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YIELD PREMIUM OR DISCOUNT FOR LABELED CORPORATE GREEN BONDS

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ABSTRACT

This study examines the yield premium or discount of 14 labeled corporate green bonds. Each green bond's yield is compared to their respective issuer's yield curve during the three-month period after the green bond's announcement date. An issuer's yield curve is constructed by plotting the yield to convention mid versus modified duration mid for each comparable vanilla bond. The yield premium or discount is the difference between a green bond's actual yield and a green bond's expected yield based on a 2nd order polynomial curve fit through the set of comparable vanilla bonds. I find green bond yields do not converge and remain at their issuer's yield curve three months after the announcement date and green bonds have an average yield discount of -7.9 bps.

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Chapter 1

Introduction

Sustainable, responsible, and impact investing (SRI) is an investment strategy that incorporates environmental, social, and corporate governance (ESG) metrics and aims to provide investors with strong financial returns while promoting positive societal or environmental impact (“SRI Basics”). The SRI market has grown considerably and accounts for about 26 percent of professionally managed assets globally. From 2014 to 2016, the amount of assets professionally managed under responsible investment approaches increased by approximately 25 percent to a total of \$22.89 trillion. Europe is the largest contributor to the pool of socially-responsible investment products and holds about 52.6 percent of the SRI market. The United States is the second largest contributor with \$8.7 trillion in assets. (Allen; “Global Sustainable Investment Review 2016”).

Investors can engage in SRI through various methods such as direct ownership of stock, fixed-income products, mutual funds, and exchange-traded funds. SRI asset classes differ among markets. For example, in Canada and Europe, 33 percent of assets are invested in equities and 64 percent of assets are invested in bonds (“Global Sustainable Investment Review 2016”). The \$895 billion climate-aligned bonds market is composed of labeled green bonds, which are designated “green” by the issuer and its use of proceeds is defined to finance green assets and projects, and unlabeled “climate-aligned” bonds, which are not marked “green” by issuers but promote a low-carbon economy. Labeled green bonds are about one-third of the size of unlabeled “climate-aligned” bonds (Boulle).

What is a Green Bond?

Green bonds are fixed-income instruments whose proceeds are dedicated towards a green or an environmentally-friendly project such as clean water, renewable energy, energy efficiency, sustainable land use, waste management, and clean transportation (Ahuja and Mackay). There are four types of green bonds, which include Green Use of Proceeds Bonds, Green Use of Proceeds Revenue Bonds, Green Project Bonds, and Green Securitized Bonds.

- Green Use of Proceeds Bonds - Green Use of Proceeds Bonds are similar to traditional bonds by offering full recourse to the issuer and sharing the same credit rating as the issuer. Proceeds are earmarked for green projects (“Explaining Green Bonds”).
 - Example: In October 2017, The International Finance Corporation issued a 5-year \$1 billion AAA-rated green use of proceeds bond focused on climate-smart finance in emerging markets (Symons).
- Green Use of Proceeds Revenue Bonds - Green Use of Proceeds Revenue Bonds offer non-recourse to the issuer and repays investors based on a revenue stream such as tolls, fees, and taxes. The proceeds are earmarked for green projects (“Explaining Green Bonds”).
 - Example: In February 2016, the Metropolitan Transportation Authority (MTA) issued a \$782.5 million Transportation Revenue Green Bonds, Series 2016A to renovate New York City Transit, Long Island Railroad, and Metro-North Railroad. The MTA’s operating revenues and state subsidies pledged to MTA will be used to repay investors (“MTA to Issue...”; “Metropolitan...”).
- Green Project Bonds - Green Project Bonds offer recourse or non-recourse to the issuer. They expose the investor directly to the risk of the project so they often are structured so

there is recourse to the issuer on the project's assets and balance sheet. Proceeds are earmarked for specific green projects ("Explaining Green Bonds").

- Example: In November 2017, Canadian Solar Inc. issued a dual-tenor ¥7.4 billion A-rated green project bond to finance Canadian Solar's 27.3 MWp Tottori Solar Power Plant in Tottori Prefecture, Japan ("Canadian Solar Raises...").
- Green Securitized Bonds – Green Securitized Bonds offer recourse to the issuer through a collection of projects that have been grouped together. Small-scale projects may not be large enough to access the bond market so combining them into bigger collections can reach other investors. They use underlying projects such as covered bonds, ABS, and other structures as collateral. The revenue generated by the assets is usually used as repayment to investors. Proceeds are earmarked for green projects or put directly into the underlying green project ("Explaining Green Bonds").
 - Example: In October 2017, Mosaic issued \$307.5 million worth of green securitized bonds with four tranches of residential solar loans. They are supported by a collateral pool of \$275 million of loans with an average FICO score of 738 ("Mosaic Closes...").

History of Green Bonds

In July 2007, the European Investment Bank (EIB) issued a €600 million Climate Awareness Bond focusing on renewable energy and energy efficiency ("History"). While the EIB introduced the idea of earmarking bond proceeds for environmentally-friendly initiatives, the first labeled green bond was issued by the World Bank in 2008. This was created in

partnership with Skandinaviska Enskilda Banken because there was increasing demand from Scandinavian pension funds to invest in ways that promote a cleaner and more climate-resistant world (Reichelt and Keenan). Initially, the green bond market was mainly for select institutional and retail investors. From 2007 to 2012, the global green bond issuance volume by supranational issuers, agencies, and public development banks totaled approximately \$8.4 billion (Azoulay, et al.).

However, the popularity and availability of green bonds began to grow quickly after the entrance of corporate issuers. The first corporate green bond was issued in November 2013 by The Environmental Defense Fund, Bank of America, and Vasakronan. Total market size grew to \$11 billion in 2013, tripled in size to \$36.6 billion in 2014, and reached \$87.2 billion in 2016 (“History”). Since 2007, the market has grown at over 50 percent compound annual growth rate (Kochetye and Jauhari).

In 2017, global green bond issuances increased by 78 percent compared to the previous year by reaching a record \$155.5 billion (Chestney). Of the \$155.5 billion, the United States, China, and France contributed to roughly 56 percent of the total issuance. Over \$221 billion in green bonds were outstanding in 2017 (Boulle).

There is growing concern about regulation limiting corporations from raising green-labeled finance in the US markets. When issuing bonds in the United States, corporations must comply with the Securities and Exchange Commission’s Rule 144a. Rule 144a has strict liability and disclosure standards that expose issuers to potential legal risks. In contrast, when issuing offshore, issuers must comply with Regulation S. Regulation S is less stringent in disclosing the use of proceeds and commitments are less legally binding compared to Rule 144a. In the future, additional corporations may avoid issuing in the US market in fear of litigation risks (Allen).

While the green bond market is relatively new and miniscule with compared to the global outstanding bond market of roughly \$92.2 trillion, it appears there is a growing interest and investor demand for green bonds in the financial markets (Brandon, et al.).

Green Bond Issuers and Investors

When green bonds were first introduced to the market in 2007, the primary issuers were supranationals like the World Bank or European Investment Bank since they already had procedures for assessing ESG risks for projects. However, greater diversity of issuers has developed and now often includes multilateral development banks, countries, corporations, municipalities, and government agencies. According to the Climate Bonds Initiative, in 2017, there were 239 issuers of labeled green bonds who covered over 37 countries and 90 percent of the green bonds issued came from issuers other than multilateral development banks (Reichelt and Keenan; Whiley). The top five issuers were the United States, China, France, Germany, and Supranationals. Furthermore, emerging economy issuances were supported by China and India. China has historically been a large issuer due to the country's growing awareness for environmental issues, which has influenced the country's policy and financial decisions ("Green Bonds Highlights 2016").

Green bond issuers can be classified into two groups. One group is focused on using the proceeds from green bonds to finance environmental initiatives. In 2017, proceeds were most commonly used to finance renewable energy. Waste management, land use, and adaptation initiatives remain the smallest investment areas since it is difficult determining which types of projects qualify. The other group of issuers recognizes an opportunity to use green bonds as a

communication tool. By offering green bonds, issuers can increase awareness of their activities, promote and mobilize financing for environmental sustainability, diversify their investor base, and engage investors who may not have normally considered their other bond offerings (Azoulay, et al.). However, as described in Chapter 2, issuers may incur additional costs associated with labelling, certification, reporting, verification, monitoring requirements, and other administrative costs for their green bonds (Kaminker).

Investors can be divided into five categories, which include mainstream institutional investors (e.g., BlackRock, State Street), sovereign and municipal governments (e.g., California State Treasurer), specialist ESG and responsible investors (e.g., Natixis, Mirova), corporate treasury (e.g., Barclays), and retail investors (e.g., retail investors through wealth managers) (“Investor Appetite”). In each of these categories, investors may invest in green bonds in order to help finance a more climate-resistant world while also creating new dialogue and avenues for engagement among bondholders (Azoulay, et al.). Originally, the first green bondholders were investors with strong environmental focuses, but it has since expanded to broader groups (“Who Buys Green Bonds?”). For investors who have a growing desire for their investments to have a positive impact, green bonds have begun to be accepted as an ideal investment vehicle for fixed-income impact investing (Reichelt and Keenan).

Chapter 2

Labeling Green Bonds

As the green bonds market began to develop, the lack of a uniform definition and standard created uncertainty as to what makes a green bond eligible to be labeled as green. The inconsistencies in a green bond's requirements can lead to "greenwashing", the concern that proceeds are not used for their intended purpose or that an issuer is promoting environmental initiatives but actually operating in ways that are still detrimental to the environment (Kaminer; Trompeter). For instance, energy companies that traditionally burn coal, which is a highly polluting practice, may issue a green bond to fund a clean coal project. Clean coal usually refers to carbon capture and storage where carbon dioxide is captured before being emitted and then buried underground. However, clean coal is misleading because it is still significantly dirtier than other sources of electricity such as natural gas, wind, or solar (Plumer). Another example includes major oil producers. In May 2017, Repsol SA issued a five-year €500 million green bond to enhance refinery facility efficiencies in Spain and Portugal and to reduce methane emissions. The green bond community was conflicted on whether the green bond deserves the green label. While upgrading facilities reduces carbon emissions compared to its current operations, supporting an oil producer's green bond may extend the use of fossil fuels and undercut efforts to slow global warming. Alternatively, investors may prefer for the green bond proceeds to be used for zero-emission renewable technologies such as solar instead of fossil fuels (Chasan). In both cases, there is a concern for greenwashing since corporations associated with negatively impacting the environment are raising funds for initiatives that continue to harm, but are still more beneficial than their current state of operations.

As a relatively new investment vehicle, there is conflict between creating guidelines that are too stringent that may restrict growth of the market and standards that are too loose that may lead to excessive greenwashing. However, in order to increase transparency for investors in the green bond market, about 80 percent of issuers in 2016 were willing to report the use of proceeds and environmental impact as well as be reviewed by an external party (Linsell). There is currently no single regulator responsible for defining and labeling bonds as green, but the two existing guidelines are The Green Bond Principles (GBP) and Climate Bonds Standard and Certification Scheme (CBS&CS).

The Green Bond Principles

The Green Bond Principles are voluntary process guidelines created in 2014 by a draft committee composed of four banks, which included Bank of America Merrill Lynch, Citi, Cr dit Agricole Corporate and Investment Banking, and JPMorgan Chase, to promote transparency and disclosure for the issuances of green bonds. The International Capital Market Association (ICMA) serves as an independent third party to perform administrative duties and manage the information exchanges between issuers, investors, underwriters, and other stakeholders (Kidney). Issuers can use these standards as a reference for issuing a credible green bond and investors can use the increased reporting to evaluate the impact of their investment. The GBP identifies ten areas that are appropriate for a green bond issuance, which include energy efficiency, renewable energy, environmentally sustainable management of living natural resources and land use, terrestrial and aquatic biodiversity conservation, pollution prevention and control, sustainable water and waste management, clean transportation, climate change adaptation, green buildings,

and eco-efficient and/or circular economy adapted production technologies and processes. Green bonds are evaluated on four key elements, which include the use of proceeds, process for project evaluation and selection, management of proceeds, and reporting. While numerical scores are not prescribed to a green bond based on how well it satisfies each of the four elements, external reviewers such as consultants or institutions with expertise in environmental sustainability, auditors, certification against an external green assessment standard, or rating agencies can be used to validate the green bond aligns with GBP ("The Green Bond Principles 2017").

Climate Bonds Standard and Certification Scheme

The Climate Bonds Standard and Certification Scheme was created by the Climate Bonds Initiative, an international non-profit organization whose goal is to encourage investments in the green and climate bond market to promote a more low-carbon economy. CBS&CS has two parts; the first is the Climate Bonds Standard and the second is the Certification Scheme. The Climate Bonds Standard provides pre-issuance and post-issuance requirements on use of proceeds, tracking, and reporting to verify a bond's green qualifications and acknowledge the funds are used to finance projects and assets that support a more sustainable environment. A bond must meet the Climate Bonds Standard in order to be eligible for the Certification Scheme. The Certification Scheme is a voluntary process where issuers pay a fee and select verifiers approved by the Climate Bond Initiative to confirm the bond meets The Climate Bonds Standard. Being certified provides confidence to issuers, investors, and other stakeholders that the bond meets industry standards in green characteristics, management, and transparency. Complying with the Climate Bonds Standard and Certification Scheme aligns fully with the Green Bond Principles,

specifies eligibility for green projects and assets, and requires certain procedures for use of proceeds, tracking, and reporting (“Climate Bonds Standard: Version 2.1”).

The voluntary nature of the guidelines currently provides a helpful framework for issuers and investors to assess the credibility of a green bond in the early stages of the market. However, as the market expands and various types of new projects emerge, more definitive standards and robust reporting may be necessary to regulate and enforce the integrity of these investments.

Rating Agencies and Second-Party Opinions

In addition to existing guidelines like GBP and CBS&CS, other forms of verification by rating agencies and second opinions by an independent reviewer assess issuance frameworks, green credentials, the management of use of proceeds, reporting, and environmental performance. Rating agencies include Moody’s and S&P. Second-party opinions include Center for International Climate and Environmental Research (CICERO), Sustainalytics, and Vigeo Eiris.

Moody’s Green Bond Assessment (GBA) uses an issuer’s offering documentation, regulatory filings, presentations, and other public information to provide an opinion on an issuer’s management, administration, and reporting on environmental projects funded by green bonds. The assessment uses five key factors: organization, use of proceeds, disclosure on the use of proceeds, management of proceeds, and ongoing reporting and disclosure. Each factor is weighted and is scored from one to five, where one is the highest rating. The composite score results in a grade from GB1 (Excellent) to GB5 (Poor). It is important to note the Green Bond

Assessment is not a credit rating and instead applies to the green bond issue, not the bond issuer (Shilling).

S&P Global Ratings Green Evaluation considers both existing frameworks and the environmental impact of green bond issuances. The Green Evaluation uses a weighted aggregate of three categories: transparency, governance, and mitigation or adaptation. The first category is transparency, which examines the use of proceeds and the overall reporting comprehensiveness. The second category is governance, which surveys the process for managing proceeds and measuring environmental impact. The third category is either mitigation or adaptation. Mitigation is used if the project relates to bringing environmental benefits in areas such as pollution control, biodiversity, natural resource depletion, and climate change. A baseline scenario is used to estimate a project's positive or negative environmental impact. Adaptation is used if the project relates to reducing exposure to natural disasters and making areas more climate resilient. The final Green Evaluation is on a scale of 0 to 100 where a higher score indicates stronger environmental impact. S&P Global Ratings Green Evaluation differs from other second opinions since it incorporates the environmental net-benefit of the projects ("S&P Global Ratings Green...").

CICERO, a Norwegian institute associated with the University of Oslo for interdisciplinary climate research, created the Shades of Green methodology. The methodology uses an issuer's documentation on sustainability or environmental policies, reporting procedures, and information gathered from meetings and correspondence to provide a qualitative assessment of a green bond's effort to promote environmental sustainability and a low-carbon economy. The ratings range from dark green to brown. Dark green is often given to zero-emission initiatives and refers to projects that are consistent with a long-term focus. Medium green is awarded to

projects that are taking steps toward the long-term future solutions, such as hybrid vehicles.

Light green is designated to programs that are currently environmentally friendly in the short-term, but will likely not exist in the long-term such as improving energy efficiency in fossil fuel processes. Lastly, brown projects do not promote environmental sustainability (“Framework for CICERO’s...”).

Sustainalytics specializes in helping investors incorporate ESG and Corporate Governance considerations into the investment process. For bond issuers, the firm provides guidance on developing frameworks that align with the GBP, conducts second-party opinions to ensure green bond proceeds are allocated properly, reviews bonds annually for consistent compliance in the management and reporting of green bond use, and serves as a certified verifier for the Climate Bonds Standard and Certification Scheme (“Green & Social Bonds Services”).

Vigeo Eiris focuses on creating greater ESG awareness in society. For green bond issuers, Vigeo Eiris examines the issuer’s ESG risks and mitigation strategies, reviews the project selection, fund allocation, and reporting process, expresses opinions on the social and environmental impacts of projects, delivers second-party opinions to align with the GBP, and serves as a CBS&CS verifier (“Green and Social Bonds/Responsible Bonds”).

As the green bond market continues to develop, rating agencies and second-party opinions will play a key role in ensuring integrity and credibility for stakeholders who want to promote the transition to a low-carbon, climate-resilient economy.

