backed securitizations of energy efficiency assets. Solar city corporation issues Green Bond using different channels, including direct sales online.

### **2.2.2. Principles of Green Bonds**

According to the Green Bond Principles (2014), Green Bond Principles are voluntary process guidelines that recommend transparency and disclosure and promote integrity in the development of the Green Bond market by clarifying the approach for issuance of a Green Bond. Therefore, the Green Bond Principles are intended for broad use by the market. They provide issuers guidance on a credible Green Bond; aid investors to evaluate the environmental impact, and assist underwriters by moving the market towards standard disclosures.

The Green Bond Principles that define a Green Bond are Use of Proceeds, Process for Project Evaluation and Selection, Management of Proceeds, and Reporting (Green Bond Principles, 2014; and UNDP, 2016). Accordingly, short and brief descriptions of the Green Bond Principles are stated as follows:

**Use of proceeds:** the issuer should declare the eligible green project categories it intends to support as legal documentation. It should also provide clear environmental benefits connected to the project(s) financed by the proceeds. Among many potential eligible Green projects some of them are: renewable energy, energy efficiency,

sustainable waste management, biodiversity conservation, low-carbon transportation, and clean water.

**Process for project evaluation and selection:** the issuer should outline the investment decision making process it follows to determine the eligibility of individual investments using the green bond's proceeds. A process of review should determine and document an investment's eligibility within the issuers stated eligible Green project categories.

**Management of proceeds:** the proceeds should be moved to a sub-portfolio or otherwise attested to by a formal internal process that should be disclosed. The issuer should inform investors that the intended types of eligible instruments for the balance of allocated/unallocated proceeds.

**Reporting:** the issuer should report at least annually on the investments made from the proceeds, detailing wherever possible the environmental benefits accrued with quantitative/qualitative indicators. The impact of the specific investments should be reported. For example, reductions in greenhouse gas emissions, number of people provided with access to clean power or clean water projects and so on.

### **2.2.3. Actors of Green Bond**

Every concerned body for the environment and climate change, and an investor who would like to invest his money on Green projects are actors of Green Bond. In general, the concerned body is the one who raises ideas about green projects and financing them, buys and sells Green Bond, and controls its implementation. According to UNDP (2016), the stakeholders also include partners (like NGOs, credit rating agencies), regulators (securities commissions and other regulatory bodies, including stock exchanges and central banks), credit guarantors and other intermediaries. Particularly, the market for Green Bond is an arrangement between two actors, the buyer-investor and the seller-issuer. However, all others help in arranging the market.

Green Bonds investor(s): are individuals, companies or institutional investors (i.e. endowment funds, hedge funds, insurance companies, asset managers, investment

companies, investment trusts, mutual funds, pension funds, sovereign wealth funds and so on) who buy Green Bonds with the expectation of a financial return. Those people who invest their money in Green Bond and collect the principal and the accrued interest coupons over the specified period of time.

Green Bonds issuer(s): Any company, government agency or financial institution that develops, registers and sells a bond. For example, the Chinese Government, European Investment Bank, Toyota and the World Bank are the only few ones. The issuer usually selects a financial institution as an underwriter to administer the issuance of the bond (UNDP, 2016). Therefore, the issuer will need to generate sufficient cash flows to repay interest accrued over the period of time and the principal capital.

### **2.3. Risks Associated with Bonds and Stocks**

The risk is the probability that an investor will lose some or all the money s/he invests. Risk is measured by the standard deviation of the return of the asset. The traditional convention shows that the risk of investing in bonds is lower as compared to the risk of investing in stocks. However, according to Estrada (2012), this traditional convention works only in short run. In long run, bonds are riskier than stocks (Estrada, 2012; Yousuf, 2013).

The concern of this study is to examine the market specific risk, i.e. the bond specific risk. However, Buffett (2012) argued that risk should be measured in terms of the probability of losing purchasing power. Buffett (2012) also claims that bonds are the most dangerous assets that have huge risks. He denounces the volatility measure of risk since long run is more stable. The data for this study is typically short. Hence, it is more important to measure beta (market risk) since the market is determined by demand and supply principles.

#### **2.3.1. Risks Associated with Bonds**

There are different risks associated to bond's investment return. The main risks among many others associated with bond market are interest rate risk, reinvestment risk, inflation risk, market risk, liquidity risk, and credit (default) risk (Curtis, 2017; CNN, 2015; Fabozzi, 2007 and Sifma, 2013).

**Interest rate risk:** This risk is associated with the duration risk. The longer the time to a bond's maturity, the greater is its interest rate risk i.e. the greater price fluctuations/volatility. When interest rates rise, bond prices fall since new bonds are issued that pay higher coupons and made the older less attractive. However, when interest rates fall, bond prices rise that made the old bonds look more attractive with the higher pay-outs.

**Reinvestment risk:** When interest rates are declining, investors have to reinvest their interest income and any return of principal, whether scheduled or unscheduled, at lower prevailing rates. This type of risk is also called **call risk**. It is the issuers right to call their bonds before it matures whenever interest rates fall by paying the par value to the beholder. The issuers minimize their cost by selling new bonds with lower yields whereas the investor has to reinvest his/her money somewhere.

**Inflation risk:** Inflation causes future value of money to be worth less than today's. This would imply that inflation reduces the purchasing power of a bond investor's future interest payments and principal. Inflation also leads to higher interest rates, which in turn leads to lower bond prices. However, bonds are fixed income instruments. Therefore, their value is skewed by inflation and deflation hedges. The longer the duration of the bond, the higher the inflation risk (Curtis, 2017; CNN, 2015; Sifma, 2013). Inflation risk can be minimized using inflation-indexed securities such as Treasury Inflation Protection Securities (TIPS).

**Market risk (systematic):** The risk that is associated with the entire bond market. If market for bonds decline, bringing the value of individual securities down with it regardless of their fundamental characteristics. This is undiversified risk related to the market demand and supply.

**Liquidity risk:** The risk that investors may have difficulty finding a buyer when they want to sell and may be forced to sell at a significant discount to market value. Liquidity risk is greater for thinly traded securities such as lower-rated bonds (Sifma, 2013). Bonds are generally the most liquid during the period right after issuance when the typical bond has the highest trading volume. However, bonds are less liquid than stocks since investors hold bonds rather than trade them due to thin market with few buyers and sellers in the bond market (Curtis, 2017; CNN, 2015; Sifma, 2013).

**Credit/Default risk:** The possibility that a bond issuer will be unable to make interest or principal payments when they are due or unable to payments on time. If the payments are not made according to the agreements in the bond documentation, the issuer can default. According to bond rating agencies (such as Standard & Poor, and Moody), bonds from the strongest issuers are rated AAA. Junk bonds are rated BA and lower from Moody's, or BB and lower from S&P (CNN, 2015) and D for bonds default (Curtis, 2017). This typical risk can be minimized by mortgage-backed and asset-backed securities issued by government agencies or government-sponsored enterprises known as “agency” securities.

### **2.3.2. Risks of Green Bond**

The probability of losing money is very small when investing in Green Bonds. The main risk associated with buying Green Bond is same as the risks associated with investing in bonds as listed in section 2.3.1. However, Green Bonds have their own specific risks. Among many the following are some of them according to UNDP, (2016).

- The risk of debt is the same as the credit/default risk of the issuer. Default risks are issuer or bond specific risks.
- The structuring of a bond implies additional risks to the issuer and the investor, i.e. the risk of increasing costs.
- Variability in transaction costs and issuance fees made costly for developing countries to issue Green Bonds that leads them for other financial mechanisms.
- Issuances of Green Bonds distort the taxation of debt market instruments.
- The reputational risk for Green Bonds issuers i.e. when bonds labeled as green issued by others are found not to be "green", destroys investors' trust.
- Additional risks such as changes in foreign market regulations on capital flows, and exchange rates when Green Bond is issued abroad.
- Offshore markets may draw liquidity away from the domestic market.

### **2.4. Advantages and Disadvantages of Green Bonds**

Ceres Investor Network on Climate Risk (INCR) stated investors' expectations from Green Bonds as follows. Primarily, a Green Bond is a fixed income instrument

whose proceeds finance projects that generate significant identifiable climate and environmental benefits. Therefore, investors need a predefined and transparent use of proceeds. Secondly, Green Bonds should finance credible green projects to remain consistent with environmental objectives to attract increased investor interest. Finally, the Green Bond Principles set forth appropriate common criteria concerning eligibility, disclosure, transparency and impact reporting for green bonds.

The specific pros and cons of Green Bonds are discussed below based on UNDP (2016) and Green Bond Principles (2014).

### **2.4.1. Advantages of Green Bonds**

Benefits of Green Bonds can be seen from three sides: investor; issuer; and climate and environmental.

**Investor Side:** Investors benefit from funding green projects, helping them to deliver on the commitments made as signatories to the Principles for Responsible Investment (PRI), as members of the Institutional Investors Group on Climate Change (IIGCC) and/or other similar bodies.

Green Bonds can foster greater transparency in the use of proceeds from a bond and help to ensure that the climate impact of fixed income investments is reported. Furthermore, Green Bonds are very safe and secure. They become an option of Investment diversification.

**Issuer Side:** Green Bonds can help in enhancing an issuer's reputation, i.e. an effective way for an issuer to demonstrate its green credentials. It displays to brand themselves as innovative and shows their commitment towards development and sustainability of the environment.

The financial risk and return characteristics of Green Bonds are the same as for classic bonds. Therefore, the main benefits are lower interest rates than loan from a bank, and give the possibility of raising larger amounts of capital and greater flexibility in the use of capital.

Local governments and companies can profit from the increase in demand from socially responsible investors since Green Bonds provide an issuer the access to such investors which they otherwise may not be able to tap with a regular bond.

### **Climate and Environment side:**

Green Bonds can play a positive role in raising awareness and building expertise among investors on green and climate issues.

Local governments and companies also used Green Bonds to raise large amounts of financial resources to support environmental projects for which funding might otherwise not be available, or which might be uneconomic if they had to rely on more expensive capital.

Green Bonds can also facilitate the establishment of public-private partnerships that might accelerate the pace of green investment and lead to the adoption of modern technologies.

### **2.4.2. Disadvantages of Green Bonds**

Green Bonds are not far from criticisms and drawbacks. The primary issue is the lack of consensus since Green Bond is becoming a source of uncertainty when assessing long term investment options.

The secondary issue raised is about transparency. Transparency and reporting are weak in the Green Bond market, which still relies on voluntary reporting. As the market grows, transparency will emerge as an increasingly important issue.

Finally, retail investment is still limited because Green Bonds are not yet well integrated into mainstream funds, indices and other products. The cost of issuing Green Bonds is very high due more administrative costs (UNDP, 2016; Green Bond Principles, 2014)

## **Chapter Three: Methods and Materials**

### **3.1. Sources and Types of Data**

The source of the data in this study is the Standard and Poor's Financial Services LLC (S&P) Dow Jones Indices, which is typically considered as secondary data. The data comprises S&P Global Green Bond index (includes only Green-labelled Bonds) and U.S. Companies' Bond index (labelled as S&P500 bond) where it is used as a benchmark. The data also includes S&P Global Green Project Bond index (unlabelled Green Bond index), S&P Global Developed Sovereign Bond index, S&P Pan-Europe Developed Sovereign Bond index, and S&P BSE GREENEX (represents for the top 25 Green Companies). The study also includes S&P500 for stock index as a benchmark. The data set is available at <http://us.spindices.com/> and is accessed on 17 February 2017. This specification is very important because the data set is rebalancing and adjusting every month.

The study also uses Yield to Maturity of different bonds from S&P indices data base. These are: Green Bond Yield to Maturity; Green Project Bond Yield; Global Developed Sovereign Bond Yield to Maturity; Pan-Europe Developed Sovereign Bond Yield to Maturity; and U.S. Companies' Bond Yield to Maturity (available at <http://us.spindices.com/>).

The U.S. 10-year Treasury Yield and 1-year Treasury bill (T-bill) are downloaded from Federal Reserve Economic Data (FRED) available at <https://fred.stlouisfed.org/>. The 10-year Treasury Yield is used as a benchmark for bond yields. The 1-year Treasury bill (T-bill) is the safest financial instruments/investments since bonds have longer maturity period. T-bills are considered to have no default risk. Hence, the interest rate on 1-year T-bill is the most appropriate for this study as risk-free rate of return since investors would expect the rate of return of investments on risk-free rate of return to be zero risk.

### **3.2. Nature of the Data**

The S&P indices are market value-weighted indices in which total return is calculated on a weighted average of the returns on each bond, where the weights are proportional to the outstanding market which reflects the return due to paid and



accrued interest, and price return, reflecting the gains or losses. The data is rebalanced monthly to consider for new issuance, size and maturity. So, the bonds return index are subject to change every month. The rebalancing is made by using reference date to determine security eligibility and index inclusion for the subsequent month.

### **3.3. Variable Specification/Definition**

The variables used in the study are specified according to S&P indices. Therefore, the name of variables, their aberrations (in parenthesis), concepts, and definitions are presented as follows.

S&P Green Bond Index (Greenbond) is global bonds that are labelled “Green” by their issuers. A green-labelled bond is a bond whose proceeds are used to finance environmentally friendly projects. These are bonds where issuers disclosed information about the use of proceeds according to the Green Bond rules, procedures and principles. The Climate Bonds Initiative has been tracking the green labelled market since 2009.

S&P Green Project Bond Index (Greenproject) are the only bonds that finance climate and environmental-friendly projects. It includes primary unlabelled bonds issued to finance single projects aiming to achieve environmental benefits. This typical bond is used to track the project finance segment of the global Green Bond index market. Because it is unlabelled, Green Project Bond is not used for analysis and discussion except in descriptive statistics.

S&P BSE GREENEX (Green25) Index includes the top 25 green companies which are good in terms of carbon emissions (i.e. greenhouse gas emissions), free-float market capitalization and turnover (liquidity). These companies are considered “Green labelled” stock. BSE considers the company's initiative to offset the carbon emissions; the offset limit being set to 2/3<sup>rd</sup> of the company's total emissions. The world here constitutes the S&P BSE 100 index and the top 25 stocks are selected according to their performance on greenhouse gas emissions, market cap and liquidity. S&P BSE GREENEX is a stock of top 25 companies.

S&P Global Developed Sovereign Bond Index (Developedbond) is issued by developed countries for their domestic markets. This is government bond index in the developed world.

S&P Pan-Europe Developed Sovereign Bond Index (EUbond) is issued by European Countries commonly EU (it also includes Norway, Switzerland and UK). This is also a typical government bond index in European countries.

Global Developed and Europe Developed are considered to be global bond indices and considered to be more realistic for comparison with global Green Bond index because developed countries took the lion's share of issuing Green Bonds and controlled the market for it.

U.S. Companies' Bond Index (S&P500bond) is comprised of a universe of bonds that are issued in the U.S. by companies (and their subsidiaries). This is a traditional corporate bond index designed to track bond market. It is used as a benchmark for bond market.

S&P500 Index (S&P500stock) for stocks (equities) are widely used as benchmark, specifically the total return index. In addition to the mainly used S&P500 index for bonds, S&P500stock are also used as benchmark. It is used for comparison purposes to the results obtained relative to S&P500 bonds and to examine the dynamics of the bond market to stocks.

