Project Title:

Spillover Between Green and Grey ETFs in the US Financial Markets

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Executive Summary

As financial markets evolve to support the transition to a low-carbon economy, understanding the interplay between **green ETFs** (which focus on renewable energy and sustainable investments) and **grey ETFs** (which track conventional energy sectors such as oil and gas) becomes increasingly important. This research proposal aims to investigate the **spillover effects** between green and grey ETFs in **US financial markets**, focusing on how shocks to one asset class influence the other and the broader market.

The study addresses a critical knowledge gap: while green and grey ETFs occupy distinct niches in the energy investment landscape, their dynamic interconnections — driven by factors such as **crude oil prices**, **stock market volatility**, and **environmental policy announcements** — have not been systematically quantified. Understanding these spillovers is essential for managing **systemic risks**, optimizing **sustainable investment portfolios**, and developing **policy frameworks** that support a balanced and equitable energy transition.

The research will employ **the Diebold-Yilmaz Spillover Index** to measure and quantify return and volatility spillovers between green and grey ETFs. Additionally, **wavelet analysis** will be used to capture the time-varying nature of these spillovers, providing both short- and long-term perspectives. By constructing a **spillover-spreading matrix**, the study will visualize the directional flow of shocks between green and grey ETFs, offering valuable insights for investors, policymakers, and researchers.

The anticipated findings will reveal that green ETFs are more sensitive to **environmental policies and ESG sentiment**, while grey ETFs are more responsive to **commodity price**

fluctuations and broader **market volatility**. This asymmetric sensitivity highlights the need for **differentiated risk management strategies** and **targeted policy interventions** to support market stability and sustainable finance.

In summary, this research will contribute to the growing body of literature on **sustainable finance**, provide empirical evidence to inform **policy and investment decisions**, and offer practical guidance on managing **financial risks** associated with the global energy transition.

Introduction

Financial markets function as interconnected systems, where the performance of one asset class or sector influences others, particularly in terms of return volatility. This phenomenon, known as the spillover effect, is particularly relevant for exchange-traded funds (ETFs). ETFs are investment vehicles that track indices or sectors, offering exposure to multiple assets at once. Among these, **green ETFs** focus on renewable energy and environmentally sustainable investments, aligning with the rise of ESG (Environmental, Social, and Governance) investing. A well-known example is the **iShares Global Clean Energy ETF**. In contrast, **grey ETFs** — such as the **SPDR Oil & Gas Exploration ETF** — are tied to conventional energy sectors like oil and gas, which continue to dominate global energy supply despite ongoing energy transitions (Smith et al., 2024).

The relevance of this study is amplified by the rapid rise of ESG investing and the global energy transition. As Li et al. (2020) emphasize, understanding the interplay between green and grey financial instruments is crucial given their distinct sensitivity to macroeconomic and policy developments. Quantifying the spillovers between these two categories of ETFs will contribute to the broader discourse on sustainable finance, risk management, and the challenges and opportunities of a low-carbon future.

This research will examine the spillover effects between green and grey ETFs in US financial markets, considering macroeconomic and market drivers such as crude oil prices, stock market indices (e.g., S&P 500), volatility metrics (e.g., VIX), and environmental policy announcements. As Bouri et al. (2021) highlight, green ETFs aim to achieve sustainability goals, while grey ETFs remain critical due to their continued role in the global energy system. By tracking

these dynamics, this study seeks to provide a comprehensive view of systemic risks and opportunities within the evolving energy landscape.

Problem Statement and Justification

As financial markets navigate the transition from fossil fuels to renewable energy, they encounter both significant risks and opportunities. ETFs, known for their liquidity and versatility, have emerged as popular vehicles for channeling investments into sustainable ventures while maintaining exposure to conventional energy markets. However, the spillover dynamics between green and grey ETFs remain underexplored. Are there significant spillover effects between these ETF categories? Are these effects driven by the same factors, or do they reflect fundamentally different sensitivities to macroeconomic and policy shocks? Answering these questions is essential for improving risk management, optimizing portfolios, and developing policies that support an equitable energy transition.

Existing literature indicates that spillovers between green and grey ETFs may follow distinct patterns. Gao et al. (2022) found that green ETFs are highly responsive to environmental policy shifts and sentiment changes, while grey ETFs are primarily influenced by crude oil prices and broader commodity cycles. This divergence underscores the need for separate analyses. Moreover, Geman and Ohana (2009) demonstrated that oil price shocks have immediate and direct effects on grey ETFs, but only indirect and delayed effects on green ETFs.

The environmental implications of these spillovers add further urgency to the research. Friede et al. (2015) conducted a meta-analysis of over 2,000 studies, concluding that ESG integration enhances financial performance, supporting the case for green ETFs as viable investment options. However, Li et al. (2020) caution that policy shocks in the renewable sector can trigger volatility in green ETFs, which can, in turn, indirectly affect grey ETFs, amplifying systemic risk.

This intricate interplay has long-term consequences for both market stability and environmental sustainability. Understanding these spillovers will not only enrich academic literature but also inform policies and investment strategies. Tolliver et al. (2021) highlight that policy announcements can trigger capital shifts between green and grey ETFs, reflecting changing market conditions and investor sentiment. By studying these spillovers, policymakers can develop strategies to mitigate risks while encouraging sustainable investments. This research will therefore

fill an important gap, providing empirical insights into the unique spillover dynamics between green and grey ETFs.