Chapter 3

Literature Review

Anthropogenic emission of greenhouse gases (GHG) is a contributing factor in climate change. Global carbon emissions are projected to increase in 2017 by around two percent, equivalent to approximately 41 billion metric tons (Welch). As part of a global effort to combat the negative effects of climate change, representatives from 175 countries ratified an agreement within the United Nations Framework Convention on Climate Change called the Paris Agreement (United Nations...). The Paris Agreement aims to prevent global temperatures from rising two degrees Celsius above pre-industrial levels by using greener energy sources, reducing carbon emissions, and committing financial resources towards building a more climate-resilient future (Domonoske). In addition to developed countries assisting developing countries to fund climate initiatives, investors are becoming more aware and supporting the fight against climate change. For example, according to an HSBC survey conducted in 2017 across corporations in Europe, the Americas, Asia, and the Middle East, “68% of investors plan to increase their climate-related investment” (Harris). In particular, one method is through green bonds. As a financial product designed to contribute positively to the environment, it is important to understand the financial and environmental value from an issuer and investor perspective. The remainder of the literature review will explore green bond financial performance and environmental impact.

Financial Performance

As a relatively new market, research on the financial performance of green bonds is inconclusive. When green bonds are compared to equivalent traditional (normal or vanilla) bonds, studies have shown green bonds offer a similar, higher, or lower yield. In a study conducted by Natixis, researchers observe the behavior of green bonds denominated in Euros by investment-grade corporate issuers from the primary market and secondary market perspective. On the primary market, the green bond yield premiums over secondary spreads are similar to secondary spreads on a new standard senior debt issue. On the secondary market, no significant difference in yield or volatility is found between the same issuer's green bond and a normal bond with the closest maturity (Azoulay, et al.). From an issuer perspective, it appears there is no financial benefit of issuing this product if investors are not charged a higher price. From an investor perspective, receiving a similar yield suggests there is no sacrifice or downside for investing green.

Furthermore, a study conducted by Antoniya Petrova investigates the returns of green bond indices compared to their mainstream counterpart using a time-series and panel data analyses in a multi-index model framework during the period of 2008 – 2016. The time-series analysis consistent with Fisher, Jensen, and Scholes (1972) measures excess returns for the S&P Green Bond Index, S&P Green Bond Project Index, and Solactive Green Bond Index compared to normal indices. The panel data analyses investigates the excess returns for five indices, which include S&P Green Bond Index, S&P Green Bond Project Index, S&P US Aggregate Bond Index, BofA Merrill Lynch US Corporate AAA Total Return Index, and BofA Merrill Lynch US Corporate Master Total Return Index. In both cases, there is no significant difference in yields between the two types of bonds (Petrova). While Petrova's study is conducted on a basket of

bonds instead of individual bonds, it reinforces the similarities between green versus vanilla bonds and furthers the discussion on the existence of these products if no financial benefit is gained by issuers or investors.

Alternatively, a study by Karpf and Mandel investigates green versus brown US American municipal bonds. The green municipal bonds included in the sample are those labeled as green bonds in the Bloomberg Terminal. By comparing and analyzing the spread between an issuer's green municipal bond and brown municipal bond, the study finds green bonds are trading at lower prices and a higher yield than expected based on the credit profile (Karpf). From an issuer perspective, it is unclear why a green bond would be issued if the municipality could raise a greater amount of funds by issuing a brown bond to finance the same green project. As an investor, it is more beneficial buying green bonds instead of brown bonds since one would receive a greater return while also financing a green initiative. Potentially over time as demand for green bonds increases, the yield will eventually decrease to a point where investors are sacrificing yield to invest green.

In contrast, research conducted by Barclays compares the Global Credit Index with the Global Green Bond Index by running regressions on credit spreads that decomposes option-adjusted spread (OAS) into common risk factors and an indicator variable for green bonds. While investors are willing to pay a price premium of about 20 bps potentially based on strong demand, green bonds have historically earned returns similar to normal bonds (Preclaw). It is advantageous for an issuer to sell green bonds for a higher price while offering a yield similar to a traditional bond. However, investors are worse off financially. Instead of buying the cheaper normal bond, they are paying more for a green bond to earn a comparable return. Paying a price

premium may be warranted if the investors believe they receive additional intangible value like psychological benefits.

In addition to investors paying a premium, a couple of studies have shown green bonds offer a lower yield. For example, Olivier Zerbib estimates the difference in yield between green bonds issued worldwide that comply with the Green Bond Principles and a similar synthetic normal bond. Zerbib uses a matching method to match each of the 135 Investment Grade senior bullet fixed-rate green bonds with synthetic bonds that have identical characteristics except for liquidity. Across the entire sample, the green bonds offer a yield significantly negative of -8 bps, especially in green bonds issued in EUR and USD with issue amounts greater than 100 million USD (Zerbib). As an issuer, the negative premium is beneficial as it lowers the cost of capital to fund green projects. Compared to Preclaw's study, investors are sacrificing additional returns. However, the lower yield is inconsistent with other studies and it does not indicate why investors are willing to accept less cash flow. The incentives behind these disparities are unclear, but may be revealed as the green bond market continues to develop.

The Climate Bonds Initiative began publishing quarterly reports on green bond pricing data in the primary market in 2016. In Q2 2017, 101 labelled green bonds were issued, but the sample includes only 19 USD and EUR bonds from both developed and emerging markets. Green bonds are evaluated on the initial price talk (IPT), order book subscriptions, spread in the secondary market, performance against an index, and issue premiums. When observing the IPT and order book, each green bond was compared to a corresponding vanilla basket that shared similar rating and sector characteristics. Compared to the IPT, green bonds in USD showed larger price movements than the market average. In addition, both USD and EUR green bonds were oversubscribed, but their metrics were line with the market. On the day a bond begins

trading on the secondary market, the price generally increases. This study observes the prices 7 and 28 days after announcement and finds green bond prices behave no differently than a normal bond. When compared to indices, EUR green bonds over performed while USD green bonds were mixed. Lastly, the new issue premium is the additional yield an investor receives when compared to vanilla bonds from the same issuer. Again, the results were mixed where some bonds offered new issue premiums while others did not. This pattern is no different from the normal bond market (Harrison). Overall, the results indicate there is no discernible difference among green bonds and vanilla bonds. However, it is evident the green bond market is growing in issuance amount and investor demand. Without consistent evidence of financial benefits for issuers and investors, the reason for the growing popularity of green bonds is still uncertain (Harrison and Boulle).

Environmental Impact

In addition to financial performance, another aspect of green bonds is the environmental impact. While green bonds are supposed to finance an issuer's green initiatives, the voluntary nature of reporting and transparency makes it difficult to determine the effect on the climate. Minimal research has been conducted on the environmental value so far. According to research by the Institute for Climate Economics, "There has been little evidence that green bonds attract new financing beyond what would have been available through traditional bonds. Most of existing green bonds and their underlying projects were likely to have occurred whether the bond issued to finance them was labeled as 'green' or not" (Shishlov, et al.). If the underlying projects would have occurred regardless of the green label, then issuers' primary motive may not be the

environmental value, but rather more about finding the most effective way to obtain funds or reach different sets of investors. Furthermore, if investing in the green label does not create additional green projects, then investors' priority may not be on making a positive environmental change.

Issuers recognize investors' growing desire for transparency and they are beginning to monitor the environmental effects of projects financed with green bonds and the amount of avoided greenhouse gas emissions from their portfolios (Shishlov, et al.). The lack of a formalized framework for measuring and disclosing environmental effects may impact the credibility of the market. In addition to weighing the financial benefit, investors may have different preferences for environmental impact that influence the way they ultimately make investment decisions. Providing metrics that evaluate the environmental value can be useful for issuers to attract certain groups of investors and for investors to verify that their investments are achieving the desired effect.

One way to measure the environmental impact is through the Carbon Yield Methodology, a framework created by Lion's Head Global Partners, ISS-Ethix, and Affirmative Investment Management and funded by The Rockefeller Foundation. The Carbon Yield Methodology quantifies the Potential Avoided Emissions (PAE) per unit of investment per year. In order to establish the PAE, the reduction in tons of carbon dioxide equivalents (tCO₂e) associated with a project may be calculated by the issuer or a third-party. Carbon yield is different from carbon credits or renewable energy certificates (RECs) because it does not hold any monetary value and is non-tradable. Instead, its purpose is to allow issuers and investors to quantify and communicate the environmental value of a green bond ("Carbon Yield Methodology"). The Carbon Yield Methodology, if accurate and reliable information is disclosed by issuers or third-

parties, can increase transparency and further establish integrity in the green bond market. The initial effort to express environmental value to investors has the potential to stimulate the growth of the market in the long-run.

Beyond GHG emissions, other measures of environmental impact may include renewable energy capacity, number of households potentially powered by energy generated, water conserved, and waste diverted (Sokol). There are many ways to assess different aspects of environmental impact, but it ultimately depends on issuers' willingness to disclose the appropriate data. The lack of environmental disclosures may not necessarily be due to issuers' unwillingness to share. Instead, the financial and environmental stakeholders may not be aligned to a common goal yet and over time, the qualitative perspective through guidelines like The Green Bond Principles and the quantitative standpoint like the Carbon Yield Methodology could connect.

Numerous studies on the financial performance of green bonds versus vanilla bonds appear to be inconclusive and the environmental value of green bonds is in its developmental stages. The reason for the existence of green bonds is still unclear because the incentives from an issuer and investor are inconsistent. For issuers, the green bond may be priced at a premium and other instances it may be priced lower than expected despite similar credit ratings. For an investor, returns may be comparable, higher, or lower than a normal bond. Even though the proceeds from green bonds are dedicated toward environmentally-friendly projects, the method of measuring and quantifying the environmental value for issuers and investors is not fully established. As the demand and market for green bonds continues to grow, a clearer representation of the behavior of green bonds financially and environmentally will emerge.

Chapter 4

Description of Methodology

The Climate Bonds Initiative's report on green bond pricing in the primary market uses an issuer's yield curve created from its vanilla bonds to investigate whether investors receive a new issue yield premium for green bond issuances. The report examines the yield premium only on the announcement date of the green bond and found no distinguishable difference between green bond and vanilla bond issuance premiums. However, regardless of a corporate green bond's deviation from the issuer's yield curve on the announcement date, I believe the green bond will converge and remain at the issuer's yield curve within three months.

Corporate Green Bonds Data

I use the Bloomberg Terminal to compile all mature and active labeled green bonds as of 02/08/2018. The "use of proceeds" field is marked with "Green Bond/Loan" to identify labeled green bonds. Bonds receive this tag when an issuer self-labels its bond as "green" or demonstrates the bond is committed to deploying funds toward environmental sustainability. Furthermore, the bond must comply with the Green Bond Principles on the use of proceeds where 100 percent of the funds are dedicated to finance GBP's approved activities ("The GBP Databases").

Next, I only include labeled green bonds whose Bloomberg Industry Classification System is "Corporates" and is denominated in USD or EUR since bonds are most commonly issued in these two currencies. Lastly, I convert issuance amounts to USD for comparison purposes. 128 labeled corporate green bonds satisfy the listed criteria. Since not all issuers have

enough comparable vanilla bonds, the sample for this study includes 14 labeled green bonds and 7 issuers as seen in Appendix A.

For each labeled green bond, I populate the Bloomberg ID, Issuer Name, Security Name, Announce Date, Issue Date, Maturity, Maturity Type, Amount Issued, Price at Issue, Yield at Issue, Coupon, Coupon Type, Currency, Bloomberg Composite Rating, and Payment Rank.

Comparable Vanilla Bonds Data

I use the Bloomberg Terminal to compile all active vanilla bonds for each green bond issuance in my sample. The same issuer issues the vanilla bonds and green bonds. Each issuance's comparable vanilla bonds must be active between the green bond's announcement date and three months after the announcement date. The vanilla bonds have issuance amounts greater than \$100 million, fixed coupon payments, and share the same currency, Bloomberg Composite Rating, and payment rank as the corresponding green bond.

For each vanilla bond, I populate the Bloomberg ID, Issuer Name, Security Name, Announce Date, Issue Date, Maturity, Maturity Type, Amount Issued, Price at Issue, Yield at Issue, Coupon, Coupon Type, Currency, Bloomberg Composite Rating, and Payment Rank.

Methodology

To compare a green bond's yield to its issuer's yield curve, I use a similar approach to the methodology in Bouille and Harrison's report, "Green Bond Pricing in the Primary Market: April – June 2017". The issuer's yield curve is constructed by plotting each comparable vanilla bond's yield to convention mid versus modified duration mid. Yield to convention mid is the lowest

yield based on mid price to all possible redemption date scenarios. Modified duration mid is used because it accounts for both the coupon and time. Then the green bond is overlaid.

I use the following formulas to pull daily yield to convention mid and modified duration mid data from the Bloomberg Terminal into Microsoft Excel for comparable vanilla bonds and the corresponding green bond. If issuers have multiple green bonds offered at different times, I include prior green bonds in later green bond issuances as long as they remain active during the later time period.

$$=BDH(\text{Security}, YLD_CNV_MID, \text{Announce Date}, \text{Announce Date} + 3 \text{ Months})$$

$$=BDP(\text{Security}, DUR_ADJ_MID, \text{"SETTLE_DT"}, \text{Date})$$

After plotting the issuer's yield curve, I fit a 2nd order polynomial curve through the set of vanilla bonds. Finally, I overlay the green bonds. A green bond above the yield curve represents a yield premium. A green bond below the yield curve represents a yield discount. The yield premium or discount is the difference between the actual yield and the expected yield. The green bond's actual yield is the yield to convention mid and the green bond's expected yield is the yield predicted by the 2nd order polynomial curve on a particular date. The coefficients for the 2nd order polynomial curve are found using the following formulas in Microsoft Excel:

$$\text{If expected yield} = aX^2 + bX + c, \text{ then:}$$

$$a = \text{INDEX}(\text{LINEST}(\text{known_ys}, \text{known_xs}^{\{1,2\}}), 1)$$

$$b = \text{INDEX}(\text{LINEST}(\text{known_ys}, \text{known_xs}^{\{1,2\}}), 1, 2)$$

$$c = \text{INDEX}(\text{LINEST}(\text{known_ys}, \text{known_xs}^{\{1,2\}}), 1, 3)$$

where “known_ys” is the array of yield to convention mid for comparable vanilla bonds and “known_xs” is the array of modified duration mid for comparable vanilla bonds on a particular date.

After finding the coefficients of the 2nd order polynomial curve, I input the green bond’s modified duration mid to calculate the expected yield for each date. For each green bond issuance, I compute the average, maximum, minimum, and standard deviation of the yield premium or discount for the three-month interval. Additionally, I plot the yield curve every 30 days and create a time series of the yield premium or discount to illustrate how it changes during the three-month period.

Chapter 5

Results

Bloomberg ID	Issuer Name	Security Name	Average	Max	Min	Standard Deviation
JK1373600	Apple Inc	AAPL 2.85 02/23/23	0.089	0.306	0.003	0.065
AN9643841	Apple Inc	AAPL 3 06/20/27	(0.072)	0.033	(0.118)	0.024
AL1276115	Bank of America Corp	BAC 2.151 11/09/20	(0.221)	(0.002)	(0.273)	0.044
QJ1388405	Electricite de France SA	EDF 3 5/8 10/13/25	0.098	0.192	0.044	0.030
QJ1305268	Electricite de France SA	EDF 3 5/8 10/13/25	0.050	0.146	(0.024)	0.035
EK2515238	Engie SA	ENGIFP 1 3/8 05/19/20	(0.093)	(0.048)	(0.113)	0.010
EK2700996	Engie SA	ENGIFP 2 3/8 05/19/26	(0.047)	0.022	(0.108)	0.031
EK4710878	European Investment Bank	EIB 1 1/4 11/13/26	(0.083)	(0.070)	(0.100)	0.011
UV5766679	European Investment Bank	EIB 0 1/2 11/15/23	(0.114)	(0.096)	(0.123)	0.005
QZ7160273	European Investment Bank	EIB 0 1/2 11/13/37	(0.167)	(0.130)	(0.182)	0.010
AN6320989	European Investment Bank	EIB 2 3/8 05/24/27	(0.110)	(0.074)	(0.142)	0.015
EK1707232	Iberdrola International BV	IBESM 2 1/2 10/24/22	(0.093)	(0.042)	(0.140)	0.024
QZ4989443	Iberdrola International BV	IBESM 0 3/8 09/15/25	(0.087)	(0.055)	(0.214)	0.025
EK9560831	Morgan Stanley	MS 2.2 12/07/18	(0.257)	(0.059)	(0.343)	0.061
AVERAGE			(0.079)	0.009	(0.131)	0.028

Table 1. Yield Premium or Discount (in %) for the Three-Month Interval after Announce Date

As seen in Table 1, 3 out of 14 labeled corporate green bonds offer a yield premium during the three-month period after the announcement date. On average, green bonds offer a yield discount of -7.9 bps with a minimum yield discount across all samples of -13.1 bps.

In addition, no green bonds converge and remain at their respective issuer's yield curve within three months after the announcement date. Green bonds issued by Electricite de France SA and Engie SA appear to fall closest in line with the issuer's yield curve, on average. Graphs of each issuer's yield curve are in the Appendix section. The time series for each green bond is below.

