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Master Thesis Economics and Business

A Green Safe Haven

Analyzing potential safe haven characteristics through crisis beta.

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In this thesis, the potential safe haven characteristics of green bonds are evaluated between 2019 and 2022 for the S&P500, STOXX600, and MSCI World. Green bonds trade at a premium with respect to their conventional counterparts. This premium is derived from non-monetary incentives. This thesis investigates whether this premium does ensure safe haven properties. Safe haven properties are evaluated using a crisis beta. The crisis beta does indicate the level of correlation with the market during extreme market conditions. Performance of green bonds during left tail return episodes are compared to the performance of gold, US 10-year treasuries, and the German 10-year Bund, which have proved safe haven status in past market crashes. Furthermore, are the implications of the crisis beta on asset pricing investigated using cross-sectional regressions. The results show that green bonds do not provide safe haven characteristics. The green bond market does not possess the depth nor the clarity of proven safe haven markets. The US 10-year bond does provide a safe haven for the S&P500 and the STOXX600. Gold does not provide safe haven abilities across all markets. Therefore, the safe haven ability of gold is fragile. This should have implications for the future adoption of gold as a safe haven.

Keywords: Green Bonds, Safe Haven, Crisis Beta

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1 Introduction

For most investors, the second week of March 2020 will be remembered as one of the worst weeks in financial history. Driven by fear for a new unknown virus investors unloaded their assets. Market indices plunged and stock market volatility rose to a record high (Baer, 2020). In times of market stress, a flight to quality is a common phenomenon. However, the COVID-19 crash displayed a real problem. Investors struggled to unload "safe assets" like treasury bonds. With financial global markets more connected than ever, spillover effects of a crash can cause real concerns. Therefore, investors are desperately in search for new safe assets which can preserve capital in extreme market conditions. Historical safe havens might not be suitable anymore in the future because of changing financial landscape. In the period prior to the COVID-19 pandemic, central banks maintained an unconventional monetary policy by buying up public debt, known as quantitative easing. However, when the COVID-19 pandemic hit economists feared a global recession with unpredictable consequences. Central banks made interventions by again increasing their quantitative easing spending and lower interest rates to almost zero. With interest rates at historical lows already, and a global debt at an all-time high, the next market crash cannot be far off. In times of financial distress, every investor seeks possibilities to keep one's portfolio safe. Finance theory offers multiple solutions for portfolio protection. Diversification, hedging, and allocation to safe havens. Investing 101 starts with diversification, investors diversify to reduce idiosyncratic risk in their portfolios. But the power of diversification might not be sufficient in today's financial system (Chua, Kritzman, and Page, 2009). Further, the study of Page and Panariello (2018) shows that diversification fails in tail events, so during times of financial turmoil. Therefore, more robust portfolio protection is necessary. Popular in finance is the use of numerous hedging methods, which are characterized by a negative correlation with the assets in need of protection. A weak (strong) hedge asset is uncorrelated (negatively correlated) with an asset on average. The main drawback of hedging is the complexity. Hedging strategies are known for relatively high cost and complex methods, paired with high leverage (Cheng and Madhavan, 2008). Furthermore, hedging creates a return drag for the long-term investor. A hedge is negatively correlated with an asset on average (Baur and Lucey, 2010), and so will diminish returns for long-term investors. The last solution to protect capital are safe haven assets. The concept of a safe haven asset refers to an investment that is expected to retain or increase in value during times of economic uncertainty or market volatility. Investors often seek out safe haven assets as a way to protect their wealth and

minimize potential losses in times of market turmoil. In this thesis I will explore the safe haven properties of gold, bonds, and green bonds.

In current literature, gold is perceived as the best safe haven asset throughout history (Baur and Lucey, 2010). Gold has a long history as a store of value and a hedge against inflation. Some fundamental features of gold make it best suitable as a safe haven asset. Gold is a physical and liquid asset that is widely accepted and traded around the world. Gold is not affected by changes in interest rates or the creditworthiness of the issuer. Bonds, including corporate bonds and government bonds, are also marked as potential safe haven assets. These assets derive their safety from the creditworthiness of the issuer. This can make bonds a safe asset in times of economic uncertainty or market volatility. However, it is important to note that the perceived safety of bonds can be influenced by a number of factors, including the creditworthiness of the issuer, the specific terms of the bond, and market conditions. Green bonds are a type of bond that is specifically issued to finance projects with a positive environmental impact, such as renewable energy or energy efficiency. Green bonds offer investors the opportunity to support environmentally responsible projects and the potential to receive a financial return. Like traditional bonds, green bonds are backed by the issuer's creditworthiness and offer a fixed income stream. MacAskill et al. (2020) find that green bonds trade at a small premium relative to conventional bonds with the same characteristics. Driven by climate change, regulatory benefits, and the trend of responsible investing, green bonds have the potential to be a safe haven.

This paper will contribute to current literature in two ways. First, this paper will examine green bonds' safe haven properties in times of financial turmoil by comparing the crisis beta to gold and conventional government bonds which are considered to be safe havens. Further, this paper examines the implications of the crisis beta on asset pricing. And will expand the current literature on the topic of the safe asset shortage by examining if governmental or corporate green bonds can play a role in the future of safe assets. The main question to be answered in this paper is: "Do green bonds exhibit characteristics of safe haven assets, and to what extent do they provide stability for investors during times of economic uncertainty?"

This question will be answered by testing the following hypotheses:
H1: Green bonds do exhibit characteristics of safe haven assets.
H2: Green bonds do not exhibit safe haven characteristics to the same extent as gold.

H3: Green bonds do exhibit better safe haven characteristics than conventional bonds.
H4: Governmental green bonds do exhibit superior safe haven characteristics than corporate green bonds.

In this thesis, I will explore the safe haven properties of gold, treasury bonds, governmental green bonds, and corporate green bonds. I will examine the historical performance of these assets, as well as the factors that can influence their perceived safety as investments. The safe haven performance of these assets will be assessed through the crisis betas, which indicates the correlation with the market during extreme market conditions. Furthermore, this study will investigate the implications of safe haven characteristics on asset pricing using the Fama-Macbeth regression model (1973). I will also consider the potential risks and rewards associated with investing in these assets, and how they may be used as part of a diversified investment portfolio.

Section 1 contains the literature review in which the assets are examined on why they make the list of potential safe havens. In this part, the determinants of the green bond market are explained, and on why green bonds may not be suitable (yet) to be considered for the safe haven status. Section 2 contains the data description. Section 3 outlines the methodology of the paper. Section 4 contains the results of the safe haven analysis through crisis betas and the implications of crisis betas on asset pricing. Section 5 contains the discussion; practical implications of the results will be outlined in this part. Section 6 is the conclusion, the most important findings in the paper will be concluded here.