The study also includes other important variables such as Yield to Maturity related to those bonds to measure the yield spread. Green Bond Yield to Maturity (GreenbondYM), Green Project Bond Yield to Maturity for (GreenprojectYM), Global Developed Sovereign Bond Yield to Maturity (DevelopedbondYM), Pan-Europe Developed Sovereign Bond Yield to Maturity (EUbondYM) and U.S. Companies' Bond Yield to Maturity (S&P500bondYM).

### **3.4. Data Description**

Describing the data set is one of the important techniques to get familiar with data set and know what type of data it is. The original data used in this study was a daily data set from November 2008 to December 2016. It could be better if we include

more data series, but the Green Bond data appears late in November 2008. Therefore, the data series is from November 2008 to December 2016.

In order to set the same time interval, the primary work is to filter the data according to the business calendar. Thus, it helps to pick the last day return record of the month. This is more common technique than aggregated monthly data.

According to Figure 3.1, all bonds return (index based) looks growing as per the gross return measure. Green 25 (the top 25 Green companies' return), Global Green Project Bond and S&P500 stock are growing much faster than any other bonds. It is expected that those variables have higher return than others since Green 25 and S&P500 stock are both stocks whereas Global Green Project Bond is unlabelled Green Bond return. However, S&P500 bond grows faster than the government bonds. This S&P500 bond return was more or less greater than that of stock returns until around 2012, but less than the stock return afterwards.

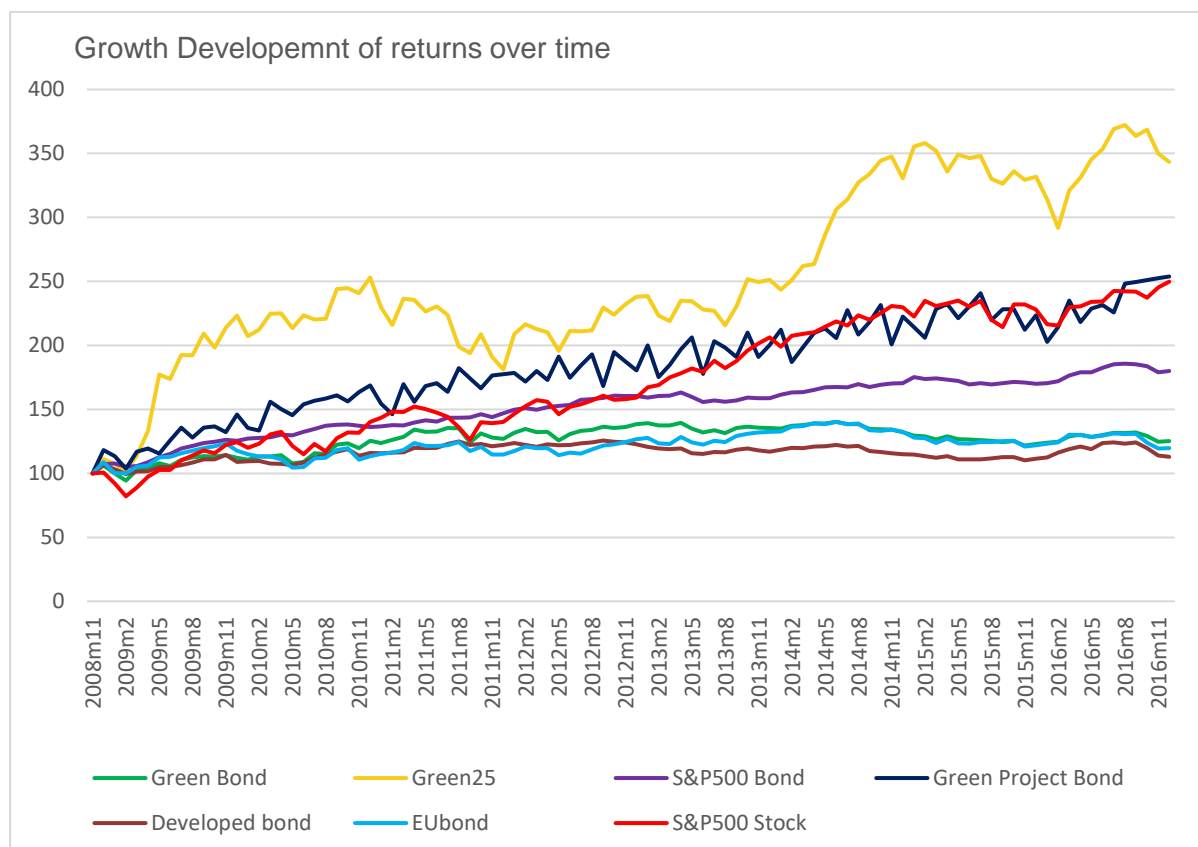


Figure 3.1: Gross Return Development of different Bond indices for the period of Nov. 2008 to Dec. 2016

### 3.5. Correlation

Correlation in general is a measure of association of two different variables. In finance, correlation is the measure of the extent to which two assets (for instance, Green Bond with other different bonds in this case) go together in relation to each other.

As appears in Table 3.1, there are relatively high correlations between Green Bond and other different bonds. However, there is relatively low association between Green Bond and stocks. Since the concern here is the association between Green Bond and others, looking at the first column would inform high correlation.

Table 3.1: Correlation between different bond returns

Correlation	Green Bond	Green Project	S&P500 Bond	Developed Bond	EU Bond	Green 25
Green Project	0.66	1.00				
S&P500 Bond	0.74	0.96	1.00			
Developed Bond	0.85	0.46	0.57	1.00		
EU Bond	0.80	0.71	0.76	0.58	1.00	
Green25	0.46	0.88	0.87	0.26	0.66	1.00
S&P500 Stock	0.59	0.95	0.95	0.34	0.75	0.92

The correlations show that there is an association between Green, traditional and government bonds. Besides, it is revealed that there is very high association between Green Project bond with S&P500 bond, Green Project Bond with S&P500 stock, and between the two benchmarks, S&P500 for bonds and stocks. This might be due the fact that Green Project Bond is unlabelled. Comparing the two benchmarks, the correlation of Green Bond with S&P500 bonds (US Companies Bond) is 0.74 showing relatively higher association than with S&P500 for stock (0.59).

## Chapter Four: Data Analysis

Both qualitative and quantitative techniques are used to assess and describe the data set. It goes through descriptive statistics to time series econometric model to address the objectives set (research questions). The study also applies statistical tools such as ratios, percentages, and inferential statistics such as t-test and F-statistic. The presentation of the outcome of those methods and analytical tools is presented in the form of tables, figures and graphs.

### 4.1. Descriptive Statistics

In order to assess the risks and returns of the bond market, the average/mean and variance (or standard deviation) are the basic elements and commonly used in relative comparative statistics including inferential statistic. The study applies log returns for its analysis purpose since the bonds are assumed to be interdependent overtime.

$$\text{log returns for bonds} = (R_t) = \log\left(\frac{R_t}{R_{t-1}}\right) \quad (4.1)$$

$R_t$  and  $R_{t-1}$  represents Bond return prices at time t and t-1, respectively.

$$\text{log returns for stock} = (R_t) = \log\left(\frac{P_t}{P_{t-1}}\right) \quad (4.2)$$

$P_t$  and  $P_{t-1}$  represents Stock prices at time t and t-1, respectively.

Table 4.1: Summary Statistics of Different Bond Returns and Stocks from Nov.2008 to Dec.2016 (total number of observations 97)

Monthly	Green Bond	Green Project	S&P500 Bond	Developed Bond	EU Bond	Green 25	S&P500 Stock
Mean Returns	0.23%	0.96%	0.61%	0.13%	0.19%	1.27%	0.94%
Median	0.24%	1.18%	0.55%	0.23%	0.43%	0.49%	1.25%
Standard deviation	2.67%	7.29%	1.39%	1.92%	2.91%	6.12%	4.05%
Sample variance	0.07%	0.53%	0.02%	0.04%	0.08%	0.37%	0.16%
Kurtosis	1.56	-0.56	3.73	1.21	1.02	3.14	0.62
Skewness	-0.07	-0.07	0.81	-0.20	-0.37	1.03	-0.46
Minimum	-8.4%	-14.9%	-2.6%	-5.1%	-8.1%	-11.7%	-11.7%
Maximum	8.3%	16.7%	6.9%	6.5%	8.3%	28.6%	10.2%

The log returns are multiplied by 100 to make the unit measurement in percentage unit forms. Therefore, the returns presented in Table 4.1 are in percentage units.

The summary in Table 4.1 shows the overall description of the data set (7 variables and 97 observations i.e. counts). The highest return obtained (1.27%) is from Green25 (i.e. stock return from top 25 Green companies). Therefore, it is a Green stock return. The next highest return (0.96%) is from Green Project (unlabeled Green index). The benchmark, S&P500 for stock is the third highest return (0.94%). Since other bonds are considered to be government bonds including Green, it is not surprising that higher return is obtained from the traditional stocks like S&P500 stock, and Green25. This result also confirms to the graphical analysis in chapter 3 section 3.4 (Figure 3.1). It is a public knowledge that stock returns out ways all other bond returns as expected at least in short run.

The standard deviation (i.e. square root of Sample variances) measures the variations from the mean return i.e. the distance from the mean. In finance, this is commonly considered as measure of risk (specifically called volatility). As per monthly return in Table 4.1, stocks are more volatile (looks risky) than bonds except Green Project Bond return. Since Green Project is unlabeled, the result supports the public knowledge that stocks are risky (more volatile). Between stocks, individual companies (6.12%) are more volatile than the benchmark, S&P500 stock (4.05%) which comprises a set of stocks. The details of annualized average returns and standard deviations are presented in the discussion part (see section 5.2 and 5.3).

All distributions, except Green25 and S&P500 bond, provide a negative skewness. This reveals that the negative risks may be underestimated when measured by the standard deviation. Kurtosis measures the degree of peak. For normal distribution, kurtosis equals three. In this case, most of the kurtosis distribution are positive (reported above zero) except Green project bond. This suggests that the observations have fatter tails, i.e. more of the data distribution is within the tails. Hence, there is a lesser probability of extreme values.

## **4.2. Growth of Bond and Stock Returns**

This section presents the average returns (i.e. log return) of the different types of the bond indices and stock returns. All bonds return looks correlated with S&P500 bond

and with S&P500 stock as a confirmation to the previous existence of relatively high correlation.

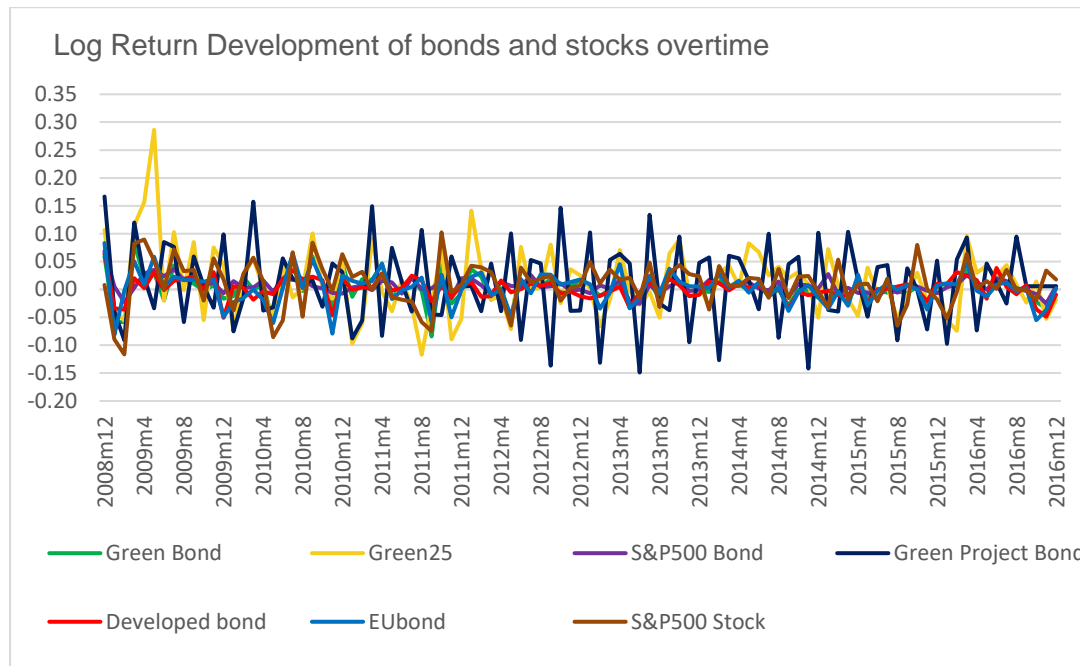


Figure 4.1: Returns Growth of Bonds and Stock for the period of Dec.2008 to Dec.2016

However, Green25 (top 25 green companies) seems to have higher deviation around the start. Furthermore, Green25 and Green Project look more volatile than any other. In Table 4.1, it is evident that both have higher dispersion from their mean returns. Other than this difference, on average the distribution and variation of the returns looks highly correlated.

### 4.3. Capital Asset Pricing Model (CAPM)

Capital Asset Pricing Model (CAPM) is a model that explains the relationship between an associated systematic risk (market risk) and expected return for assets, specifically bonds and stocks. CAPM has two different components i.e. time value of money and associated risk. The time value of money is represented by risk-free rate ( $r_f$ ) and the opportunity cost of holding money in any investment over a period of time. The associated risk is the amount of compensation the investor demands for taking an additional risk of his/her money in any investment. This risk measure is beta (systematic risk) that compares the returns of the asset to the market over a period of time and to the market premium ( $R_m - r_f$ ): the return of the market in excess of the risk-free rate (Investopedia, 2017).

Single Index Model (SIM) is the simpler version of CAPM that resembles simple linear regression model with one explanatory variable. However, SIM is a statistical tool. It is a single factor model for asset returns. In this study, CAPM/SIM is an appropriate model since the returns are realized (ex-post). The other reason is that it uses the market index to proxy for the common or systematic risk factor.

There are two approaches of specifying CAPM/SIM. The primary approach is using the return index as it is. Another approach that is widely and commonly used in many research papers and books is excess return approach. The study applies the second specification approach (i.e. excess returns method). Therefore, the risk measure (beta) reflects how risky an asset is compared to overall market risk. It is a function of the volatility of the asset and the market as well as the correlation between the two (Ibid).

The study uses bonds (S&P 500 bond) and stocks (S&P 500 stock) as a market to measure the associated risk over a period of time. The excess Green Bond return is regressed against excess of S&P500 bond and stock (both used as benchmarks) to examine the associated risk in relation to the traditional bonds and stocks. Hence, the specification of the model is as follows.