Apple Inc. (AAPL)

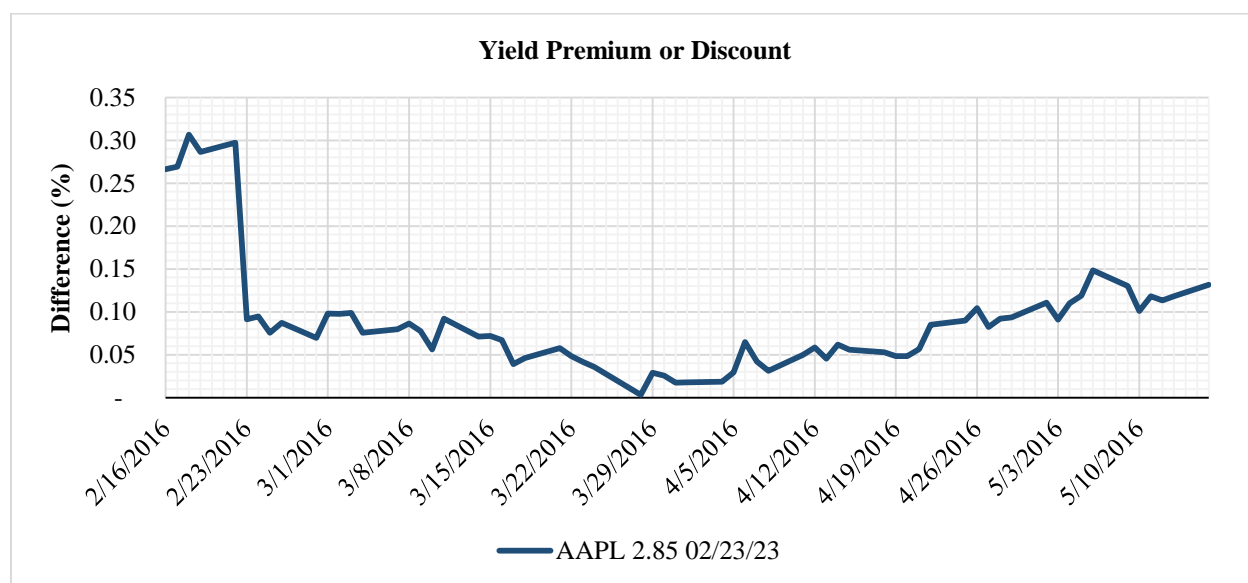


Figure 1. AAPL 2.85 02/23/23 Time Series

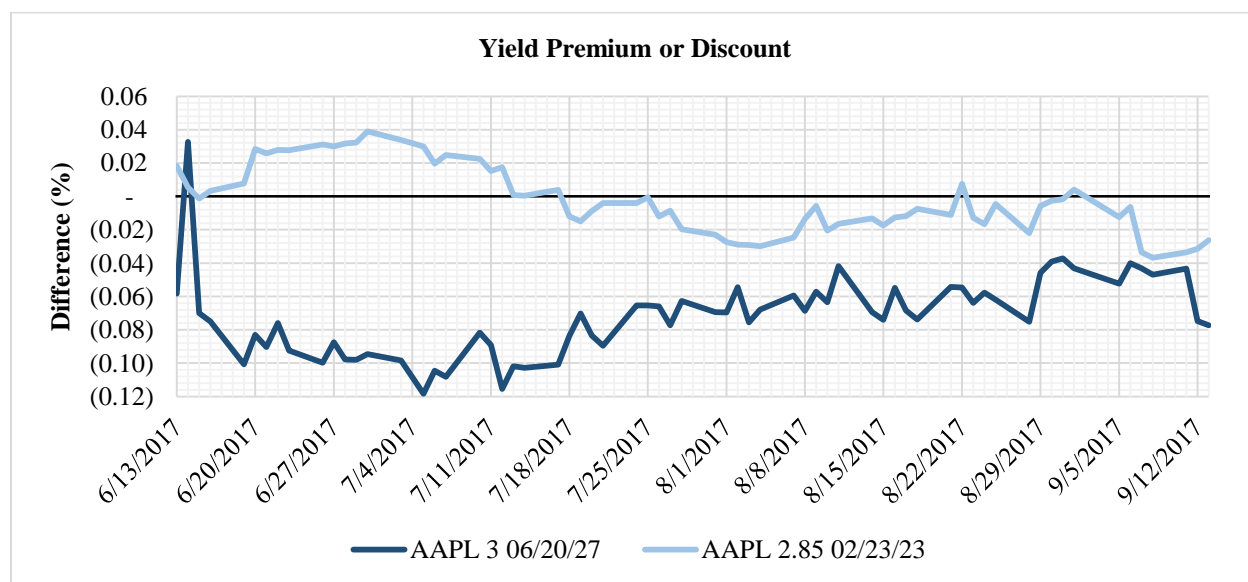


Figure 2. AAPL 3 06/20/27 Time Series

Bank of America Corp. (BAC)

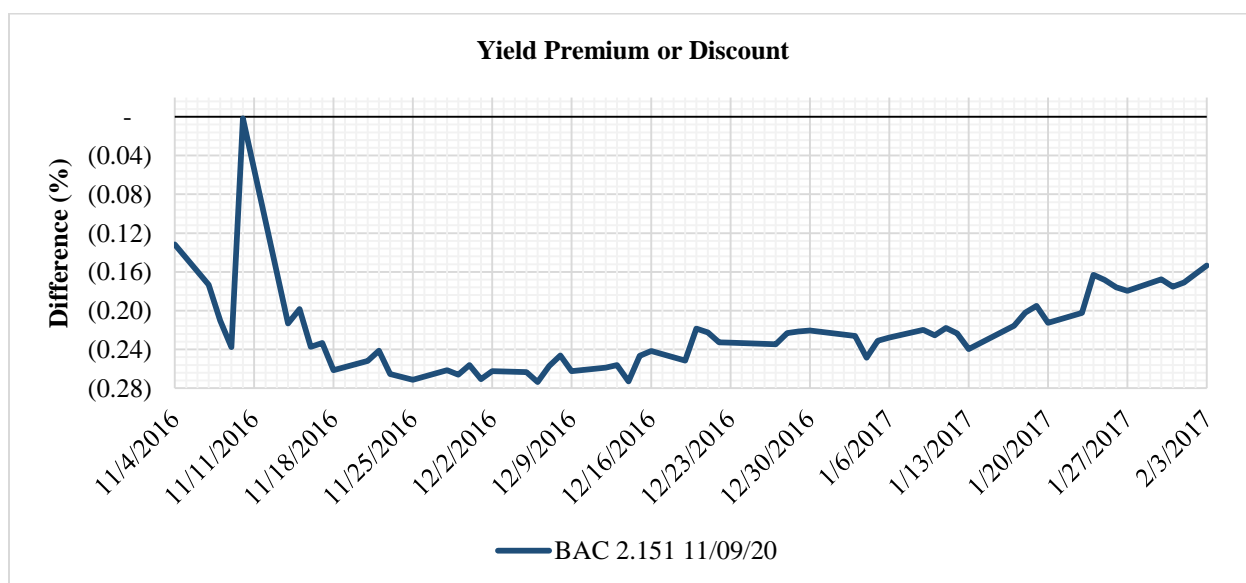


Figure 3. BAC 2.151 11/09/20 Time Series

Electricite de France SA (EDF)

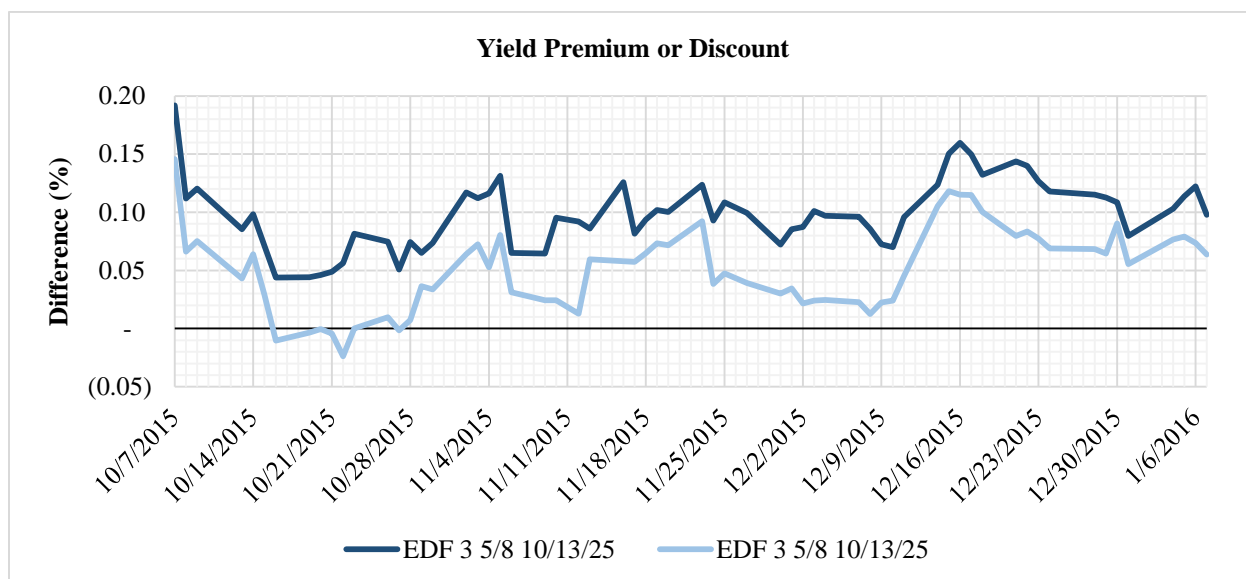


Figure 4. EDF 3 5/8 10/13/25 Time Series

Engie SA (ENGIFP)

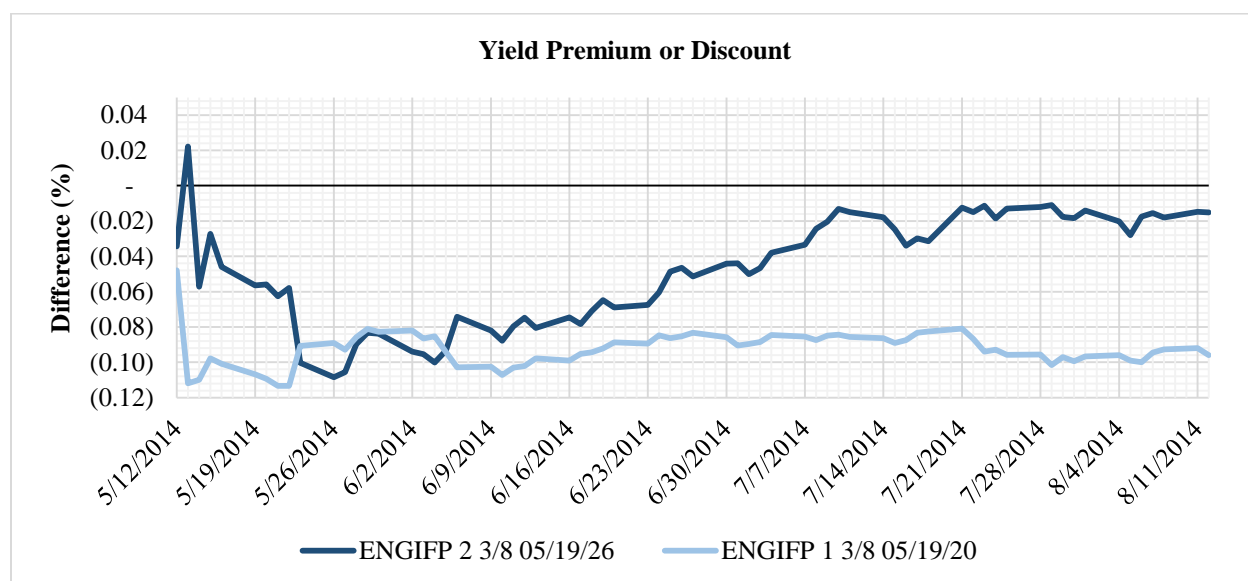


Figure 5. ENGIFP 2 3/8 05/19/26 and ENGIFP 1 3/8 05/19/20 Time Series

European Investment Bank (EIB)