2.1 The Safe Haven Idea

According to the dictionary, a safe haven is a place where you are protected from harm or danger ("Safe Haven," n.d.). In the general run of both academic and trade literature, the term safe haven refers to the assets preferred by investors to secure capital during periods of uncertainty (Janani et al. 2022). The implied assumption in these assets, currencies, or even countries is associated with relatively low risk and high liquidity during times of market stress. So, a safe haven does not need to be so much as a particular asset. Spitznagel and Taleb (2021) define a safe haven as a risk-mitigating payoff that can come in many forms. An insurance contract, gold, or an option could all act as a safe haven. Baur and McDermott (2016) define a safe haven asset 'as an asset that is either uncorrelated or negatively correlated with other assets during periods of financial distress' (Baur and Lucey, 2010; Baur and McDermott, 2010). In this paper I will follow the distinction between a diversifier, a hedge, and a safe haven made by Baur and Lucey (2010). A hedge is an asset that is uncorrelated or negatively correlated with another asset on average. A diversifier is defined as an asset that is positively correlated with another asset on average. And a safe haven is uncorrelated or negatively correlated with an asset in times of market stress or turmoil. Further a safe have should be considered strong (weak) when the asset is negatively (uncorrelated) correlated with another in times of market stress.

The difference between a safe haven and a hedge must be clear. A hedge is on average negatively correlated or uncorrelated, in times of market stress this asset does not have the properties to prevent losses. In times of market stress, a hedge is characterized by a positive correlation with an asset, outside of market stress this asset is negatively correlated and therefore negatively correlated on average.

Why do perceive investors certain assets as safe? Following the study of Caballero et al. (2017) assets are perceived safe when the criterium of high liquidity is met and when the asset is not (limited) sensitive to risk factors like, inflation risk, exchange risk, and idiosyncratic risk. Besides the fundamentals of the asset, the belief in safe assets may be as important, to the extent that it could be a self-fulfilling prophecy. Certain assets are marked as safe because of historical performance during market crashes and the expectation of it to be safe in the future despite weakening fundamentals. The framework used to evaluate the proposed safe haven assets is based around security and will substantiate on where assets derive their safeness from.

1. Sensitivity to risk factors
2. Liquidity
3. Creditworthiness
4. Diversification
5. Return

The paper of Caballero et al. (2017) proposes the idea that a safe asset should not be sensitive to risk factors or insensitive to information. Secondly, liquidity is very important in seeking the best safe haven asset. According to Habib and Stracca (2012), most liquid markets may get a premium when market liquidity may dry up. In the search for safe assets, creditworthiness is important. Investors should consider assets as safe only if they are issued by entities with strong credit ratings, indicating that these entities can withstand market volatility. However safe assets can also get creditworthiness from their design and investors' belief in the asset. So, creditworthiness should be seen in a broader perspective than only the credit rating of the issuing entity. Safe haven assets are typically a small part of a diversified portfolio, which helps investors to form the impact of market downturns. Therefore, these investments often provide conservative returns in the long term and do not provide the same level of potential returns as other types of investments. But this is considered to be a fair trade-off for the added security and stability provided in the most volatile times.

2.1.2 Destruction of safe haven assets

A Safe haven is uncorrelated or negatively correlated with an asset in times of market stress. According to this definition, a safe haven asset does only lose its safe haven status if it co-moves with the stock market in a crisis. The asset would not automatically and necessarily lose its safe haven status if the price of the safe haven asset fell in non-crisis periods. In fact, the decoupling of safe haven assets from equity markets in normal times is a necessary condition for a safe haven asset to be different from a risk-free safe asset (Gulko, 2002). In other words, a safe asset is safe at all times whilst a safe haven asset is only safe (and only needs to be safe) during times of crisis or turmoil.

2.2 Gold

In the current market environment, gold represents an important role. Maybe not as important as it used to be, but gold still attracts significant attention because of the physical properties it has. Throughout history gold has been a store of value, a medium of exchange, and, an inflation-neutral asset. In the last century the use of gold has changed. Gold is not used anymore as a medium of exchange with the introduction of fiat currencies. However, gold still had an important role in fiat currencies. For years fiat currencies have been linked to gold, by deriving the value of the currency in ounce of gold. Central banks still use gold as a store of value to defend the value of their assets. Throughout financial history, gold has had an important role. Nowadays, gold is still a popular asset to invest in. Gold is a globally accepted and easily traded asset, making it a liquid asset that can be converted into cash relatively quickly. Furthermore, gold is not exposed to credit risk of an issuing entity, so it is not subjected to default risk. This is an advantageous characteristic, especially in periods of uncertainty when investors tend to move their capital to safe assets. Gold is known to retain value in periods of high inflation. In the study of McCown & Zimmerman (2006) is shown that gold does provide a hedge against inflation with returns close to those of treasury bonds. Furthermore, McCown and Zimmerman find that gold has a beta of zero in the period between 1970 and 2006. Zero-beta assets are uncorrelated with the market and therefore are robust against market risk. Besides a hedge against inflation gold can be used as a hedge against exchange rate volatility of the American Dollar and the British Pound (Ciner, Gurdgiev, and Lucey, 2013). In the study by Baur and McDermott (2016) is shown that gold is a strong safe haven asset. Gold provides a better protection against market crashes than the 10-Year US treasury bond. This is remarkable to reconcile, treasuries are highly liquid fixed-income securities while gold does provide less liquidity and does not provide fixed yield, and is subjected to price volatility. The preference for gold seems to indicate a special role that cannot be explained by the risk-return characteristics. Baur and McDermott (2016) find that the specialty of gold might be related to gold's history as a store of value, use as medium of exchange, and safe haven status throughout multiple crisis episodes. This preference for gold could be explained from a behavioral standpoint. Baur and McDermott provide 3 possible explanations. Individuals under stress pay more attention to positive information than to negative information (Mather and Lighthall, 2012). So, investors pay more attention to the positive experiences of gold in the past and do not acknowledge the negative experiences. Another explanation is linked to ‘local thinking’, in situations of financial distress investors do not have the time to overlook all possible resources

(Gennaioli and Shleifer, 2010). Therefore, investors choose well-known opportunities. The tangibility of gold plays a part in the decision for this asset. In times of uncertainty investors have literally something to hold onto. Finally, risk-seeking behavior is fueled by losses, explained by the prospect theory (Kahneman and Tversky, 1974). Investors prefer gold (risky) over Treasure bonds (risk-free). However, when decision-making depends on past information, the safe haven return is self-fulfilling as long as investors are reminded of past experiences. Therefore, the safe haven status of gold might be fragile. If gold does not prove to be a sufficient safe haven in future crashes. Investors' perception of gold safe haven status might change, and this self-fulfilling return will not hold up anymore. Hence, is it helpful to consider different safe havens.

2.3 Bonds

The US treasury bond is often referred to as risk-free. Therefore, US treasuries are one of the most popular investment vehicles. Government bonds are classified as fixed-yield securities, which are often liquid and safe, depending on the creditworthiness of the issuer. US government bonds are considered one of the most reliable investments in the world because the bonds are backed by the US government. In general, the creditworthiness of a bond is derived from the fundamentals of the issuer. In the case of government bonds, the safety or default risk is based on the fundamentals of the country's economic status. In the global financial system, the US treasury does fulfill an important role. US treasuries serve as benchmarks for other different financial securities, investors also use US treasuries for the pricing of other investments. Furthermore, US Treasuries serve as a hedge against geopolitical risks. When local investors are concerned about the political situation in their country, investors use the US treasuries as a safe place to store their capital. Throughout history the demand for treasury bonds tends to increase in times of market stress, driving up the prices and lowering yield. Investors tend to move their capital to safe assets in the flight for quality. Typically, long-term US treasury bonds exhibit a negative or low beta coefficient (He and Krishnamurthy, 2020). For example, in the financial global crisis in 2007-2009, the yields of the 1-year, 5-year, and 10-year Treasury bonds fell as the stock market fell. Therefore, including US Treasury in an equity portfolio will have diversification benefits. But in March 2020 when the stock market crashed due to the Covid-19 pandemic the US treasury yields went up, showing a positive correlation with the stock market. Thus, the ambiguous safe haven status of bonds should be considered in the investment decision.

