VILNIUS UNIVERSITY FACULTY OF ECONOMICS AND BUSINESS ADMINISTRATION

FINANCE AND BANKING

Matas Gaigalas

MASTER THESIS

PELNINGUMO SKIRTUMŲ TARP ATSINAUJINANČIOS IR TRADICINĖS ENERGETIKOS ĮMONIŲ PRIEŽASTYS: KAPITALO STRUKTŪROS, PALŪKANŲ NORMŲ IR RINKOS KONKURENCIJOS VAIDMUO	**DRIVERS OF PROFITABILITY DIFFERENCES BETWEEN RENEWABLE AND TRADITIONAL ENERGY COMPANIES: THE ROLE OF CAPITAL STRUCTURE, INTEREST RATES, AND MARKET COMPETITION**

Student ______________________
(signature)

Supervisor ______________________
(signature)
Supervisor: Darius Saikevičius PhD

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1. INTRODUCTION

The energy sector is going through one of its biggest transformations in history now. There are growing concerns about climate change, new technologies, and regulations that are driving the shift from fossil-fuel-based energy to more renewable energy sources. This transition means renewable energy companies—referred to in this thesis as innovative energy firms, mostly working with wind, solar, hydro, and other clean energies—are becoming increasingly significant in energy markets worldwide. At the same time, traditional energy companies, which referred to in this analysis as businesses whose main job is working with fossil fuels like oil, gas, and coal, are still strongest if we look at size, profits, and financial stability. This type of dual system creates big questions related to the financial output of companies competing in two very different technology and economy situations.

From a practical perspective, **understanding how profits differ between renewable and traditional energy firms matters to investors, policy decision-makers, and company leaders**. In most cases, renewable energy projects require substantial upfront capital and depend heavily on external funding, making these firms more vulnerable to factors like rising interest rates. If renewable energy firms will have lower profits, it will be hard for them to attract investment or keep growing steadily for many years. In the area of theoretical discussions, the topic connects with corporate finance and energy economics, because it gives a way to study how company debt, business competition, and general economy features work together to create company profit results in very different sectors.

Researchers have been looking at how energy company profits work for a long time. Earlier writings have examined how much revenue renewable firms generate, the effects of crude oil price changes on fossil energy companies. Other research has focused on innovation, firm size, or government support as determinants of renewable firm performance. However, existing studies often analyze these factors separately or focus on relatively short time periods. As a result, there remains limited empirical evidence on whether the observed profitability gap between renewable and traditional energy companies reflects operational inefficiency—understood as weaker cost control, lower productivity, or inferior asset utilization—or whether it is instead driven by financial structure and macroeconomic exposure. In particular, the combined effects of leverage, interest rates, and commodity price dynamics have not been sufficiently integrated into a single analytical system.

The novelty of this master's thesis lies in its detailed examination of profitability differences between renewable and fossil-fuel energy firms. By combining firm-level financial data with macroeconomic indicators over an extended period, the research offers a wider view of the structural drivers of profitability. Unlike studies that attribute renewable underperformance primarily to technological disadvantages, this thesis focuses on the role of capital structure, which in this study is mainly measured by the debt-to-assets ratio and reflects the degree to which firms rely on debt financing. The research contributes to the literature by demonstrating how financial leverage and exposure to interest rate regimes shape profitability outcomes in the energy sector.

The research problem addressed in this thesis can be formulated as follows: what factors explain the profitability differences between renewable and traditional energy companies, particularly regarding whether this underperformance is due to operational cost of transition or a symptom of financial structuring?

The aim of the Master's thesis is to evaluate the drivers of profitability differences between renewable and traditional energy companies, with particular focus on capital structure, interest rates, and market competition.

To achieve our aim, we need to follow our objectives:

1. To analyse and systematise scientific literature on profitability and capital structure in the energy sector.
2. Compare financials of renewable and traditional energy companies.
3. Estimate profitability differences using key financial indicators.
4. Examine the impact of leverage, interest rates, and oil price dynamics on firm profitability.
5. To determine whether profitability differences persist after controlling for financial and macroeconomic factors.

The thesis applies both theoretical and empirical research methods. The theoretical part is based on the analysis, comparison, and synthesis of scientific literature related to corporate finance and energy economics. The empirical part relies on quantitative analysis using secondary firm-level financial data from Bloomberg Terminal. The analysis uses quarterly panel dataset descriptive statistics, multiple linear regression models and dominance analysis. To ensure robustness, regressions standard errors are clustered at the firm level to account for serial correlation in firm-specific observations.

The thesis is structured into five main sections. The Introduction establishes the research problem, relevance, and aim. Second part discusses earlier literature on energy sector and different drivers of profitability in different companies. The third chapter presents the research methodology, including data description, variable construction, and econometric approach. The fourth chapter discusses the empirical results and evaluates the determinants of profitability differences between renewable and fossil fuel energy companies. The final section summarizes the main findings and presents conclusions and recommendations.

During the preparation of this thesis, artificial intelligence was used. More specifically, Google Gemini large language model was utilized as a supporting instrument during the preparation of this Master's thesis. It assisted in identifying some relevant academic literature and assisting in debugging Python and R code applied in econometric modelling and data visualization. Results generated by artificial intelligence were reviewed and verified.

Several limitations of the study should be acknowledged. The analysis is constrained by the availability of continuous financial data over the long-term horizon (2011–2024). Specifically, the requirement for a balanced panel limited the sample size, as many renewable energy firms are recent market entrants or lack historical data covering the earlier years of the analysis. Furthermore, the selection of surviving firms introduces potential survivorship bias. Despite these constraints, the focus on established industry leaders ensures data consistency and provides meaningful insights into the structural financial mechanisms shaping profitability in the global energy sector.

2. PROFITABILITY, CAPITAL STRUCTURE, AND MARKET DYNAMICS IN THE ENERGY SECTOR

This chapter reviews the scientific literature related to profitability, capital structure, and financial performance in the energy sector. The review focuses on studies examining differences between renewable and traditional energy companies, as well as research addressing the role of leverage, interest rates, market competition, and macroeconomic factors in shaping firm outcomes. By synthesising theoretical and empirical contributions from corporate finance, energy economics, and industrial organisation, the chapter aims to identify the main determinants of profitability and to highlight areas where existing research provides mixed or incomplete evidence. The reviewed literature serves as the theoretical foundation for the empirical analysis and helps to position the research problem addressed in this thesis within the broader academic debate.

2.1 The Energy Transition and Firm Performance

The global energy sector is undergoing a profound structural transformation driven by climate change mitigation objectives, regulatory intervention, and technological change. International agreements and policy frameworks increasingly emphasize the need to reduce greenhouse gas emissions and accelerate the deployment of renewable energy technologies. Reports such as the IPCC Sixth Assessment underline the urgency of this transition, identifying the rapid expansion of low-carbon energy systems as a necessary condition for limiting global temperature increases (IPCC, 2023). At the same time, the European Union has progressively strengthened its climate policy architecture through instruments such as the EU Emissions Trading System, Renewable Energy Directives, and the European Green Deal, reshaping incentives and constraints faced by energy firms (Oberthür & von Homeyer, 2023).

Early academic contributions to the energy transition literature largely focused on innovation, technological diffusion, and sustainability-oriented business models. From this perspective, renewable energy development was framed primarily as a process of technological substitution, in which cleaner and more efficient technologies gradually replace incumbent fossil fuel systems. Studies grounded in innovation economics and transition theory highlighted the role of new technologies, learning effects, and policy support in enabling renewable energy adoption (Markard & Truffer, 2008). While this literature provides important insights into the drivers of structural change, it offers limited guidance on how the transition affects firm-level financial performance, particularly for large, listed energy companies.

More recent research has begun to shift attention toward the economic and financial consequences of the energy transition. Rather than assuming that sustainability-oriented strategies necessarily lead to superior financial outcomes, this strand of literature recognizes that the transition may impose short and medium term costs on firms. Egli and Johnstone (2015) argue that ignoring the economic impacts of climate change can be costly, but they also emphasize that the adjustment process itself can generate financial pressures, especially for capital-intensive industries. This perspective challenges overly optimistic narratives suggesting that renewable energy expansion is automatically associated with improved profitability.

At the firm level, the energy transition alters production structures, investment requirements, and risk exposure. Renewable energy firms typically operate business models characterized by high upfront capital expenditures, long investment horizons, and dependence on external financing. In contrast, fossil fuel firms often benefit from established infrastructure, shorter investment cycles, and revenue streams closely linked to global commodity markets. These structural differences imply that firms may respond very differently to macroeconomic conditions, regulatory changes, and financial shocks, even when operating within the same sector.

Empirical evidence increasingly supports the view that the transition creates uneven financial outcomes across firms. Comparative studies of renewable and fossil fuel energy companies suggest that, despite strong growth prospects, renewable firms often exhibit weaker accounting profitability than their fossil fuel counterparts. This divergence has been particularly visible during periods of energy market stress, when fossil fuel producers were able to capture significant commodity rents, while renewable firms faced rising costs of capital and input price pressures (International Energy Agency [IEA], 2024). Such findings highlight the importance of distinguishing between long-term environmental objectives and short-term financial performance.

Furthermore, the financial implications of the energy transition are shaped not only by technology choice but also by policy design and macroeconomic conditions. While climate policies aim to improve the competitiveness of low-carbon technologies, their effectiveness in enhancing firm profitability remains an open question. (Bayer & Aklin, 2020). As a result, renewable firms may remain financially vulnerable even in policy environments that strongly favor decarbonization.

In summary, the literature increasingly recognizes that the energy transition represents not only a technological and environmental shift but also a financial reallocation process with heterogeneous effects on firms. Understanding firm performance during this transition therefore requires moving beyond innovation-centric narratives and examining how capital intensity, financing structure, and exposure to macroeconomic and policy shocks shape profitability outcomes. This perspective provides the foundation for analyzing return on equity differences between renewable and fossil fuel energy firms in the subsequent sections of this literature review.

2.2 Measuring Firm Performance in Energy Markets

Assessing firm performance in the energy sector presents specific challenges due to the capital-intensive nature of production, long investment horizons, and exposure to regulatory and macroeconomic forces. The literature distinguishes broadly between market-based and accounting-based measures of performance, each capturing different dimensions of firm outcomes. Market-based indicators, such as stock returns or valuation ratios, reflect investors' expectations regarding future profitability and growth prospects, while accounting-based indicators measure realized financial performance derived from firms' operating and financing decisions.

A substantial body of research in environmental and energy economics has relied on market-based measures to evaluate the financial implications of climate policy, innovation, and energy transitions. Stock returns are often used to capture how investors respond to policy announcements, carbon pricing, or changes in energy prices. While these measures are useful for understanding expectations and risk pricing, they may be volatile and sensitive to short-term market sentiment. Moreover, market-based indicators do not directly capture how firms convert revenues and assets into profits, particularly in industries where financing structure plays a central role.

Accounting-based measures, such as return on assets (ROA) and return on equity (ROE), offer a complementary perspective by focusing on realized profitability. In capital-intensive sectors, these measures are especially informative because they reflect both operational performance and financing costs. ROA captures how efficiently firms utilize their asset base to generate profits, while ROE incorporates the effects of leverage and interest expenses by relating net income to shareholders’ equity. As a result, ROE is particularly sensitive to capital structure decisions and changes in borrowing conditions.

Several studies emphasize that environmental strategies and regulatory exposure influence accounting profitability through firm-specific channels. Clarkson et al. (2011) show that firms’ environmental performance and managerial quality are closely linked to financial outcomes, suggesting that profitability cannot be assessed independently of strategic and financial choices. In the context of the energy sector, this implies that firms pursuing renewable energy strategies may face distinct profitability dynamics depending on their financial health and capital structure.