#### 4.3.1. S&P500 Bond as Market Benchmark

$$\text{Greenbond return} - R_f = \alpha + \beta(\text{S\&P500 bond} - R_f) + \vartheta_t \quad (4.3)$$

$$\text{Excess Greenbond return} = \alpha + \beta(\text{Excess S\&P500 bond return}) + \vartheta_t$$

Where  $\vartheta_t$  – error term assumed to white noise and

$R_f$  – is the 1 – year US treasury bills (T – Bill)

The excess return over the risk-free rate is denoted by the following equation:

$$\text{Excess } R_{\text{Green}} = \alpha + \beta(\text{Excess } R_{\text{S\&P500bond}}) + \vartheta_t \quad (4.4)$$

In general, we can re-write the equation as

$$R_i = \alpha + \beta(R_M) + \vartheta_t \quad (4.5)$$

Where  $R_i$  – expected return (excess Green bond return) and

$R_M$  – risk premium (excess Market return)for Bonds



### 4.3.2. S&P500 Stock as Market Benchmark

A similar specification also follows for S&P500 stock return as a benchmark.

$$\text{Greenbond return} - R_f = \alpha + \beta(\text{S\&P500 stock} - R_f) + \vartheta_t$$

$$\text{Excess Greenbond return} = \alpha + \beta(\text{Excess S\&P500bond return}) + \vartheta_t$$

The representation of excess returns over the risk-free rate:

$$\text{Excess } R_{\text{Green}} = \alpha + \beta(\text{Excess } R_{\text{S\&P500 stock}}) + \vartheta_t \quad (4.6)$$

In short;

$$R_i = \alpha + \beta(R_M) + \vartheta_t \quad (4.7)$$

Where  $R_M$  – here is risk premium (excess Market return)for stocks

CAPM reveals that the expected return of a security or a portfolio equals the rate on a risk-free security plus a risk premium. If this expected return fails to meet or beat the required return, the specific portfolio or security has higher or lower systematic risk. Therefore, the investment decision needs more inspection. The Security Market Line (SML) plots the results of the CAPM for all different risks (i.e. betas) (Ibid).

### 4.4. Times Series Econometric Model

Knowing the relationship between expected returns of Green Bond and the markets (both with bond and stock markets i.e. S&P500 for bonds and stocks) and estimating beta (associated systematic risk) is not enough. Because this does not show the real historical causation, and it does not answer whether the cumulative price return or an immediate price return affects. Besides, it does not indicate how long the effect continues to affect (how long the effect lasts). Therefore, time series econometric modelling answers these issues. Hence, a dynamic regression model usually includes both lagged dependent and independent variables as regressors to examine whether the previous effect exists or not.

Accordingly, the study employs Autoregressive Distributed Lag Model (ARDL) to examine the effect of own lags and lags of other explanatory variables. ARDL is chosen as most appropriate model since the return of assets assumes that previous own and other explanatory variables' price return affects today's price return.

The specification of the ARDL is as follows:

$$Y_t = \alpha_0 + \beta_1 Y_{t-1} + \dots + \beta_p Y_{t-p} + \phi_1 X_t + \phi_2 X_{t-1} + \dots + \phi_q X_{t-q} + \mu_t \quad (4.8)$$

$$Y_t = \alpha_0 + \sum_{i=1}^p \beta_i L^i Y_t + \sum_{j=0}^q \phi_j L^j X_t + \mu_t \quad (4.9)$$

This is called ARDL(p, q). Where, L represents lag operator

$Y_t$  – excess Green Bond return and  $Y_{t-j}$  – its lags,  $j = 1, 2, \dots, p$

$X_t$  – excess S&P500 bond and stock return and  $X_{t-i}$  – its lags,  $i = 0, 1, 2, \dots, q$

$\mu_t$  – error term overtime period

The decision how far back in time the effect has to exist (i.e. the length of the distributed lag) to examine the effects depends:

- i. On the basis of the statistical significance of the lagged variables, and
- ii. The resulting model is well specified (e.g. it does not suffer from serial correlation).

There are different measures and criteria to determine lag length. These criteria are penalizing free parameters to combat over fitting. If it is assumed that the effects are lasting forever, it is considered to be *infinite* distributed lag models. However, if we assume that the effect of a change affects economic outcomes for a certain period of time, then it is *finite* distributed lag models. Accordingly, either of the following information criteria applies.

AIC =  $2K - 2\ln L$  - Akaike Information Criterion

BIC =  $(K \ln N - 2\ln L)$  - Bayesian Information Criterion

Where K is Model degrees of freedom (number of parameters)

N is total number of observations in the sample estimation

and L is Optimized value of Likelihood Function

The optimal lag orders p and q (possibly different across regressors) can be obtained by minimizing a model selection criterion, e.g. the Akaike information criterion (AIC) or the Bayesian information criterion (BIC) (Kripfgan and Schneider, 2016). The lag length that minimizes the AIC or BIC (most appropriate for explanatory models) is chosen for the model as in Table 4.2.

Table 4.2: Determination of lag length of Green Bond, S&P500 bond and S&P500 stock

. varsoc Greenbond								
Selection-order criteria								
Sample: 2009m3 - 2016m12						Number of obs = 94		
lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-344.009				90.2636	7.34061	7.35154	7.36767
1	-231.382	225.25	1	0.000	8.39552	4.96557	4.98743	5.01968*
2	-229.173	4.4185*	1	0.036	8.1824*	4.93984*	4.97263*	5.02101
3	-228.933	.47862	1	0.489	8.31615	4.95603	4.99974	5.06425
4	-228.591	.68412	1	0.408	8.4338	4.97002	5.02467	5.10531
Endogenous: Greenbond								
Exogenous: _cons								
. varsoc SP500bond								
Selection-order criteria								
Sample: 2009m3 - 2016m12						Number of obs = 94		
lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-412.144				384.687	8.79031	8.80123	8.81736
1	-184.519	455.25*	1	0.000	3.09757*	3.96849*	3.99034*	4.0226*
2	-184.269	.50041	1	0.479	3.14743	3.98444	4.01723	4.06561
3	-184.066	.40623	1	0.524	3.20134	4.0014	4.04511	4.10962
4	-183.881	.36965	1	0.543	3.25751	4.01874	4.07338	4.15402
Endogenous: SP500bond								
Exogenous: _cons								
. varsoc SP500stock								
Selection-order criteria								
Sample: 2009m3 - 2016m12						Number of obs = 94		
lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-492.533				2127.77	10.5007	10.5116	10.5278
1	-300.114	384.84*	1	0.000	36.2372	6.42796	6.44982*	6.48207*
2	-299.252	1.7246	1	0.189	36.3441	6.43089	6.46367	6.51206
3	-297.873	2.7572	1	0.097	36.0536*	6.42283*	6.46655	6.53106
4	-297.566	.6142	1	0.433	36.5909	6.43758	6.49222	6.57286
Endogenous: SP500stock								
Exogenous: _cons								

Where “VARSO” is to mean – Vector Auto Regressive Specification Order

Therefore, the lag length of the Autoregressive Distributed Lag Model is determined by the information criteria in STATA. In addition, STATA has two more additional criteria (FPE and HQIC) as an auto setting.

All the information criteria in table 4.2 above suggest that all the variables (global Green Bond, S&P500 bond, and S&P500 stock), have lag length one. Using the same procedure, the lag length of the government bonds (such as global Developed Sovereign bond and Pan-European developed bond) and top 25 Green companies' stock is also determined (see Annex 2). Hence, the government bonds also have lag length one and same is true for the top 25 Green companies stock.

Following the determination of lag length, the Autoregressive Distributed Lag Model appeared to have only one lag. That is,  $ARDL(1,1)$ . Therefore, the ARDL model includes only one month back in time in its dynamic nature. However, the study applies  $ARDL(2, 2)$  for convenience. Therefore, the full model looks the following:

$$ARDL(1,1) = Y_t = \alpha_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \phi_1 X_t + \phi_2 X_{t-1} + \phi_3 X_{t-2} + \mu_t$$

$$Y_t = \alpha_0 + \sum_{i=1}^2 \beta_i L^i Y_t + \sum_{j=0}^2 \phi_j L^j X_t + \mu_t \quad (4.10)$$

#### 4.4.1. Auto and Partial Correlation of Errors

Autocorrelation is useful to check if the residuals from a time series analysis seem to behave like white noise. Regression models (specifically Autoregressive – AR model) could also be used for testing whether lags of error term are correlated or not. That is, regressing the lags (lag 1, 2, 3, 4 ...) on independent variables of the original AR including lags of residuals and examines the statistical significance of those lags. Since this method works by trial and error, the study uses the Autocorrelation Function (ACF) method for convenience.

The correlogram of the returns indicates that up to lag 6 (see Figure 4.2), error term lags of returns and realized returns of Green Bond are correlated. The ACF of the S&P500 bond and its lag of residuals are also strongly correlated up until lag 7. The stock is also highly correlated with its error lags till lag 8. That means, the effect of error term has strong positive autocorrelation of order 6, 7 and 8, respectively for

Green bond, S&P500 bond and S&P500 stock. However, the correlogram of log returns in Figure 4.2 shows that residual is white noise and are not correlated overtime. Hence, the function for all returns is autocorrelation of order zero. The ACF of other government bonds and Green 25 is presented in Annex 3.

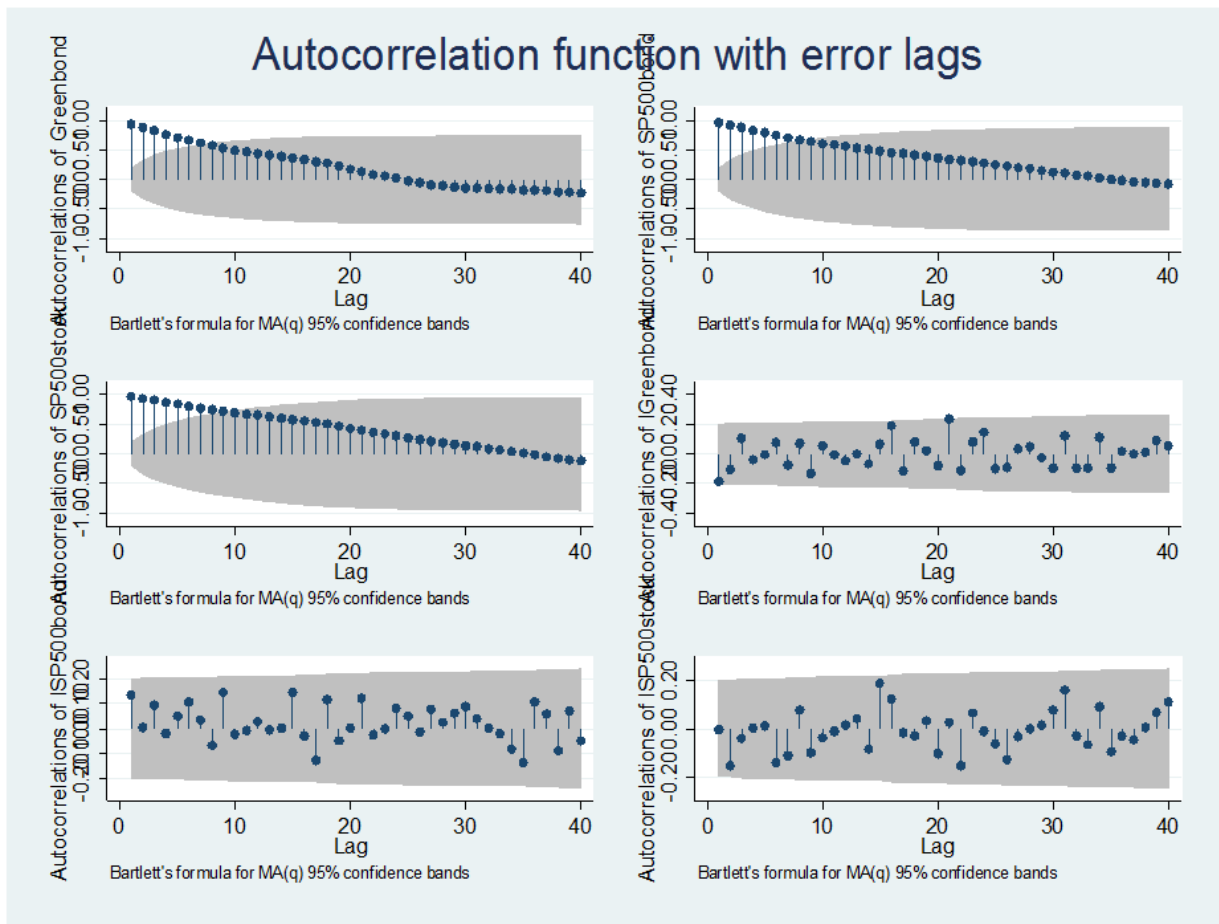


Figure 4.2: Autocorrelation function with lags of residuals

Determination of time lag length of the error term is also important because it tells us how far the error term exists to affect the variables. This can be figured out by using partial autocorrelation function (PACF). The partial autocorrelation function is a conditional correlation. According to Cowpertwait and Metcalfe (2009), the partial autocorrelation at lag  $k$  is the correlation that results after removing the effect of any correlations due to the terms at shorter lags. Therefore, the number of non-zero partial autocorrelations gives the order of the AR model.

As indicated in Figure 4.3, there seems no partial autocorrelation of all variables of log returns. The lags slightly outside the box are implications of conditional correlations. Thus, these partial autocorrelation fluctuations might be due to the

usual business cycles. The PACF of other government bonds and Green 25 is presented in Annex 4.

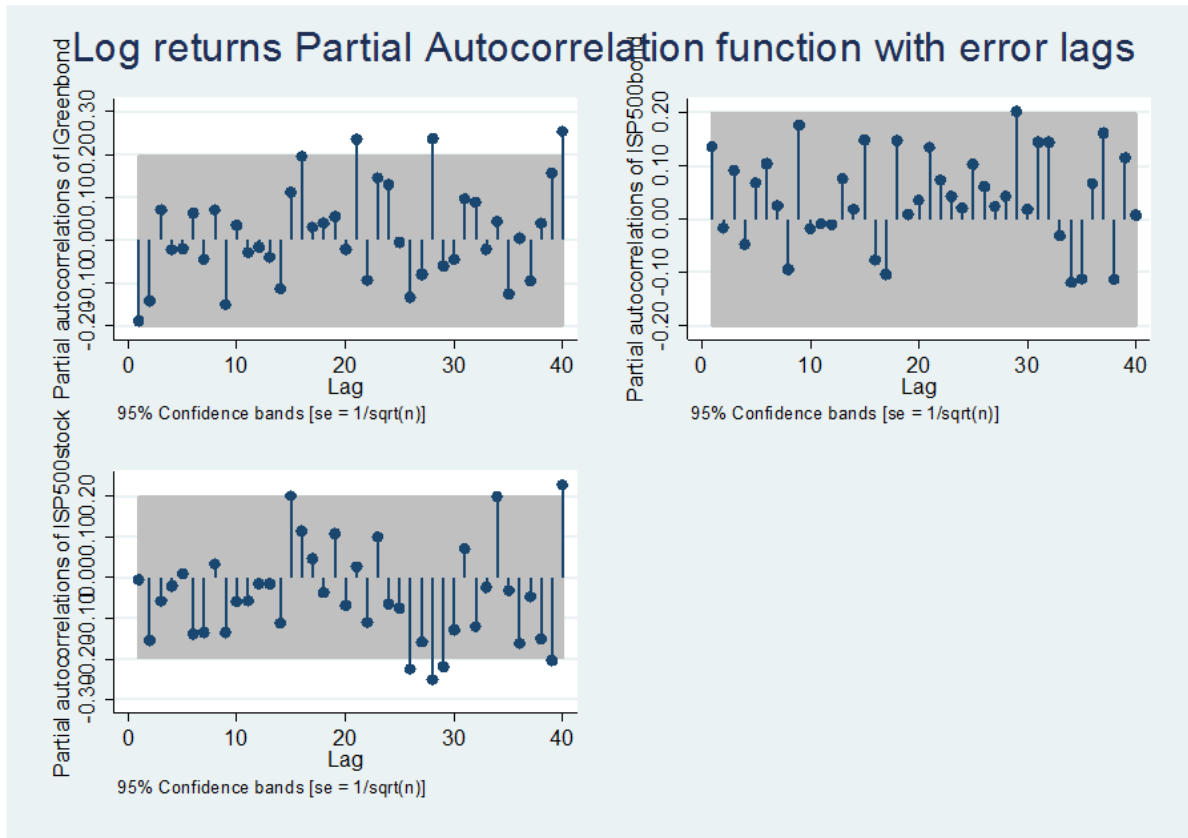


Figure 4.3: Partial Autocorrelation function with lags of residuals

Since the data set is monthly, it is commonly believed to use 12 lags, but looking at autocorrelation and partial autocorrelation figures it is enough to take 8 lags. The standard model for Autoregressive of the residuals is presented as follows.

$$\mu_t = \alpha_0 + \rho_1\mu_{t-1} + \rho_2\mu_{t-2} + \dots + \rho_n\mu_{t-n} + u_t \quad (4.11)$$

By construction, the moving average autocorrelation of the residuals is:

$$\mu_t = \theta_0u_t + \theta_1u_{t-1} + \theta_2u_{t-2} + \dots + \theta_nu_{t-n} \quad (4.12)$$

Breusch–Godfrey tests are applied for testing the significance level of residual lags. To make the outcome robust, the study employs the procedure of the Newey-West standard error correction method (HAC-Heteroskedasticity and Autocorrelation Consistent standard errors) instead of elaborating models specifically for the autocorrelation. The ARDL is complete by considering equation (4.11) and (4.12) with 12 lags for considering monthly data.

$$Y_t = \alpha_0 + \sum_{i=1}^2 \beta_i L^i Y_t + \sum_{j=0}^2 \phi_j L^j X_t + \mu_t \quad (4.13)$$

## Chapter Five: Results and Discussion

### 5.1. Introduction to Development of Returns of Bonds

There was a new record for Green Bond issuance in 2016 (hit at \$93.4 billion) and this year's expectation is to surpass the 2016 by double (Moody's Investor Service, 2017). This is an amount of issuance worth of billions with an expected increase at a rate of 120 percent. However, it is necessary to know the growth of returns of Green Bonds if it can grow as of its issuance.