Objectives

The primary objective of this research is to quantify and evaluate spillover effects between green and grey ETFs in US equity markets. To achieve this, the study will pursue the following specific objectives:

- Collect relevant data on green and grey ETFs, including return series, volatility indices, and key macroeconomic indicators. Data stationarity will be verified using the Augmented Dickey-Fuller (ADF) test and other unit root tests to ensure reliability.
- Apply the Diebold-Yilmaz Spillover Index to measure the magnitude and trends of spillovers between green and grey ETFs, quantifying their interconnectedness.
- Use wavelet analysis to examine the time-varying nature of spillovers, enabling the identification of short- and long-term patterns.
- Construct a spillover-spreading matrix to visually represent the distribution of returns and volatility between green and grey ETFs, highlighting directional flows.
- Differentiate between short- and long-term spillover effects to better capture their temporal dynamics.
- Derive policy and risk management recommendations based on the findings to support sustainable finance practices.

This research aims to contribute novel insights into sustainable finance literature and provide practical guidance for integrating green and conventional investments in the context of an evolving energy landscape.

Data and Model

This study will utilize monthly return data for green and grey ETFs, supplemented by macroeconomic data such as crude oil prices, S&P 500 returns, and the VIX. These variables serve as key indicators of market efficiency and volatility, aligning with the study's focus on the relationship between renewable and conventional markets. Data will be sourced from **Yahoo Finance**, a reputable provider of financial time series data, ensuring consistent and comprehensive

coverage. Challenges such as missing data and formatting inconsistencies will be addressed during preprocessing. As Engle (1982) noted, high-quality data is essential for reliable volatility analysis.

Preliminary Model and Preprocessing

Data preprocessing involves excluding missing values, looking for outliers, and time series consistency. Stationarity is an important econometric assumption. In order to check for this, we will use the Augmented Dickey-Fuller (ADF) test on the time series. Stationarity is necessary to measure the interdependence of financial markets reliably, Forbes and Rigobon (2002) said. This ADF test equation looks like this:

$$\Delta Yt = a + \beta_t + \gamma Y_{t-1} + \delta i = 1 \sum^{k} i \ \Delta Y_{t-1} + \epsilon_t \quad (1)$$

where ΔYt is the first difference of the series, t represents time, and ϵt is the error term. The null hypothesis states that the data has a unit root (non-stationary).

For the measurement of spillovers, we will use Diebold-Yilmaz Spillover Index. It calculates how much of the forecast error variance in one ETF was driven by shocks in other ETFs and can be used to assess the directionality and magnitude of spillovers. It is an index of the degree of market interdependence, as Diebold and Yilmaz (2009) noted. The spillover index generalized variance decomposition framework is like this:

$$H_{ij}(h) = \sum_{j=1}^{n} \sigma^{\{_{\{}{}^{2}} \ i \quad (2)$$

where $Hij(h)$ is the contribution of variable, j to the forecast error variance of variable, i over h step-ahead forecasts, and $\sigma ij2\sigma$ represents the variance. The spillover index $S(h)$ is then computed as:

$$S(h) = \frac{\sum_{i \neq j} H_{ij}(h)}{\sum_i H_j(h)} \times 100 \quad (3)$$

The spillover-spreading matrix will further illustrate these flows, showing shock transmission networks between green and grey ETFs. Gao et al. (2022) highlighted the significance of such matrices in discerning systemic threats and prospects in energy transition dynamics.

Moreover, we will measure the temporal variation of spillovers using wavelet analysis. Spillovers can be broken down into time-frequency discrete, providing a fine-grained view of their activity. This strategy is particularly suited for studying how shocks from the external environment

(change in crude oil prices, for example, or policy changes) impact ETFs at different time periods. As Geman and Ohana (2009) emphasised, time-frequency analysis is fundamental for assessing the impact of shocks to oil prices on energy markets. The wavelet transform could be written as:

$$W_x(a,b) = \int_{-\infty}^{\infty} x(t)\psi^* \left(\frac{t-b}{a}\right) dt \tag{4}$$

where $x(t)$ is the original time series, $\psi*$ is the complex conjugate of the wavelet function, a is the scale, and b is the time translation. Through these approaches, this study will give us a complex understanding of spillover dynamics drawing upon insights from econometric models and wavelets. Together, these strategies will contribute to a fuller picture of risk transfer and financial resilience in ETFs, addressing systemic risks and opportunities related to sustainable finance and energy transitions.

Expected Results

This research expects to uncover significant spillover effects between green and grey ETFs, driven by macroeconomic conditions, policy changes, and shifts in investor sentiment. Green ETFs are likely to be more sensitive to environmental policies and ESG sentiment (Gao et al., 2022), while grey ETFs will be primarily influenced by oil prices and market volatility (Geman & Ohana, 2009).

These findings will highlight how green and grey ETF dynamics influence market stability and sustainability. Friede et al. (2015) stress that ESG integration affects financial performance and systemic spillovers. By providing empirical evidence on these interactions, this study will enrich discussions on systemic risks and opportunities in financial markets, helping policymakers and investors align financial strategies with long-term sustainability goals as stated in Tolliver et al., (2021).

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