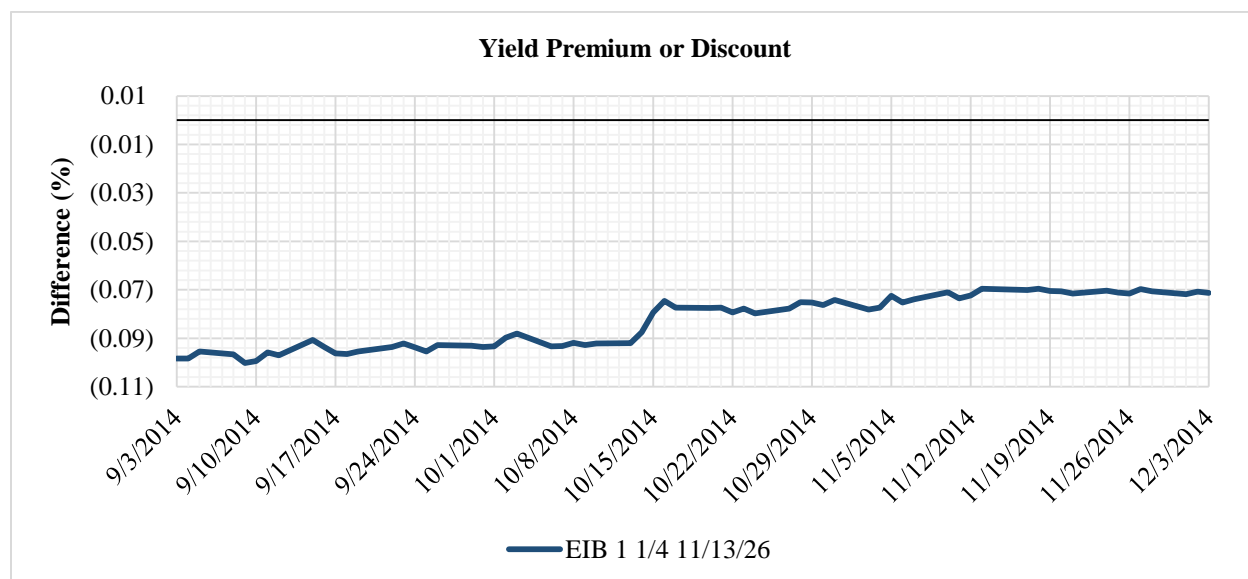


Figure 6. EIB 1 1/4 11/13/26 Time Series

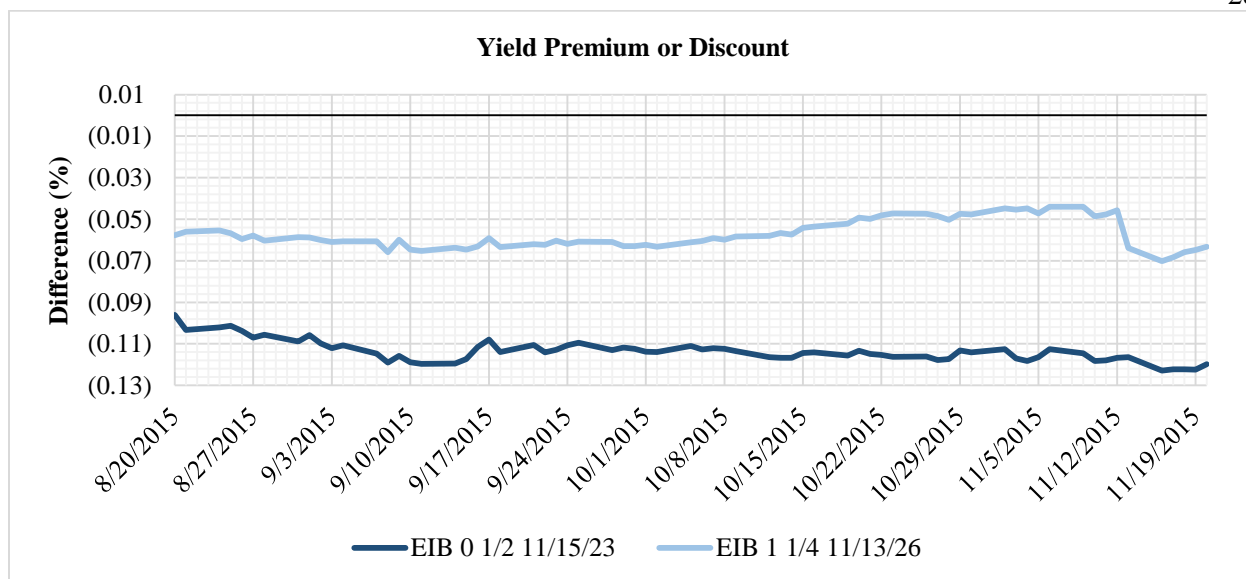


Figure 7. EIB 0 1/2 11/15/23 Time Series

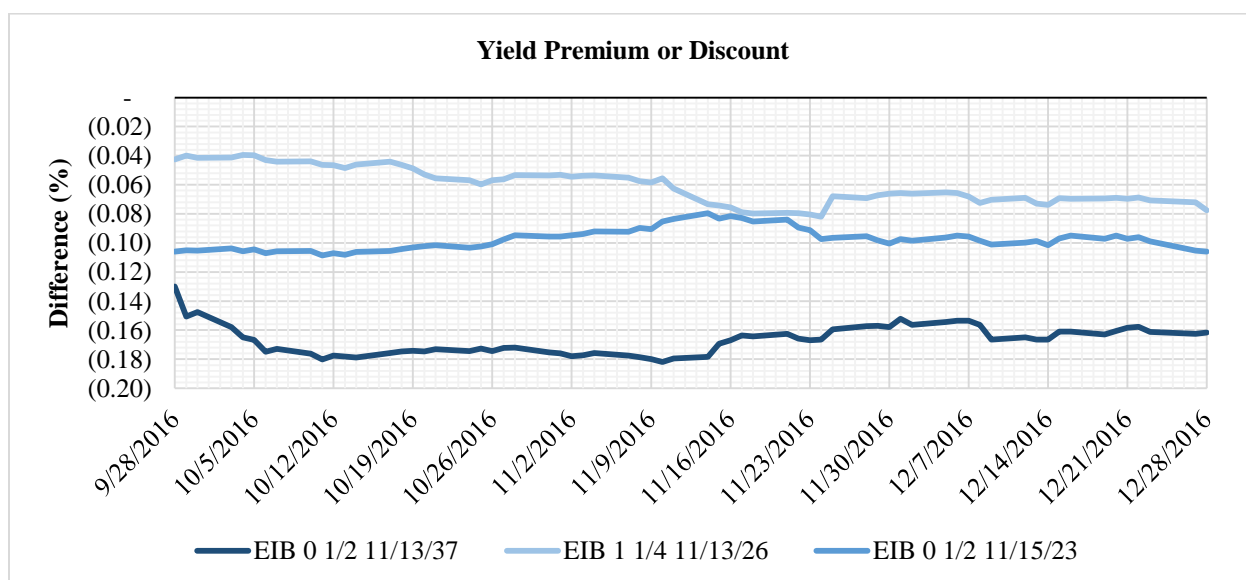


Figure 8. EIB 0 1/2 11/13/37 Time Series

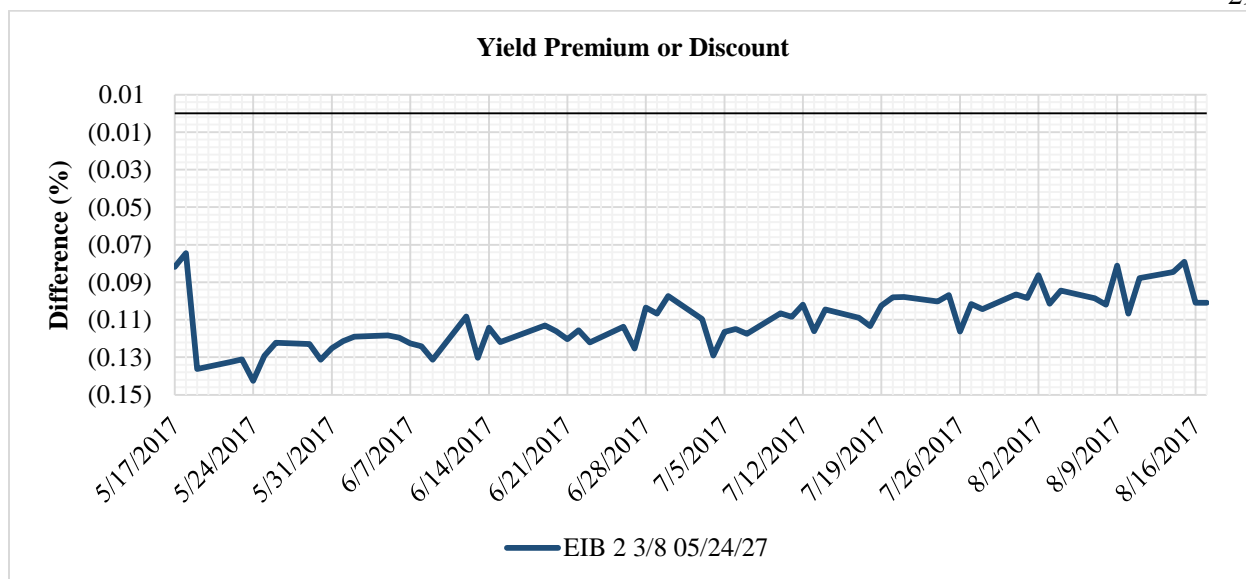


Figure 9. EIB 2 3/8 05/24/27 Time Series

Iberdrola International BV (IBESM)

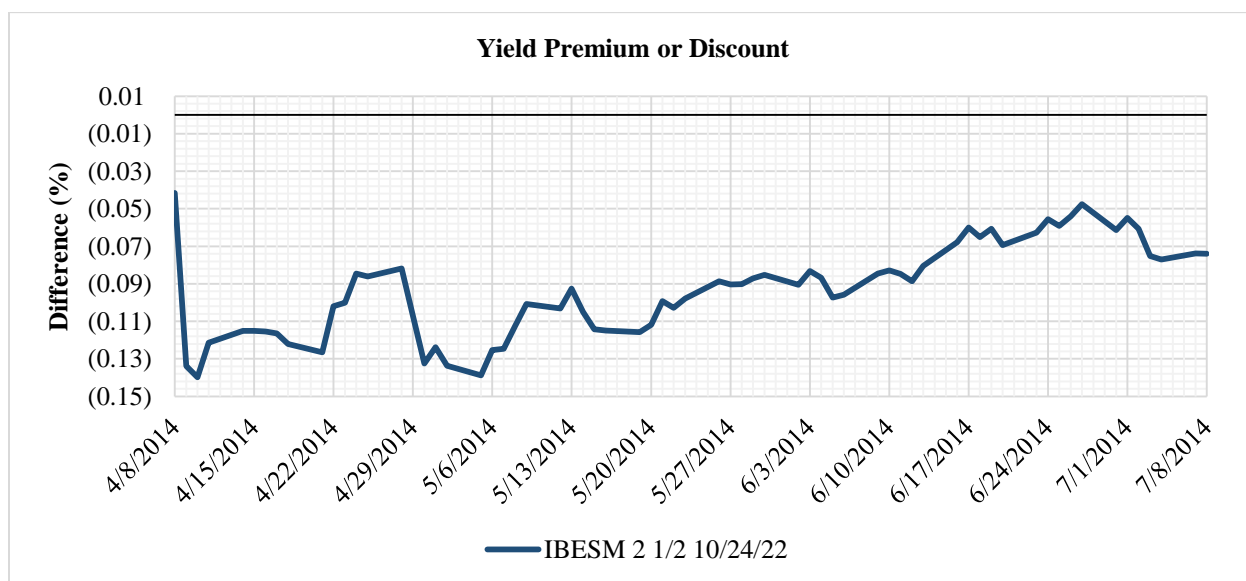


Figure 10. IBESM 2 1/2 10/24/22 Time Series

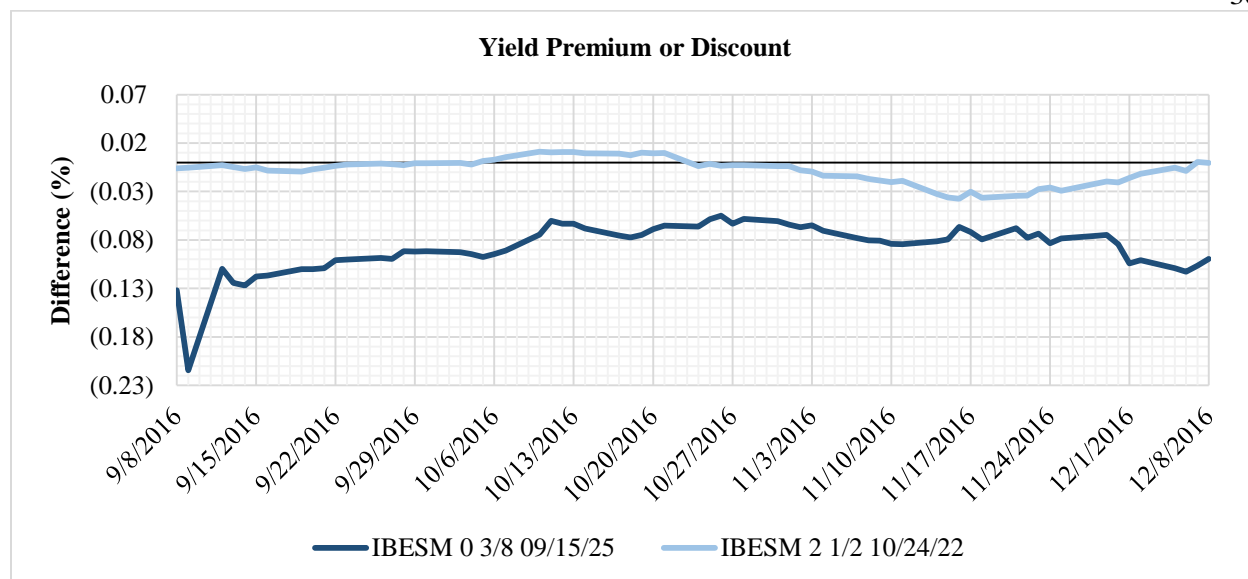


Figure 11. IBESM 0 3/8 09/15/25 Time Series

Morgan Stanley (MS)

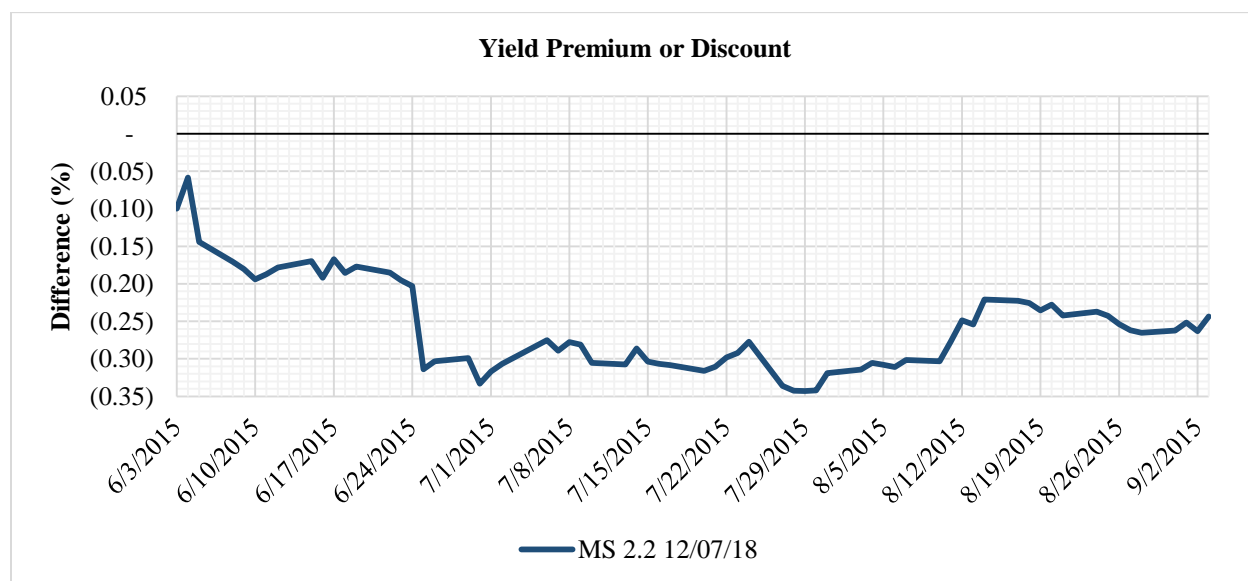


Figure 12. MS 2.2 12/07/18 Time Series

Chapter 6

Analysis

I conduct analysis on the average yield premium or discount to identify features that may explain a green bond's time series path. First, I analyze a green bond's convergence to the issuer's yield curve for issuers with multiple green bonds. Then, I examine the average yield premium or discount segmented by industry, currency, amount issued, and maturity in years.

Issuers with Multiple Green Bonds

No green bonds converge and remain at their issuer's yield curve during the three-month period after the announcement date. However, AAPL, EIB, and IBESM issued multiple green bonds at different dates so the behavior of prior green bond issuances can be studied in later periods beyond the initial three months. As seen in Figure 13, all prior green bonds appear to converge towards the issuer's yield curve at least one year after their announcement date. In particular, AAPL and IBESM nearly fall back in line with the issuer's yield curve. Furthermore, as seen in Figures 2, 5, 8, and 11 in Chapter 5, the multiple green bonds issued by AAPL, EIB, ENGIFP, and IBESM appear to move inversely.

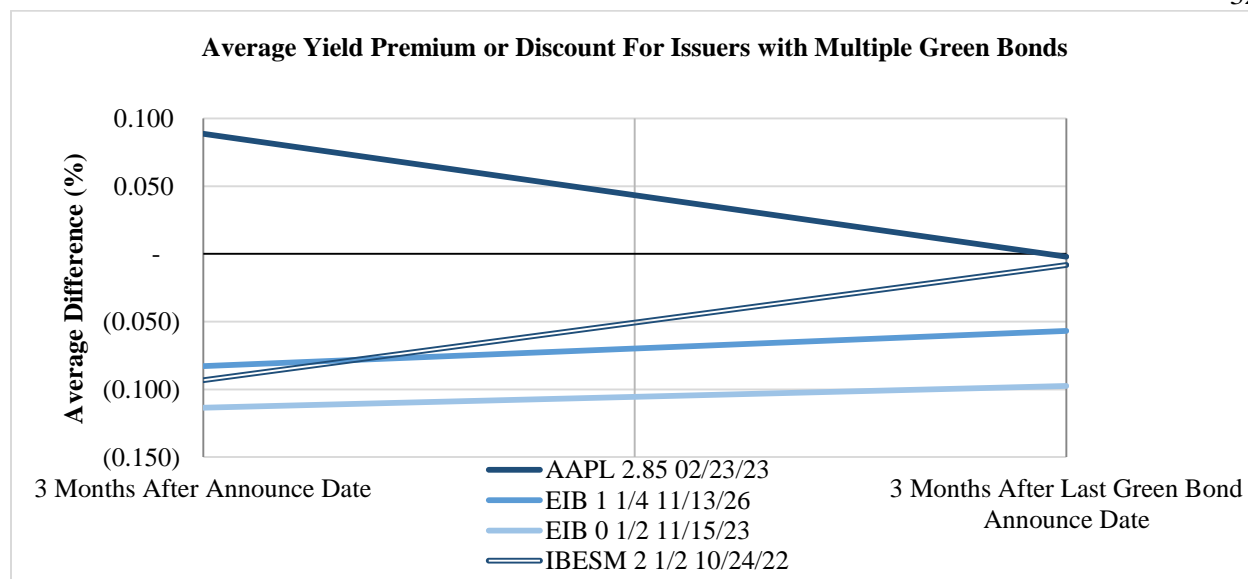


Figure 13. Average Yield Premium or Discount for Issuers with Multiple Green Bonds

Segmented by Industry

As designated by Bloomberg, my sample covers the following sectors: technology, utilities, government, and financials. Most green bonds in the sample are classified as utilities. As seen in Figure 14, the financial sector provides the largest average yield discount of -23.9 bps and highest volatility.

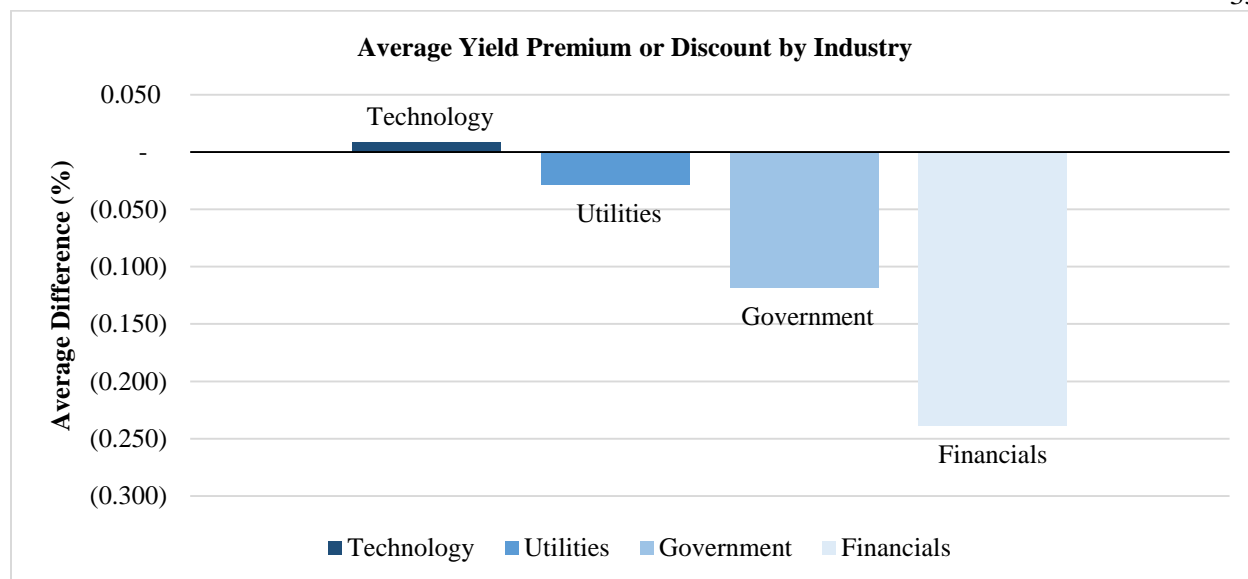


Figure 14. Average Yield Premium or Discount by Industry

Segmented by Currency

The sample is limited to green bonds denominated in EUR or USD since bonds are most commonly issued in those two currencies. There are seven green bonds denominated in EUR and seven green bonds denominated in USD. EUR green bonds appear to offer a larger yield discount of -9.8 bps while USD green bonds offer a yield discount of -6.0 bps. The average yield premium or discount by currency is in Figure 15.