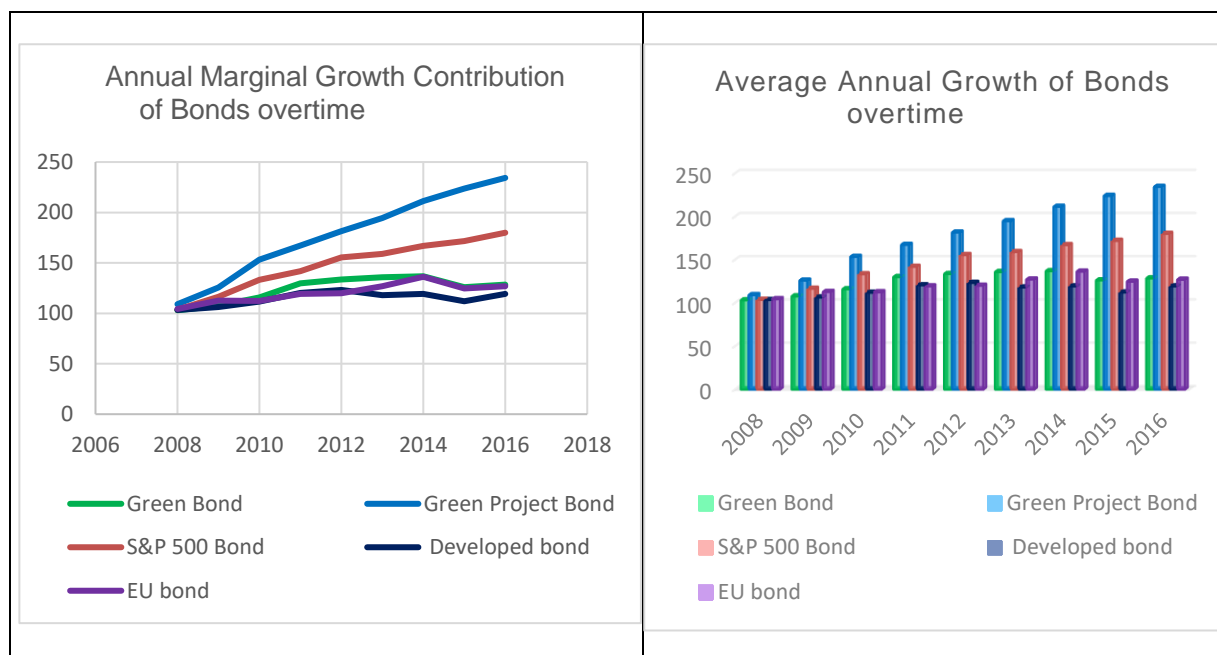


Figure 5.1: Average Annual Growth and its Contribution to in each year from Nov.2008 to Dec.2016

The rate at which the growth of annual return for bonds seems to grow at a decreasing rate, specifically government bonds including labelled Green Bond. It is evident that the benchmark, S&P500 bond, and Green Project Bond (i.e. unlabelled) have higher growth than any other bond growth. The main derive is to look at the growth rate of Green Bond, and hence it grows much faster than the two government bonds but lower than the market for bonds and Green project bond. This result validates the normalized growth of bonds overtime that has been presented earlier (see Figure 3.1).

The marginal contribution is similar to the bar chart except it shows the additional contribution, in which it also reveals the same result.

## 5.2. Returns and Risks of Bonds and Stocks

As a convention, bonds are less volatile than stocks at least in short run. However, there is a different scenario in the case of return of those financial instruments. That is, return on stocks is much higher than return on bonds as evidenced in section 3.4 and 4.1 earlier on monthly bases. Moreover, the annualized risk-return trade-off revealed that stocks (Green25 with 15.2 % and S&P500 stock with 11.33%) have higher returns than any other bonds as presented in Figure 5.2. However, those stocks are also more volatile and are relatively risky assets. Green25 (21.19%) and S&P500 stock (14.03%) have higher annualized standard deviations than bonds (both traditional and government bonds).

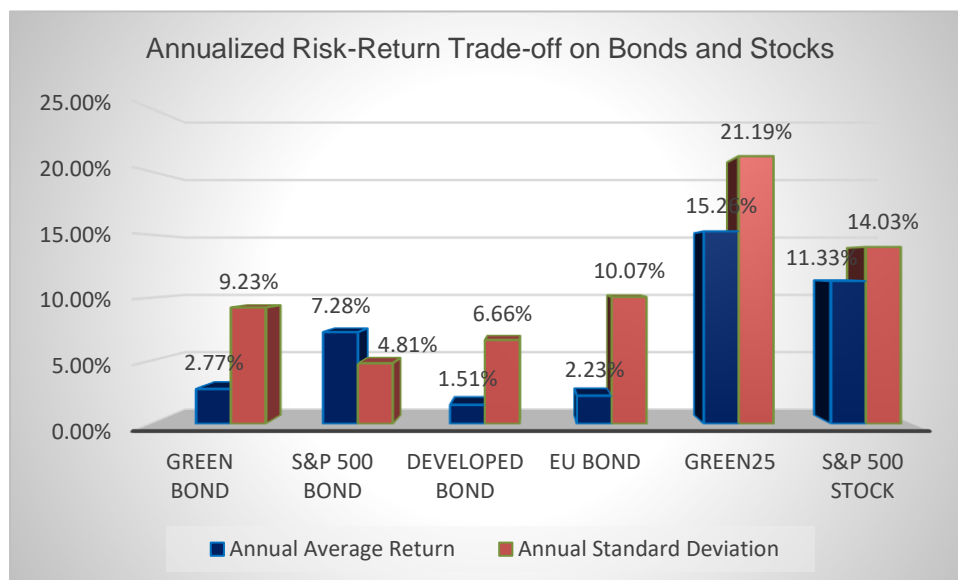


Figure 5.2: Risk-return trade-off (Annualized Returns and Std. Deviations for the period of Dec. 2008-Dec. 2016)

### 5.2.1. Risk-Return Trade-off of Bonds

Analysis of risk-return trade-off among bonds could inform that the higher risk could give the possibility of higher returns with higher potential loss. A comparison among bonds could not inform for sure that there are high returns and risks. This is because risk is the probability of deviation of an actual return from its expected return.

Accordingly, as indicated in Figure 5.2, the annualized return from the benchmark, S&P500 bond, is highest of all (7.28%) with a standard deviation of (4.81%). S&P500



bond hits the smallest annual standard deviation of all other bonds. The next higher annual return (2.77%) is from Green Bond, but with the second highest annual standard deviation (9.23%) from the bond market. Hence, Green Bond looks more volatile than the benchmark. Government bonds such as Global Developed and EU Developed bonds have annual return of 1.51% and 2.23% with their respective annual standard deviations of 6.66% and 10.07%, respectively.

### 5.3. Analysis of Risks and Returns in Relation to Bond Market

#### 5.3.1. Return Analysis of Green Bond with Bond

Return is the money an investor has to make on the investment. One of the investment option is bonds including the Green one. Considering the benchmark, S&P500 bond, it would be more feasible to compare them initially in terms of their return. The hypothesis is based on the concept that Green Bond has less risk and should have less return. And hence, assume that annual average return of Green Bond is equal to annual average return of S&P500 bond. That is,

$$H_0: \bar{R}_{Green} = \bar{R}_{S\&P500\ bond}, \bar{R} \text{ is the annual return of bonds}$$

Table 5.1: Annual Return of Green Bond against S&P 500 bond

	Green Bond	S&P500 bond
Annual average return	2.77%	7.28%
Annual standard error	0.94%	0.49%
t-test	$t = \frac{\bar{R}_{Green} - \bar{R}_{S\&P500\ bond}}{SE_{Green} + SE_{S\&P500\ bond}} = \frac{2.77\% - 7.28\%}{0.94\% + 0.49\%} = -3.15$	

The test rejects the null hypothesis at 5% level. That is, annual average return of Green Bond is less than that of annual average return of S&P500 bond (US companies' bond). The annual return difference is statistically significant against the corporate bond (traditional bond).

Similarly, the study extends the comparison of annual return of Green Bond against government bonds (such as global Developed bond and EU developed bond). As per Table 5.2, the test fails to reject the null hypothesis of annual return of Green Bond is equal to annual return of government bonds. Hence, the test is statistically

insignificant. Therefore, there is no difference in annual average return between government bonds and Green Bond. This seems reasonable since government is the largest issuer of Green Bond.

Table 5.2: Annual Return of Green Bond against Government bonds

	Green Bond	Developed bond	EU bond
Annual average return	2.77%	1.51%	2.23%
Annual standard error	0.94%	0.68%	1.02%
t-test	$t = \frac{\bar{R}_{Green} - \bar{R}_{Developed}}{SE_{Green} + SE_{Developed}}$ $\frac{2.77\% - 1.51\%}{0.94\% + 0.68\%} = 0.78$		$t = \frac{\bar{R}_{Green} - \bar{R}_{EU}}{SE_{Green} + SE_{EU}}$ $\frac{2.77\% - 2.23\%}{0.94\% + 1.02\%} = 0.28$

Table 5.2 assumes government bonds as a market (benchmark) in order to compare and contrast the annual average return differences. However, the return of those government bonds has been tested against the benchmark, S&P500 bond in Table 5.3.

Table 5.3: Annual Return of Government bonds against S&P500 bond

	S&P500 bond	Developed bond	EU bond
Annual average return	7.28%	1.51%	2.23%
Annual standard error	0.49%	0.68%	1.02%
t-test	$t = \frac{\bar{R}_{Developed} - \bar{R}_{S\&P500bond}}{SE_{S\&P500bond} + SE_{Developed}}$ $\frac{1.51\% - 7.28\%}{0.49\% + 0.68\%} = -4.93$		$t = \frac{\bar{R}_{EU} - \bar{R}_{S\&P500bond}}{SE_{S\&P500bond} + SE_{EU}}$ $\frac{2.23\% - 7.28\%}{0.49\% + 1.02\%} = -3.34$

The annual return analysis of Government bonds against the market is similar to the analysis of Green Bond annual average return. That is, annual return of government bonds is equal to annual return of S&P500 bond. The test rejects the null hypothesis at 5% significance level. The annual average return of the market is much higher than those of government bonds.

### 5.3.2. Risk Analysis of Green Bond with Bond

The decision of investing in certain assets depends on the level of risk the investment bears. As a rule of thumb, to earn the higher returns, an investor has to take greater risk, and vis-a-vis. Therefore, analysis of risk is one of the critical issues

in the investment analysis. This is because if an investor does not know how much risky the investment is, the probability of losing his investment or probability of no return is most likely.

Accordingly, risk of asset investment (in this case bonds specifically Green Bond) is equally likely to the risk of the market (benchmark) is the null hypothesis. That is,

$$H_0: \text{Variance of bond returns} = \text{Variance of S\&P500 bond returns}$$

Table 5.4: The F-test of two-sample variances for the Green Bond against Other bonds.

Monthly	Green Bond	Developed bond	EU bond	S&P500 bond
Average return	0.23%	0.13%	0.19%	0.61%
Variance	0.07%	0.04%	0.08%	0.02%
F	<b>3.684</b>	<b>1.914</b>	<b>4.378</b>	
P(F<=f) one-tail	3.5E-10	0.0008	2.22E-12	
F Critical one-tail	1.40	1.40	1.40	
Observations	97	df	96	

As per Table 5.4, the test rejects the null hypothesis. The risk level of all bonds whether traditional or government bonds are statistically significant and different from the benchmark (S&P500 bond). The F-statistic is greater than the F-critical value (1.40) in all cases. Therefore, Green Bond (3.68), global Developed (1.91), and EU bond (4.38) have positive and statistically significant F-statistic that reveals all bonds are riskier than the benchmark. Individual bond markets have larger risk than the market as a verification of the risk measure of volatility in earlier section.

Investment in Green Bond has higher risk than the traditional (corporate) bonds. However, the annual return of the market is higher than Green and government bonds as expected.

#### 5.4. Analysis of Risk and Returns in Relation to Stock Market

The risk-return analysis with stock is similar to the previous risk-return analysis with bonds except that the benchmark for the market here is stock (S&P500 stock).

### 5.4.1. Return Analysis of Bonds with Stock

In this analysis, the benchmark is S&P500 stock. It is important to compare bond return with stock return. This is because stocks are alternative investment opportunities. The public fact is that bond return is less than stock return. Therefore, the initial assumption is that annual average return of bonds is equal to annual average returns of S&P500 stock.

That is,  $H_0: \bar{R}_{\text{Bonds}} = \bar{R}_{\text{S\&P500 stock}}$ ,  $\bar{R}$  is the annual return of bonds and Stocks

Table 5.5: Test for Annual Return of Bonds against S&P 500 stock

	Green Bond	Developed bond	EU bond	S&P500 stock
Annual average return	2.77%	1.51%	2.23%	11.33%
Annual standard error	0.94%	0.68%	1.02%	1.42%
t-test	$t = \frac{\bar{R}_{\text{Green}} - \bar{R}_{\text{S\&P500stock}}}{SE_{\text{Green}} + SE_{\text{S\&P500stock}}}$ $\frac{2.77\% - 11.33\%}{1.42\% + 0.94\%} = -3.63$	$t = \frac{\bar{R}_{\text{Developed}} - \bar{R}_{\text{S\&P500stock}}}{SE_{\text{S\&P500stock}} + SE_{\text{Developed}}}$ $\frac{1.51\% - 11.33\%}{1.42\% + 0.68\%} = -4.68$	$t = \frac{\bar{R}_{\text{EU}} - \bar{R}_{\text{S\&P500stock}}}{SE_{\text{S\&P500stock}} + SE_{\text{EU}}}$ $\frac{2.23\% - 11.33\%}{1.42\% + 1.02\%} = -3.73$	

The test rejects the null hypothesis at 5% level for all bonds. That is, annual average returns of the bond market are less than that of annual average return of S&P500 stock. This a confirmation to the traditional convention that return on stocks is higher than return on bonds at least in short run. Hence, return on Green Bond and government bonds is statistically significant different from return on stock.