Empirical comparisons between renewable and fossil fuel energy firms further highlight the relevance of accounting-based performance measures. Tomczak (2019), for example, compares financial ratios across electricity producers and finds that fossil fuel–based firms tend to exhibit higher profitability ratios, despite renewable firms often displaying stronger efficiency or liquidity indicators. These findings indicate that differences in profitability are not necessarily driven by inferior operational performance but may instead reflect differences in capital intensity, leverage, and cost of financing.

More recent research also suggests that accounting-based measures are better suited for analyzing medium-term adjustment processes during the energy transition. While market valuations can respond rapidly to policy announcements or changes in investor sentiment, accounting profitability adjusts more slowly and captures the cumulative effects of investment decisions, financing costs, and regulatory burdens. This distinction is particularly relevant when examining how interest rates, debt levels, and policy instruments jointly affect firm performance.

Given these considerations, ROE emerges as a particularly appropriate metric for analyzing profitability differences in the energy sector. It allows for a direct comparison of renewable and fossil fuel firms while explicitly incorporating the role of leverage and financing costs. By focusing on ROE, this thesis aligns with the literature emphasizing the importance of capital structure and macroeconomic conditions in shaping firm performance, providing a robust framework for examining profitability during the energy transition.

2.3 Profitability Differences Between Fossil Fuel and Renewable Firms

A central question in the literature on the energy transition concerns whether renewable energy firms are financially comparable to traditional fossil fuel companies. While renewable energy is widely regarded as environmentally superior and strategically important for long-term decarbonization, empirical studies increasingly suggest that renewable firms often underperform fossil fuel firms in terms of accounting-based profitability. This profitability gap has been documented across different countries, time periods, and segments of the energy sector, raising concerns about the financial sustainability of renewable-focused business models in the absence of favorable financing conditions.

One of the most direct empirical comparisons is provided by Tomczak (2019), who examines the financial standing of electricity producers using renewable and fossil fuel sources. Using a range of financial ratios, the study finds that fossil fuel–based firms generally exhibit higher profitability measures, including return-based indicators, while renewable firms tend to display weaker profit margins. Importantly, Tomczak notes that renewable firms are not necessarily less efficient operationally; instead, their lower profitability is closely linked to higher capital intensity and financing requirements. This distinction is crucial, as it suggests that the profitability gap reflects structural and financial characteristics rather than inferior management or technology.

Evidence from utility-level panel data further supports this interpretation. Ruggiero and Lehkonen (2017) analyze the relationship between renewable energy expansion and the financial performance of electric utilities and find a negative association between a country's renewable power share and firms' long-term financial performance. They attribute this effect to transition-related costs, including the devaluation of conventional assets and the burden of financing new renewable capacity. From a firm-level perspective, these results imply that increased exposure to renewable energy investments can exert downward pressure on profitability during the adjustment phase of the transition.

More recent work focusing specifically on renewable energy firms highlights the importance of firm-specific financial characteristics in explaining performance differences. Morina, Ergün, and Hysa (2021) investigate the drivers of profitability among renewable energy companies in the European Union and find that firm size, market concentration, and support schemes exhibit mixed effects, while financial structure plays a central role. Their findings suggest that leverage and financing conditions are key determinants of profitability, reinforcing the view that renewable firms' financial outcomes are shaped more by balance sheet dynamics than by operational inefficiency.

Macroeconomic conditions can further amplify profitability differences between fossil fuel and renewable firms. During periods of elevated energy prices, fossil fuel producers are often able to capture substantial commodity rents, translating into strong cash flows and high accounting profitability. Recent assessments by the International Energy Agency show that oil and gas companies achieved significantly higher net profit margins than renewable energy firms and utilities during the 2022–2023 energy crisis, highlighting the asymmetric financial benefits of commodity price shocks (IEA, 2024). These dynamics help explain why fossil fuel firms can outperform renewables in profitability terms despite facing long-term transition risks.

The scale and persistence of these profitability differences are also emphasized in broader political economy analyses of the energy sector. Semieniuk et al. (2023) document record fossil fuel profits during recent inflationary periods and argue that these profits reflect structural advantages related to pricing power and market positioning. While their analysis is not limited to firm-level accounting measures, it reinforces the broader conclusion that fossil fuel firms have been able to generate exceptional financial returns under certain macroeconomic conditions, whereas renewable firms remain constrained by financing costs and capital intensity.

Taken together, the literature suggests that profitability differences between fossil fuel and renewable energy firms are both systematic and economically meaningful. Renewable firms often operate under financial constraints that suppress accounting profitability, particularly during periods of rising interest rates or macroeconomic stress. Fossil fuel firms, by contrast, benefit from shorter investment cycles and direct exposure to commodity price movements, which can enhance profitability in the short to medium term. These findings motivate a closer examination of the financial mechanisms—such as leverage, interest rate sensitivity, and market conditions—that underlie observed return on equity differences between renewable and traditional energy companies.

2.4 Capital Intensity and Financial Structure in Renewable Energy

A defining characteristic of renewable energy firms is their high capital intensity. Unlike fossil fuel companies, which often operate assets with shorter investment cycles and greater flexibility in production, renewable energy firms rely on infrastructure-heavy projects such as wind farms, solar parks, and grid-scale installations. These projects require substantial upfront investment, while operating costs remain relatively low once capacity is installed. As a result, renewable firms typically face long payback periods and depend heavily on external financing to fund expansion.

The literature emphasizes that this investment profile has important implications for firms' financial structure. Renewable energy projects are frequently financed through long-term debt, project finance arrangements, or hybrid public–private funding mechanisms. While such structures can support deployment in low-interest-rate environments, they also increase leverage and expose firms to refinancing and interest rate risks. From an accounting perspective, higher leverage directly affects return on equity by amplifying the impact of interest expenses on net income, particularly when revenue growth is constrained.

Empirical studies highlight the central role of capital structure in shaping renewable firm performance. Morina et al. (2021) show that firm-specific financial characteristics, including leverage, are among the most important determinants of profitability for renewable energy companies in the European Union. Their findings suggest that differences in profitability cannot be fully explained by market concentration or support schemes alone, pointing instead to balance sheet composition as a key driver. Similarly, Tomczak (2019) observes that renewable electricity producers often exhibit weaker profitability ratios despite competitive operational efficiency.

Recent evidence further reinforces the importance of financing conditions for green firm performance. Van den Engel, Swart, and Schramm (2024) demonstrate that increases in real interest rates have a statistically significant negative effect on green investment in the United States. Although their analysis focuses on investment outcomes rather than accounting profitability, the results are directly relevant for understanding renewable firm performance. Reduced investment capacity and higher financing costs ultimately constrain cash flow generation and suppress return on equity, particularly for firms operating with elevated leverage.

From a comparative perspective, fossil fuel firms generally benefit from greater flexibility in capital allocation and faster cash flow realization. Their revenues are closely tied to commodity prices and can adjust more rapidly to market conditions, allowing firms to benefit directly from price upswings. In contrast, renewable firms' revenues are often fixed or regulated over long horizons, limiting their ability to offset higher financing costs through price adjustments. This asymmetry reinforces the role of capital structure in explaining persistent profitability differences between renewable and fossil fuel firms.

Taken together, the literature indicates that lower profitability among renewable energy firms is not primarily the result of operational inefficiency but rather a consequence of their financial structure and exposure to financing conditions. High leverage, long investment horizons, and sensitivity to interest rates suppress return on equity, particularly during periods of monetary tightening. These insights provide a clear theoretical foundation for examining how capital structure contributes to profitability gaps during the energy transition.

2.5 The Impact of Interest Rates and Monetary Policy on Renewable Firm Profitability

Interest rates and monetary policy play a central role in shaping firm performance in capital-intensive industries, including the energy sector. For renewable energy firms in particular, profitability is closely linked to financing conditions due to the long-duration nature of their investments and their reliance on external capital. Unlike fossil fuel firms, which often generate cash flows more immediately and can benefit directly from commodity price increases, renewable firms typically face long payback periods, fixed or regulated revenues, and limited pricing flexibility. As a result, changes in interest rates can have a disproportionate impact on their financial outcomes.

From a valuation perspective, renewable energy projects are highly sensitive to discount rates. Higher interest rates reduce the present value of long-term cash flows while simultaneously increasing borrowing costs, exerting downward pressure on investment viability and profitability. Empirical evidence supports this mechanism. Van den Engel, Swart, and Schramm (2024) show that increases in real interest rates significantly reduce green investment activity in the United States, highlighting the importance of financing conditions for renewable energy development. Although their analysis focuses on investment rather than accounting profitability, reduced investment capacity and higher financing costs ultimately constrain cash flow generation and suppress return on equity.

Beyond project-level valuation effects, monetary policy influences firm performance through balance sheet and credit channels. Firms with higher leverage and greater dependence on external financing tend to respond more strongly to monetary tightening, as higher interest rates increase debt servicing costs and restrict access to new capital. In this context, renewable energy firms are particularly vulnerable due to their capital structure and financing needs. Bauer, Offner, and Rudebusch (2024) provide evidence that green stocks in Europe react more negatively to monetary policy shocks than conventional firms, suggesting that green-oriented business models are more exposed to changes in monetary conditions.

This differential sensitivity implies that monetary policy can amplify profitability differences within the energy sector. During periods of rising interest rates, renewable firms may experience a simultaneous increase in financing costs and a decline in investment capacity, while fossil fuel firms remain relatively insulated due to stronger cash flows and shorter investment cycles. Consequently, higher interest rates may not only reduce renewable profitability but also widen the profitability gap between renewable and fossil fuel firms.

The interaction between monetary policy and climate policy further complicates the financial landscape. While climate-related policy commitments and support mechanisms aim to improve the competitiveness of renewable energy, their effectiveness may be undermined in tightening monetary environments. Policy-driven revenue stability may be insufficient to offset higher borrowing costs, particularly for highly leveraged firms. This interaction helps explain why renewable firms can exhibit periods of underperformance despite supportive policy frameworks.

Overall, the literature suggests that interest rates and monetary policy represent critical yet often underemphasized determinants of renewable firm profitability. The sensitivity of renewable firms to financing conditions reflects structural features of their business models rather than temporary market inefficiencies. These insights motivate the empirical examination of interest rate effects and interaction terms in profitability regressions, as understanding the financial fragility of renewable firms is essential for assessing the economic viability of the energy transition.

2.7 Climate Policy, Paris Agreement, and Financial Markets

Beyond immediate market reactions, the literature emphasizes that the credibility and consistency of climate policy commitments are crucial for shaping longer-term financial outcomes. Event studies capture short-run abnormal returns around policy announcements, but these effects often reflect revisions in expectations rather than realized improvements in firm profitability. In the case of the

Paris Agreement, positive market reactions signal optimism regarding future regulatory support and demand growth for low-carbon technologies, yet such optimism may dissipate if policy implementation is delayed or perceived as uncertain.

Several studies argue that financial markets differentiate between symbolic climate commitments and enforceable regulatory frameworks, reacting primarily to credible and implementable policies rather than international declarations alone (Bolton & Kacperczyk, 2021; Pankratz & Zeisberger, 2021). While international agreements such as the Paris Agreement signal political intent, their firm-level impact depends on subsequent national and regional policy implementation and its interaction with financial conditions (Kahn et al., 2021). When supportive climate policies coincide with favorable financing environments, renewable energy firms may benefit from lower perceived risk and improved access to capital (Görgen et al., 2020). Conversely, during periods of monetary tightening, higher interest rates can offset or even dominate the positive valuation effects of climate policy announcements (IEA, 2023; Giglio et al., 2021).