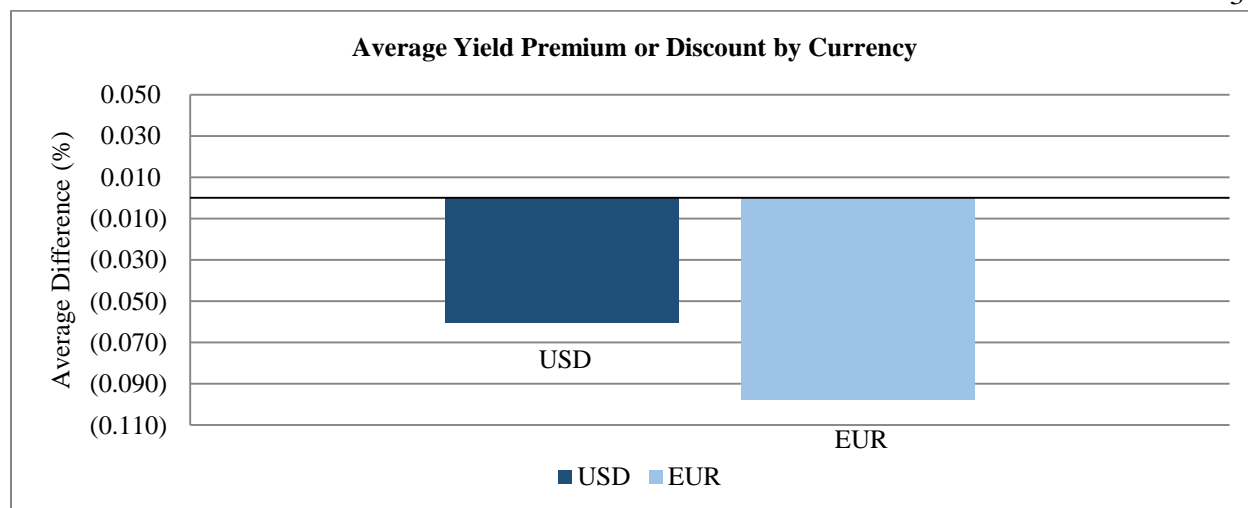


Figure 15. Average Yield Premium or Discount by Currency

Segmented by Amount Issued

The amount issued in the sample ranged from \$500 million to \$1.9 billion. The scatterplot in Figure 16 indicates there is a moderate positive correlation of 0.354 between amount issued and the yield premium or discount. Smaller issuance amounts appear to deviate from their respective issuer's yield curve more than larger issuance amounts three months after the green bond's announcement date.

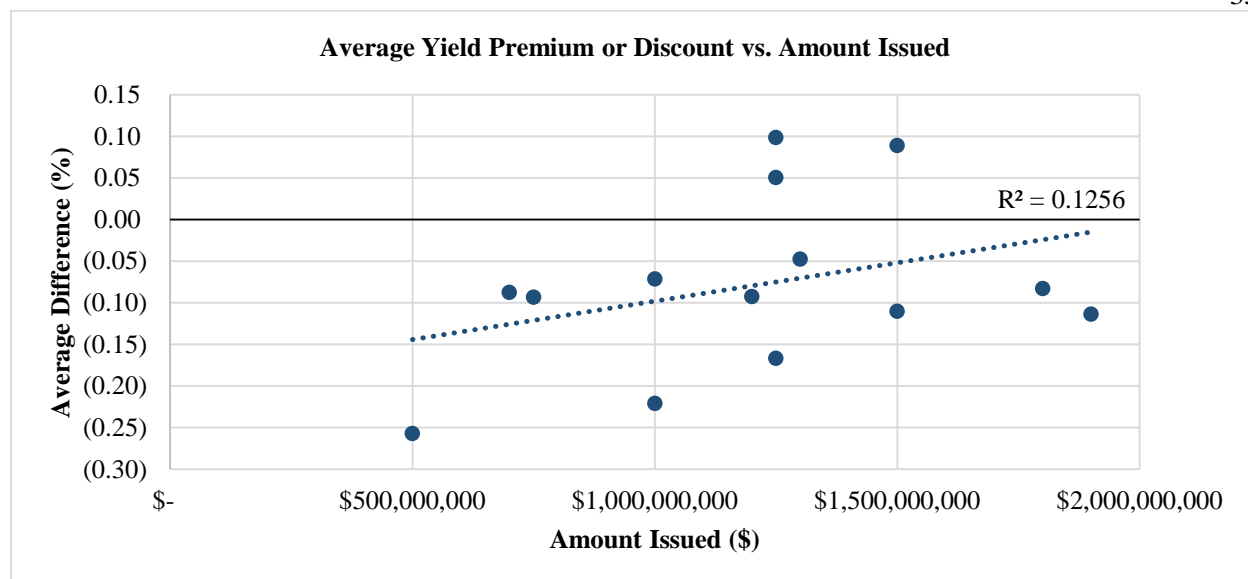


Figure 16. Average Yield Premium or Discount by Amount Issued

Segmented by Maturity

The maturity in years in the sample ranged from 3.50 years to 21.12 years. The scatterplot in Figure 17 shows a weak positive correlation of 0.127, suggesting maturity does not have a significant impact on the yield premium or discount three months after the announcement date.

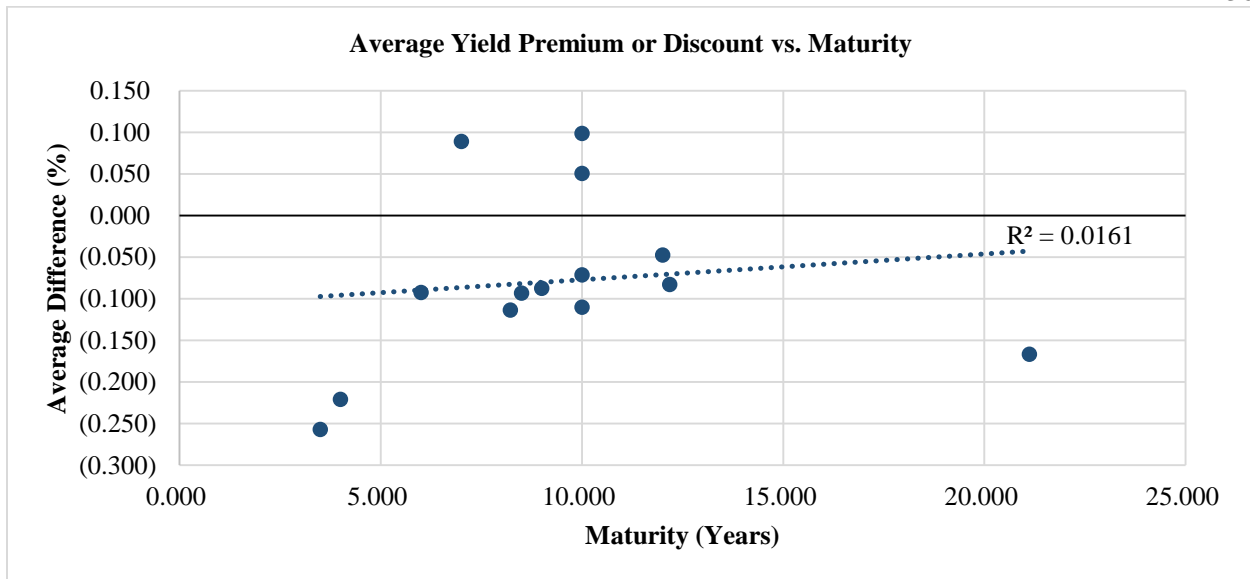


Figure 17. Average Yield Premium or Discount by Maturity

Significance Test

Green bonds issued by government, financials, and in EUR have yield discounts that are statistically significantly different from zero. Amount issued and maturity do not appear to have a significant effect. However, it is important to note this study includes only 14 green bonds so these results may not be entirely representative of the green bond universe. The results of the multivariate regressions are in Figure 18.

	Coefficients	Standard Error	t Stat	P-value
Technology	0.0086	0.0508	0.1687	0.8694
Utilities	(0.0286)	0.0293	(0.9755)	0.3523
Government	(0.1185)	0.0359	(3.2962)	0.0081
Financials	(0.2390)	0.0508	(4.7021)	0.0008

Adjusted R Square	0.604
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	Coefficients	Standard Error	t Stat	P-value
USD	(0.0603)	0.0401	(1.5063)	0.1579
EUR	(0.0977)	0.0401	(2.4400)	0.0312

Adjusted R Square	0.274
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	Coefficients	Standard Error	t Stat	P-value
Intercept	(0.1925)	0.1005	(1.9154)	0.0818
Amount	0.0000	0.0000	1.1751	0.2648
Maturity	0.0004	0.0072	0.0617	0.9519

Adjusted R Square	(0.033)
--------------------------	---------

Figure 18. Multivariate Regression Results

Chapter 7

Discussion and Conclusion

This study contributes to existing literature and expands on corporate green bonds' financial performance. In particular, it expands on Boulle and Harrison's report, "Green Bond Pricing in the Primary Market: April – June 2017". Boulle and Harrison's report examines the yield premium or discount on the green bond's announcement date while this study tracks it over a three-month interval after the green bond's announcement date. For corporations that issue multiple green bonds, Figure 13 provides insight on how prior green bond issuances behave in later periods beyond three months.

11 of 14 of the green bonds in my sample exhibited a yield discount during the period three months after the announcement date. Since Boulle and Harrison's report indicates that green bonds and vanilla bonds are often oversubscribed, it suggests corporations can issue green bonds to lower the cost of capital to fund green projects without sacrificing investor demand. It also allows corporations to attract a subgroup of investors who are interested in incorporating more exposure to SRI criteria in investment strategies in a cheaper method than through vanilla bonds.

Investing in green bonds may negatively affect an investor's financial performance. However, based on the analysis, investing in green bonds issued by utility companies with larger issuance amounts denominated in USD may reduce the likelihood of receiving a yield discount. In this study, green bonds issued by Electricite de France SA share these characteristics and returned a yield premium. Alternatively, investors may be willing to accept a lower yield in exchange for an intangible psychological benefit of promoting a more sustainable and environmentally resilient economy.

After comparing, the yield of 14 labeled corporate green bonds to their respective issuer's yield curve during the three-period after the green bond's announcement date, I found a green bond's yield does not converge and remain at their issuer's yield curve after three months. On average, green bonds offer a yield discount of -7.9 bps. However, for corporations that issue multiple green bonds, prior green bond issuances began to converge towards the issuer's yield curve at least one year after the announcement date. Green bonds issued by government, financials, and in EUR have yield discounts that are statistically significantly different from zero.

As the market becomes more robust, larger sample sizes can be used in studies. Future research for green bonds can provide additional insight on the financial performance and environmental impact. Financially, future work could explore if the green bond yield differences persist, how green bonds compare to other SRI instruments, and if and how green bonds add value to corporations. Environmentally, future studies can measure the environmental impact of green bonds and evaluate whether they are an effective driver for incentivizing both issuers and investors to promote a low-carbon economy. The evolution of the green bond market and its prevalence in SRI will be fascinating to witness in the coming years.

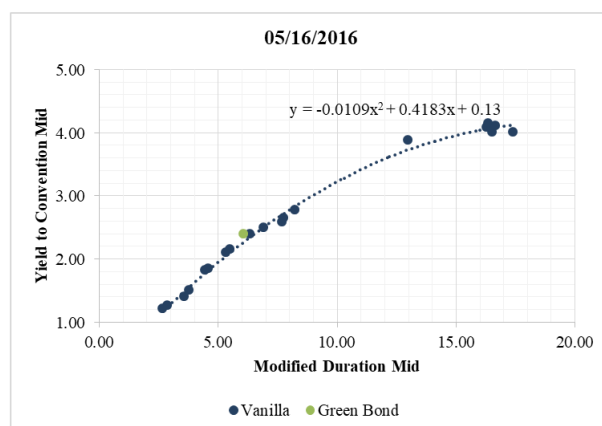
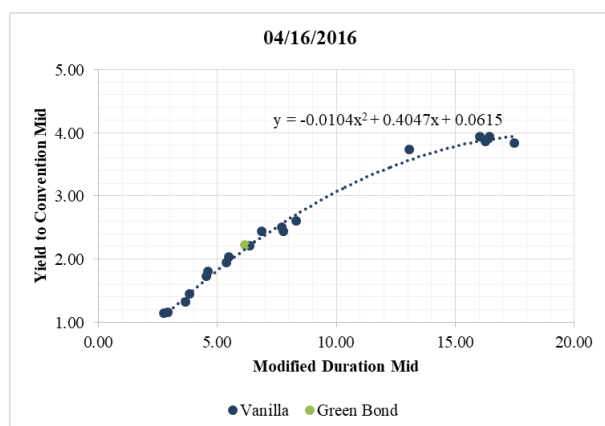
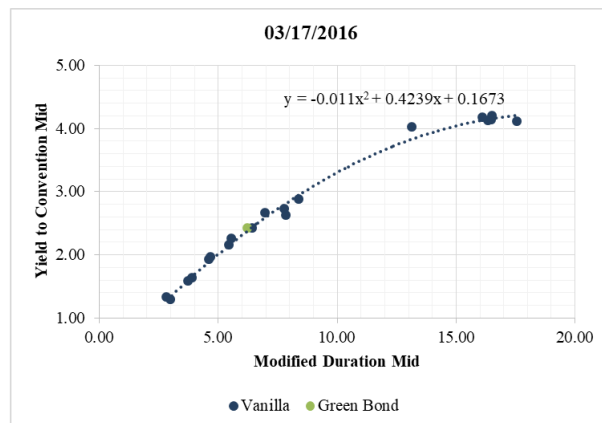
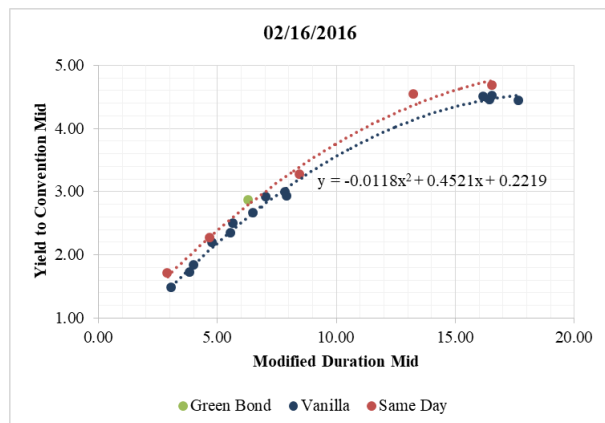
Appendix A

Labeled Corporate Green Bond Sample

Bloomberg ID	Issuer Name	Security Name	Announce Date	Issue Date	Maturity	Maturity Type	Amount Issued	Price at Issue	Yield at Issue	Coupon	Coupon Type	Currency	BBG Composite	Payment Rank
JK1373600	Apple Inc	AAPL 2.85 02/23/23	2/16/2016	2/23/2016	2/23/2023	CALLABLE	\$ 1,500,000,000	\$ 99.89	2.867	2.850	FIXED	USD	AA+	Sr Unsecured
AN9643841	Apple Inc	AAPL 3.06/20/27	6/13/2017	6/20/2017	6/20/2027	CALLABLE	\$ 1,000,000,000	\$ 99.77	3.027	3.000	FIXED	USD	AA+	Sr Unsecured
AL1276115	Bank of America Corp	BAC 2.151 11/09/20	11/4/2016	11/9/2016	11/9/2020	CALLABLE	\$ 1,000,000,000	\$ 100.00	2.151	2.151	FIXED	USD	A-	Sr Unsecured
QJ1388405	Electricite de France SA	EDF 3.5/8 10/13/25	10/7/2015	10/13/2015	10/13/2025	CALLABLE	\$ 1,250,000,000	\$ 99.16	3.727	3.625	FIXED	USD	A-	Sr Unsecured
QJ1305268	Electricite de France SA	EDF 3.5/8 10/13/25	10/7/2015	10/13/2015	10/13/2025	CALLABLE	\$ 1,250,000,000	\$ 99.16	3.727	3.625	FIXED	USD	A-	Sr Unsecured
EK2515238	Engie SA	ENGIEP 1.3/8 05/19/20	5/12/2014	5/19/2014	5/19/2020	AT MATURITY	\$ 1,200,000,000	\$ 99.35	1.490	1.375	FIXED	EUR	A-	Sr Unsecured
EK2700996	Engie SA	ENGIEP 2.3/8 05/19/26	5/12/2014	5/19/2014	5/19/2026	AT MATURITY	\$ 1,300,000,000	\$ 98.49	2.522	2.375	FIXED	EUR	A-	Sr Unsecured
EK4710878	European Investment Bank	EIB 1.1/4 11/13/26	9/3/2014	9/10/2014	11/13/2026	AT MATURITY	\$ 1,800,000,000	\$ 98.74	1.363	1.250	FIXED	EUR	AAA	Sr Unsecured
UN5766679	European Investment Bank	EIB 0.1/2 11/15/23	8/20/2015	8/27/2015	11/15/2023	AT MATURITY	\$ 1,900,000,000	\$ 99.89	0.514	0.500	FIXED	EUR	AAA	Sr Unsecured
QZ7160273	European Investment Bank	EIB 0.1/2 11/13/37	9/28/2016	10/5/2016	11/13/2037	AT MATURITY	\$ 1,250,000,000	\$ 97.75	0.614	0.500	FIXED	EUR	AAA	Sr Unsecured
AN6320989	European Investment Bank	EIB 2.3/8 05/24/27	5/17/2017	5/24/2017	5/24/2027	AT MATURITY	\$ 1,500,000,000	\$ 98.92	2.498	2.375	FIXED	USD	AAA	Sr Unsecured
EK1707232	Iberdrola International BV	IBESM 2.1/2 10/24/22	4/8/2014	4/24/2014	10/24/2022	AT MATURITY	\$ 750,000,000	\$ 99.72	2.538	2.500	FIXED	EUR	BBB+	Sr Unsecured
QZ4989443	Iberdrola International BV	IBESM 0.3/8 09/15/25	9/8/2016	9/15/2016	9/15/2025	AT MATURITY	\$ 700,000,000	\$ 98.95	0.495	0.375	FIXED	EUR	BBB+	Sr Unsecured
EK9560831	Morgan Stanley	MS 2.2 12/07/18	06/03/2015	06/08/2015	12/07/2018	AT MATURITY	\$ 500,000,000	\$ 99.92	2.223	2.200	FIXED	USD	A-	Sr Unsecured