### 5.4.2. Risk Analysis of Bond with Stock

Investment decision matters for the gain or loss of money invested. The decision depends on the information set available and future expectations. This in turn relies on the probability of success and failure. Here again, the probability of failure indicates that the possibility of loss, that is, the risk associated with investment. The

possibility to earn higher returns is associated with the probability of taking greater risk.

In finance, bonds and stocks are the two main instruments. Investors may invest in either of the two according to the level of risk they assume or in both assets for risk sharing and diversifying portfolio. The basic idea is construction of null hypothesis of risk of bond return is equal to risk associated with stock returns. Specifically,

$$H_0: \text{Variance of bond returns} = \text{Variance of S\&P500 stock returns}$$

Table 5.6: The F-test of two-sample variances for Bonds against S&P500 stock

Monthly	Green Bond	Developed bond	EU bond	S&P500 stock
Average return	0.23%	0.13%	0.19%	0.94%
Variance	0.07%	0.04%	0.08%	0.16%
F	<b>0.433</b>	<b>0.225</b>	<b>0.515</b>	
P(F<=f) one-tail	2.8E-05	1.4E-12	0.0007	
F Critical one-tail	0.714	0.714	0.714	
Observations	97	df	96	

The F-test in Table 5.6 fails to reject the null hypothesis. The risk associated with bond return is the same as the risk associated with stock return in this case. The F-statistic of all bonds are less than the F-critical value. This result is neutral, so an investor may invest in either option. However, stock returns are significantly higher than bond returns.

The study used 8-year data set which is considerably short. If the time is too short, the theory suggests that the risk of bonds is less than that of stocks. However, this result is only from the variance risk measure which is influenced by the top upper side and lower downside risks.

## 5.5. Bond Yield

Bond Yield is the single interest rate that equates the present value of bond's payment to the bond's price. Yield to Maturity (YTM) is the average rate used to value and discount all the bond's payments. This is an anticipated (expected) bond yield which is different from the realized (actual) bond yield.

The YTM in Figure 5.3 shows that the yield of government bonds is less than S&P500 bond and Green Bond. Therefore, government bonds (global Developed bond and EU developed bond) are with less expected returns for investors. On the other hand, Green Bond has less yield than the US companies' corporate bond (S&P500 bond) except for some period of time. In most cases, the expected return of bond yield (YTM) of Green Bonds is lower as compared to the market benchmark. This outcome is a confirmation to the return and risk analysis (with total return data) in previous case. This indicates that government bonds including Green bear lower return than the market.

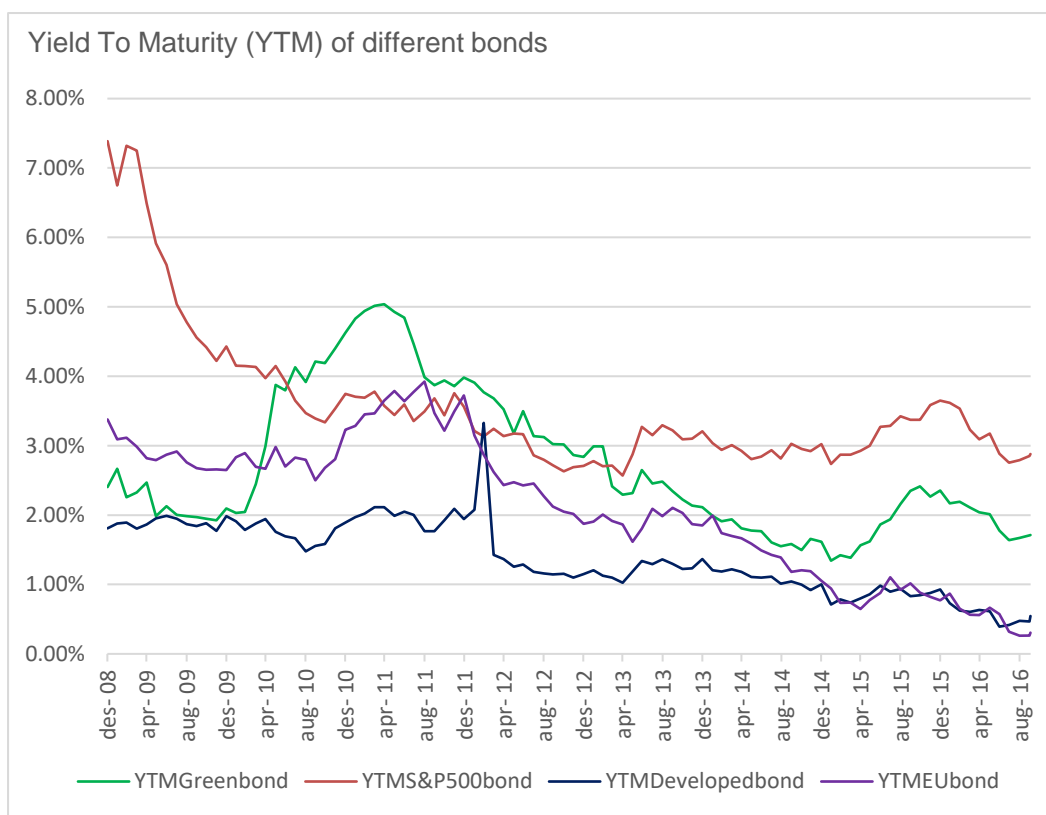


Figure 5.3: Yield to Maturity of different bonds over a period of Dec.2008 to Dec.2016

## 5.6. Yield Spread

Yield Spread (commonly known as Credit Spread) is the difference between yields on different debt instruments. Typically, yield spread shows the level of risk an asset stands. That is, the higher the risk an asset bears, the higher its yield spread. There are different measures of yield spread. Some of them are:

- ✚ Absolute yield spread = yield on bond A – yield on bond B. This is commonly known as “Yield Spread”.
- ✚ Relative yield spread = (yield on bond A – yield on bond B)/yield on bond B
- ✚ Yield Ratios = yield on bond A / yield on bond B.

Yield spread is also a typical difference between bond yield (the realized one, but not YTM) and the risk-free interest rate (US T-bill). Therefore, investors must look at the yield spread to invest on bonds. In this study, the absolute yield spread measure is used. The study applies market benchmark for yields, i.e. the 10-year Treasury Yield. Besides, the same result is obtained from S&P500 bond yield as benchmark (see Annex 5).

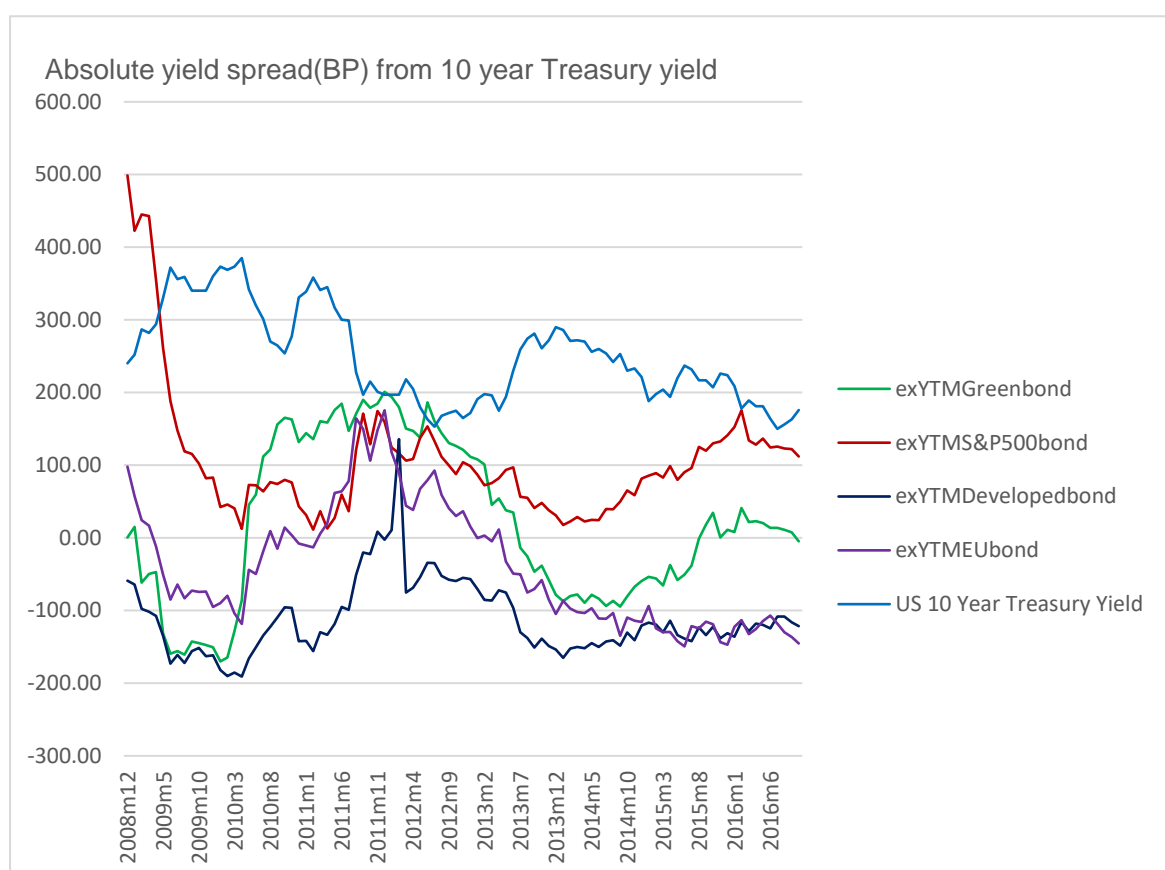


Figure 5.4: Absolute yield spread of different bonds over a period of Dec.2008 to Oct.2016 on Basis Point (BP)

As a tradition, bonds issued by large companies', a stable government and financially healthy corporations trade at a relatively low spread in relation to US Treasuries. This indicates that investors should focus on the excess yield over the risk-free interest.

Yield spread is investors' benchmark for valuing bonds so that they choose the bond with less spread. This is because an increase in interest rates for an existing bond leads to a decline in price of that bond and vice-versa.

The absolute yield spread of each bond yield is an excess of the 10-year treasury yield, the result is pretty the same as the YTM. Figure 5.4 shows that the government bonds have less absolute yield spread that indicates that government bonds have less risk content comparing to other corporate bonds.

## 5.7. CAPM - Analysis of Risk and Volatility

Risks can be diversifiable (firm specific/residual) denoted by  $\sigma_{\varepsilon_j}^2$  that is a type of risk that comes from the asset investment (in this case, bond and stock investment). On the other hand, risks can also be non-diversifiable (systematic/market) risk represented by  $\beta_j^2 \sigma_m^2$  that is raised from market problems (due to demand and supply) such as business cycle, inflation, liquidity and so on. In general, the total risk is the summation of the above two risks.

$$\sigma_j^2 = \beta_j^2 \sigma_m^2 + \sigma_{\varepsilon_j}^2 \quad (5.1)$$

In this study, the main concern is the systematic risk that measures the volatility of the day-to-day fluctuations in bond and stock markets. These risks can be captured by the fraction of proportions of R-square in a regression based models. The R-square is the proportion of the systematic risk measured by the variance. However, the variation that is not explained by the model (typically proportion of 1-Rsquare) is the unsystematic risk.

### 5.7.1. Risks and Volatility of Green Bonds in Relation to Bond

The CAPM output in Table 5.7 is helpful to investigate whether these two bonds return go together or not. Hence, S&P500 bond is the market index (benchmark). As can be seen, there is a positive and a statistically significant relationship between the two bonds. When S&P500 bond increases by 100%, then the Green Bond increase by 91%.



Table 5.7: CAPM of Green Bond on the bench mark, S&P500bond

Ex1yGreenbond	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
Ex1ySP500bond	0.9063***	0.1738	5.21	0.000	0.5612	1.2514
Constant	-0.3448	0.2461	-1.40	0.164	-0.8334	0.1437
. test Ex1ySP500bond = 1					Number of obs. = 97	
( 1) Ex1ySP500bond = 1					F (1, 95) = 27.18	
F( 1, 95) = 0.29					Prob > F = 0.0000	
Prob > F = 0.5912					R-squared = 0.2224	
					Adj R-squared = 0.2143	
					Root MSE = 2.3588	

\*\*\* Statistically significant at 1 percent level

Since R-square of the model is very low, the variation of the interest variable is not well explained by the model. Whether the systematic risk of the benchmark and the Green Bond go together, it needs a null hypothesis of  $\beta = 1$ . The test fails to reject the null hypothesis since it is statistically insignificant and is not different from 1. Unlike the variance measure of risk, CAPM reveals that Green Bond has a similar systematic risk and is equally volatile with S&P500 bond index. Hence, the output of the CAPM only shows the systematic risk. Besides, the variance measure includes upside and downside risks that does not really show the exact measure.

### 5.7.2. Risks and Volatility of Green Bonds in Relation to Stocks

This section is an extension of the variance risk measure. However, this CAPM measure is more detailed on market specific risk. It takes S&P500 stock as market index. Accordingly, there is a positive relationship between Green Bond and the stock market benchmark. Therefore, when S&P500 stock increases by 100%, the Green Bond increase by around 45% which is considerably very low.

As indicated in Table 5.8, the variation in the dependent variable (Green Bond) is not entirely explained by the model since R-square is very low (0.46). It is explained by other factors than S&P500 Stock.

Table 5.8: CAPM of Green Bond on the bench mark, S&P500 Stock

Ex1yGreenbond	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
Ex1ySP500stock	0.4478***	0.0492	9.11	0.000	0.3502	0.5455
Constant	-0.3468	0.2011	-1.72	0.088	-0.7461	0.0524

. test Ex1ySP500stock = 1		Number of obs = 97
( 1) Ex1ySP500stock = 1		F (1, 95) = 82.94
F( 1, 95) = 126.08		Prob > F = 0.0000
Prob > F = 0.0000		R-squared = 0.4661
		Adj R-squared = 0.4605
		Root MSE = 1.9546

\*\*\* Statistically significant at 1 percent level

To measure the systematic risk, the construction of the null hypothesis of  $\beta = 1$  is necessary. The test rejects the null hypothesis since it is statistically significant and is different from 1. This shows that the systematic risk of the market, S&P500 stock, is higher than Green Bond (see Table 5.8). This result from CAPM supports the public knowledge and literature in the field of finance. However, the previous measure of risk (variance related risk measure) shows no difference in risk content of bonds and stocks because it considers the upside and downside risks.