This interaction between policy credibility and macroeconomic conditions helps explain why renewable firm performance exhibits strong time variation. Policy-driven valuation gains are more likely to materialize during periods of low interest rates and accommodative financial conditions, whereas their effect may be muted or reversed when borrowing costs rise. As a result, climate policy does not operate in isolation but interacts with broader economic cycles, shaping both investor expectations and firm-level financial outcomes.

The literature also highlights heterogeneity in policy responses across firms. According to Kruse, Mohnen & Sato (2024) companies with established renewable portfolios and clearer exposure to green revenues tend to benefit more from climate policy announcements than diversified or transition-phase firms. This heterogeneity suggests that policy signals are capitalized into financial markets unevenly, reinforcing differences in performance across firms within the energy sector. Importantly, such differences may be reflected more strongly in market valuations than in accounting-based profitability measures, particularly in the short run.

Overall, existing evidence indicates that climate policy influences financial markets primarily through expectation and credibility channels rather than direct and immediate improvements in profitability. While agreements such as the Paris Accord can enhance investor sentiment toward renewable energy, their financial impact remains contingent on policy follow-through, financing conditions, and firm-specific characteristics. This perspective underscores the importance of jointly considering climate policy and macro-financial factors when assessing the performance of renewable energy firms.

2.8 Carbon Pricing, the EU Emissions Trading System, and Firm-Level Financial Performance

While international climate agreements such as the Paris Agreement primarily influence financial markets through expectations and credibility effects, carbon pricing mechanisms aim to affect firm behavior more directly by altering relative costs. The European Union Emissions Trading System (EU ETS) represents the most prominent market-based climate policy instrument in Europe, designed to internalize the cost of carbon emissions and incentivize low-carbon investment through a cap-and-trade framework. In contrast to broad policy commitments, the ETS operates continuously and imposes explicit costs on regulated firms based on their verified emissions.

A substantial body of literature demonstrates that the EU ETS has been effective in achieving its environmental objectives. Bayer and Aklin (2020) provide robust evidence that the ETS significantly reduced carbon emissions despite relatively low carbon prices for much of its early operation. These findings confirm that carbon pricing can influence production decisions and emissions intensity at the firm and sector level. However, the translation of these environmental outcomes into improved firm-level financial performance is far less clear.

Empirical studies examining the financial effects of carbon pricing suggest that ETS-related impacts are heterogeneous and often modest. Research focusing on stock market responses shows that carbon policy signals can be capitalized into asset prices, particularly following regulatory announcements or reforms. Hengge, Panizza, and Varghese (2023) find that financial markets react to carbon policy surprises, indicating that investors update expectations in response to changes in regulatory stringency. However, these effects are primarily reflected in market valuations rather than sustained improvements in accounting profitability.

Firm-level analyses based on verified emissions data further highlight the limits of carbon pricing as a driver of financial performance. Benchora and Galanti (2024) show that firms’ exposure to carbon emissions within the EU ETS affects stock returns and risk pricing, but the magnitude and direction of these effects vary across firms and periods. Importantly, carbon exposure does not consistently translate into higher profitability for low-emission firms or lower profitability for high-emission firms, suggesting that compliance costs and allowance allocation mechanisms may dampen the direct financial impact of carbon prices.

This evidence contrasts sharply with the effects associated with broad climate policy commitments. Whereas the Paris Agreement generated relatively strong and immediate market reactions driven by expectations and perceived policy credibility, the ETS appears to exert a more gradual and indirect influence on firm performance. Carbon pricing affects costs incrementally and is often anticipated by firms, allowing them to adjust production, pass through costs, or hedge exposure. As a result, the ETS may be effective as an emissions-reduction tool without producing large or immediate changes in firm profitability.

From a financial perspective, the effectiveness of carbon pricing is further constrained by firms' capital structure and financing conditions. Dechezlepretre, Nachtigall & Venmans (2023) find that for renewable energy firms, higher carbon prices do not automatically offset the disadvantages associated with high leverage and interest rate sensitivity. Even when carbon prices rise, the resulting competitive advantage may be insufficient to counteract increases in borrowing costs or tightening monetary conditions. This interaction helps explain why empirical studies frequently find weak or statistically insignificant relationships between carbon prices and accounting-based profitability measures.

Overall, the literature suggests a clear distinction between expectation-driven policy effects and cost-based regulatory mechanisms. While international climate agreements can shift investor sentiment and reallocate capital toward green firms in the short run, carbon pricing through the EU ETS operates more subtly, influencing firm behavior and emissions outcomes without guaranteeing improved financial performance. This distinction is critical for interpreting empirical results that show limited profitability effects of carbon prices, despite strong evidence of environmental effectiveness.

2.9 Oil Prices, Energy Cycles, and Sector Interdependence

Despite fundamental differences in technology and environmental impact, renewable and fossil fuel energy firms remain interconnected through broader energy market dynamics. Oil prices play a central role in shaping expectations, investment decisions, and financial performance across the entire energy sector. As a result, oil price shocks influence not only fossil fuel producers but also renewable energy firms through indirect channels, even when their direct exposure to oil markets is limited.

Early empirical studies document a strong relationship between oil price movements and energy stock returns. Kumar, Managi, and Matsuda (2012) show that oil price changes affect clean energy stock prices, particularly during periods of market stress. Similarly, Managi and Okimoto (2013) find that oil prices exert a significant influence on both fossil fuel and alternative energy markets, suggesting that energy sub-sectors are linked through common macroeconomic and financial channels. These findings challenge the notion that renewable energy firms operate independently of fossil fuel market dynamics.

More recent literature emphasizes the role of investor behavior and attention in transmitting oil price shocks across the energy sector. Jingjian et al. (2023) demonstrate that oil price shocks affect energy stock returns more strongly when investor attention is high, amplifying sector-wide co-movements. This mechanism implies that oil price volatility influences renewable energy firms not only through cost or substitution effects but also through financial market narratives and sentiment. When oil prices rise or fall sharply, investors may reassess the outlook for the entire energy sector, leading to correlated movements in renewable and fossil fuel stocks.

Oil price dynamics can also affect renewable firm performance through macroeconomic channels. Oil price increases often coincide with broader inflationary pressures and tighter monetary conditions, which can raise financing costs for capital-intensive renewable firms. Conversely, sharp declines in oil prices may reduce the relative cost advantage of renewable energy, affecting revenue expectations and investment incentives. These indirect effects highlight how oil prices interact with interest rates, policy conditions, and investor expectations to shape firm-level financial outcomes.

The persistence of these linkages suggests that renewable energy firms are not fully decoupled from fossil fuel cycles, particularly in the short to medium term. While long-run structural trends favor renewable energy adoption, short-run profitability and financial performance remain sensitive to commodity price fluctuations and broader energy market conditions. This interdependence complicates empirical efforts to isolate the financial performance of renewable firms from fossil fuel dynamics and underscores the importance of controlling for oil prices in firm-level analyses.

Overall, the literature indicates that oil prices continue to act as a dominant macroeconomic driver within the energy sector. Even as renewable energy expands, oil price shocks influence financial performance through investor attention, inflationary pressures, and sector-wide reallocation of capital. Recognizing this interdependence is essential for understanding observed profitability patterns and for interpreting empirical results that show strong oil price effects alongside renewable energy expansion.

2.10 Competitive Pressure and Creative Destruction in Energy Markets

The expansion of renewable energy not only reshapes production technologies but also alters competitive dynamics within the energy sector. As renewable firms increase their market share, they introduce competitive pressures that affect the financial performance of incumbent fossil fuel companies. This process is commonly interpreted through the lens of **creative destruction**, a concept introduced by Schumpeter (1942), which describes how innovation and structural change redistribute economic rents by displacing or weakening established firms.

In the context of the energy transition, creative destruction does not necessarily imply the immediate exit of fossil fuel firms from the market. Instead, it often manifests as gradual erosion of profitability, reduced market power, and declining returns on capital for incumbents. As renewable energy capacity expands, fossil fuel firms may face lower demand growth, increased price competition, and declining utilization rates of existing assets. These pressures can translate into weaker accounting-based profitability, even if firms remain operationally efficient.

Empirical studies support the existence of competitive displacement effects in energy markets. Research examining the financial performance of electric utilities suggests that increased penetration of renewable energy can reduce revenues and margins for conventional power producers. Ruggiero and Lehkonen (2017) show that growth in renewable energy generation is associated with lower long-term financial performance of electric utilities, reflecting the cost of adapting to a changing energy mix. These findings indicate that renewable expansion can generate zero-sum dynamics within the sector, where gains by renewable firms are accompanied by losses for incumbents.

The competitive effects of renewable expansion are further amplified by the structure of electricity markets. Renewable energy sources often have low marginal costs and are prioritized in dispatch, which can suppress wholesale electricity prices and reduce revenues for conventional generators. This phenomenon, sometimes referred to as the “merit-order effect” places additional pressure on fossil fuel firms by reducing profitability even when demand remains stable. Over time, these dynamics can weaken the financial position of incumbent firms and limit their ability to invest or adapt.

Prior research indicates that competitive pressure in the energy sector interacts closely with macroeconomic and financial conditions rather than operating in isolation (Aghion et al., 2016). Oil price fluctuations and financing environments can either dampen or amplify displacement effects: high oil prices may temporarily sustain fossil fuel profitability despite increasing renewable penetration, while periods of low prices or monetary tightening tend to intensify competitive pressure on incumbent firms (Bjørnland et al., 2021). These dynamics suggest that creative destruction in the energy sector unfolds as a gradual and context-dependent process, shaped by commodity cycles, financial conditions, and policy frameworks rather than as a uniform or linear transition (Geels et al., 2017).

Overall, the literature highlights that renewable energy expansion can have measurable negative effects on the profitability of traditional energy firms. These effects reflect competitive displacement rather than technological inefficiency and are consistent with a Schumpeterian interpretation of the energy transition. Understanding these dynamics is essential for assessing how market share shifts influence firm-level financial outcomes and for interpreting empirical findings that link renewable growth to declining returns on equity among fossil fuel incumbents.

2.11 Synthesis and Research Gap

The literature reviewed in this chapter suggests that differences in firm performance during the energy transition cannot be explained by technology choice alone. Although renewable energy plays a central role in decarbonization strategies, many studies show that renewable firms tend to generate lower accounting-based profitability than fossil fuel companies. This pattern appears to be driven less by operational inefficiency and more by structural characteristics such as capital intensity, leverage, and financing costs.

A recurring finding across the literature is the importance of macro-financial conditions. Renewable energy firms typically rely on long-term, debt-financed investments, which makes their profitability particularly sensitive to interest rate movements. When borrowing costs rise, return on equity can decline sharply, even in the presence of supportive climate policy. This helps explain why renewable firm performance often varies over time and across economic cycles.

Climate policy affects financial outcomes through different mechanisms. Broad policy commitments, such as the Paris Agreement, tend to influence financial markets by shaping expectations and investor sentiment. In contrast, carbon pricing mechanisms like the EU Emissions Trading System operate more gradually by altering cost structures. While carbon pricing has been effective in reducing emissions, its impact on firm-level profitability is less consistent, particularly once financing conditions are taken into account.

The literature also highlights that renewable and fossil fuel firms remain linked through broader energy market dynamics. Oil price fluctuations, investor attention, and competitive interactions continue to affect renewable firms, despite their lower direct exposure to fossil fuels. At the same time, the expansion of renewable energy can place downward pressure on the profitability of incumbent fossil fuel firms, reflecting competitive displacement rather than immediate technological substitution.

Overall, existing research provides valuable insights into individual aspects of the energy transition, but it rarely considers financial structure, macroeconomic conditions, policy variables, and competitive effects together. This thesis contributes to the literature by examining these factors jointly and by focusing on return on equity as a measure of realized financial performance. In doing so, it aims to provide a more complete picture of why profitability differs between renewable and fossil fuel energy companies.