In the study of He et al. (2016) is shown that the safety of a bond is determined on a relative basis. Government bonds are safe because their fundamentals are relatively strong compared to other assets. Hager (2016) highlights that the US Treasury bond retains strong value relative to other assets, even though the fundamentals have deteriorated over the last decade. The US public debt has never been as high caused by the quantitative easing (QE) of the FED. With fundamentals deteriorating, downgrading US credit rating. One should expect less demand for US Treasury bonds, but the opposite is true. Investors are obliged to choose the least bad asset in this case. The study of He et al. (2016) further highlights that a high debt float, high float means high liquidity, but cuts on both sides. A large float offers high liquidity which creates more demand and reduces roll-over risk. However, when demand is low a high debt float could have negative consequences as roll-over risk looms. This would not mean an immediate threat to US treasuries, but in the future a high debt float can cause major problems. With the deteriorating fundamentals of the US government, investors will search for other low-risk assets (Hager, 2016).

Besides US treasuries, German government bonds are considered a safe asset in the Eurozone. The German Bund does not provide the safety of the US treasuries but is globally regarded as a low-risk asset. The German economy is the largest in Europe and has maintained a budget surplus in recent years, indicating a strong financial position and credit rating. In the study by Di Santis (2012) is shown that the German Bund benefitted from the Euro crisis. As a liquid and safe asset, the yield of the German Bund decreased when South-European economies displayed financial troubles. Confirming the safe status of the Bund in the Eurozone. Another potential government that could satisfy the safe have requirements is the Chinese government. Chinese government bonds have been increasingly viewed as potential safe asset. China, as the second-largest economy, has been steadily increasing their influence in global financial markets. Chinese government bonds make an attractive investment by combining higher yields relative to developed market bonds and lower risk relative to emerging markets (Chen, 2021). Chinese government bonds are already more widely accepted, which could lead to significantly more power in the financial system. The acceptance of Chinese bonds can pose a threat to the safe haven status of US Treasuries. However, there are some barriers to overcome. Currently, the Chinese financial markets are still underdeveloped compared to the US. Although the Chinese bond market is ranked as the third largest market, debt held by foreigners is still low (Lake, 2015).

2.4 Green bonds

Green bonds are fixed-income securities that are issued to finance projects that have a positive environmental impact. The similarity with conventional bonds is large in terms of structure and features, but the proceeds from the bond are specifically earmarked for green projects such as renewable energy, energy efficiency, or sustainable transportation. Green bonds can be issued by governmental institutions, corporations, or financial institutions and are often used to fund projects that align with environmental, social, and governance (ESG) principles. Green bonds could potentially be considered a safe haven because they offer a fixed income stream and are backed by the issuer's creditworthiness like conventional bonds. However, this is not the main reason why green bonds may be able to receive safe haven status. Green bonds offer additional benefits over conventional bonds to investors who are interested in supporting environmentally responsible projects. With increasing environmental awareness among investors, the demand for green investments automatically increases. Public corporations are forced through regulators or shareholders to comply with this trend and invest in environmentally responsible projects. So, besides the fundamentals of a fixed-income asset, these green bonds also benefit from the movement of more attention toward climate-friendly projects. Climate-friendly investments gained large momentum in the past decade. Since environment becomes a more important topic. Governments introduce new rules and laws in favor of the climate. To force corporations to comply with internationally agreed climate targets. Corporations with strong ESG principles are less impacted by these regulatory changes and may even benefit from these interventions by subsidization (Kuang, 2021).

MacAskill et al. (2020) conduct a study into the determinants of the green bond market and analyze the potential of a green premium. Their study concludes that there is a slight positive consensus regarding a green premium in the primary market for green bonds. Further is highlighted that this could impact the pricing of green bonds. The price of a green bond is not only dependent on economic motives but also partially determined by non-economic motives. MacAskill et al. (2020) indicate that the green premium is more pronounced in the secondary market. The existence of a green premium is supported by Patridge & Medda (2018), who observe a green premium in pair-wise analysis where the bonds are identical except for the green component. In the secondary market the green premium is more pronounced. MacAskill et al. (2020) show that green bonds issued by governmental or municipal institutions have the highest premium because of lower risk exposure. Investors tend to be risk-averse when

investing in a new financial asset. But could the premium of green bonds indicate potential safe haven characteristics?

The existence of a financial premium can indicate a number of things. In general, when investors are willing to pay a premium that can indicate that the asset is perceived as more valuable or desirable than similar assets. This premium can be based on different factors, but in the case of green bonds, the non-economic value of investing in environmentally friendly projects does have an impact. In the study of Chopra and Mehta (2022) is shown that green bonds show strong safe haven characteristics, especially with high emission sectors. The study of Dong et al. (2022) provides results with a longer time frame of 10 years in which they compare hedging abilities and safe haven abilities between conventional bonds and green bonds under different circumstances. Dong et al. conclude that the safe haven abilities of green bonds are superior to conventional bonds especially when economic and political uncertainty is high.

2.5 Green bond market

Green bonds are a relatively new type of bond that has gained popularity in the past 10 years. These bonds are issued to finance projects that have positive environmental and climate benefits, such as renewable energy, energy efficiency, and sustainable transportation. The performance of green bonds over the past decade has been strong, with the market growing rapidly in terms of size and diversity.

David and Wood (2011) conducted small research where investors were asked about their motivation behind the decision to invest in green bonds. At the time the green bond market accounted for $3.5 billion. The interviewees stated that prospects for growth in the green bond market were high, but there were also concerns. Definitions, standards, issuance scale, and liquidity concerns were marked as potential barriers to expansion. With these concerns in mind, the cumulative issuance of over $2 trillion in 2022 (CBI) confirms a major expansion of the green bond market. However, multiple obstacles had to be overcome. Unclear definitions resulted in “greenwashing”, where companies disclose misleading information about environmental projects to benefit from positive publicity (Delmas & Burbano, 2011). To combat “greenwashing”, green bonds can be certified to receive a green label, which means that the proceeds must be used to finance green projects for which the bond is issued.

Despite clearer definitions, higher standards, and the rapid expansion of the green bond market this market is not mature. In the study of Deschryver and Mariz (2020), the authors question the drivers behind the rapid growth and future potential of the green bond market. Despite, believing in the great potential of the green bond market, the development of this market should take another direction. Deschryver and Mariz (2020) point out that the green bond market is still a small market compared to conventional bonds, estimated at $1 trillion (CBI) at the end of 2022 compared to the $53 trillion debt market in the US (Sifma, 2022). Because of the limited market size and multiple adopted standards under which bonds are issued, clarity and liquidity constitute serious concerns for investors. Deschryver and Mariz (2020) argue that the green bond market still cannot provide enough data to investors to make an educated investment decision. They also point out that green bond issuance is associated with higher costs because of a special certification process to receive the green label. It is questioned whether there is an advantage to green bond issuance at all. And finally, Deschryver and Mariz (2020) make a solid case for the expansion of the green bond market in the last decade. As a consequence of unconventional monetary policy after the financial crisis in 2008, the green bond market benefitted. Monetary policy resulted in low-interest rates and thereby the search for yield. Institutional investors and pension funds were coming under pressure to fund ways to allocate their capital in a more productive way. Thus, the argument can be made that the expansion of the green bond market was mainly driven by the positive economic climate and low-interest rates.