## 5.8. The Relationship between Green and Global Bond Market

The underlying assumption here is that bonds are interdependent and is evidenced from the correlation matrix (see Table 3.1) that there is a relatively high association among bonds. The study includes additional hypothesis that own previous return or price affects today's/future return or price. This is known as dynamic regression model, especially ARDL, that includes both lagged dependent and independent variables as regressors.

To deal with ARDL model, it is important to discuss and look on the specific variables of interest though the nature of the data was presented in earlier chapters. Green Bond seems to be on its usual fluctuations, and increases in net level up until 2014, but afterwards drops dramatically (seen in Figure 5.5), which is a reverse to the Moody's Investor Service (2017) issuance of Green Bond.

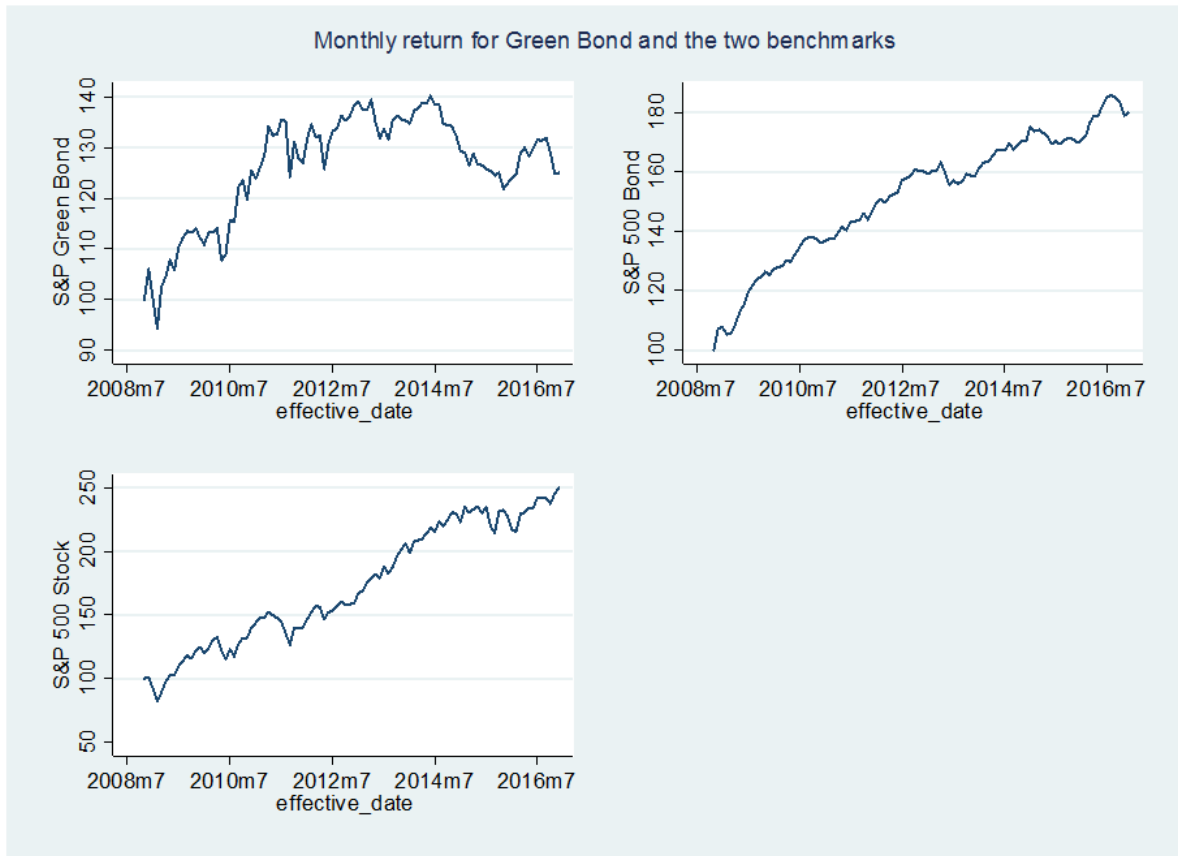


Figure 5.5: Monthly return of Green Bond, S&p500 bond and S&p500 stock over a period of Dec.2008 to Dec.2016

The return indices of the two important variables (i.e. S&P500 bond and S&P500 stock that are used as a market benchmark) are also represented in Figure 5.5. It shows that the two variables, market for bonds and for stocks, follow the trend. Besides, the graphical chart of other variables is attached in the Annex 6.

Thus, transforming the variables to log forms or difference ones is very crucial to solve the stationarity problem. This because these benchmark variables show a kind of trend or non-stationary process as depicted in Figure 5.5. This indicates that the means and variances of these variables change overtime. Therefore, the data is transformed in to log returns. That is,  $lnR_t = 100 \ln\left(\frac{R_t}{R_{t-1}}\right)$  which is specified in equation (4.1).

The graphical representation (Figure 5.6) looks more unstable specifically up until 2012 for Green Bond. There seem stochastic data series for Green Bond specifically at the beginning.

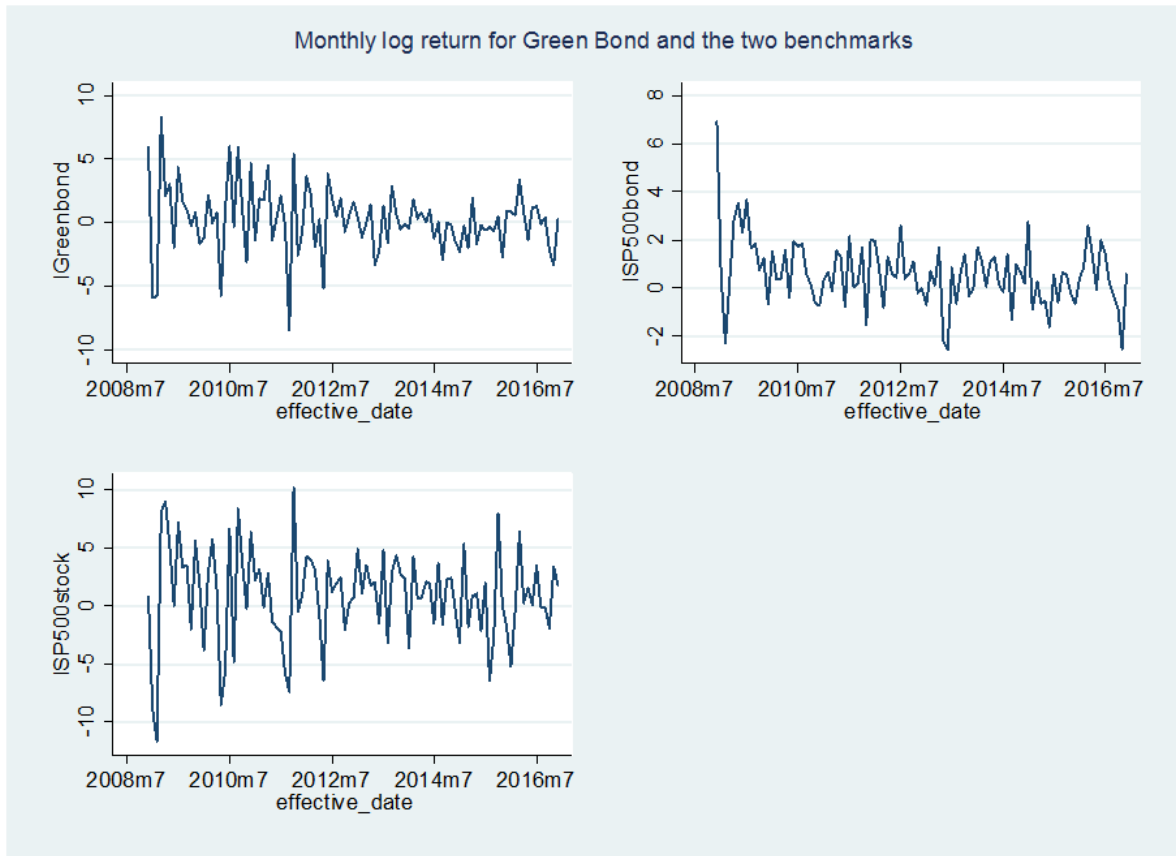


Figure 5.6: Monthly log return of Green Bond, S&P500 bond and S&P500 stock over a period of Dec.2008 to Dec.2016

The graphical representation of the market indices on Figure 5.6 looks similar to Green Bond. In general, the line graphs indicate that the data seems stochastic series. The log returns of these variables seem to have a problem of stationarity. However, it did not show the problem of trend.

To test stationarity, the study employs the Augmented Dicky-Fuller test for unit root (see Annex 1) and reveals no evidence for stationarity problems. Accordingly, the Dicky Fuller test statistic for Green Bond  $|-3.566|$  is greater than the critical value  $|-3.527|$ . Therefore, the test rejects the null hypothesis ( $H_0 = \text{unit root}$ ) and the time series data of log return of Green Bond is stationary.

The specification of the model, ARDL, for the study is presented in chapter 4. The variables of interest,  $Y_t$  and  $X_t$  are  $I(1)$  variables and their differences are also  $I(0)$ . This made the model to sustain its basic ARDL framework. The model satisfies almost all the assumptions of the time series and test results (see Annex 1 for time series post estimation tests). There seems a problem of serial correlation for the monthly return data which is a typical nature of time series in the first model.

However, there is no evidence of serial correlation for log returns. For convenience, the study applies HAC (Heteroskedasticity and Autocorrelation Consistent) standard errors to consider problems of serial correlation.

According to the model results in Table 5.9, there is statistically significant and positive effect of S&P500 bond on Green Bond. Hence, this significant and positive relationship is a confirmation to the CAPM output discussed earlier.

Table 5.9: Autoregressive Distributed Lag Model of Green Bond on S&P500 bond

Regression with Newey-West standard errors					Number of obs = 95	
Maximum lag: 8					F (5, 89) = 19.84	
					Prob >F = 0.0000	
InGreenbond	Coef	Newly- West Std. Err.	t	P>t	[95% Conf. Interval]	
InGreenbond						
L1.	-0.3049***	0.0672	-4.53	0.000	-0.4384	-0.1713
L2.	-0.1354	0.0986	-1.37	0.173	-0.3312	0.0605
InSP500bond						
--.	0.9809***	0.1462	6.71	0.000	0.6904	1.2714
L1.	0.2360	0.1615	1.46	0.148	-0.0850	0.5569
L2.	-0.2161	0.1633	-1.32	0.189	-0.5406	0.1084
Constant	-0.1950	0.2724	-0.72	0.476	-0.7361	0.3462

\*\*\* Statistically significant at 1 percent level

Accordingly, when the S&P500bond increases by 100%, Green Bond increases by around 98% which is significantly high. Green Bond's own lag affects negatively.

The construction of the null hypothesis, i.e. beta ( $\phi$ ) of S&P500bond is equal to 0 and equal to 1 yields the indication of how significant result is. Following this, HO:  $\phi = 0$  and HO:  $\phi = 1$  are the null hypotheses.

Table 5.10: Test statistic of ARDL model for Green Bond on S&P500 bond

test L.InGreenbond = 0	test lnSP500bond = 0	test lnSP500bond = 1
(1) L.InGreenbond = 0	(1) lnSP500bond = 0	(1) lnSP500bond = 1
F (1, 89) = 20.56	F (1, 89) = 45.02	F (1, 89) = 0.02
Prob > F = 0.0000	Prob > F = 0.0000	Prob > F = 0.8966

The test results reveal that the previous return of the Green Bond has a negative and statistically significant effect on the current return of the Green Bond. The increase return before one month affects negatively today's return may be due to interest rate (yield rate) adjustment. On the other hand, the market has a statistically significant effect and is different from zero. However, beta is not different from one (since  $F < 10$ ) which proves that the systematic risk of Green Bond and the market (S&P500 bond) are equally volatile as of CAPM. The market and Green Bond go together since the test fails to reject the null hypothesis.

This positive relationship between Green Bond returns and market index for bonds (S&P500bond) may be due to the reason that investors buy/invest on both bonds for diversification purposes. That is, investors put a portion of their asset on high yield bond for expectations to earn more relatively and the other portion on Green Bond to prevent empty pockets.

## 5.9. The Relationship between Green Bond and Global Stock Market

This section is an extension of section 5.8. However, the discussion on this part is on the relationship of Green Bond and the global stock market. The specifications and graphical representations of the variables of interest are discussed in the previous section as well. Hence, Table 5.11 presents the ARDL model of Green Bond and the global stock market index (S&P500 for stocks).

The lag effect of Green Bond is statistically insignificant unlike ARDL model for bond market. However, stock market has a negative lag effect (at least one month), i.e. higher previous return from stock market creates an incentive for investors to invest more on stock. This is a sound argument because future stock prices are expected to increase theoretically.

Table 5.11: Autoregressive Distributed Lag model for Green Bond on S&P500 Stock

Regression with Newey-West standard errors					Number of obs. = 95	
Maximum lag: 8					F (5, 89) = 13.01	
					Prob >F = 0.0000	
InGreenbond	Coef	Newly-West Std. Err.	t	P>t	[95% Conf. Interval]	
InGreenbond						
L1.	-0.0112	0.0700	-0.16	0.874	-0.1504	0.1280
L2.	-0.0372	0.0920	-0.40	0.687	-0.2200	0.1457
InSP500stock						
--.	0.4324***	0.0654	6.61	0.000	0.3024	0.5625
L1.	-0.1360***	0.0501	-2.71	0.008	-0.2355	-0.0365
L2.	-0.0098	0.0684	-0.14	0.887	-0.1457	0.1262
Constant	-0.0698	0.2205	-0.32	0.752	-0.5079	0.3684

\*\*\* Statistically significant at 1 percent level

The CAPM and ARDL model leads to a same outcome on the relationship of Green Bond and stock market. Hence, there is a significant and positive relationship between Green Bond and stock market, benchmark. A 100% increase in S&P500stock return leads to a 43% increase in Green Bond return.

Table 5.12: Test statistic of ARDL model for Green Bond on S&P500 Stock

test InSP500stock = 0 (1) InSP500stock = 0 F (1, 89) = 43.66 Prob > F = 0.0000	test InSP500stock = 1 (1) InSP500stock = 1 F (1, 89) = 75.20 Prob > F = 0.0000	test L. InSP500stock = 0 (1) L. InSP500stock = 0 F (1, 89) = 7.37 Prob > F = 0.0080
test L. InSP500stock = 1 (1) L. InSP500stock = 1 F (1, 89) = 514.53 Prob > F = 0.0000		

The relationship on the level of risk and volatility reveals that the bond and stock market do not go together. This reveals that there is a statistically significant difference on the systematic risk they stand (Figure 5.12). Accordingly, Green Bond has less systematic risk and is less volatile than its S&P500 stock, the benchmark. This result supports CAPM and finance theory.

The same result is obtained from individual top 25 Green companies (see Annex 7). Top 25 Green companies have positive and statistically significant effect on Green Bonds. However, the systematic risk of Green Bonds is also lower than those companies as of S&P500 stock.

### **5.10. Post Estimation Tests of ARDL**

Post estimation tests are very useful to look at how the model behaves and how the specification is satisfied (see Annex 1 for post estimation tests). Here is a summary of the post estimation tests.

The data is stationary series and has been tested using Dicky-fuller test specifically the log returns. The Model is linear in parameter (functional specification is true) checked using link test. The RESET confirms to the link test that the model does not have structural equation specification problem. The Serial Correlation is tested using the Bruesch-Godfrey test which confirms that there is an evidence of problem of serial correlation for monthly return of Green Bond, but no evidence of serial correlation for the log return of all variables. Thus, HAC is employed to correct the standard errors and consider for serial problems if any.