3. EMPIRICAL APPROACH AND DATA FOR ENERGY SECTOR ANALYSIS

The primary objective of this study is to determine the structural drivers of profitability differences between the **Traditional** (Fossil Fuel) and **Innovative** (Renewable) energy sectors. Specifically, the research aims to isolate whether the observed performance gap is driven by operational inefficiency, capital structure, or sensitivity to macroeconomic policy. In this study, capital structure primarily refers to firms' leverage, measured by the debt-to-assets ratio.

To achieve these research goals and rigorously test the formulated hypotheses, a multi-stage quantitative methodological framework is employed. The empirical strategy proceeds from descriptive inference to causal attribution through distinct analytical phases. First, **comparative financial analysis** is used to establish the structural differences in profitability, liquidity, and leverage between the two groups. Second, **multivariate panel data regressions (Pooled OLS with Cluster-Robust Standard Errors)** are estimated to quantify the causal impact of financial leverage, interest rates, and market displacement on corporate returns. Finally, **Dominance Analysis** is conducted as a robustness check to decompose the explained variance, allowing for a ranking of the relative importance of internal capital structure versus external macroeconomic factors in driving financial performance. To ensure robustness of the results, the specification includes year fixed effects to control for macroeconomic and global shocks common to all firms over time, as well as cluster-robust standard errors clustered at the firm level to account for serial correlation and heteroskedasticity within firms.

3.1 Data Description and Sample Selection

The empirical analysis is based on a balanced quarterly panel dataset covering the period from the first quarter of 2011 to the third quarter of 2024, yielding a total of 55 quarterly observations for each firm. All firm-level financial information and macroeconomic variables were obtained from the Bloomberg Terminal. To ensure comparability across firms operating in different regions, all monetary values are expressed in U.S. dollars.

3.1.1 Sample Selection Criteria

The final sample consists of 20 major publicly listed energy companies. Firms were selected using purposive sampling rather than random selection in order to capture industry leaders whose financial performance reflects systemic trends within the global energy sector. The sample is divided into two sub-sectors based on firms' primary sources of revenue and energy production.

The **Traditional Energy** group (N = 11) includes companies that generate more than 90 percent of their revenue or energy output from fossil fuel exploration, production, and refining activities. This group is composed of established supermajors and large upstream producers such as ExxonMobil, Shell, and Chevron, which historically dominate global energy indices and capital flows.

The **Innovative Renewable Energy** group (N = 9) includes firms that generate at least 60 percent of their electricity from renewable sources, such as wind, solar, hydro, or geothermal, or derive the majority of their revenue from the production of renewable energy technologies. This classification captures both pure-play renewable firms and aggressive transition leaders, including companies such as Vestas and NextEra Energy. Ørsted was excluded from the final sample to avoid classification bias, as its business model underwent a substantial transformation during the sample period.

A detailed overview of each firm's energy mix is provided in **Annex 1 and 2**, while **Annex 3** summarizes key firm characteristics, including market capitalization, geographic location, and primary stock index membership.

3.1.2 Variables

The dataset includes a broad set of firm-level financial variables, including total assets, total debt, EBITDA, sales revenue, net income, cash and cash equivalents, capital expenditures, and research and development (R&D) expenditures. From these raw variables, several financial ratios are constructed.

Profitability is measured using return on common equity (ROE). Financial leverage is captured using total debt relative to total assets and net debt to EBITDA. Liquidity is assessed using the current ratio. Investment behavior is proxied by R&D intensity, defined as R&D expenditure scaled by revenue, and capital expenditure intensity, measured as capital expenditures relative to total assets.

In addition to firm-level characteristics, the analysis incorporates several macroeconomic control variables. These include Brent crude oil prices to capture commodity market conditions, the U.S. 10-year Treasury yield as a proxy for the risk-free interest rate, the EU Emissions Trading System (ETS) carbon price to reflect climate policy intensity, and the MSCI World Index to control for global market movements.

The U.S. 10-year Treasury yield is used because global energy markets and energy firm financing are predominantly denominated in U.S. dollars. Major energy commodities, including crude oil and natural gas, are priced internationally in USD, and large publicly listed energy companies raise capital in global financial markets where U.S. interest rates play a central role in determining long-term financing costs. As a result, U.S. Treasury yields provide a consistent and internationally relevant benchmark for the cost of capital faced by capital-intensive energy firms. By contrast, domestic interest rates primarily reflect local inflation and monetary conditions and may not accurately capture global funding conditions for multinational energy companies.

The EU ETS carbon price is employed as a proxy for climate policy intensity for all firms in the sample. Although non-European firms are not directly subject to the ETS for their domestic operations, the EU ETS represents the most liquid, transparent, and economically significant carbon pricing mechanism globally. Moreover, many multinational energy companies maintain substantial upstream or downstream operations within the European Union, resulting in direct regulatory exposure. Beyond direct effects, the EU ETS carbon price functions as a widely monitored indicator of global regulatory stringency and transition risk, influencing investor expectations and capital allocation decisions across international financial markets.

Table 1. Data description.

Category	Description
Sample Period	Q1 2011 – Q3 2024 (55 quarterly observations)
Data Frequency	Quarterly
Total Firms	20 publicly listed energy companies
Data Source	Bloomberg Terminal
Currency	U.S. Dollars (USD)

3.2 Empirical methodology

To rigorously quantify the profitability disparity observed in the univariate analysis, we first estimate a baseline Pooled OLS regression. The objective is to determine the magnitude of the "Renewable Penalty" on Return on Equity (ROE) before controlling for firm-specific characteristics.

Model 1: The Raw Comparison

Model 1 regresses ROE solely on the sector binary variable ($D_{Renewable}$). Standard errors are clustered at the firm level to account for serial correlation within companies over time.

$$ROE_{it} = \beta_0 + \beta_1 D_{Renewable} + \varepsilon_{it} \quad (1)$$

Model 2: Controlling for Macroeconomic Cycles

A potential critique of Model 1 is that the profitability gap might be driven by specific "bad years" that disproportionately affected the renewable sector. To address this, Model 2 introduces **Time Fixed Effects** ($Year_t$). This controls for global systemic shocks—such as the 2015 oil price collapse, the 2020 COVID-19 pandemic, and the 2022 energy crisis, that affect all firms simultaneously.

$$ROE_{it} = \beta_0 + \beta_1 D_{Renewable} + \sum \gamma_t I(Year_t) + \varepsilon_{it}$$

(2)

H1 (The Baseline Performance Hypothesis): Traditional energy firms exhibit statistically higher unadjusted Return on Equity (ROE) compared to Innovative renewable firms, independent of global macroeconomic cycles.

Model 3: Financial health

To disentangle the drivers of the observed profitability gap, we estimate a multivariate OLS regression controlling for firm-specific financial health. Previous univariate analysis suggested a raw underperformance by renewable firms. However, theoretical literature suggests that capital-intensive sectors often carry higher leverage, which mechanically suppresses equity returns during periods of distress or high servicing costs.

We therefore test whether the "Green Discount" in ROE is a result of operational inefficiency or financial leverage. We introduce **Total Debt to Total Assets** ($(\frac{Debt}{Assets})_{it}$) to control for solvency risk and **Current Ratio** ($Liquidity_{it}$) to control for liquidity.

The estimation takes the following form:

$$ROE_{it} = \beta_0 + \beta_1 D_{Renewables} + \beta_2 (\frac{Debt}{Assets})_{it} + \beta_3 Liquidity_{it} + \beta_4 \ln(Assets) + \gamma_t Year_t + \varepsilon_{it}$$

(3)

H2 (The Capital Structure Hypothesis): The profitability gap between the sectors is primarily driven by differences in financial leverage (Debt-to-Assets ratio). Once leverage is controlled for, the statistical significance of the sector classification disappears.

Model 4: Innovation Cost

Having established the unconditional profitability gap between renewable and traditional energy firms in the baseline specifications, Model 4 introduces firm-specific microeconomic controls to identify the underlying transmission channels of underperformance. The objective of this model is to determine whether lower return on equity (ROE) among renewable firms reflects intrinsic operational characteristics—such as higher innovation expenditure and capital intensity—or instead arises from differences in financial structure, particularly leverage and scale.

The dependent variable remains firm-level ROE. The explanatory variables include a renewable sector indicator alongside four continuous firm characteristics. Firm size is measured by the logarithm of total assets (ln $(Assets)$) to control for economies of scale. Operational investment is proxied by R&D intensity ($R\&D\_Intensity_{it}$), defined as R&D expenditure scaled by revenue, while capital expenditure intensity ($Cap\_Intensity_{it}$) measured as capital expenditures relative to total assets, which controls for the heavy upfront investment typical of firms in the transition phase of renewable energy deployment.

The model 4 equation is defined as:

$$ROE_{it} = \beta_0 + \ \beta_1 D_{Renewables} + \beta_2 \ln{(Assets)} + \ \beta_2 (\frac{Debt}{Assets})_{it} + \beta_3 R\&D\_Intensity_{it} + \beta_4 Cap\_Intensity_{it} + \beta_5 Liquidity_{it} + \gamma_t Year_t + \varepsilon_{it}$$

(4)

H3 (The Innovation Cost Hypothesis): Operational intensity variables, specifically Research & Development (R&D) and Capital Expenditure (Capex) intensity, act as negative drivers of short-term profitability due to the high upfront investment requirements of the renewable transition.

Model 5: Decoupling

While Model 4 focused on firm-specific internal drivers of profitability, Model 5 shifts attention to systematic external factors that may influence return on equity (ROE) across the energy sector. A central question in energy finance is whether renewable energy firms have partially decoupled from the commodity price cycles that historically dominate fossil fuel companies profitability. This model tests whether the observed ROE differential reflects genuine business model inefficiency or simply differing exposure to macroeconomic shocks.

To address this question, ROE is regressed on two key macroeconomic variables: Brent crude oil prices (Oil_Price_t) and the MSCI World Index ($Market\_Index_t$), capturing global commodity conditions and broad market performance, respectively. Firm size, measured as the logarithm of total assets ($\ln(Assets)_{it}$), is included to control for scale effects that may confound macro sensitivities. A renewable sector indicator is retained to test whether any residual profitability gap remains after accounting for these systematic influences.

$$ROE_{it} = \beta_0 + \beta_1 D_{Renewables} + \beta_2 \text{Oil\_Price}_t + \beta_3 Market\_Index_t + \beta_4 \ln(Assets)_{it} + \varepsilon_{it} \quad (5)$$

H4 (The Decoupling Hypothesis): Traditional energy firms exhibit a high positive correlation with fossil fuel commodity cycles (Oil Prices), whereas renewable firms demonstrate statistical decoupling from oil price fluctuations.

Model 6: Monetary Policy Fragility

Model 6 tests the Fragility Hypothesis, examining whether renewable energy firms are more sensitive to changes in financing conditions than traditional energy companies. While previous models control for static differences in leverage, this specification focuses on the interaction between sector classification and monetary policy to capture asymmetric responses to interest rate movements.

The dependent variable is firm-level return on equity (ROE). The model includes a renewable sector dummy, the US interest rate (Int_Rate_t), and an interaction term between the two ($(D_{Renewables} \times Int\_Rate_t)$). The interaction term allows the effect of interest rate changes on profitability to differ between renewable and traditional firms. In addition, the EU Emissions Trading System (ETS) carbon price ($Carbon_t$) is included to proxy the intensity of climate regulation and assess whether policy support mitigates the impact of rising capital costs.