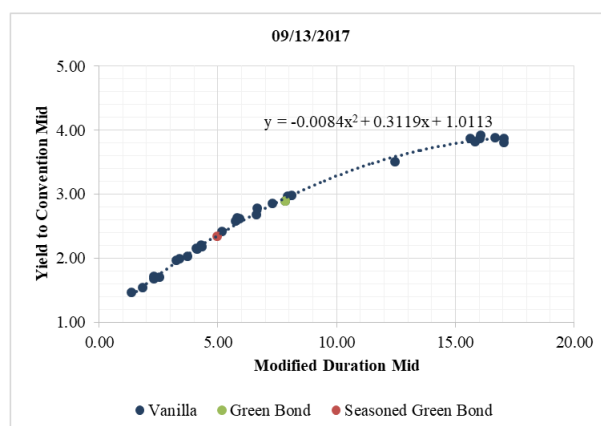
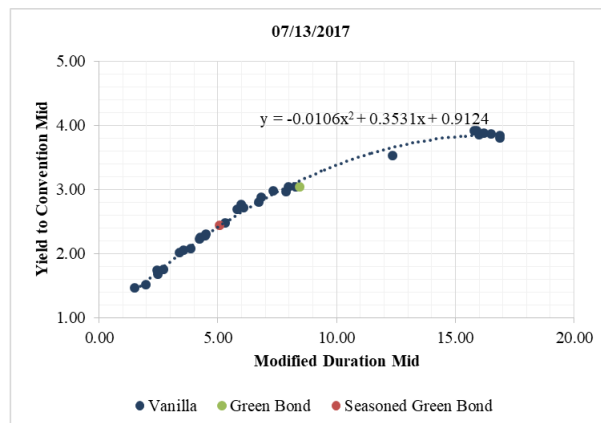
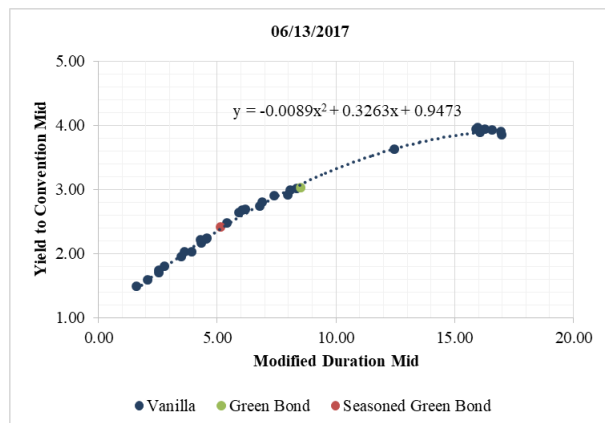
Appendix B

AAPL 2.85 02/23/23 Yield Curve Graphs



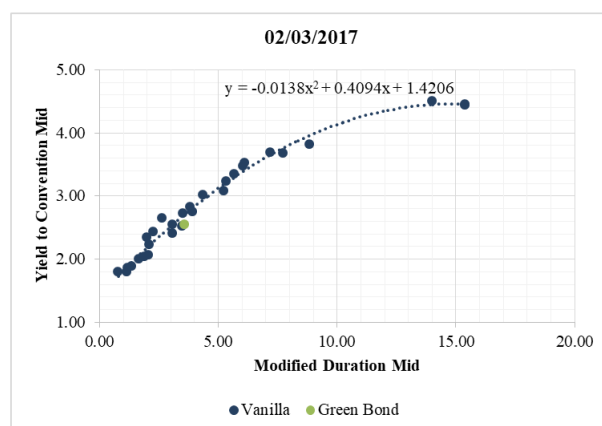
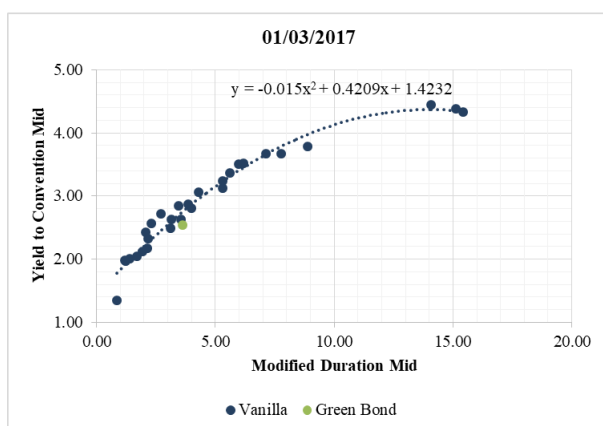
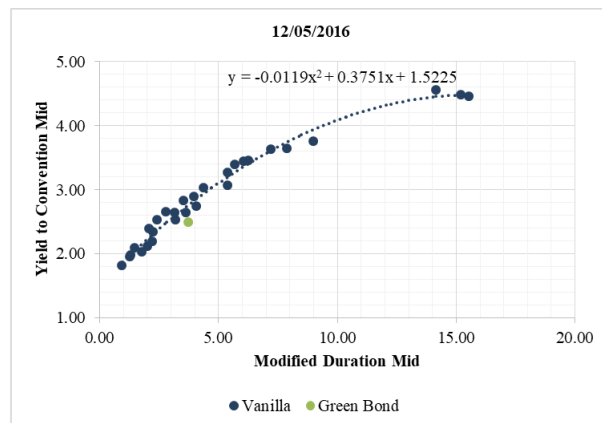
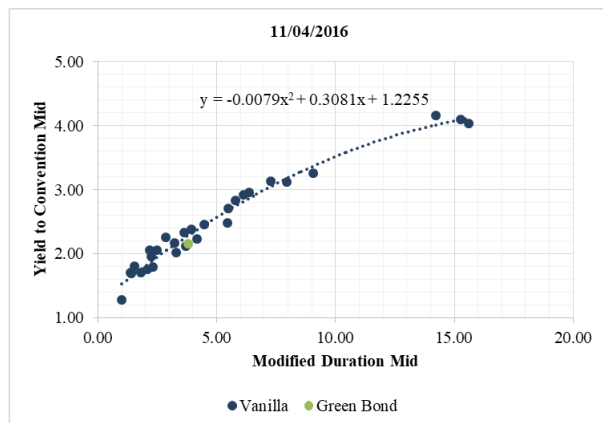
Appendix C

AAPL 3 06/20/27 Yield Curve Graphs



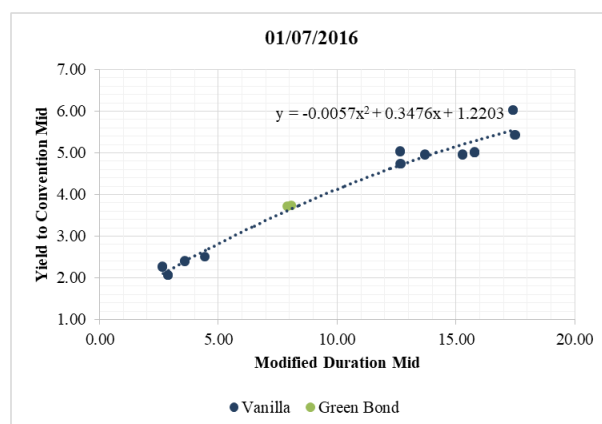
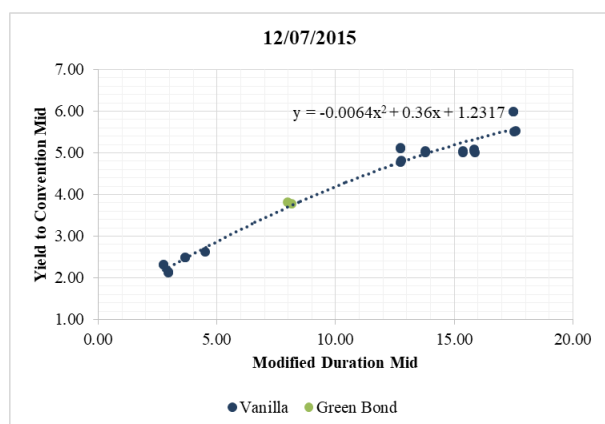
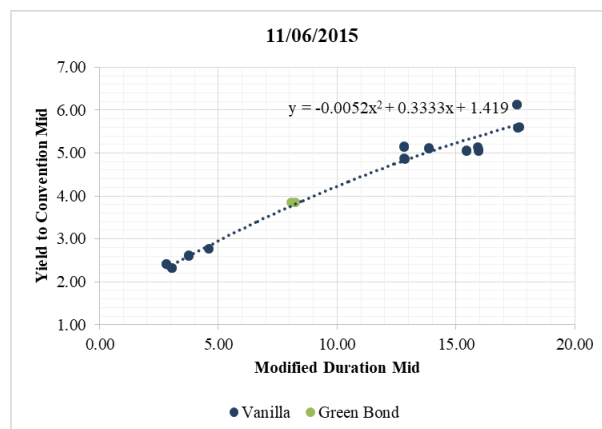
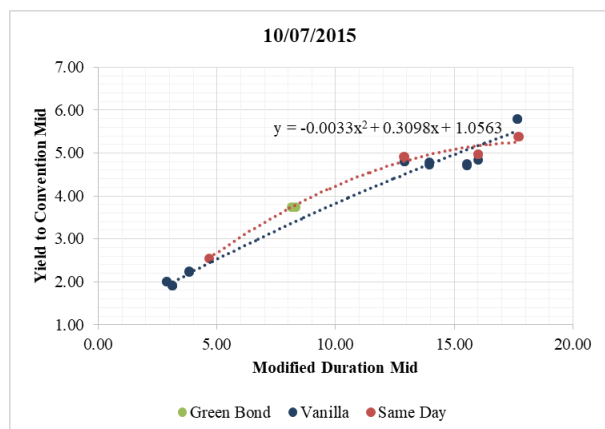
Appendix D

BAC 2.151 11/09/20 Yield Curve Graphs



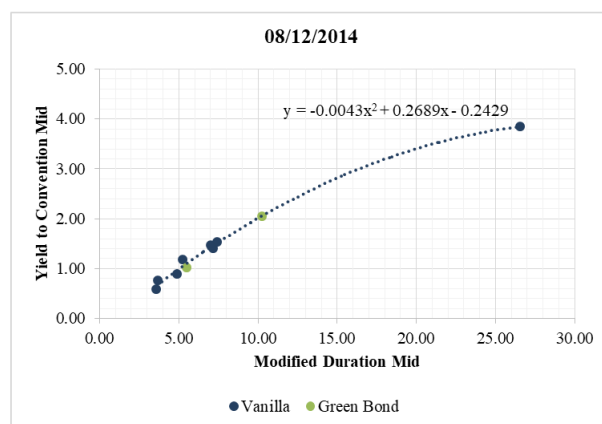
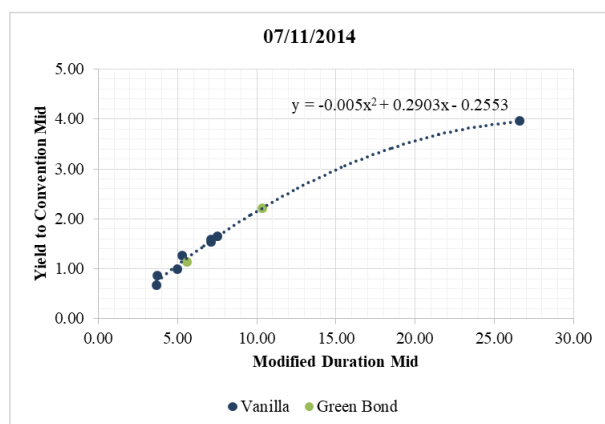
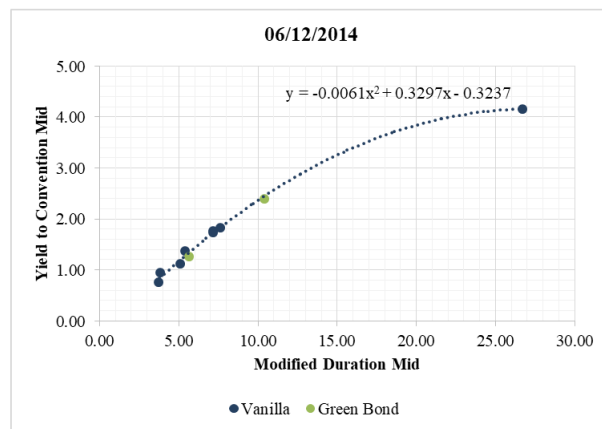
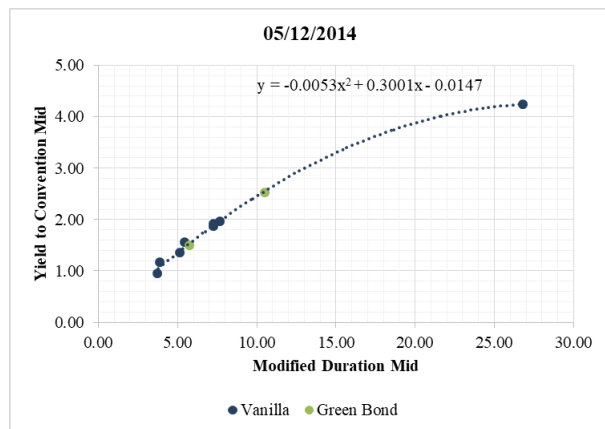
Appendix E

EDF 3 5/8 10/13/25 Yield Curve Graphs



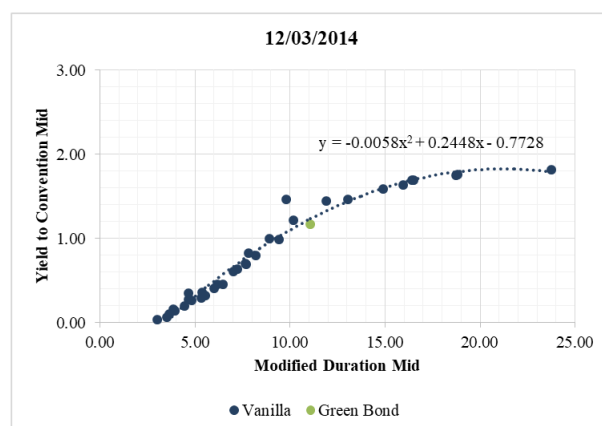
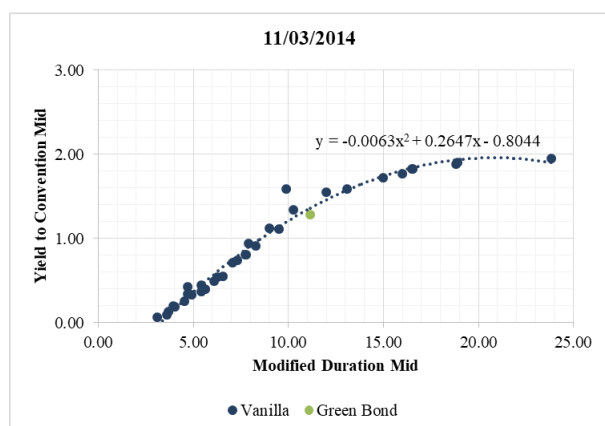
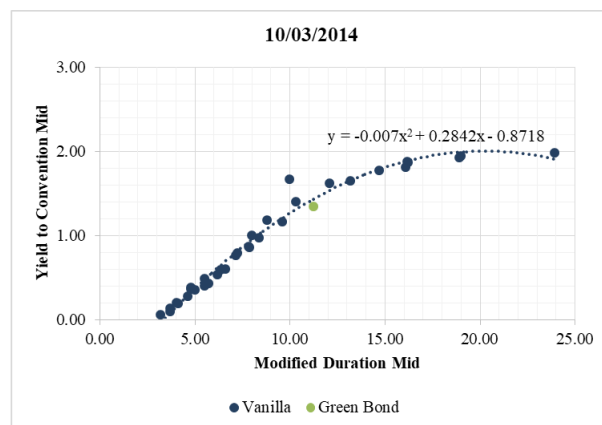
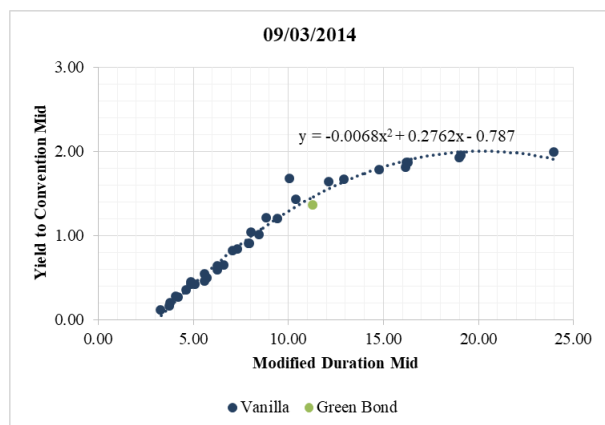
Appendix F