Furthermore, the test for Homoskedasticity using White's test reports that the data series is Homoskedastic. The distribution of error term (residuals) is plotted and looks there is no pattern. The test extends to look at the relationship of the error term and fitted values, the error term is close to zero which looks like white noise.



## Chapter Six: Conclusion

The market for Green Bond grows from time to time since 2007. It becomes one of the environmental-friendly financial instruments. The proceeds of the Green Bond are invested in low-carbon emissions, energy efficiency and in environmental sustainable development projects. Green Bond has grown and expanded tremendously. Green Bond (labelled as Green) grew very fast up until 2014. In this typical data, the return for Green Bond declined after 2014 unlike many reports by Moody's Investor Service and World Economic Forum (as described in section 5.1). However, Green Project Bond (unlabelled) grew very fast which pulled the global Green Bond up even for the period where Green labelled went down.

In dealing with the study objectives, the study has employed diverse methods of analysis from descriptive statistics (such mean-variance risk measures) through CAPM to time series econometrics model such as ARDL (presented in section 4.1 to 4.4).

The annual return of Green Bond and the benchmark (S&P500 bond) indicate a significant difference. This supported the evidence to theory that corporate bonds yield more than the government bonds (since Green Bond is mostly considered as government). A test on government bonds (against each other) including Green has been performed and there showed no significance difference. However, the test on government bonds (EU developed bond and Developed bond) against the benchmark, S&P500 bond, showed a statistically significant difference in annual returns. That is, government bonds (including Green Bond) yield a lower return than the market.

The YTM showed that the yield of Government bonds is less than S&P500 bond and Green Bond. This is in line with the annual return measure. Thus, in turn is one of the confirmations that government bonds (global Developed bond and EU developed bond) have lower expected returns. The comparison goes far about Green Bond and corporate bond (S&P500 bond), it leads to the same outcome except for some period of time. This outcome is the same as the risk and return analysis (with total return data) using different data set (YTM).

In the bonds market, government bonds including Green have experienced higher risk according to the risk-return trade-off and variance risk analysis than the bond market. This measure may not be appropriate since variance risk measure contained the upside and downside risk (section 5.2 and 5.3.2).

The study also has applied a return analysis against stock market by taking the benchmark (S&P500 stock). As expected, the annual return in the stock market (Green25 and S&P500 stock) is higher than annual return of Green Bond and other government bonds. The test also showed a significant difference at 5 percent significance level. This supported the evidence to theory that stock return yield is higher than the government bonds (since Green Bond is mostly considered as government).

The analysis has gone far to examine the risk and volatility of stocks and bonds. The evidence from the return-risk trade-off and variance risk measure showed no significance difference in risk content of bonds market relative to stocks. However, stocks indicated more fluctuation from mean return in actual measure. It would be in favour of Buffet (2012) if the time is too long, but in this study, it was not that long. The test fails to reject the null hypothesis, i.e. bonds including Green have equivalent risk content with stocks. However, variance risk measure is influenced by extreme fluctuations (typically known as upside and downside risks).

The analysis to investigate the relationship of Green Bond with bonds and stocks, the same outcome is produced from the CAPM and ARDL model, i.e. the market S&P500 bond and stock have a positive and significant effect on Green Bond (detailed presentation is in section 5.7, 5.8 and 5.9). The study has employed two CAPM and two ARDL models for the bond and stock market benchmarks. The excess return over the risk-free rate (one year US Treasury Bill rate) of Green Bond has positively and statistically significant relationship with S&P500 bond and S&P500 stocks.

The summary in Table 6.1 shows that when the corporate bonds and stocks have increased by 100%, this led Green Bond to increase by 91% and 45%, respectively in CAPM. ARDL confirms this result. That is, Green Bond increases by 98% in relation to bond and 43% in relation to stock.

Table 6.1: Comparison of ARDL and CAPM in relation to bond and stock benchmarks for Green Bond

<b>ARDL</b>		<b>CAPM</b>	
Maximum lag: 8, and Newly-West Std. Err. (in parenthesis)		Std. Err. (in parenthesis)	
InGreenbond	beta	Ex1yGreenbond	beta
InGreenbond	<b>ARDL1</b>		<b>CAPM1</b>
L1.	-0.3049***(0.0672)		
InSP500bond		Ex1yGreenbond	0.9063***(0.1738)
--.	0.9809***(0.1462)		
	<b>ARDL2</b>		<b>CAPM2</b>
InSP500stock		Ex1ySP500stock	0.4478*** (0.0492)
--.	0.4324***(0.0654)		
L1.	-0.1360***(0.0501)		

\*\*\* Statistically significant at 1 percent level

The positively and statistically significant effect on Green Bonds model in relation to S&P500 bonds could be due to two reasons. The first might be investment diversification and the second could be problem of labelling “Green” using the criteria.

The systematic risk of Green Bond was the same as the risk of the bond benchmark (S&P500 bond) in both CAPM and ARDL models. Green Bond and S&P500 bond has gone together. However, this outcome disproves the variance risk measure analysis as the latter is influenced by extreme values. Similarly, the study has gone deeply through the risk and volatility of the bond in relation to stock market. The test reveals that there is a statistically significant difference on the systematic risk they stand. This test also disproves the variance risk measure. Accordingly, Green Bond has less systematic risk and has been less volatile than its S&P500 stock. This outcome is confirmed by the CAPM and ARDL models. Financial theory supported this outcome that at least in short run, stocks are more volatile and are riskier than bonds. This is against Buffet (2012).

The ARDL satisfies almost all the assumptions of time series econometrics. In addition, HAC is used if any problem is left to correct the standard errors.

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# Annexes

## Annex 1: Post Estimation Tests of the ARDL Model

### 1. Stationarity tests using Dickey-Fuller test

```
. dfuller lGreenbond, regress lags(8)
```

```
Augmented Dickey-Fuller test for unit root          Number of obs   =          88
```

Test Statistic	Interpolated Dickey-Fuller		
	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-3.566	-3.527	-2.900

```
MacKinnon approximate p-value for Z(t) = 0.0064
```

D.lGreenbond	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
lGreenbond					
L1.	-1.274358	.3573352	-3.57	0.001	-1.985758 - .5629584
LD.	.1143776	.3379968	0.34	0.736	-.5585223 .7872775
L2D.	.0980127	.3153669	0.31	0.757	-.5298345 .72586
L3D.	.1862727	.2914716	0.64	0.525	-.3940026 .766548
L4D.	.065492	.2636819	0.25	0.804	-.4594584 .5904423
L5D.	.0044297	.2341133	0.02	0.985	-.4616542 .4705135
L6D.	.1782074	.1966331	0.91	0.368	-.2132592 .5696739
L7D.	.132445	.1479933	0.89	0.374	-.162187 .427077
L8D.	.1512113	.093494	1.62	0.110	-.0349209 .3373436
_cons	.166049	.2617642	0.63	0.528	-.3550836 .6871815

. dfuller lSP500bond, regress lags(8)

Augmented Dickey-Fuller test for unit root                      Number of obs    =                      88

Test Statistic	Interpolated Dickey-Fuller			
	1% Critical Value	5% Critical Value	10% Critical Value	
Z(t)	-3.752	-3.527	-2.900	-2.585

MacKinnon approximate p-value for Z(t) = 0.0034

D.lSP500bond	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lSP500bond						
L1.	-.8730984	.2327036	-3.75	0.000	-1.336376	-.4098211
LD.	-.0757537	.2149991	-0.35	0.726	-.503784	.3522766
L2D.	.064399	.2033515	0.32	0.752	-.3404428	.4692408
L3D.	.1526657	.1902967	0.80	0.425	-.226186	.5315173
L4D.	-.0756652	.1806025	-0.42	0.676	-.4352172	.2838867
L5D.	-.0604459	.1645987	-0.37	0.714	-.3881368	.2672449
L6D.	.0843812	.1503135	0.56	0.576	-.21487	.3836324
L7D.	.0416323	.1226841	0.34	0.735	-.202613	.2858776
L8D.	-.1756723	.0858237	-2.05	0.044	-.3465342	-.0048104
_cons	.3759866	.1748981	2.15	0.035	.0277911	.724182

. dfuller lSP500stock, regress lags(8)

Augmented Dickey-Fuller test for unit root                      Number of obs    =                      88

Test Statistic	Interpolated Dickey-Fuller			
	1% Critical Value	5% Critical Value	10% Critical Value	
Z(t)	-4.233	-3.527	-2.900	-2.585

MacKinnon approximate p-value for Z(t) = 0.0006

D. lSP500stock	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lSP500stock						
L1.	-1.651652	.3901502	-4.23	0.000	-2.428381	-.8749227
LD.	.5179281	.3592714	1.44	0.153	-.1973264	1.233183
L2D.	.3827696	.3224775	1.19	0.239	-.2592337	1.024773
L3D.	.3507915	.288363	1.22	0.227	-.2232952	.9248782
L4D.	.3168215	.2592858	1.22	0.225	-.1993769	.8330199
L5D.	.3535352	.2245121	1.57	0.119	-.093434	.8005044
L6D.	.2523039	.181493	1.39	0.168	-.1090209	.6136286
L7D.	.1068575	.1385626	0.77	0.443	-.1689995	.3827144
L8D.	.1353838	.0966595	1.40	0.165	-.0570506	.3278182
_cons	1.543832	.5548366	2.78	0.007	.439237	2.648426



## 2. Functional specification test

```
. linktest, lag(8)
```

```
Regression with Newey-West standard errors      Number of obs      =          95
maximum lag: 8                                F( 2,          92) =         17.15
                                                Prob > F           =         0.0000
```

lGreenbond	Newey-West					
	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
_hat	1.004946	.1716445	5.85	0.000	.6640455	1.345847
_hatsq	-.0071541	.0600194	-0.12	0.905	-.1263577	.1120496
_cons	.0126848	.2840221	0.04	0.964	-.5514076	.5767771

## 3. RESET Model Specification test

```
. estat ovtest
```

```
Ramsey RESET test using powers of the fitted values of lGreenbond
Ho: model has no omitted variables
      F(3, 86) =          0.50
      Prob > F =          0.6823
```

## 4. Test for Serial Correlation

```
. estat bgodfrey
```

```
Breusch-Godfrey LM test for autocorrelation
```

lags (p)	chi2	df	Prob > chi2
1	0.000	1	0.9850

H0: no serial correlation

## 5. White's test for Homoskedasticity

```
. estat imtest, white
```

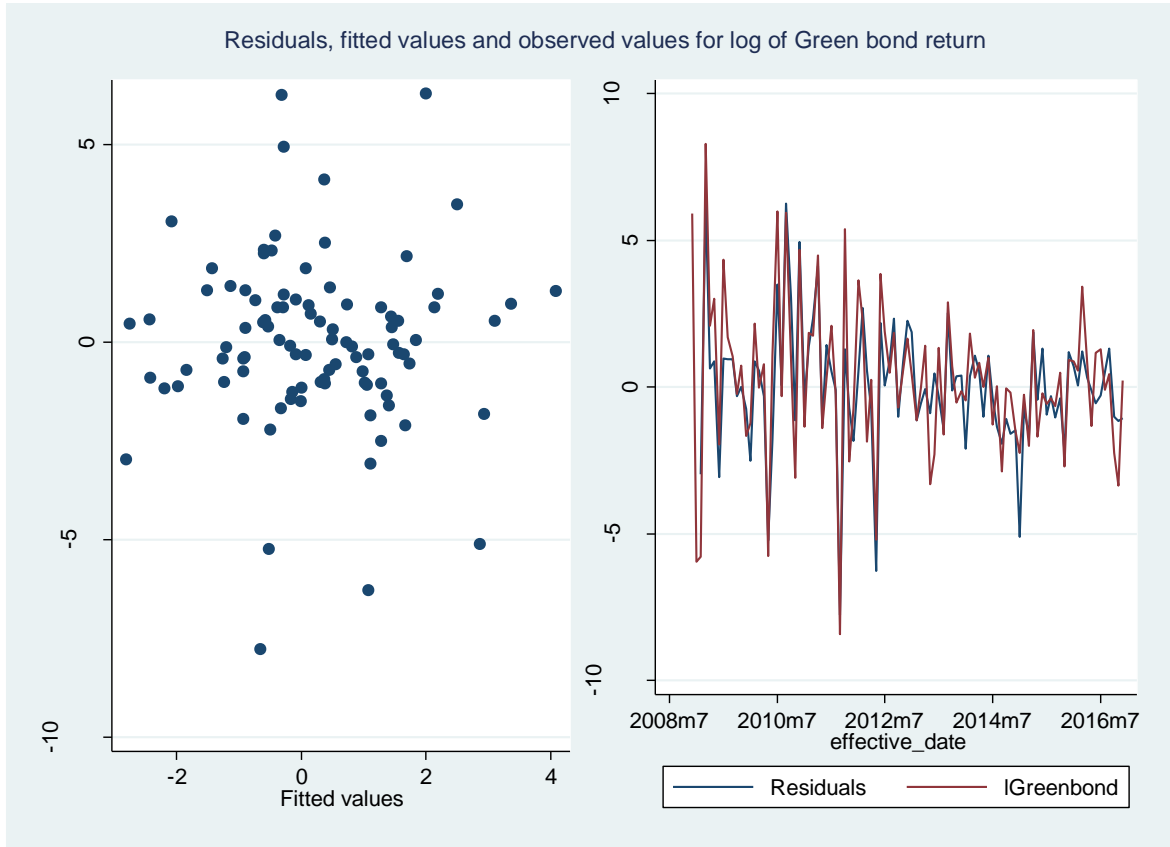
White's test for  $H_0$ : homoskedasticity  
against  $H_a$ : unrestricted heteroskedasticity

```
chi2(20)      =      16.05  
Prob > chi2   =      0.7134
```

Cameron & Trivedi's decomposition of IM-test

Source	chi2	df	p
Heteroskedasticity	16.05	20	0.7134
Skewness	1.92	5	0.8596
Kurtosis	5.68	1	0.0171
Total	23.66	26	0.5955