The estimated specification is:

$$ROE_{it} = \beta_0 + \beta_1 D_{Renewables} + \beta_2 \text{Int\_Rate}_t + \beta_3 (D_{Renewables} \times Int\_Rate_t) + \beta_4 Carbon_t + \beta_5 \ln(Assets) + \beta_6 \left(\frac{Debt}{Assets}\right)_{it} + \varepsilon_{it} \quad (6)$$

Two hypotheses are evaluated. **H5** (**Monetary Asymmetry) hypothesis** predicts a positive interest rate effect for traditional firms and a negative, statistically significant interaction term, indicating that higher rates disproportionately reduce renewable firm profitability. **H6** (**Policy Insufficiency) hypothesis** predicts that carbon price coefficient is positive and economically large enough to offset the adverse effects of rising financing costs.

Model 7: Creative Destruction, Impact of Renewable Energy Expansion

The next stage of the empirical analysis shifts the unit of investigation from comparative sectoral performance to the impact of renewable energy expansion on the incumbent fossil fuel industry. Drawing on Schumpeterian theories of creative destruction, Model 7 tests the **H7** (**Displacement Hypothesis)**: whether the aggregate growth of the renewable energy sector exerts a negative effect on the profitability of traditional energy firms.

To capture competitive pressure from renewable firms, a time-varying aggregate measure of renewable sector penetration is constructed. The Renewable Market Share variable is defined at the quarterly level as the ratio of total revenues generated by innovative renewable firms to total revenues generated by all firms in the sample. This variable serves as a proxy for the evolving balance of market power within the energy sector.

The model is estimated using a restricted subsample consisting exclusively of traditional energy firms. The dependent variable is return on equity (ROE). Control variables include Brent crude oil prices and the MSCI World Index to account for commodity price cycles and global economic conditions.

The estimation equation is defined as:

$$ROE_{Traditional,t} = \beta_0 + \beta_1 Ren\_Share_t + \beta_2 \text{Oil\_Price}_t + \beta_3 Market\_Index_t + \varepsilon_{it}$$

$$Ren\_Share_t = \frac{\sum_{i \in INNOV} Revenue_{it}}{\sum_{i \in ALL} Revenue_{it}}$$

(7)

Model 8: Dynamics

The static pooled OLS models estimated in the previous section provide an average assessment of relative sector performance over the full sample period. However, profitability in the energy sector is inherently time-varying and highly sensitive to exogenous macroeconomic and policy shocks. To capture this temporal heterogeneity, Model 8 adopts a year-on-year interaction framework that allows the profitability differential between renewable and traditional firms to vary freely across years. Specifically, the model includes a full set of year fixed effects and interaction terms between each year indicator and the renewable sector dummy. This specification relaxes the assumption of constant coefficients and enables the identification of year-specific excess returns for renewable firms relative to traditional energy firms.

The estimation equation is defined as:

$$ROE_{it} = \beta_0 + \beta_1 \mathrm{D}_{Renewables} + \sum_{2012}^{2024} \gamma \, \mathrm{I}(Year_t) + \sum_{2012}^{2024} \delta_t \cdot (\mathrm{D}_{Renewables} \times \mathrm{I}(\mathrm{Yeart}_t)) + \varepsilon_{it} \quad (8)$$

where I(Year_t) denotes time fixed effects capturing the baseline performance of traditional energy firms in year t relative to the omitted base year, and δ_t represents the interaction coefficient of interest. Each δ_t measures the excess return on equity of renewable firms relative to traditional firms in a given year.

3.3 Robustness Check: Relative Importance Analysis

To validate the regression-based findings and address potential multicollinearity among explanatory variables, a **Dominance Analysis** is employed as a robustness check (Budescu, 1993). While standard OLS coefficients indicate the direction and statistical significance of relationships, they do not provide a reliable ranking of predictor importance when independent variables are correlated. This limitation is particularly relevant in the energy sector, where macroeconomic variables such as oil prices and interest rates often move together.

Dominance Analysis overcomes this issue by decomposing the model's total explanatory power and assigning each predictor a relative contribution to the explained variance in return on equity. This allows for a comparison of how much each variable contributes to profitability variation, rather than whether it is statistically significant in isolation.

To examine whether profitability drivers differ structurally across sectors, a **split-sample approach** is adopted. Separate dominance analyses are conducted for traditional energy firms and renewable energy firms. In addition, to mitigate simultaneity concerns, firm-specific variables are included with a one-period lag, while macroeconomic variables enter contemporaneously.

The dependent variable is firm-level return on equity. Lagged internal drivers include leverage, firm size, and R&D intensity. External drivers include Brent crude oil prices and interest rates. This setup allows for a direct comparison of the relative importance of internal financial structure versus external macroeconomic conditions across the two sectors.

4. DETERMINANTS OF PROFITABILITY IN THE TRADITIONAL AND RENEWABLE ENERGY COMPANIES

This chapter presents the findings of the quantitative analysis examining the financial performance determinants of Traditional and Innovative energy firms over the period 2011Q1 to 2024Q3. The empirical strategy proceeds in three stages to rigorously test the research hypotheses. First, we present the descriptive statistics and univariate tests to establish the baseline structural differences in profitability, liquidity, and leverage between the sectors. Second, we estimate a series of Pooled OLS regressions (Models 1–7) to isolate the causal impact of capital structure, macroeconomic policy, and market displacement on Return on Equity (ROE). Finally, we employ Dominance Analysis and time-varying models (Model 8) to evaluate the relative importance of these drivers and reconstruct the historical timeline of the "Green Premium". Collectively, these results aim to determine whether the observed profitability gap is a result of operational inefficiency or financial fragility in a rising interest rate environment.

Figure 1. Distribution of Key Financial Ratios (2011Q1 – 2024Q3)

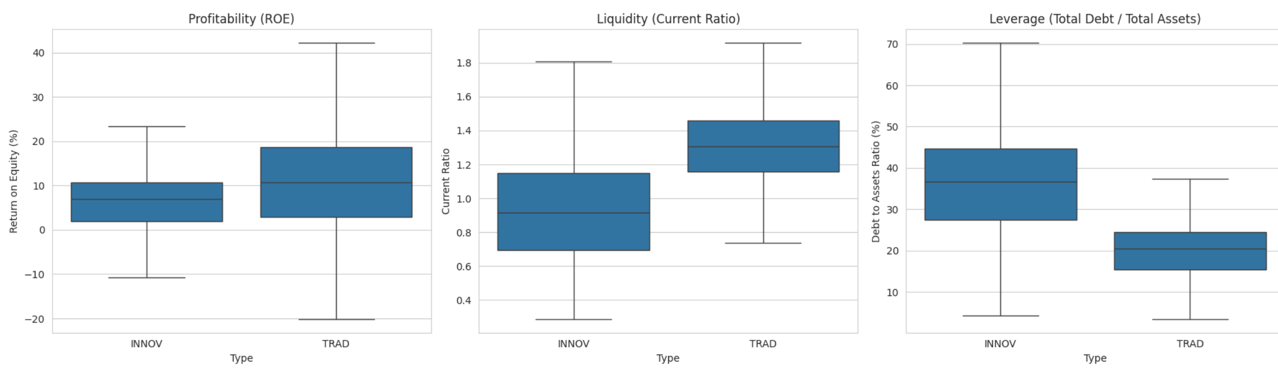


Figure 1 presents boxplots of key financial indicators for the full sample period. Firms are classified into two groups: TRAD, representing traditional energy companies operating in fossil-fuel-based energy production, and INNOV, representing innovative renewable energy firms engaged in the development and generation of energy from renewable sources.

The profitability distribution shows a clear structural advantage for TRAD firms, which exhibit a higher median ROE than INNOV firms. Although traditional firms display greater dispersion in profitability, their central tendency reflects stronger cash-generating capacity.

Liquidity patterns also differ markedly between the two groups. TRAD firms maintain a median current ratio well above one, indicating conservative liquidity management. In contrast, INNOV firms frequently operate with current ratios below one, consistent with leaner working capital structures normal in capital-intensive growth industries.

Leverage ratios further reinforce the capital structure hypothesis. INNOV firms operate with substantially higher debt levels, exhibiting debt-to-asset ratios that commonly exceed 35 percent. In contrast, TRAD firms maintain markedly more conservative balance sheets, with debt typically accounting for less than 20 percent of total assets.

Figure 2. Trends in Profitability: ROE (2011Q1-2024Q3)

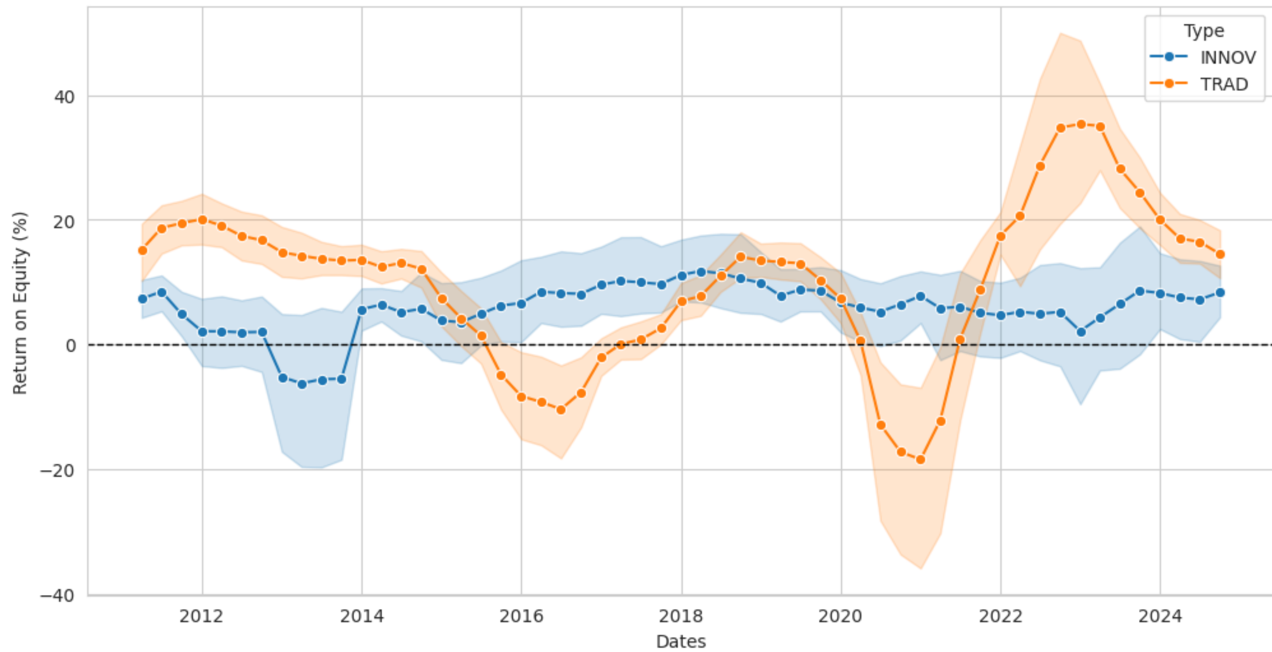


Figure 2 illustrates the time-series evolution of average ROE for both sectors from 2011 to 2024, highlighting the cyclical nature of energy markets. The figure reveals a clear counter-cyclical pattern during major commodity shocks. During the oil price collapses of 2015–2016 and 2020, traditional firm profitability declined sharply, at times turning negative, while renewable firm ROE remained relatively stable.

By contrast, the post-2021 period is characterized by a sharp divergence in performance. As oil prices surged during the energy crisis, traditional firms ROE increased to historically high levels, exceeding 30 percent, while renewable firm profitability remained largely unchanged. This pattern suggests that although renewable firms offer stability during downturns, they do not benefit from commodity-driven upside cycles to the same extent as fossil fuel producers.