In order for the green bond market to be perceived as safe, several challenges must be addressed. Regardless of the growing interest in environmental investments and the increasing urgency of climate change, further progress is required to unlock the full potential of green bonds. To establish itself as a credible fixed-income market, the adoption of higher reporting and disclosure standards is inevitable. Standardization would increase the appeal to a larger number of investors and issuers. Additionally, the participation of more large issuers is crucial to deepen the market and attract the attention of large institutions. This will eventually improve the reputation and legitimacy of the green bond market.

3 Data

The data consists of daily closing prices for MSCI world, S&P500, STOXX600, US10YR treasury, and iShares Green Bond Index. For the gold price, the daily closing spot price is used. All data is extracted from Eikon Refinitiv DataStream. All green bonds used in this analysis are marked with the green label in Eikon Refinitiv. To investigate the potential difference in safe haven qualities of green bonds a distinction is made between corporate green bonds and governmental green bonds. Both bond portfolios have comparable characteristics and are collected from Eikon Refinitiv, closing prices of individual bonds are collected from Eikon Refinitiv DataStream. The bonds are active between January 1^{sts} 2019 and November 30th, 2022. This period is chosen because the COVID-19 pandemic is included in this sample. The uncertainty and fear which was fueled by the virus did hit all global financial markets. This crisis is unique because not only financial markets were hit, but this crisis had clear consequences which spilled over the real economy. Another interesting phenom was the period of unconventional monetary policy, with the first time in history when interest rates were negative. Furthermore, does this period provide the best sample coverage of green bonds. Green bonds are a relatively new financial asset, therefore usable data is still limited. Especially governmental institutions hardly issue sizeable green bond programs. A reason could be that these governmental entities can already borrow against a low rate, and the incentive for issuing green bonds might not be as strong as with corporate entities. To provide an analysis with a substantial amount of active bonds this period is chosen. All bonds in this study are issued before 1-1-2019 and mature after 1-1-2024, to prevent liquidity concerns right before maturity. The average issuance for corporate green bonds is 625 million and for governmental green bonds 1500 million. All bonds are investment grade and are fixed coupon only. The Government bond portfolio consists of 29 bonds and the corporate bond portfolio consists of 97 bonds.

The iShares Green Bond Index (Ticker: $BGRN) is used to represent the performance of the global green bond market. This index includes dollar-nominated, investment-grade green bonds (iShares USD Green Bond ETF | BGRN, 2018). Gold, US10YR treasury, and GB10YR bund are used to represent traditional safe havens. The US Treasury and the German Bund are chosen because of their comparability to green bonds. Prices of these bonds are influenced by the same determinants.

3.1 Descriptive statistics

Table 1

	Annualized return	*Arithmetic return*	*Geometric return*	*Skewness*	*Kurtosis*	*Standard Deviation*	*Minimum*	*Median*	*Maximum*
MSCI World	9,07%	0.029%	0.021%	-1.38	19.15	0.309%	-11.006%	0.076%	8.063%
S&P500	12,33%	0.037%	0.027%	-1.17	18.21	1.440%	-13.616%	0.071%	8.578%
Stoxx600	6,54%	0.019%	0.012%	-1.69	21.22	1.195%	-12.968%	0.091%	7.754%
Gold	6,62%	0.026%	0.022%	-0.56	7.28	0.934%	-5.198%	0.060%	4.844%
US10YR	-1,83%	-0.007%	-0.008%	-0.07	6.41	0.498%	-2.506%	0.000%	2.587%
GB10YR	-3,46%	-0.0128%	-0,015%	0.19	6.18	0.430%	-1.99%	0.000%	2.181%
Ishares Green Bond Index	-2,13%	-0.008%	-0.009%	-0.88	8.67	0.309%	-2.121%	0.000%	1.522%
GOVGB-portfolio	-2,57%	-0.009%	-0.010%	-0.12	5.35	0.304%	-1.405%	0.003%	1.286%
CORPGB-portfolio	-1,75%	-0.007%	-0.007%	-1.39	16.16	0.239%	-2.397%	0.001%	1.010%

Note: Table 1 presents the Descriptive of the data, all descriptive statistics are supplied using STATA.

Table 1 contains the descriptive statistics for all six assets and the three indices under study. The daily arithmetic and geometric returns are calculated for every asset. During longer investment periods of multiple years, the geometric return is more useful because the compounding effect is incorporated. A disadvantage of the arithmetic return is that its incompatible with starting and ending values. Over multiple periods arithmetic returns can overstate the ending value. As in Table 1 is shown, the S&P500 has the highest daily return but is also the most volatile. All fixed-income securities have a negative return during the period, this can be explained by the low-interest rates which became almost zero when the COVID-19 pandemic hit.

Figure 1 shows the total return of all assets in the period between 1-1-2019 and 30-11-2022. All indices experience a positive return in this period, the S&P500 has the highest overall return.

The STOXX600 experienced the worst return of the equity indices. This is because Covid-19 had major implications on daily life in Europe. Of the potential safe haven assets, only gold experienced a positive overall return in the sample period. Furthermore, Figure 1 shows a clear market crash in March 2020. After March 2020, the equity indices show a fast recovery fueled by low-interest rates and multiple rounds of monetary stimulus.

Figure 1: Return graph of safe havens and market returns

Note: In Figure x the returns between 1-1-2019 and 30-11-2022 are presented.

In line with theory, equity assets show a higher return over the whole period. These higher returns do result in more risk compared to the safe haven assets, the volatility of the equity indices is higher than the volatility of the safe haven assets. This is consistent with literature in which safety (volatility) comes at the cost of lower returns (Wang, et al., 2021). The standard deviation of the S&P500 and the STOXX600 is much larger than the MSCI world. Which implies higher volatility for the S&P500 and the STOXX600. The lowest standard deviation is for the Corporate Green Bond portfolio.