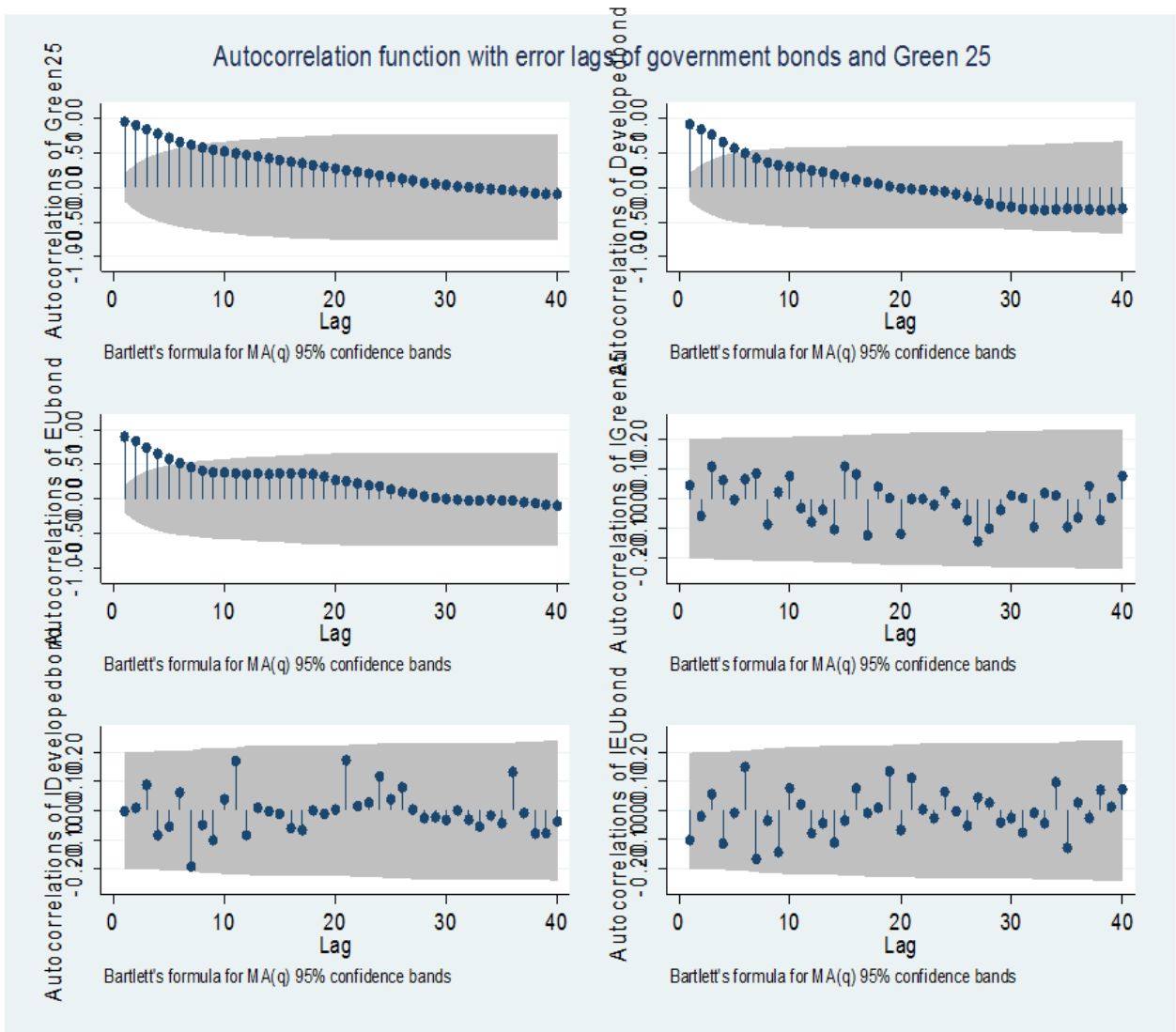
## 6. Fitted values Vs Residuals looking at the Distribution Residuals



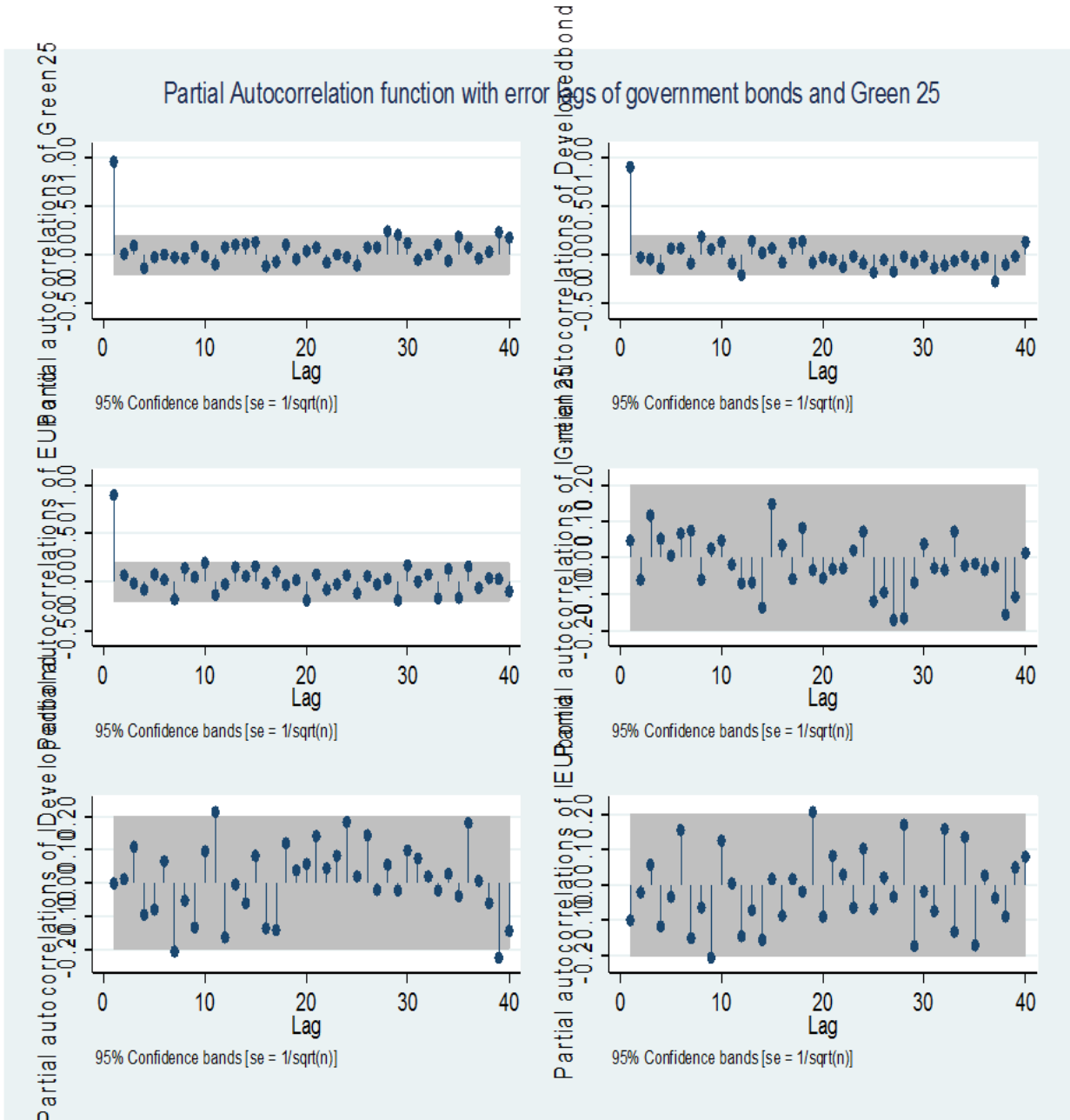
## Annex 2: Determination of lag length for Government bonds and Green stock

. varsoc Developedbond									
Selection-order criteria									
Sample: 2009m3 - 2016m12						Number of obs		=	94
lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC	
0	-296.684				32.9772	6.33369	6.34462	6.36075	
1	-195.506	202.35*	1	0.000	3.91334*	4.20226*	4.22412*	4.25638*	
2	-195.304	.40426	1	0.525	3.9804	4.21924	4.25202	4.30041	
3	-194.378	1.8529	1	0.173	3.98675	4.2208	4.26452	4.32903	
4	-193.292	2.1707	1	0.141	3.97972	4.21899	4.27363	4.35427	
Endogenous: Developedbond									
Exogenous: _cons									
. varsoc EUbond									
Selection-order criteria									
Sample: 2009m3 - 2016m12						Number of obs		=	94
lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC	
0	-329.733				66.619	7.03687	7.04779	7.06392	
1	-238.349	182.77*	1	0.000	9.737*	5.1138*	5.13566*	5.16792*	
2	-238.348	.00177	1	0.966	9.94636	5.13506	5.16785	5.21623	
3	-238.258	.17939	1	0.672	10.1412	5.15443	5.19815	5.26266	
4	-237.932	.65297	1	0.419	10.2881	5.16876	5.2234	5.30404	
Endogenous: EUbond									
Exogenous: _cons									
. varsoc Green25									
Selection-order criteria									
Sample: 2009m3 - 2016m12						Number of obs		=	94
lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC	
0	-520.722				3876.09	11.1005	11.1114	11.1275	
1	-373.403	294.64*	1	0.000	172.332*	7.98729*	8.00915*	8.04141*	
2	-373.401	.00404	1	0.949	176.033	8.00853	8.04131	8.0897	
3	-373.085	.63191	1	0.427	178.619	8.02308	8.0668	8.13131	
4	-372.129	1.9116	1	0.167	178.796	8.02402	8.07866	8.1593	
Endogenous: Green25									
Exogenous: _cons									

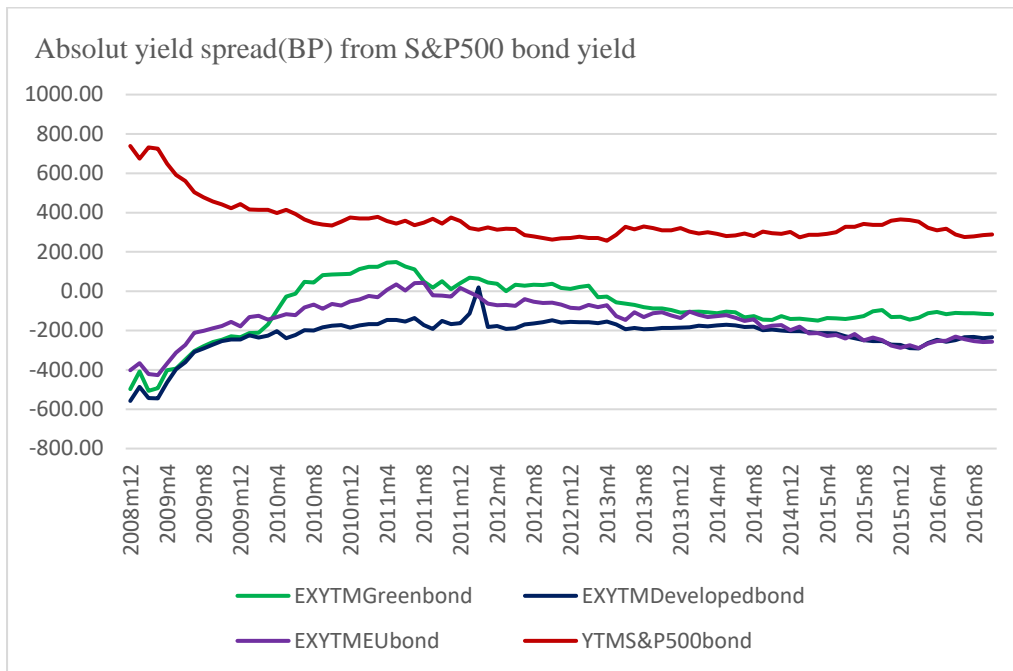
**Annex 3: Autocorrelation Function of Government bonds and Green stock (in real monthly returns and log returns)**



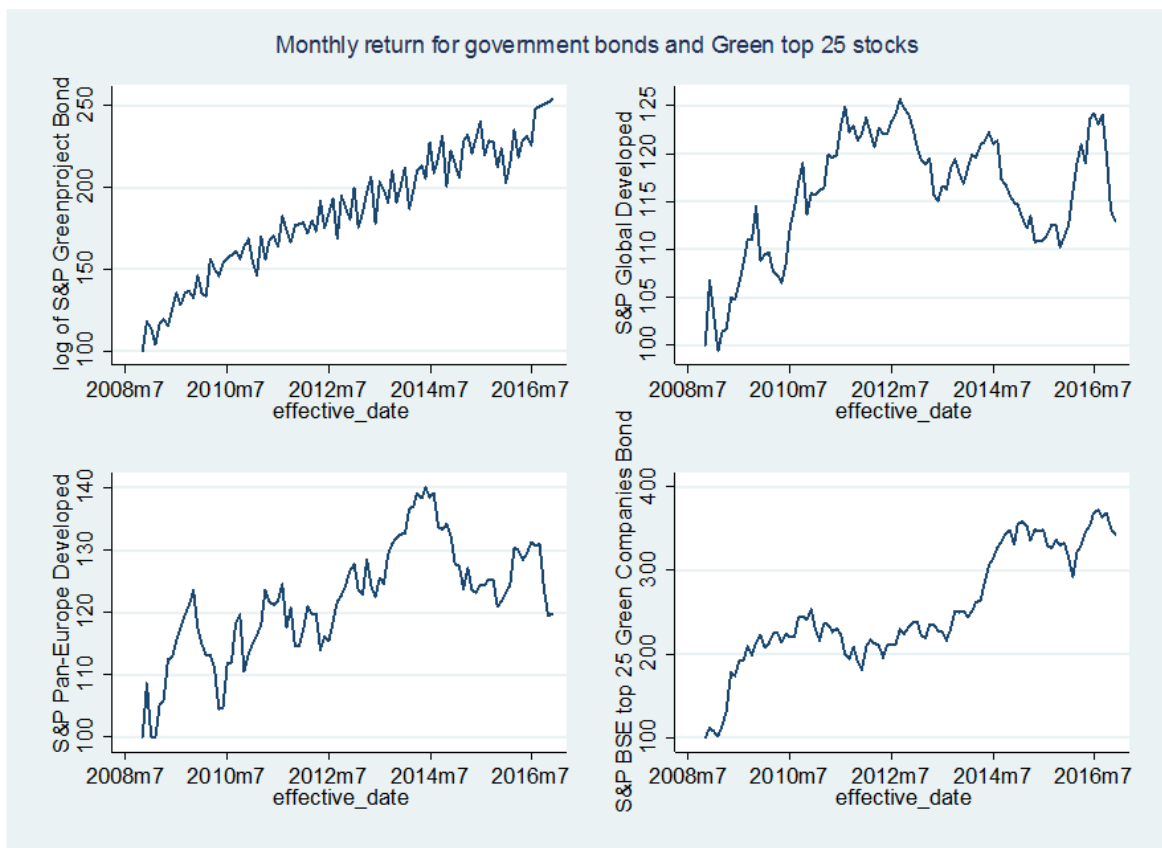
**Annex 4: Partial Autocorrelation Function of Government bonds and Green stock (in real monthly returns and log returns)**



**Annex 5:** Absolute yield spread of different bonds over a period of Dec.2008 to Oct.2016 on Basis Point (BP), S&P500 as benchmark



**Annex 6:** Monthly return of Government bonds and Green 25 over a period of Dec.2008 to Oct.2016



## Annex 7: ARDL model of Green Bond with Green stock (Green25)

```
. newey lGreenbond 1(1/2).lGreenbond 1(0/2).lGreen25, lag(8) cformat(%9.4f)
```

```
Regression with Newey-West standard errors      Number of obs      =          95
maximum lag: 8                                F( 5,              89) =         15.97
                                                Prob > F            =         0.0000
```

lGreenbond	Newey-West					[95% Conf. Interval]	
	Coef.	Std. Err.	t	P> t			
lGreenbond							
L1.	-0.1772	0.0788	-2.25	0.027	-0.3339	-0.0206	
L2.	-0.1222	0.1476	-0.83	0.410	-0.4156	0.1712	
lGreen25							
--.	0.2159	0.0357	6.05	0.000	0.1451	0.2868	
L1.	0.0169	0.0478	0.35	0.725	-0.0780	0.1118	
L2.	-0.0563	0.0552	-1.02	0.311	-0.1660	0.0534	
_cons	0.0922	0.2702	0.34	0.734	-0.4447	0.6291	



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