4.1 Baseline Results: Unadjusted Profitability Differences

Table 2 reports the baseline estimates of profitability differences between renewable and traditional energy firms. Model 1 presents the unconditional comparison by regressing return on equity (ROE) solely on sector classification.

The results point to a clear structural profitability gap. The coefficient on the renewable sector dummy is −4.12 and statistically significant at the 10 percent level. In economic terms, this implies that, without accounting for firm characteristics or macroeconomic conditions, renewable energy firms generate ROE that is on average 4.12 percentage points lower than that of traditional fossil fuel companies. Given that the estimated intercept for traditional firms is approximately 9.9 percent, this gap corresponds to a relative underperformance of nearly 40 percent.

Model 2 introduces year fixed effects to control for common shocks affecting the energy sector, including major events such as the 2015 oil price collapse and the 2020 pandemic. The inclusion of time effects substantially increases the model's explanatory power, with the R-squared rising from 0.019 to 0.194, emphasize the importance of industry cycles in shaping energy firm profitability. Importantly, the coefficient on the renewable dummy remains virtually unchanged. This stability indicates that the observed "green discount" is not driven by a small number of unfavorable years, but rather reflects a persistent feature of the sector over the full 2011–2024 sample period.

4.2 Capital Structure and Firm-Level Drivers of Profitability

Models 3 and 4 extend the baseline analysis by introducing firm-level financial and operational controls in order to identify the mechanisms underlying the observed profitability gap. The results provide strong support for the capital structure hypothesis. In Model 3, the inclusion of leverage, measured as total debt relative to total assets, fundamentally alters the results. Leverage emerges as the most important determinant of ROE, with a negative and highly significant coefficient of −0.312. This estimate implies that a one percentage point increase in the debt-to-assets ratio is associated with a decline in ROE of approximately 0.31 percentage points. Given that renewable firms exhibit substantially higher leverage than traditional firms, this variable absorbs much of the negative variation previously attributed to sector affiliation.

Once leverage and firm size are taken into account, the renewable sector dummy loses statistical significance and changes sign, becoming positive. In Model 3, the coefficient increases to approximately +3.88, indicating that conditional on comparable balance sheet structures and scale, renewable firms do not underperform their fossil fuel counterparts. Firm size, measured by the logarithm of total assets, enters with a positive and statistically significant coefficient of around 1.09, confirming the presence of economies of scale and the profitability advantages enjoyed by large incumbents.

These findings suggest that renewable firms are not inherently less efficient from an operational standpoint. Rather, their lower observed profitability reflects differences in financial structure and scale. If renewable firms operated with leverage and asset bases comparable to those of traditional energy majors, their expected returns would be statistically indistinguishable from, and potentially higher than, those of fossil fuel firms.

Model 4 further examines whether the profitability gap can be attributed to heavy investment in innovation and capacity expansion. Neither R&D intensity nor capital expenditure intensity enters the regression with statistical significance. This indicates that short-term profitability in the energy sector is more closely linked to balance sheet strength than to current investment intensity. Overall, the results confirm that the "green discount" observed in the baseline models is primarily a financial phenomenon driven by leverage and capital structure rather than by operational inefficiency or technology-related costs.

Table 2. Regression Results: Drivers of Profitability (Models 1–4)

Variable	**(1) Baseline**	**(2) Time Controls**	**(3) Financial Structure**	**(4) Operational Drivers**
Renewable Dummy (1=Yes)	**-4.122***	**-4.122***	3.877*	4.038
	(p=0.051)	*(p=0.052)*	*(p=0.096)*	*(p=0.116)*
Leverage (Debt/Assets)			**-0.286*****	**-0.283*****
			(p=0.000)	*(p=0.000)*
Size (Log Assets)			**1.097***	**0.915****
			(p=0.059)	*(p=0.041)*
Liquidity (Current Ratio)			2.140	2.214
			(p=0.243)	*(p=0.218)*
R&D Intensity				-0.701
				(p=0.564)
Capex Intensity				0.217
				(p=0.707)

Constant	**9.974*** **	**14.536*** **	3.598	4.897
	(p=0.000)	*(p=0.000)*	*(p=0.687)*	*(p=0.499)*
Year Fixed Effects	No	Yes	Yes	Yes
Observations	1,100	1,100	1,100	1,100
R-squared	0.019	0.194	0.281	0.286
Adj. R-squared	0.018	0.183	0.270	0.273
F-statistic	3.82	31.74	30.62	439.2

*Notes: Dependent variable is Return on Equity (ROE). Robust standard errors clustered by firm are used to calculate p-values (reported in parentheses). Significance levels: * p<0.10, ** p<0.05, *** p<0.01.*

4.3 Monetary Policy, Climate Policy, and Financial Fragility

Table 3 reports the estimation results for Models 5 and 6, which shift attention away from firm-level characteristics toward macroeconomic and policy-related drivers of profitability. These models are designed to evaluate the Fragility Hypothesis by examining how renewable and traditional energy firms respond to commodity price movements, changes in financing conditions, and regulatory incentives.

4.3.1 Macroeconomic Sensitivity and Sector Decoupling (Model 5)

Model 5 serves as a test of the decoupling hypothesis, which suggests that renewable energy firms are insulated from fossil fuel commodity cycles. The results do not support full decoupling. The coefficient on the Brent oil price is positive and statistically significant, indicating that oil market dynamics remain an important driver of profitability across the energy sector. Economically, a ten-dollar increase in oil prices is associated with an increase in average sectoral ROE of approximately 1.7 percentage points.

Once oil prices and firm size are included in the regression, the renewable sector dummy becomes statistically insignificant. This result is central to the interpretation of the baseline profitability gap. It suggests that part of the apparent underperformance of renewable firms in the raw data reflects their limited exposure to oil price windfalls rather than weaker underlying performance. When the oil price effect is accounted for, renewable and traditional firms exhibit statistically indistinguishable baseline profitability levels.

4.3.2 The Interest Rate Trap and Policy Fragility (Model 6)

Model 6 extends the analysis by introducing an interaction between sector classification and the U.S. 10-year Treasury yield in order to assess asymmetric responses to monetary policy. The results reveal a pronounced divergence in how the two sectors respond to changes in interest rates.

For traditional energy firms, the standalone interest rate coefficient is positive and highly significant. This indicates that higher interest rates are associated with higher ROE for fossil fuel incumbents. Economically, a one-percentage-point increase in interest rates corresponds to an increase in ROE of roughly 7.7 percentage points. This pattern is consistent with the view that traditional energy firms benefit from inflationary environments through strong cash flows, pricing power, and interest income on cash holdings.

In contrast, the interaction term between the renewable sector dummy and interest rates is negative and highly significant. This coefficient captures the additional impact of rising interest rates on renewable firms relative to traditional firms. Combining the base effect and the interaction term yields a near-zero net effect for renewable firms. In practice, this implies that the positive effects of inflation and higher rates are almost entirely offset by increased financing and debt servicing costs associated with renewable project finance.

These results provide strong support for the Fragility Hypothesis. While monetary tightening acts as a substantial support for fossil fuel firms, it effectively neutralizes renewable firm profitability. The renewable business model therefore appears far more exposed to changes in the cost of capital.

The model also includes the EU ETS carbon price as a proxy for climate policy support. The estimated coefficient is positive but only marginally significant. Moreover, the economic magnitude of this effect is small relative to that of interest rates. A ten-euro increase in carbon prices raises ROE by approximately half a percentage point, whereas a one-percentage-point increase in interest rates shifts the relative profitability balance by nearly eight percentage points. This contrast suggests that current carbon pricing mechanisms provide only limited financial support and are insufficient to counteract the effects of monetary tightening.

Overall, the results indicate a clear policy imbalance: renewable firm profitability is far more sensitive to central bank policy than to climate regulation. This imbalance helps explain why renewable firms struggle to sustain profitability during periods of rising interest rates despite ongoing policy support.

Table 3. Macroeconomic and Policy Drivers of Profitability (Models 5–6)

Variable	(5) Macro Sensitivity	(6) Policy Fragility

Renewable Dummy (1=Yes)	0.063	**21.814*** **
	(p=0.973)	*(p=0.000)*
Leverage (Debt/Assets)		**-0.281*** **
		(p=0.000)
Size (Log Assets)	**1.940*** **	**0.933* **
	(p=0.001)	*(p=0.098)*
Oil Price (Brent)	**0.167** **	
	(p=0.011)	
Global Market Index	**0.003** **	
	(p=0.030)	
Interest Rate (US 10Y)		**7.707*** **
		(p=0.000)
Renewable × Interest Rate		**-7.935*** **
		(p=0.000)
Carbon Price (EU ETS)		**0.054* **
		(p=0.084)
Constant	**-32.789*** **	**-15.602* **
	(p=0.000)	*(p=0.077)*

Observations	1,100	1,100
R-squared	0.138	0.293
Adj. R-squared	0.135	0.290
F-statistic	9.92	10.27

*Notes: Dependent variable is Return on Equity (ROE). Robust standard errors clustered by firm are used to calculate p-values (reported in parentheses). Significance levels: * p<0.10, ** p<0.05, *** p<0.01.*

4.4 Creative Destruction and Competitive Displacement

Table 4 reports the results for Model 7, which focuses exclusively on firms in the traditional energy sector. Unlike the previous specifications that compare renewable and fossil fuel companies directly, this model examines whether the expansion of the renewable sector generates a negative external effect on the profitability of incumbent fossil fuel firms. In doing so, it provides a direct test of the Displacement Hypothesis.

The control variables confirm the core economic logic of traditional energy firms. The coefficient on the Brent oil price is positive and highly significant, indicating a strong dependence on commodity market conditions. Economically, a ten-dollar increase in oil prices is associated with an increase in return on equity of approximately 2.5 percentage points. The global market index is also statistically significant, reflecting the pro-cyclical nature of energy demand and reinforcing the importance of macroeconomic conditions for incumbent profitability.

Crucially, even after controlling for these powerful macroeconomic drivers, the renewable market share variable exhibits a negative and statistically significant relationship with traditional firm profitability. The estimated coefficient implies that increases in the aggregate revenue share of renewable firms are associated with economically meaningful declines in the ROE of fossil fuel incumbents. Specifically, a one percentage point increase in renewable market share corresponds to a reduction in traditional firms ROE of nearly two percentage points, holding oil prices and global market conditions constant.

This result provides strong empirical support for a Schumpeterian interpretation of the energy transition. The growth of renewable energy does not simply expand total energy supply to meet new demand. Instead, it displaces incumbent production and compresses margins in the fossil fuel sector. The effect is consistent with a zero-sum dynamic in which gains by renewable firms come at the expense of traditional energy companies.

Overall, the findings challenge the notion that fossil fuel incumbents are insulated from the energy transition by their scale or exposure to commodity price cycles. While periods of high oil prices can temporarily obscure these pressures, the results indicate that renewable expansion acts as a persistent structural constraint for traditional energy firms, independent of short-term fluctuations in commodity markets.

Table 4. Impact of Renewable Growth on Traditional Firms (Model 7)

Variable	**(7) Creative Destruction**
Renewable Market Share	**-197.720****
	(p=0.014)
Oil Price (Brent)	**0.251*****
	(p=0.000)
Global Market Index	**0.008*****
	(p=0.000)
Constant	-6.388
	(p=0.490)
Observations	605
R-squared	0.320
Adj. R-squared	0.317
F-statistic	19.55

*Notes: The sample is restricted to Traditional Energy firms only (N=12). Dependent variable is Return on Equity (ROE). Values in parentheses are p-values based on robust standard errors clustered by firm. Significance levels: * p<0.10, ** p<0.05, *** p<0.01.*

4.5 Dynamics: Relative Performance over Time (Model 8)

Model 8 extends the analysis by allowing the relative profitability of renewable firms to vary across years through interactions between the renewable sector indicator and time dummies. Full regression results are reported in **Annex 4**, while **Figure 3** visualizes the estimated interaction coefficients, showing year-specific deviations in renewable firm ROE relative to traditional energy firms, benchmarked to 2011.