4 Methodology

The main objective of this paper is to investigate the potential safe haven characteristics of green bonds. In this analysis the safe haven status of gold, government bonds, and green bonds will be examined. Gold, US 10-year treasury, and the German 10-year Bund have proven their safe haven status in past episodes of extreme market conditions. The performance of green bonds will be compared to the performance of these proven safe haven assets. The safe haven potential of green bonds will be tested using the iShares green bond index to represent the overall market. A green government bond portfolio and a green corporate bond portfolio outline possible differences regarding experienced safety. To qualify as a safe haven an asset should be negatively correlated (uncorrelated) in times of financial turmoil to be a strong (weak) safe haven. In this paper I will differentiate between a diversifier, hedge, and safe haven according to the definitions of Baur and McDermott (2010). To examine safe haven potential, the beta of an asset will be held against the necessities of a safe haven. A safe haven study is only relevant if concentrated on the left tail of the return distribution, this is the area where safe haven qualities have to come forward. To examine the left tail of the return distribution the worst 10% and 5% trading days are chosen to represent extreme market conditions. I have chosen to analyze two crisis betas to if an asset's correlation changes under extreme market conditions. The betas are estimated using a time-varying linear regression based on the following equations.

$$R_{i,t} = \alpha_i + \beta_i F_t + \varepsilon_{i,t} \quad \text{(eq1)}$$

$$R_{i,t} = \alpha_i + \beta_{i,10\%}(F_t D_{10}) + \varepsilon_{i,t} \quad \text{(eq2)}$$

$$R_{i,t} = \alpha_i + \beta_{i,5\%}(F_t D_5) + \varepsilon_{i,t} \quad \text{(eq3)}$$

From this model α_i and β_i are obtained for every specific asset i, using the daily return of the asset and the market. In eq1 the overall beta of the asset is estimated. Eq2 and eq3 provide the regressions for the estimation of the crisis betas for an asset. The crisis betas are estimated by adding a dummy variable, which is triggered when the daily stock returns do exceed the threshold of 10% or 5% worst trading days. This process will be repeated three times, where all three indices serve as market factor. Every tested asset will have an overall beta, a 10% crisis beta, and a 5% crisis beta per market. The S&P500, STOXX600, and the MSCI WORLD are proxied as the market factor.

In the second part of this study, I will analyze the implications of the crisis beta on asset pricing. In asset pricing theory risk factors are employed to explain the returns of an asset. The Fama-Macbeth (1973) two-step regression approach is a practical way to measure how these risk factors influence asset return. This model aims to determine the risk premium associated with the exposure to this risk factor. In this part, I examine the cross-sectional returns of the assets for the betas obtained from the first regression. When assets do provide financial safety in turmoil, investors might be willing to pay a premium for this asset and thus will accept a lower return. So, the crisis beta can have implications for asset pricing if these assets do provide a form of safe haven protection in financial bad times. To examine the cross-sectional returns on the betas the following linear regression model is used:

$$R_{i,t} = \gamma_{t,0} + \gamma_{t,1}\beta_i + \varepsilon_{i,t} \quad \text{(eq4)}$$

$$R_{i,t} = \gamma_{t,0} + \gamma_{t,1}\beta_i + D_{crisis}\gamma_{t,2}\beta_{10,i} + \varepsilon_{i,t} \quad \text{(eq5)}$$

In this regression the gammas are estimated using the beta(s) obtained from the time series regression. This regression model will be repeated three times, because of different betas for every market factor. In eq4 the effect of the overall beta on the returns will be tested. In equation eq5 the effect of the crisis beta on the returns is incorporated. Only the 10% crisis beta will be used to examine the effect on the cross-sectional returns to reduce noise in the regression model. To see if the crisis beta has a significant impact on the cross-sectional returns results of both equations are compared to draw conclusions.

5 Results

In this section I present the results of the safe haven analysis. Assets provide hedging abilities when the overall beta is negative, which indicates a negative correlation with the market over the whole period. However, hedging does not necessarily indicate safe haven characteristics. Safe haven assets may experience positive correlation with the market on average (positive beta). The safe haven abilities only come forward in the left tail of market returns. During the markets' worst trading days, safe haven assets are negatively correlated with the market. This negative beta will help to preserve capital or even opens the opportunity to benefit from a market crash.

When both the overall beta and the crisis beta indicate a positive correlation, the corresponding asset can only be used as a diversifier. If an asset possesses negative crisis betas this could have implications on asset pricing. Investors might be willing to accept a lower risk premium because of the risk profile of this asset. In this analysis, the beta for every asset will be derived with different indices as the market return. The crisis betas are denoted as the asset's beta on the worst 5% and 10% trading days.

5.1 Green bonds safe haven

To test the safe haven abilities of green bonds (H1) the overall beta and crisis betas are derived for the iShares green bond Index (ISHARESGREEN). Table 2 contains the results of the time series regressions, deriving the overall beta and the crisis betas. For the S&P500 as market index, the overall beta of ISHARESGREEN is 0.0240, $p<0,001$. The crisis betas derived for the S&P500 are positive and higher than the overall beta. In extreme market conditions, the correlation between the market and ISHARESGREEN did increase towards the left tail. The betas of ISHARESGREEN are low, which indicates a weak correlation with the market. Compared to the S&P500, the ISHARESGREEN did show similar correlations for the STOXX600 and the MSCIWORLD. In both cases the overall beta is lower than the 10% and 5% crisis betas. This indicates that ISHARESGREEN returns did display a stronger correlation with the market in the worst 10% and 5% trading days. However, the crisis betas are low and display a weak positive correlation with the market. Concluding, ISHARESGREEN does not provide safe haven characteristics nor hedging characteristics in a portfolio, but diversification benefits can be achieved by taking advantage of low betas and lowering the total volatility of a portfolio.

5.2 Gold vs Green

Historically gold is considered to possess safe haven characteristics. Throughout history investors tend to allocate capital towards gold in times of financial turmoil because of easy market mechanisms and the physicality of gold. In this section I will compare the betas and crisis betas of gold and green bonds to check if green bonds can match the expected safe haven performance of gold (H2). Table 2 contains the results of the beta estimations of gold and green bonds. Observing GOLD, it is shown that the overall beta is lower than both crisis betas for every market. For all three markets the 10% and 5% crisis betas indicate a stronger correlation with market returns compared to the overall beta. For every market the 5% crisis beta is higher

than the 10% crisis beta, indicating stronger correlation with the market the further returns are located to the left in the return distribution. Comparing this to the ISHARESGREEN, the crisis betas also denote a stronger correlation compared to the overall beta. However, the crisis betas of ISHARESGREEN do not increase by as much as the crisis betas of GOLD. This indicates a more stable correlation for ISHARESGREEN compared to GOLD in extreme market conditions. When observing the results of CORPGB and GOVGB, both portfolios did show identical patterns. CORPGB as GOVGB experienced a positive correlation with the market on average during the period. The crisis betas for both portfolios were higher than the overall beta, indicating a stronger positive correlation in extreme market conditions. The 10% crisis betas and 5% crisis betas for both portfolios did not diverge much. So, correlation with the market returns under extreme conditions is relatively stable for both portfolios across the markets.

5.3 Treasuries vs green bonds

The US government and the German government are considered safe, the creditworthiness of these authorities is backed by two of the most prosperous economies. US Treasuries are noted among the lowest-risk assets. In this section I compare the betas and crisis betas of conventional bonds to green bonds (H3). These government bonds provide a sound comparison to the requirements that green bonds must comply with to be considered a safe haven. Both assets are influenced by common factors. Table 2 contains the results of the beta estimation of the US 10-year treasury bond (US10YR), the German 10-year Bund (GB10YR) and the different green bond portfolios. As explained in section 4.2 the crisis betas of ISHARESGREEN, GOVGB, and CORPGB are higher than the overall beta. All tested green bond securities appeared to have a higher correlation under extreme market conditions, resulting in the exclusion of a safe haven status. Comparing the betas of the ISHARESGREEN, GOVGB, and CORPGB to conventional government bonds, GB10YR appeared to have a negative overall beta across all three markets. However, the magnitude of the betas to the S&P500 and the MSCIWORLD is small and not significant, therefore these betas should be assessed with caution. The GB10YR did only provide a significant overall beta for the STOXX600 (-0.0424), this negative beta does indicate a hedging ability for the STOXX600 during the sample period. Furthermore, the estimated crisis betas for all three markets are higher than the overall betas. The results of the time-varying regressions for the crisis betas were not significant, therefore these crisis betas provide no valuable information.