ENGIFP Yield Curve Graphs



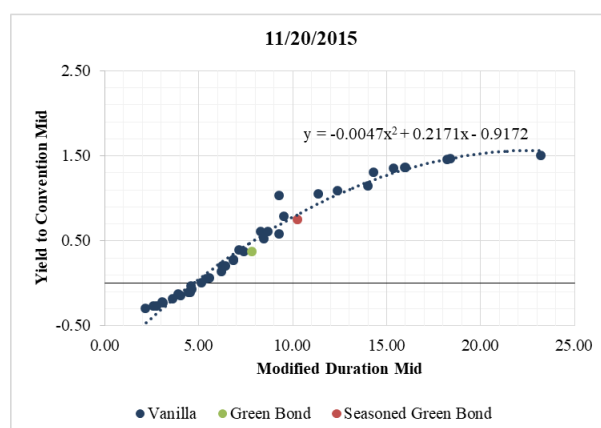
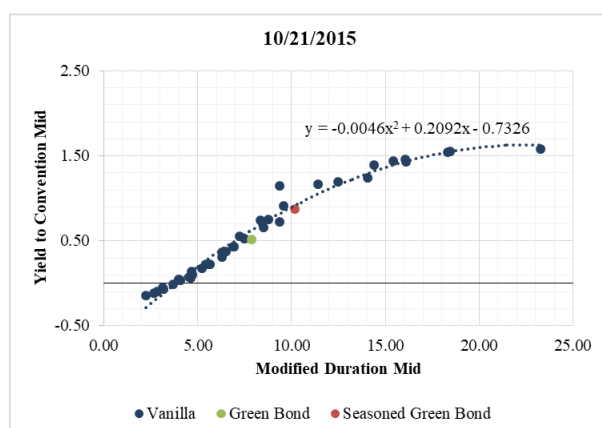
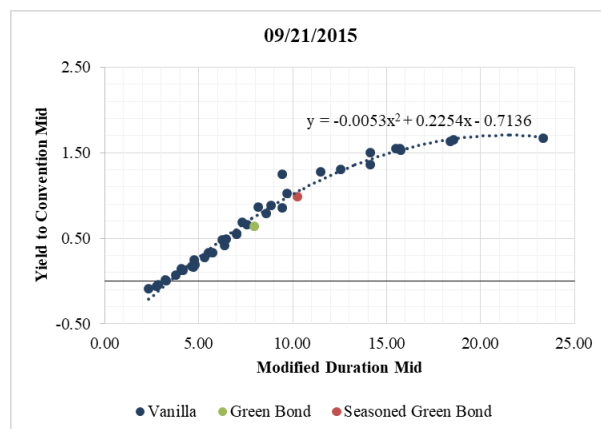
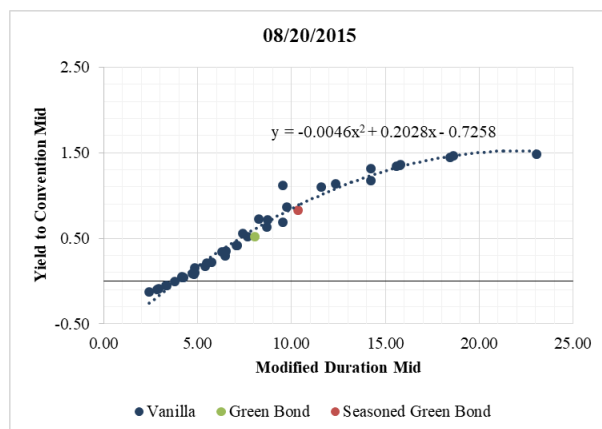
Appendix G

EIB 1 1/4 11/13/26 Yield Curve Graphs



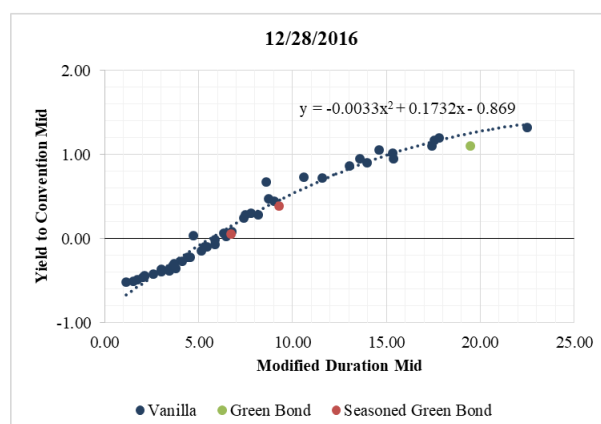
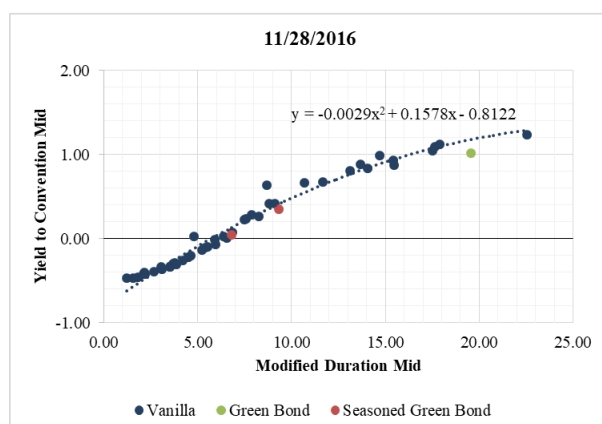
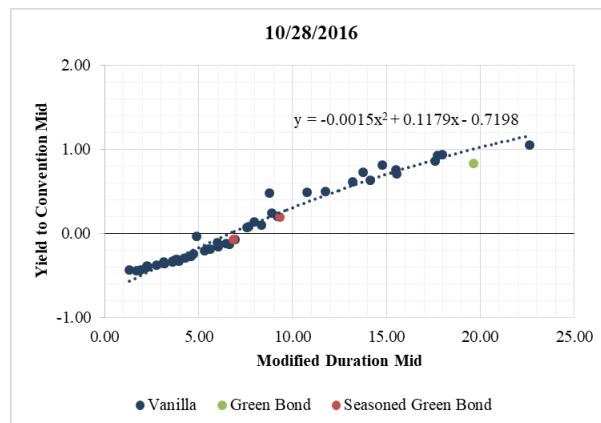
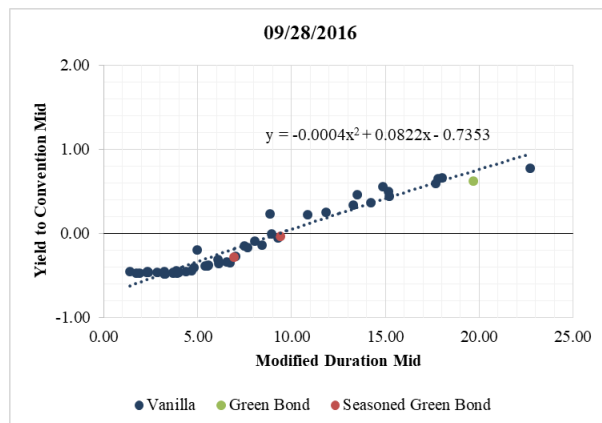
Appendix H

EIB 0 1/2 11/15/23 Yield Curve Graphs



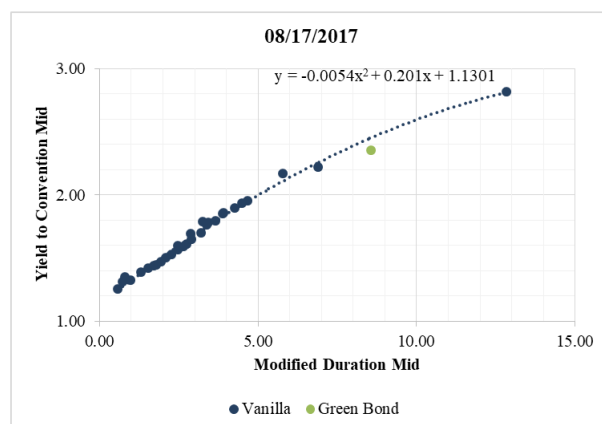
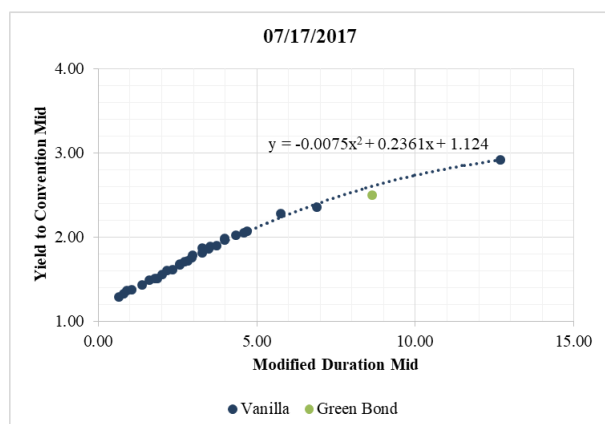
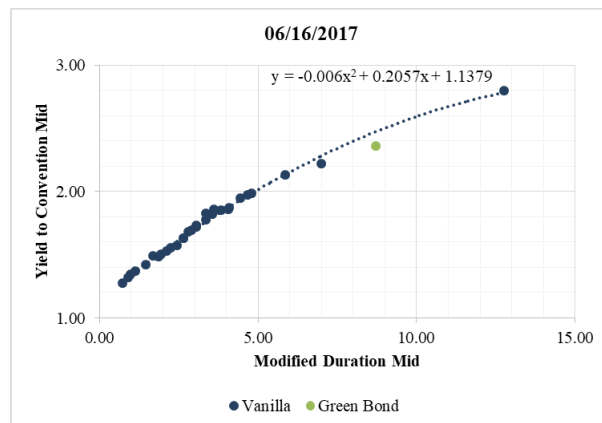
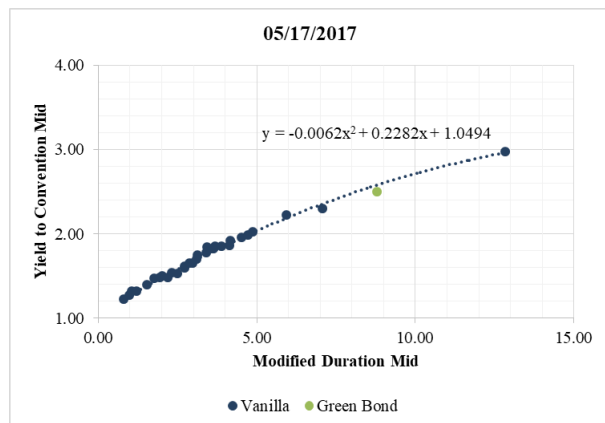
Appendix I

EIB 0 1/2 11/13/37 Yield Curve Graphs



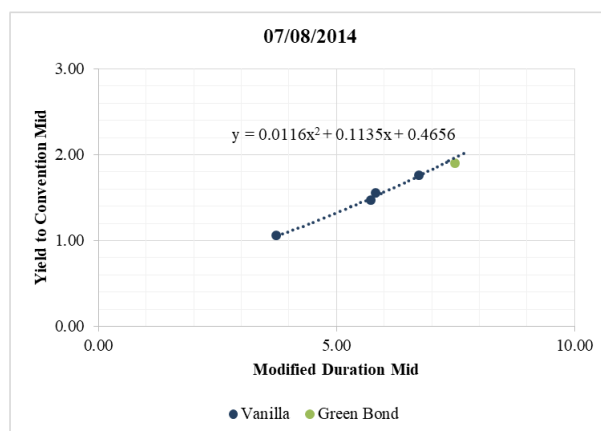
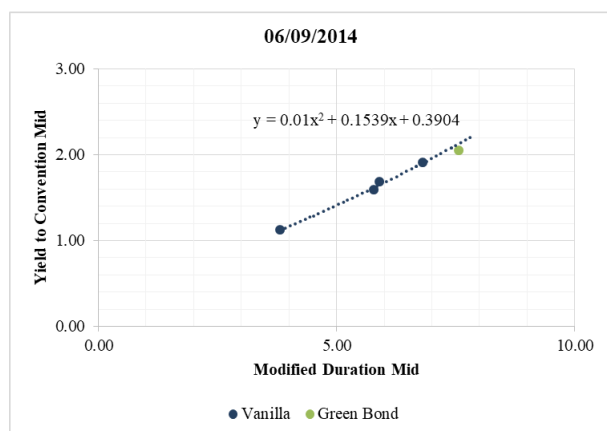
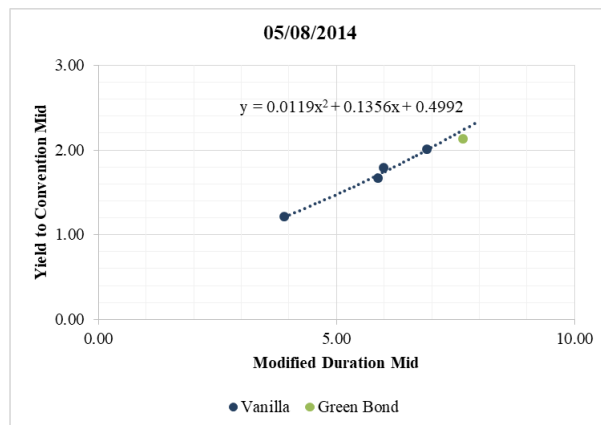
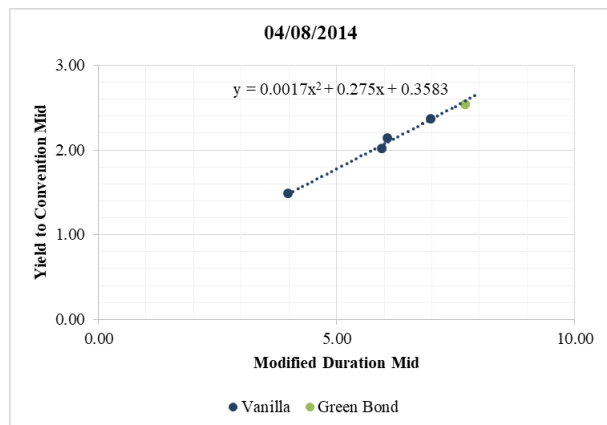
Appendix J

EIB 2 3/8 05/24/27 Yield Curve Graphs



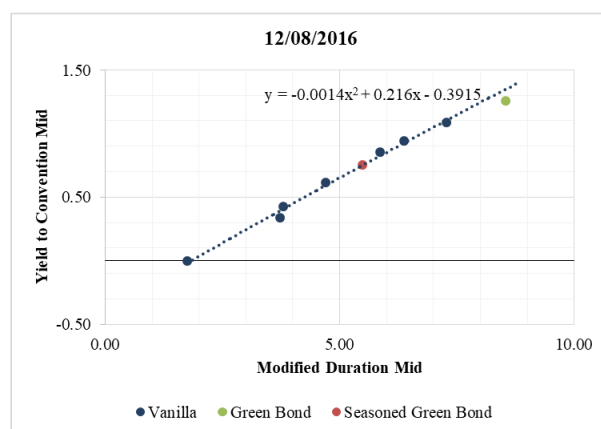
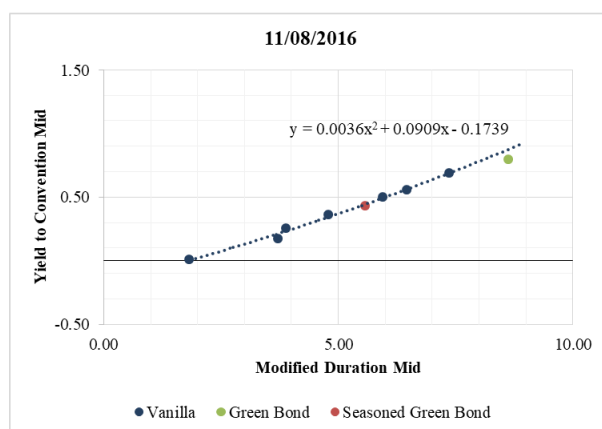
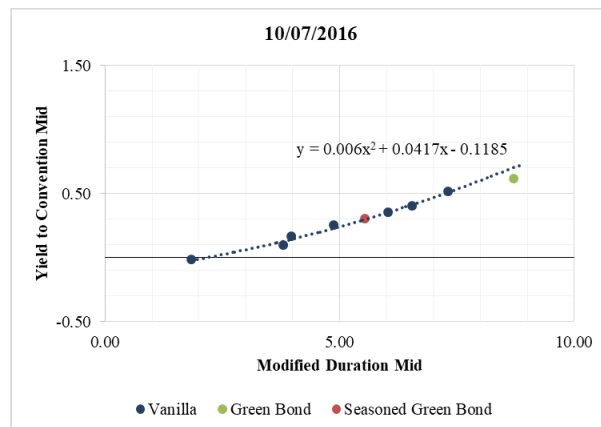
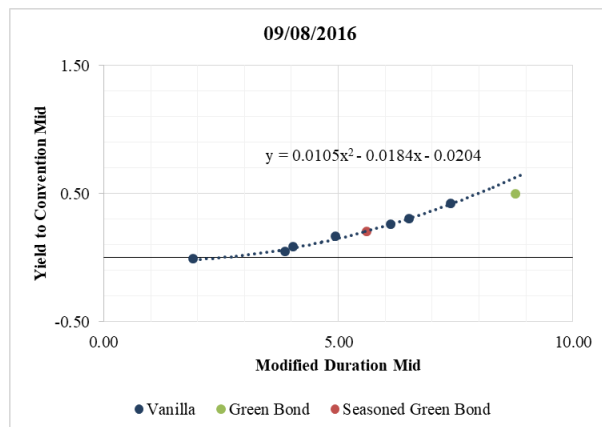
Appendix K