A key result of this specification is the identification of a **negative structural intercept of −12.65 percentage points for renewable firms**, indicating a persistent baseline profitability disadvantage relative to traditional energy companies. The year-specific interaction coefficients shown in Figure 4 should therefore be interpreted as **additions to (or subtractions from) this negative baseline**, rather than as absolute performance measures.

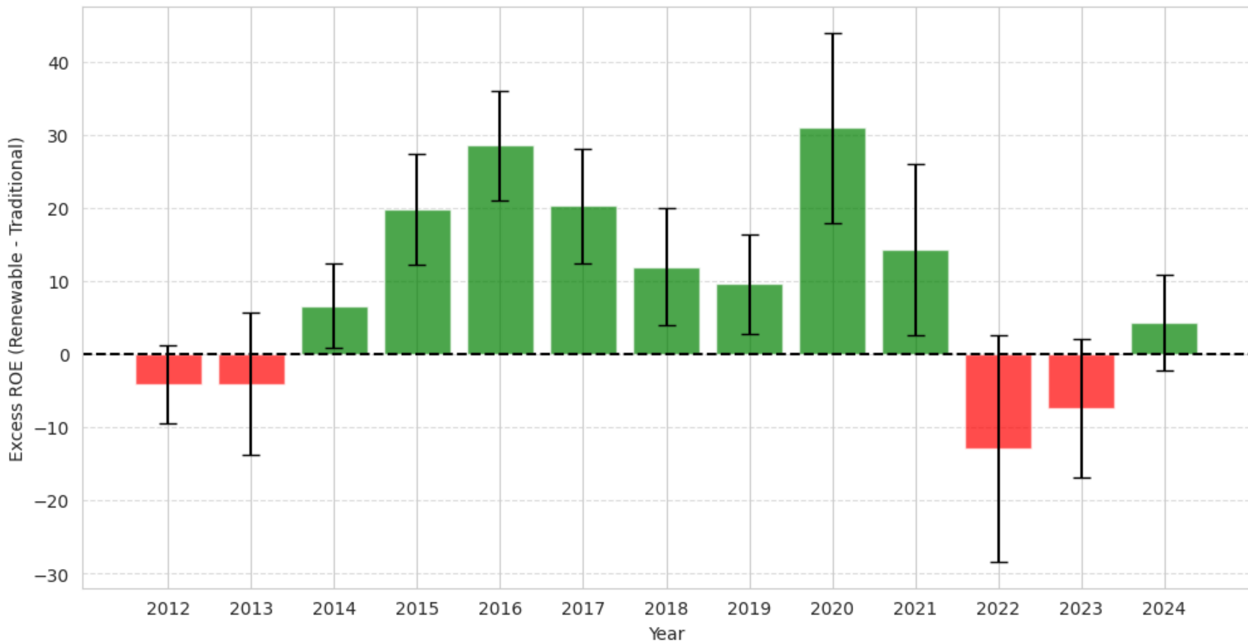
For renewable firms to outperform traditional firms in absolute terms in any given year, the positive interaction effect must be large enough to fully offset the −12.65 percentage point structural deficit. This threshold is crossed clearly in only two periods. In **2016**, during the oil price collapse, the interaction coefficient is sufficiently positive to eliminate the baseline gap, reflecting severe profitability losses among fossil fuel firms while renewable firms maintained relatively stable revenues. A similar, but even stronger, effect occurs in **2020**, when the interaction coefficient exceeds +30 percentage points following the announcement of the EU Green Deal and a surge in ESG-driven investment. In both cases, renewable firms temporarily outperform traditional firms in absolute ROE terms.

In other years, however, positive interaction effects are smaller and insufficient to close the structural gap. For example, in years such as **2018** and **2024**, the interaction coefficients are positive but remain below the +12.65 percentage point threshold. As a result, traditional energy firms continue to exhibit higher absolute profitability, despite relative improvements in renewable firm performance.

The analysis also highlights periods of relative underperformance. During **2022–2023**, the interaction coefficients turn negative, reflecting a reversal in relative performance as rising energy prices and interest rates benefited traditional firms while increasing financing costs penalized renewable firms. This reinforces the sensitivity of renewable profitability to macro-financial conditions.

Overall, the results from Model 8 demonstrate that renewable firm performance is highly regime-dependent. While policy-driven optimism and commodity market stress can temporarily offset structural financial disadvantages, these effects are episodic rather than persistent. The underlying profitability gap remains in place for most of the sample period, consistent with earlier findings that capital structure and financing conditions play a dominant role in shaping renewable firm ROE.

Figure 3. The Renewable Premium: impact of each year on ROE (relative to traditional energy companies



4.6 Robustness Check: Dominance Analysis Results

The results of the dominance analysis, illustrated in **Figure 4** for traditional firms and **Figure 5** for renewable firms, reveal a clear divergence in the underlying drivers of profitability across the two sectors. While the regression models identify statistically significant effects, the dominance analysis clarifies how the sources of ROE variation differ fundamentally between incumbent fossil fuel firms and renewable energy companies.

Figure 4. Dominance Analysis: Drivers of ROE (Traditional Firms)

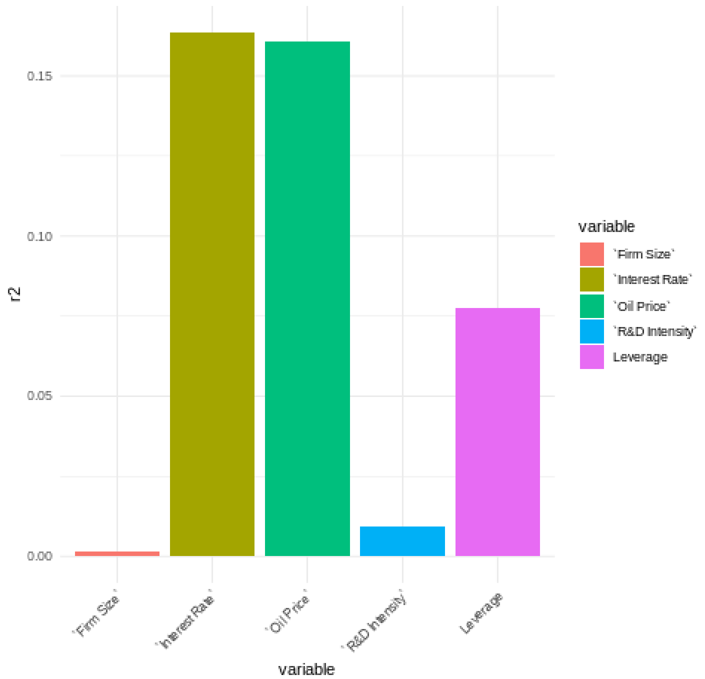
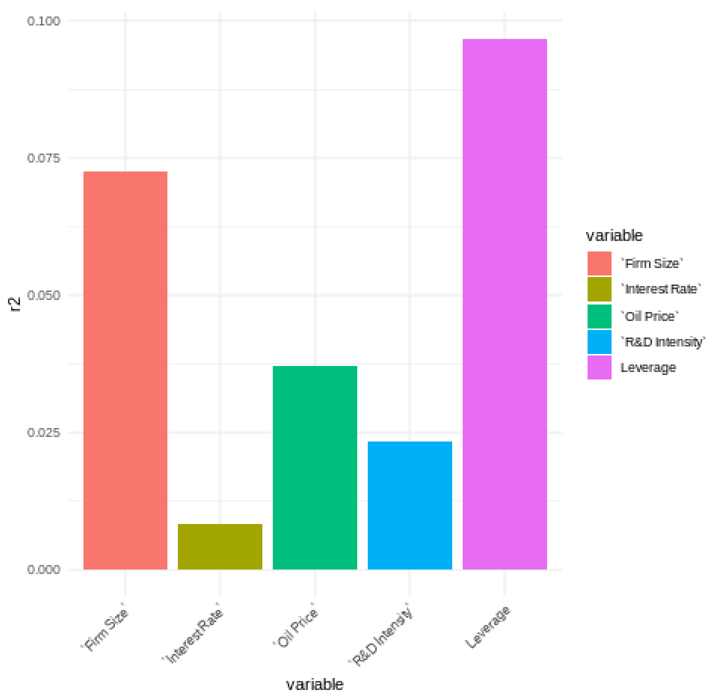


Figure 5. Dominance Analysis: Drivers of ROE (Renewable Firms)



Traditional Energy Firms: A Macro-Driven Profitability Model

For traditional energy firms, profitability is primarily shaped by external macroeconomic conditions. Interest rates and oil prices emerge as the two most important drivers, with relative contributions of approximately 0.164 and 0.161 to the model's explanatory power, respectively. Together, these variables account for the majority of the variation in return on equity.

Firm-specific characteristics play a noticeably smaller role. Leverage contributes only modestly to explained variance, with a relative importance of around 0.077, indicating that internal capital structure decisions are secondary to external price and monetary conditions. This pattern suggests that traditional energy firms function largely as **macro-dependent entities**, with profitability closely tied to global commodity cycles and the cost of capital rather than managerial balance-sheet choices.

Renewable Energy Firms: A Structure-Dependent Profitability Model

In contrast, the dominance analysis for renewable energy firms points to a fundamentally different profitability structure. Leverage is the single most important determinant of ROE variation, contributing approximately 0.097 to explained variance, followed closely by firm size at 0.073. These results indicate that internal financial structure and scale constraints dominate profitability dynamics in the renewable sector.

Macroeconomic variables play a far smaller role. Oil prices explain only a limited share of ROE variation (approximately 0.037), while interest rates rank lowest among all predictors, contributing just 0.008. This finding refines the Fragility Hypothesis established in the regression analysis. While earlier models show that renewable firms are negatively affected by rising interest rates, the dominance analysis demonstrates that **variation in profitability is driven primarily by debt levels rather than by changes in interest rates themselves**.

In other words, renewable firm profitability is largely endogenous. Volatility in ROE arises from aggressive capital structures and scale limitations, which amplify the impact of financing conditions. Unlike traditional firms, which are carried by macroeconomic cycles, renewable firms remain constrained by their own balance sheets.

Overall, the dominance analysis confirms that the two sectors operate under distinct financial regimes. Traditional energy firms behave as macroeconomic proxies, with profitability largely determined by oil prices and monetary conditions. Renewable energy firms, by contrast, function as asset-intensive structures in which leverage and firm size outweigh external market signals. These findings reinforce the central conclusion of the thesis: **reducing leverage is the most effective pathway for stabilizing and improving renewable firm profitability**, particularly in an environment of volatile interest rates.