The overall betas of US10YR were negative and significant at a 1% significance level across all three indices. So, for all three markets US10YR was considered a hedge in the sample period. Examining the crisis betas for US10YR when the S&P500 is proxied as market factor, the 5% and 10% crisis beta were lower than the overall beta at a 5% significance level. This indicates stronger negative correlations with the market under extreme conditions. The 5% crisis beta compared to the 10% crisis beta showed a lower crisis beta in the 5% worst trading days. Thus, when moving further into the left tail of market returns US10YR displayed a stronger negative correlation, showing stronger safe haven characteristics under worse circumstances. For the STOXX600 the crisis betas did show a similar pattern. The 10% crisis beta (-0.1572) and the 5% crisis beta (-0.1549) were lower than the overall beta. In this case both crisis betas are almost similar which indicates a stable performance when moving to the left tail of STOXX600 returns. Despite a less pronounced difference between the 5% crisis beta and the 10% crisis beta the safe haven ability for the STOXX600 appeared to be stronger. Both crisis betas are lower compared to the crisis betas for S&P500 and MSCIWORLD. This could be due to the exchange rate which implies the magnitude of safe haven characteristics. For the MSCIWORLD the overall beta of US10YR was negative (-0.0757) and significant at a 1% level. The 10% crisis beta (-0.0925) and the 5% crisis beta (-0.0978) were lower than the overall beta. However, both crisis betas were not significant, these crisis betas did not provide valuable information.

5.4 Governmental vs Corporate green bonds

In this section the safe haven qualities of green bonds issued by governmental institutions and corporations will be compared (H4). In sections 5.1, 5.2, and 5.3 is explained that ISHARESGREEN, GOVGB CORPGB did not provide a hedging ability nor a safe haven ability across all markets during the sample period. ISHARESGREEN, GOVGB, and CORPGB did return positive overall betas and positive crisis betas. For all three assets, the 10% and 5% crisis betas were higher than the overall beta, which indicates stronger correlations with the market under extreme conditions. The difference between the 5% and 10% crisis beta is not much, indicating a stable correlation when moving further into the left tail of market returns.
Despite the green bonds not providing safe haven betas the assets could still be considered as diversifiers. The overall betas and the crisis betas for ISHARESGREEN, GOVGB, and CORPGB are low. Low-beta assets can be used to reduce overall volatility in a portfolio.

Table 2: Overall betas and crisis Betas for the S&P500, STOXX600, and MSCIWORLD.

RM=S&P	GOLD	US10YR	GB10YR	ISHARES GREEN	CORPGBW	GOVGBW
BETA	0,0613***	-0,0686***	-0,0062	0,0240***	0,00984*	0,0123*
CRISIS BETA 10%	0,2403***	-0,09803**	0,0402	0,0860***	0,08734***	0,0768***
CRISIS BETA 5%	0,2899***	-0,1200**	0,0396	0,1015***	0,0932***	0,0765**
RM= STOXX600						
BETA	0,0741***	-0,0941***	-0,0424***	0,0148*	0,0175***	0,0161**
CRISIS BETA 10%	0,2143**	-0,1572***	-0,0508	0,0553*	0,0874***	0,1001***
CRISIS BETA 5%	0,2945**	-0,1549**	-0,0158	0,0899**	0,1106***	0,1125***
RM=MSCI WORLD						
BETA	0,1119***	-0,0757***	-0,0120	0,0326***	0,0199***	0,0179**
CRISIS BETA 10%	0,2795***	-0,0925*	0,0491	0,1092***	0,1143***	0,0997***
CRISIS BETA 5%	0,3584***	-0,0978	0,0572	0,1366***	0,1261***	0,1068***

Note: The crisis beta is calculated by deriving the beta during the worst 10% and 5% trading days of the S&P500, Stoxx600, and the MSCI World. *, **, and *** represent statistical significance at the 10% level, 5% level, and 1% level for the tested beta coefficients.

5.5 Crisis Beta Implication on asset pricing

In this section the results of the Fama-Macbeth cross-sectional regression model are presented in Table 3. For the S&P500, STOXX600, and MSCIWORLD two cross-sectional regressions per market are performed. In the first regression the daily returns are regressed on the overall beta obtained from the time series regression, which are presented in Table 2. In the second regression the 10% crisis beta is added to the model to investigate if the crisis beta holds explanatory power regarding the risk premium. To check if the crisis beta contains a significant influence on the risk premium of an asset the *robust_risk_premium* will be compared to the *robust_risk_premium_crisis.* The *robust_risk_premium* is the average of the daily risk premia calculated from daily returns and the asset's respective overall beta. The *robust_risk_premium_crisis* is calculated from daily asset returns and the asset's respective crisis beta when the market does exceed the threshold of 10% worst trading days and the overall

beta otherwise. The 10% worst trading days are marked by a dummy variable denoting 1 when the market exceeds this threshold, otherwise this variable is 0. The significance of the robust risk premia is determined by using a two-sided t-test. The t-value of the *robust_risk_premium(_crisis)* is the risk premium divided by the corresponding standard error. The required significance of this test is estimated to be a 10% significance level because of a limited number of observations.

5.5.1 Results cross-sectional regressions

Table 3 contains the results of the cross-sectional regressions. For the S&P500 the *robust_risk_premium* is 0,00208 compared to the *robust_risk_premium_crisis* of 0,0027. However, for both estimated results the corresponding p-values were 0,34 and 0,22 which widely exceeded the significance level of p-value <0,10 used in this analysis. Furthermore, the R-squared of the second regression was higher than the R-squared of the first regression (0,438; 0,365), which did indicate a better fit in the second model. Similar to the S&P500 the results of cross-sectional regressions for the STOXX600 were not significant. The *Robust_risk_premium* was 0,0016 and the *Robust_risk_premium_crisis* was 0,0029. Corresponding P-values were 0,317 and 0,1059 which did both exceed the significance level of p-value < 0,10. The R-squared of the second cross-sectional regression (column 4) was higher compared to the regression in column 3 (0,4388 > 0,413) which did indicate a better fit in the model where crisis betas are incorporated. For the MSCI WORLD the *Robust_risk_premium* was 0,0018 and the *Robust_risk_premium_crisis* was 0,0026 with corresponding p-values of 0,303 and 0,160 respectively. Both variables did exceed the significance level of p-value <0,10 and are therefore not significant. The R-squared of regression 6 is slightly higher than the R-squared of regression 5. Which did indicate a slightly better fit for the model in regression 6.