IBESM 2 1/2 10/24/22 Yield Curve Graphs



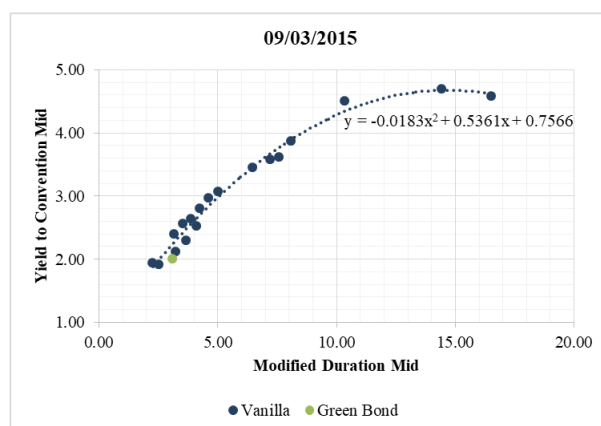
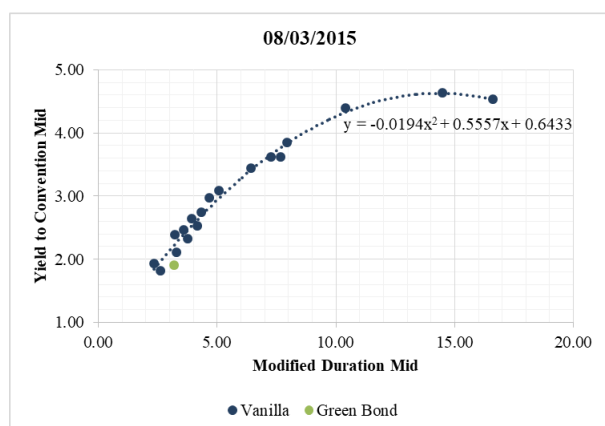
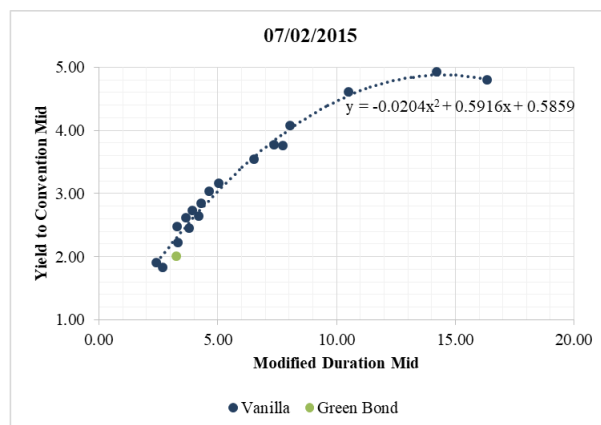
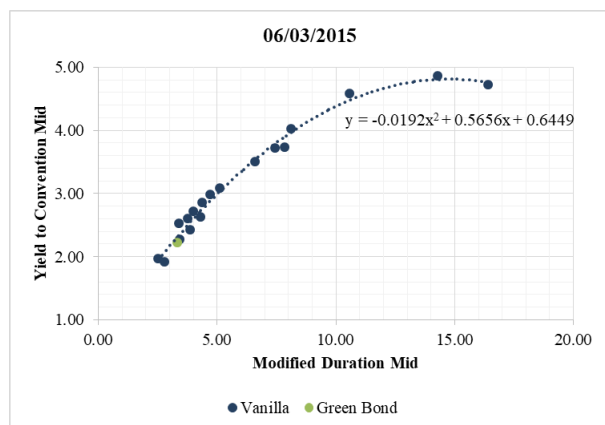
Appendix L

IBESM 0 3/8 09/15/25 Yield Curve Graphs



Appendix M

MS 2.2 12/07/18 Yield Curve Graphs



Appendix N

Analysis Data

Date	Security Name	Average	Max	Min	Standard Deviation
5/16/2016	AAPL 2.85 02/23/23	0.089	0.306	0.003	0.065
9/13/2017	AAPL 2.85 02/23/23	(0.002)	0.039	(0.037)	0.020
	CHANGE	(0.091)	(0.267)	(0.040)	(0.045)
12/3/2014	EIB 1 1/4 11/13/26	(0.083)	(0.070)	(0.100)	0.011
11/20/2015	EIB 1 1/4 11/13/26	(0.057)	(0.044)	(0.070)	0.007
	CHANGE	0.026	0.026	0.030	(0.004)
12/28/2016	EIB 1 1/4 11/13/26	(0.061)	(0.040)	(0.082)	0.012
	CHANGE	(0.004)	0.004	(0.012)	0.005
	TOTAL CHANGE	0.022	0.030	0.018	0.002
11/20/2015	EIB 0 1/2 11/15/23	(0.114)	(0.096)	(0.123)	0.005
12/28/2016	EIB 0 1/2 11/15/23	(0.098)	(0.079)	(0.109)	0.007
	CHANGE	0.016	0.017	0.014	0.002
7/8/2014	IBESM 2 1/2 10/24/22	(0.093)	(0.042)	(0.140)	0.024
12/8/2016	IBESM 2 1/2 10/24/22	(0.008)	0.011	(0.037)	0.013
	CHANGE	0.085	0.053	0.102	(0.011)

Table 2. Analysis of Average Yield Premium or Discount (in %) for Issuers with Multiple Green Bonds

Bloomberg ID	Security Name	Average	Max	Min	Standard Deviation	Industry
JK1373600	AAPL 2.85 02/23/23	0.089	0.306	0.003	0.065	Technology
AN9643841	AAPL 3 06/20/27	(0.072)	0.033	(0.118)	0.024	Technology
	AVERAGE	0.009	0.170	(0.058)	0.045	
QJ1388405	EDF 3 5/8 10/13/25	0.098	0.192	0.044	0.030	Utilities
QJ1305268	EDF 3 5/8 10/13/25	0.050	0.146	(0.024)	0.035	Utilities
EK2515238	ENGIFP 1 3/8 05/19/20	(0.093)	(0.048)	(0.113)	0.010	Utilities
EK2700996	ENGIFP 2 3/8 05/19/26	(0.047)	0.022	(0.108)	0.031	Utilities
EK1707232	IBESM 2 1/2 10/24/22	(0.093)	(0.042)	(0.140)	0.024	Utilities
QZ4989443	IBESM 0 3/8 09/15/25	(0.087)	(0.055)	(0.214)	0.025	Utilities
	AVERAGE	(0.029)	0.036	(0.093)	0.026	
EK4710878	EIB 1 1/4 11/13/26	(0.083)	(0.070)	(0.100)	0.011	Government
UV5766679	EIB 0 1/2 11/15/23	(0.114)	(0.096)	(0.123)	0.005	Government
QZ7160273	EIB 0 1/2 11/13/37	(0.167)	(0.130)	(0.182)	0.010	Government
AN6320989	EIB 2 3/8 05/24/27	(0.110)	(0.074)	(0.142)	0.015	Government
	AVERAGE	(0.118)	(0.093)	(0.137)	0.010	

Table 3. Analysis of Average Yield Premium or Discount (in %) by Industry

Bloomberg ID	Security Name	Average	Max	Min	Standard Deviation	Currency
JK1373600	AAPL 2.85 02/23/23	0.089	0.306	0.003	0.065	USD
AN9643841	AAPL 3 06/20/27	(0.072)	0.033	(0.118)	0.024	USD
AL1276115	BAC 2.151 11/09/20	(0.221)	(0.002)	(0.273)	0.044	USD
QJ1305268	EDF 3 5/8 10/13/25	0.050	0.146	(0.024)	0.035	USD
QJ1388405	EDF 3 5/8 10/13/25	0.098	0.192	0.044	0.030	USD
AN6320989	EIB 2 3/8 05/24/27	(0.110)	(0.074)	(0.142)	0.015	USD
EK9560831	MS 2.2 12/07/18	(0.257)	(0.059)	(0.343)	0.061	USD
	AVERAGE	(0.060)	0.077	(0.122)	0.039	
EK2515238	ENGIFP 1 3/8 05/19/20	(0.093)	(0.048)	(0.113)	0.010	EUR
EK2700996	ENGIFP 2 3/8 05/19/26	(0.047)	0.022	(0.108)	0.031	EUR
EK4710878	EIB 1 1/4 11/13/26	(0.083)	(0.070)	(0.100)	0.011	EUR
UV5766679	EIB 0 1/2 11/15/23	(0.114)	(0.096)	(0.123)	0.005	EUR
QZ7160273	EIB 0 1/2 11/13/37	(0.167)	(0.130)	(0.182)	0.010	EUR
EK1707232	IBESM 2 1/2 10/24/22	(0.093)	(0.042)	(0.140)	0.024	EUR
QZ4989443	IBESM 0 3/8 09/15/25	(0.087)	(0.055)	(0.214)	0.025	EUR
	AVERAGE	(0.098)	(0.060)	(0.140)	0.016	

Table 4. Analysis of Average Yield Premium or Discount (in %) by Currency

Bloomberg ID	Security Name	Average	Max	Min	Standard Deviation	Amount Issued
EK9560831	MS 2.2 12/07/18	(0.257)	(0.059)	(0.343)	0.061	\$ 500,000,000
QZ4989443	IBESM 0 3/8 09/15/25	(0.087)	(0.055)	(0.214)	0.025	\$ 700,000,000
EK1707232	IBESM 2 1/2 10/24/22	(0.093)	(0.042)	(0.140)	0.024	\$ 750,000,000
AN9643841	AAPL 3 06/20/27	(0.072)	0.033	(0.118)	0.024	\$1,000,000,000
AL1276115	BAC 2.151 11/09/20	(0.221)	(0.002)	(0.273)	0.044	\$1,000,000,000
EK2515238	ENGIFP 1 3/8 05/19/20	(0.093)	(0.048)	(0.113)	0.010	\$1,200,000,000
QJ1388405	EDF 3 5/8 10/13/25	0.098	0.192	0.044	0.030	\$1,250,000,000
QJ1305268	EDF 3 5/8 10/13/25	0.050	0.146	(0.024)	0.035	\$1,250,000,000
QZ7160273	EIB 0 1/2 11/13/37	(0.167)	(0.130)	(0.182)	0.010	\$1,250,000,000
EK2700996	ENGIFP 2 3/8 05/19/26	(0.047)	0.022	(0.108)	0.031	\$1,300,000,000
JK1373600	AAPL 2.85 02/23/23	0.089	0.306	0.003	0.065	\$1,500,000,000
AN6320989	EIB 2 3/8 05/24/27	(0.110)	(0.074)	(0.142)	0.015	\$1,500,000,000
EK4710878	EIB 1 1/4 11/13/26	(0.083)	(0.070)	(0.100)	0.011	\$1,800,000,000
UV5766679	EIB 0 1/2 11/15/23	(0.114)	(0.096)	(0.123)	0.005	\$1,900,000,000

CORRELATION	0.354
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Table 5. Analysis of Average Yield Premium or Discount (in %) by Amount Issued

Bloomberg ID	Security Name	Average	Max	Min	Standard Deviation	Maturity in Years
EK9560831	MS 2.2 12/07/18	(0.257)	(0.059)	(0.343)	0.061	3.50
AL1276115	BAC 2.151 11/09/20	(0.221)	(0.002)	(0.273)	0.044	4.00
EK2515238	ENGIFP 1 3/8 05/19/20	(0.093)	(0.048)	(0.113)	0.010	6.01
JK1373600	AAPL 2.85 02/23/23	0.089	0.306	0.003	0.065	7.01
UV5766679	EIB 0 1/2 11/15/23	(0.114)	(0.096)	(0.123)	0.005	8.22
EK1707232	IBESM 2 1/2 10/24/22	(0.093)	(0.042)	(0.140)	0.024	8.51
QZ4989443	IBESM 0 3/8 09/15/25	(0.087)	(0.055)	(0.214)	0.025	9.01
AN6320989	EIB 2 3/8 05/24/27	(0.110)	(0.074)	(0.142)	0.015	10.01
AN9643841	AAPL 3 06/20/27	(0.072)	0.033	(0.118)	0.024	10.01
QJ1388405	EDF 3 5/8 10/13/25	0.098	0.192	0.044	0.030	10.01
QJ1305268	EDF 3 5/8 10/13/25	0.050	0.146	(0.024)	0.035	10.01
EK2700996	ENGIFP 2 3/8 05/19/26	(0.047)	0.022	(0.108)	0.031	12.01
EK4710878	EIB 1 1/4 11/13/26	(0.083)	(0.070)	(0.100)	0.011	12.18
QZ7160273	EIB 0 1/2 11/13/37	(0.167)	(0.130)	(0.182)	0.010	21.12

CORRELATION	0.127
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Table 6. Analysis of Average Yield Premium or Discount (in %) by Maturity

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ACADEMIC VITA

Academic Vita of Brandon L. Chang

blkchang@gmail.com

EDUCATION

The Pennsylvania State University – Schreyer Honors College

- *Smeal College of Business* | Bachelor of Science in Finance
- *College of the Liberal Arts* | Minor in Economics

The University of Amsterdam

- *College of Social Sciences* | Amsterdam Exchange Program

University Park, PA

Class of 2018

Dean's List (7/7)

Amsterdam, NL

January 2017 – June 2017

EMPLOYMENT

PricewaterhouseCoopers

Risk Consulting Intern | Financial Services

New York, NY

Summer 2017

- Advised a \$67B AUM diversified financial services company on impact of DOL Fiduciary Rule to business operations and law
- Created system and information exchange mappings to illustrate dependencies and effects of work streams across business units
- Contributed to project management organization by preparing client PowerPoint presentations and supporting team logistics

Goldman Sachs

IMD Controllers Summer Analyst

Jersey City, NJ

Summer 2016

- Worked closely with team to monitor and review Goldman Sachs Asset Management mutual funds in areas including performance, dividend distribution, budgeting, SEC filings, prospectuses, and annual report release
- Constructed policy and procedure database by expanding and modifying operational guidelines for securities lending, SEC yields, swing pricing, Korean dividends, and management fees; informed and presented policies to staff during weekly meeting

AmerisourceBergen Corporation

Corporate Accounting Intern

Conshohocken, PA

Summer 2015

- Generated Hyperion ad hoc reports to analyze variances in accruals and monthly corporate expenses to ensure proper records
- Supported accounting team by running G/L account detail, creating journal entries, consolidating balance sheets, generating invoices, preparing check deposit forms, and reviewing SEC reports to ensure accurate reporting of company financials

Bank of America Student Leaders Program

Philadelphia Youth Network, Inc. Intern | External Affairs Department

Philadelphia, PA

Summer 2014

- Selected as 1 of 5 students in Pennsylvania for a paid full-time summer internship with a local nonprofit organization
- Collaborated in a team of 5 to develop project plan and implement social media into the WorkReady Expo that reached over 600 attendees and increased the company's social media presence on numerous platforms

LEADERSHIP AND ACTIVITIES

Business and Society House

President

University Park, PA

August 2014 – May 2016

- Managed 10 Executive and Chair Board members and organized community-wide events for members to explore business at a more comprehensive level and gain a well-rounded experience through professional development, social, and volunteer events
- Strategized a recruitment effort to target incoming freshmen and increased membership by over 50 members
- Restructured the organization by establishing new positions and reassigning responsibilities to improve efficiency and communication between Executive and Chair Board members

Sapphire Leadership Academic Program

Communications Captain

University Park, PA

August 2014 – May 2018

- Led a team of 3 Chair members to expand community outreach by building an alumni database, developing a website, strengthening social media presence, and designing and composing the alumni newsletter reaching over 450 Sapphire alumni
- Enhanced organizational effectiveness by maintaining membership records and providing weekly update to faculty and students

Delta Sigma Pi – Alpha Gamma Chapter

Vice President for Pledge Education

University Park, PA

January 2015 – May 2018

- Guided 20 new pledge brothers through an 8-week pledging program by instructing the class about the history, purpose, and objectives of the fraternity and leading professional development workshops on résumés, interviews, and social media
- Established and managed Pledge Committee of 8 brothers to coordinate weekly meeting logistics and assist the pledge class

Wall Street Boot Camp

Certificate Recipient

University Park, PA

January 2016 – May 2016

- Accepted into a 40-student cohort from over 300 applicants to prepare for a career in the financial services industry by participating in weekly sessions hosted by Wall Street professionals and expanding knowledge of Wall Street careers

Penn State Investment Association*Analyst | Consumer Staples Sector***University Park, PA***September 2015 – May 2017*

- Analyzed securities and supported members of the Nittany Lion Fund, a \$7 million student-run investment fund
- Participated in weekly educational sessions and sector breakout meetings led by members of the Nittany Lion Fund to learn about the Fund's investments, valuation techniques, and current market conditions

HONORS AND INTERESTS

Honors: Eagle Scout, Ralph H. Wherry Student Service Senior Award, The Evan Pugh Scholar Award, The President Sparks Award, The President's Freshman Award, Glick Sapphire Honors Scholarship, Sam Wherry Honors Scholarship, Sharp Scholarship

Interests: Saxophone, Penn State Centre Dimensions Jazz Ensemble, golfing, biking, camping, hiking, ice hockey