Table 3: Fama-Macbeth cross-sectional regression results

	S&P500		STOXX600		MSCI World	
	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
Risk_premium_Overall	**0,53**	**2,63**	**0,41**	**-0,55**	**0,46***	**1,27**
Risk_premium_Crisis		**-1,13**		**0,43**		**-0,42**
Robust_Risk_premium	**0,00208**		**0,0016**		**0,0018**	
Robust_risk_premium_Crisis		**0,0027**		**0,0029**		**0,0026**
Constant	**-0,01**	**0,05**	**-0,007**	**-0,003**	**-0,02**	**0,01**
R-squared	**0,365**	**0,438**	**0,413**	**0,4388**	**0,561**	**0,577**

Note: Table 3 contains the results of the cross-sectional Fama-Macbeth regressions. The first column for every market factor does display the results of the cross-sectional regressions where the overall beta is the only explanatory variable. In the second regression for every market factor, the crisis betas are incorporated and used as regressors when the market does exceed the threshold of 10% worst trading days in the market. Furthermore, does Table 3 display the constant of the regressions and the models' corresponding R-squared. To indicate significance: *, **, and *** represent statistical significance at the 10% level, 5% level, and 1% level for the tested coefficients.

5.6 Liquidity

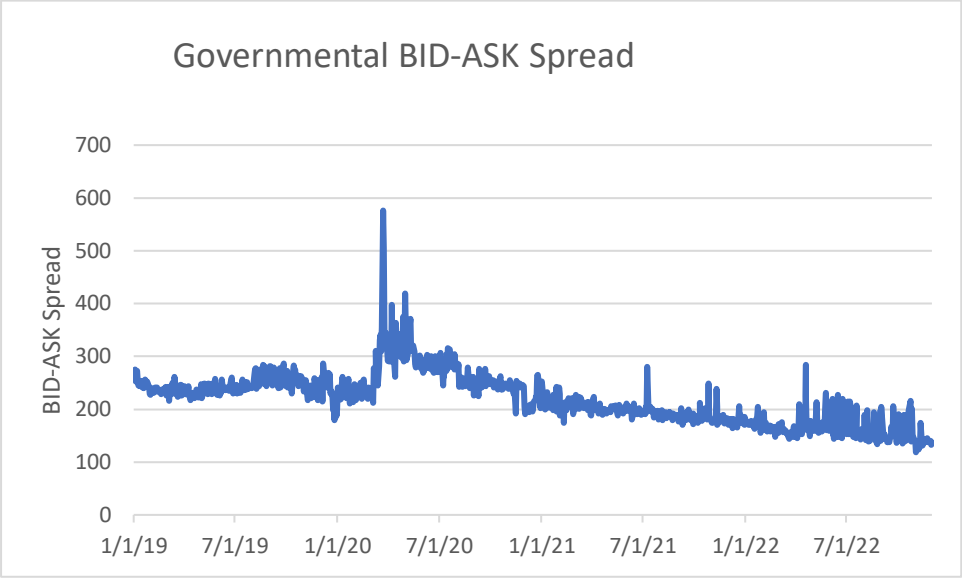
An important feature of a safe haven is liquidity at all times. When markets experience extreme left tail conditions markets tend to dry up. Illiquidity is amplified and capital does shift to liquid markets which causes liquidity premiums to rise (Vayanos, 2004). Assessing safe haven potential of green bonds liquidity is important. In the study of Upper (2000) different dimensions of market liquidity are explained. Tightness and depth are important concepts and are necessary for market liquidity. A market is tight if there are enough limit orders or quotes near the last trading price so that new buy and sell orders can be executed without great

discontinuities in prices. Tightness is directly measured by the bid-ask spread. A market is considered tight when the bid-ask spread is narrow, meaning the difference between the bid price and the ask price is relatively small. A market is deep if large orders can be executed without much effect on prices (Upper, 2000).

Figure 2 and Figure 3 show the Bid-Ask spread of the governmental green bond portfolio (GOVGB) and the corporate green bond portfolio (CORPGB). The average bid-ask spread of GOVGB is 210 bps and peaks at 576 bps. For CORPGB the average bid-ask spread is 499 bps and peaks at 849 bps. As expected, corporate bonds are less liquid than governmental bonds. This can be explained by the average issuance amount of both categories. The average issuance amount for government green bonds in this sample is 1150 million and for corporate green bonds only 625 million. The bid-ask spread of both portfolios can be considered high, which means high transaction costs resulting in an illiquid market. Compared to the Bid-Ask spread of the US 10 Year treasury of 14 bps, it is not hard to conclude that both green bonds are nowhere near the level of liquidity provided by an established safe haven (IMF, 2022).

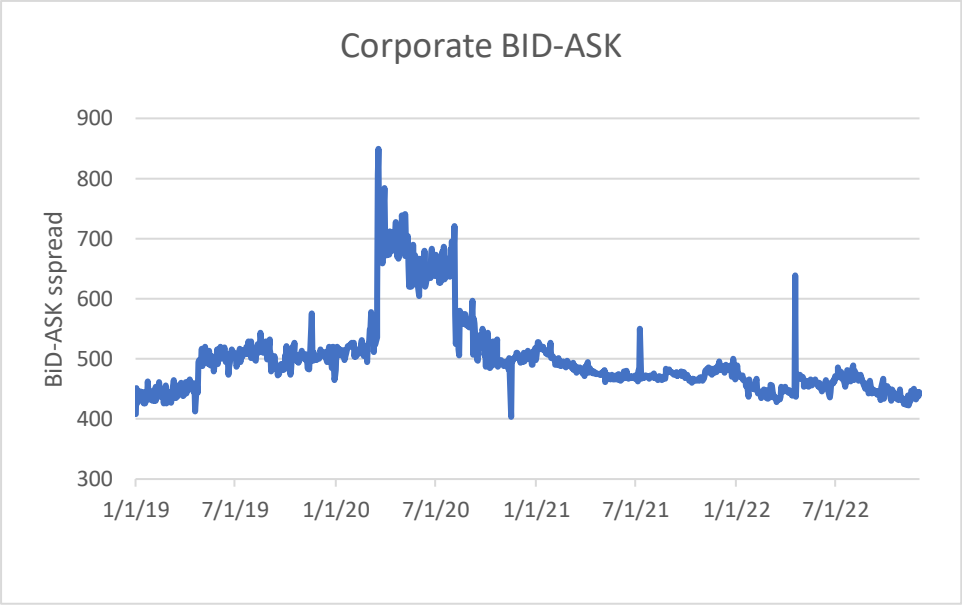
Tables 4, 5, and 6 (Appendix A) provide the average bid-ask spreads for both portfolios on the worst 10% and 5% of a given index. The bid-ask spread gives a clear indication that the liquidity worsens during extreme market conditions. What is interesting is that the effect on the average bid-ask spread moving from the worst 10% trading days to the worst 5% trading days is limited. This could be because of a short widening of the bid-ask spread after which the bid-ask spread does return to crisis baseline. Figure 2 presents the development of the bid-ask spread for GOVGB during the sample period. For GOVGB Figure 2 supports the rapid reduction of the bid-ask towards a lower 10% baseline. For CORPGB this effect was more pronounced. After a major widening in the bid-ask spread the spread during March 2020 the spread did stabilize at a high level, shown in Figure 3.

Figure 2



Note: the bid-ask spread of the GOVGB portfolio are shown. The on the y-axis the bid-ask spread is denoted in bps (100bps = 1%).

Figure 3



Note: Figure x the bid-ask spread of the CORPGB portfolio are shown. The on the y-axis the bid-ask spread is denoted in bps (100bps = 1%).

6 Discussion

In this study, the safe haven characteristics of different potential or proven safe haven assets are investigated by determining the crisis beta. When the crisis beta of an asset is negative, the asset is negatively correlated during the market's worst trading days. So, when markets experience extreme conditions, these assets are able to provide financial shelter. Assets are considered to be a safe haven when the crisis beta is non-positive. When the overall beta of an asset is negative this asset did act as a hedge for the tested market in this period. The overall beta does not provide a meaningful explanation for a safe haven characteristic, because safe haven performance is only concentrated on performance in the left tail of market returns. Assets with positive crisis betas are only suited for diversification purposes within a portfolio. The results in Table 2 showed that only the US10YR was negatively correlated with the markets during the whole period and in the worst 10% and 5% trading days. US10YR only provided significant crisis beta for S&P500 and STOXX600. Therefore, US10YR can be considered a safe haven asset for these two markets during the sample period. Significant overall betas were found across all three markets, meaning that US10YR served as a hedge during this period. The GB10YR did only show a significant negative overall beta for STOXX600 and thus did provide hedging ability for this market. Despite gold being considered a safe haven in multiple papers, gold did not display negative crisis betas. The crisis betas of GOLD were higher than the overall beta for every market. This indicates a stronger correlation for GOLD moving further into the left tail of market returns. This has implications for the safe haven status of gold. When a safe haven does not provide safe haven returns this indicates that the safe haven is fragile. In future market drawdowns investors might favor other safe assets over gold to store capital. The estimated betas for green bonds did not show safe haven properties. The overall betas for the ISHARESGREEN and both green bond portfolios suggested a positive correlation with the markets on average. The correlation displayed on the worst trading days was similar. The crisis betas of the ISHARESGREEN and both green bond portfolios were higher than the overall beta, which indicates that all three instruments experienced higher correlation with market returns in the left tail. So, the "green premium" identified in previous research did not show in the ability to provide a safe haven or a hedge. Green bonds can only be considered to be a diversifier in a portfolio.

The implication of the crisis beta on asset pricing was examined by looking at the results of the cross-sectional regressions in section 4.5. The output of the results did not display significant

results. However, the relationship between crisis betas and the risk premium should be straightforward. The results did show higher robust risk premia when crisis betas were included in the model. A higher correlation than average in extreme market conditions, ensure that investors should expect the receive a higher risk premium for this asset. The majority of the crisis betas were positive and higher than an asset's overall beta. If the crisis betas of the tested assets were to be negative, this should have a negative effect on the risk premium because in crisis these assets do move in the opposite direction of the market. Thus, investors are keen to accept a lower risk premium.

The ideal safe haven asset should be assessed following the proposed framework in Section 2 of this thesis. A safe asset should not be sensitive to risk factors, should be liquid in times of financial turmoil, creditworthiness should be not threatened, the asset should provide diversification or a hedge, and should give returns in the market's worst trading days. Assessing green bonds through this framework. Proving a positive correlation during extreme market conditions and liquidity concerns in the green bond market. There can be concluded that green bonds are currently not suitable to be adopted as safe haven in a portfolio. However, green bonds might be better suited as a diversifier. This study should be repeated when the green bond market does become a more credible and mature market. With more data and a longer time frame results might be different. Furthermore, to test the robustness of possible safe haven qualities periods of different interest rate regimes should be tested. In the sample used for this analysis interest was historically low, which affected fixed-income instruments.

Overall, the results of this study contribute to the ongoing debate about the role of green bonds in portfolio diversification and their potential as a safe-haven asset. The findings suggest that even though investors like to pay a premium for green bonds this is not translated to hedging or safe haven abilities. The results highlight the importance of considering the specific characteristics of green bonds when incorporating them into a portfolio and the need for further research on their behavior during extreme market conditions. Furthermore, does this research highlight the fragile safe haven performance of gold. Despite gold being famous in the financial environment for its safe haven status it might not be the best alternative to choose during extreme market conditions.

Future research could further explore how the relationship between green bonds and firm performance develops over time. As green bonds increase in popularity, the magnitude of the

effect on firm performance may change. Rising popularity could mean that novelty wears off, but it could also mean that green bonds grow into a mature and valuable fixed-income product. Furthermore, earlier research indicated that green bonds increase media attention (Tang and Zhang, 2018) and help build a larger investor base. Firms may use the instrument for the sole purpose of boosting stock performance. Therefore, the scalability of the green bond market depends on a paradigm shift. Currently green bonds still have a limited economic benefit and green bonds are mostly used as a communication tool to stakeholders. As Deschryver and Mariz (2020) proposed standardization of reporting to acquire a data-driven legitimacy in this juvenile market. This will reduce transaction costs and will attract a wider investor base.

6.1 Conclusion

In this paper, I evaluate the potential role of green bonds as a hedge (negative correlation on average) or safe haven (negative correlation in extreme market declines) for the MSCI World, S&P500, and STOXX600. Green bonds are compared to safe havens identified by current literature to investigate if green bonds deserve the safe haven status. In the secondary market, green bonds trade at a premium compared to conventional bonds. This premium is explained by non-monetary incentives; therefore, this premium could lead to superior returns in extreme market declines. Using daily data from January 2019 to December 2022, I find that green bonds using crisis betas do not provide a safe haven or a hedge. Furthermore, I make the distinction between corporate green bonds and governmental green bonds, but both portfolios do not provide a safe haven or a hedge. When comparing returns to conventional safe havens I find that only the US10YR treasury does provide a hedge for the S&P500 and the STOXX600 and MSCI World and a safe haven for the S&P500 and STOXX600. Interesting is that gold does not provide a hedge or a safe haven during this period, despite being labeled as safe haven in previous studies. This means that gold is fragile as safe haven asset and may not be the best choice to preserve capital in extreme market conditions.

So, assessing the requirements for a safe haven through the proposed framework. We can conclude that green bonds are nowhere near to receiving a safe haven status. The bonds are creditworthy and deliver diversification benefits by allocating towards ESG projects. However, sensitivity to risk factors, liquidity, and returns on the market's worst trading days are still a concern. Therefore, green bonds cannot be adopted as a safe haven in a portfolio.

This research has shown the potential of green bonds as a safe haven. Because of a difference in incentive to invest in green bonds against conventional bonds future safe haven performance is not impossible, especially when effects of climate change become more prevalent in daily life and green-financed corporations become favorable. The green bond market is still young and illiquid therefore the adoption of green bonds as portfolio protection is still too early. When the green bond market becomes more mature and more institutions/corporations issue green bonds, it has the potential to be a safe haven. Future research should aim to identify green bond trading behavior over a longer period in which different interest rate policies are conducted.

Appendix A

In Table 4, 5, and 6 the average bid-ask spread of the governmental green bond and the corporate green bond portfolio are shown for the worst 1%, 5%, and 10% of the markets trading days.

Table 4

Bid-ask worst days MSCI	*5%*	*10%*
Government portfolio	0,222647	0,214283
Corporate portfolio	0,531386	0,508607

Table 5

Bid-ask worst days STOXX600	*5%*	*10%*
Government portfolio	0,231755	0,21636
Corporate portfolio	0,532841	0,51117

Table 6

Bid-ask worst days S&P500	*5%*	*10%*
Government portfolio	0,229047	0,215813
Corporate portfolio	0,532041	0,513362

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