Table 5. Summary of Hypothesis Testing Results

Hypothesis	Description	Key Statistical Evidence	Status
H1	**Baseline Performance:** Traditional firms exhibit higher unadjusted ROE than Renewable firms.	The renewable sector dummy is negative and marginally significant (β=−4.12,p=0.051) across baseline specifications.	**Accepted**
H2	**Capital Structure:** The profitability gap is driven by leverage differences, not sector.	**Debt/Assets** is the dominant negative driver (β=−0.31,p<0.001). Once controlled, the **Renewable Dummy** becomes statistically insignificant (p>0.10).	**Accepted**
H3	**Innovation Cost:** R&D and Capex intensity negatively impact short-term profitability.	Coefficients for **R&D Intensity** and **Capex Intensity** are statistically insignificant (p>0.05).	**Rejected**
H4	**Decoupling:** Traditional firms are tethered to oil prices; Renewable firms are decoupled.	**Oil Price** is the #2 driver for Traditional firms ($R^2_{Contribution}$=16%) but ranks low for Renewables (3.7%).	**Accepted**
H5	**Monetary Asymmetry:** Rising interest rates disproportionately hurt renewable firms.	The interaction term ($D_{Renewables} \times Int\_Rate_t$) is negative and highly significant (β=−7.94,p<0.001), neutralizing the positive base effect seen in Traditional firms.	**Accepted**
H6	**Policy Insufficiency:** Carbon pricing offsets the cost of capital shocks.	**Carbon Price** is positive but marginal (β=0.05,p=0.08). The magnitude is too small to offset the interest rate penalty (β=−7.94).	**Rejected**

H7	**Displacement:** Renewable market share growth reduces Traditional firm profitability.	**Renewable Market Share** has a significant negative impact on Traditional ROE ($\beta=-197.72, p=0.014$).	**Accepted**

Summary of results

The results reveal a persistent profitability gap between renewable and traditional energy firms in the raw data. While renewable firms exhibit lower average ROE in baseline models, this gap is not driven by operational inefficiency or technology costs. Once firm size, leverage, and macroeconomic conditions are accounted for, the renewable sector effect becomes statistically insignificant.

This indicates that the observed 'green discount' is entirely mediated by capital structure: renewable firms appear less profitable solely because they carry significantly higher debt burdens. Dominance analysis confirms a fundamental divergence in business drivers: Traditional firms function as macro-proxies driven by oil prices, whereas Renewable firms are structure-dependent uniquely fragile to leverage and interest rate shocks.

Finally, despite this financial fragility, the analysis confirms Schumpeterian creative destruction: the aggregate growth of the renewable market share exerts a statistically significant negative displacement effect on the profitability of incumbent fossil fuel firms.

5. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. A review of scientific literature indicates that debates regarding profitability differences between renewable and traditional energy companies have persisted for an extended period, with no consensus on a single underlying cause. Several studies identify capital structure and company size as significant factors, while others emphasize the impact of commodity price fluctuations or policy support. However, the evidence remains inconclusive on whether renewable energy companies consistently operate less efficiently, highlighting the need for further data-driven research.

2. The findings of this thesis indicate that, on average, renewable energy companies exhibit lower profitability than traditional fossil fuel companies, even after controlling for economic and financial factors. This disparity is particularly evident in return on equity measures, where the gap between the two sectors is substantial. These results are consistent with both descriptive statistics and baseline regression analyses.

3. However, when additional control variables are introduced, the findings change significantly. Accounting for company size, leverage, interest rate fluctuations, and oil prices renders the renewable energy variable statistically insignificant. Therefore, the lower profitability of renewable energy companies appears to be more closely associated with financial characteristics than with operational performance alone.

4. Capital structure is a critical factor underlying these differences. Renewable energy companies typically maintain higher debt-to-asset ratios, increasing their exposure to interest rate fluctuations and challenges in securing new financing. In contrast, traditional energy firms generally possess stronger cash flows and exercise more prudent financial management, resulting in greater financial resilience.

5. The results demonstrate that the two sectors respond differently to external economic factors. Traditional energy companies are primarily influenced by oil price movements and broader economic cycles, whereas renewable energy companies are more affected by financing costs and financial management practices. Consequently, periods of rising interest rates present greater challenges for renewable firms, even when supportive energy or environmental policies remain in place.

Recommendations

1. Renewable energy companies should prioritize optimizing their capital structure to improve long-term profitability. Reducing excessive reliance on debt and increasing the proportion of equity financing may decrease sensitivity to interest rate fluctuations and enhance financial stability.

2. Public policies supporting renewable energy development should prioritize reducing financing costs. Policymakers could implement mechanisms that specifically target financing costs. Recommendations include offering state-backed interest rate guarantees or concessional financing for green infrastructure projects to decouple the energy transition from central bank monetary cycles.

Research limitations and directions for future research

1. A key limitation of this study is survivorship bias, which arises from the use of a balanced panel covering the 2011–2024 period. The sample includes only firms that remained publicly listed and operational throughout the entire timeframe, thereby excluding renewable energy companies that exited the market due to bankruptcy or delisting during industry downturns. As a result, the analysis likely overstates the historical profitability and financial stability of the renewable sector, as it focuses on firms that successfully survived industry consolidation. Given that even these surviving firms exhibit financial vulnerability, the overall risk profile of the broader renewable energy sector may be more pronounced than the results suggest. In addition, data availability constraints limited the number of renewable firms included in the sample, as many entered the market only in more recent years, reducing the scope of the empirical analysis.

2. Future research could address these limitations by employing unbalanced panel data, extending the observation period, or incorporating alternative data sources such as project-level information or firm surveys. Further examination of the interaction between policy design and financial conditions may also provide deeper insights into the long-term profitability and resilience of renewable energy companies.

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7. SUMMARY

The global energy sector is undergoing a profound structural transformation driven by climate change policy, technological progress, and the rapid expansion of renewable energy sources. While renewable energy companies play a central role in the transition toward a low-carbon economy, their financial performance relative to traditional fossil fuel energy firms remains a subject of debate. This study examines whether renewable energy companies systematically underperform conventional energy firms and identifies the financial and macroeconomic factors that explain observed performance differences.

The research focuses on a comparative analysis of large publicly listed renewable and traditional energy companies over the period from 2011 to 2024 third quarter, using quarterly firm-level data. Profitability is measured by return on equity (ROE), while explanatory variables include leverage, firm size, liquidity, capital investment, R&D expenditure. Other macroeconomic indicators analyzed are oil prices, interest rates, world stock market index and carbon pricing. The analysis applies panel regression to analyze drivers' importance.

The findings show that renewable energy firms display lower profitability than traditional energy firms in unadjusted comparisons. Once firm size, capital structure, and macroeconomic conditions are controlled for, the sectoral profitability gap disappears. The results indicate that lower profitability of renewable firms is explained by differences in leverage, as renewable firms operate with substantially higher debt levels. Further analysis highlights a structural contrast between the two sectors: traditional energy firms are primarily influenced by macroeconomic factors such as oil prices, whereas renewable firms are more sensitive to financial structure and interest rate conditions. Despite this vulnerability, the expansion of the renewable sector is associated with a statistically significant displacement effect on the profitability of incumbent fossil fuel firms, providing evidence consistent with Schumpeter's creative destruction.

Overall, the findings suggest that the lower profitability of renewable energy firms is driven by financial structure and macroeconomic exposure. From a policy perspective, the results highlight the importance of stable financing conditions and targeted financial support mechanisms to improve the competitiveness of renewable energy companies. For investors, the study underscores the need to account for interest rate risk and leverage when evaluating renewable energy investments.

Lithuanian Summary

Pasaulinis energetikos sektorius šiuo metu išgyvena reikšmingą struktūrinę transformaciją, kurią lemia klimato kaitos politika, technologinė pažanga ir spartus atsinaujinančių energijos šaltinių plėtimasis. Nors atsinaujinančios energetikos įmonės atlieka svarbų vaidmenį pereinant prie mažo anglies dioksido kiekio ekonomikos, jų finansiniai rezultatai, palyginti su tradicinėmis iškastinio kuro energetikos įmonėmis, vis dar kelia diskusijų. Šiame tyrime analizuojama, ar atsinaujinančios

energetikos įmonės sistemiškai pasižymi prastesniais finansiniais rezultatais nei tradicinės energetikos įmonės, bei identifikuojami finansiniai ir makroekonominiai veiksniai, paaiškinantys pastebimus veiklos rezultatų skirtumus.

Tyrimas grindžiamas didelių viešai listinguotų atsinaujinančios ir tradicinės energetikos įmonių palyginamąja analize 2011–2024 metų trečiojo ketvirčio laikotarpiu, naudojant ketvirtinius įmonių lygmens duomenis. Pelningumas matuojamas nuosavo kapitalo grąžos (ROE) rodikliu, o aiškinamieji kintamieji apima finansinį svertą, įmonės dydį, likvidumą, kapitalo investicijas ir mokslinių tyrimų bei eksperimentinės plėtros išlaidas. Taip pat analizuojami makroekonominiai rodikliai: naftos kaina, palūkanų normos, pasaulio akcijų rinkos indeksas ir anglies dioksido kaina. Analizėje taikomas panelinė regresija, siekiant įvertinti veiksnių svarbą.

Tyrimo rezultatai rodo, kad nors nepakoreguotuose palyginimuose atsinaujinančios energetikos įmonės pasižymi mažesniu pelningumu nei tradicinės energetikos įmonės. Įvertinus įmonės dydį, kapitalo struktūrą ir makroekonomines sąlygas, sektoriaus pelningumo skirtumas išnyksta. Gauti rezultatai leidžia teigti, kad mažesnis pelningumas paaiškinamas finansinio sverto skirtumais, nes atsinaujinančios energetikos įmonės veikia esant gerokai didesniam įsiskolinimo lygiui. Papildoma analizė atskleidžia struktūrinį skirtumą tarp dviejų sektorių: tradicinių energetikos įmonių pelningumą daugiausia lemia makroekonominiai veiksniai, tokie kaip naftos kainos, tuo tarpu atsinaujinančios energetikos įmonės yra labiau jautrios finansinei struktūrai ir palūkanų normų pokyčiams. Nepaisant šio pažeidžiamumo, atsinaujinančios energetikos sektoriaus plėtra siejama su statistiškai reikšmingu neigiamu poveikiu tradicinių iškastinio kuro įmonių pelningumui, kas patvirtina Schumpeterio kūrybinės destrukcijos teoriją.

Apibendrinant galima teigti, kad mažesnį atsinaujinančios energetikos įmonių pelningumą lemia finansinė struktūra ir makroekonominis jautrumas. Politikos formavimo požiūriu, rezultatai pabrėžia stabilių finansavimo sąlygų ir tikslingų finansinės paramos priemonių svarbą siekiant didinti atsinaujinančios energetikos įmonių konkurencingumą. Investuotojams šis tyrimas pabrėžia būtinybę vertinant investicijas į atsinaujinančią energetiką atsižvelgti į palūkanų normų riziką ir įsiskolinimą.

Annex 1

Table 6. List of Analyzed Traditional Energy (TRAD) Companies and Characteristics

Ticker	Company Name	Region	Sector (Type)	Primary Energy Source / Mix
XOM	Exxon Mobil Corp.	USA	Integrated Oil & Gas	~99% Fossil Fuel (Oil, Gas, Refining)
CVX	Chevron Corp.	USA	Integrated Oil & Gas	~99% Fossil Fuel
SHEL	Shell plc	UK/Global	Integrated Oil & Gas	>95% Fossil (Transitioning to LNG)
BP	BP plc	UK/Global	Integrated Oil & Gas	>95% Fossil Fuel
TTE	TotalEnergies SE	France	Integrated Oil & Gas	>90% Fossil (Growing Solar/Wind arm)
EQNR	Equinor ASA	Norway	Integrated Oil & Gas	>95% Fossil (Major Offshore Wind dev.)
ENI	Eni S.p.A.	Italy	Integrated Oil & Gas	>95% Fossil Fuel
COP	ConocoPhillips	USA	Upstream E&P	100% Fossil Fuel (Exploration only)
EOG	EOG Resources	USA	Upstream E&P	100% Fossil Fuel (Shale specialists)
OXY	Occidental Petroleum	USA	Upstream E&P	100% Fossil Fuel
PBR	Petrobras	Brazil	Integrated Oil & Gas	>95% Fossil (Deepwater Oil)

Annex 2

Table 7. List of Analyzed Innovative Energy (INNOV) Companies and Characteristics

Ticker	Company Name	Region	Sector (Type)	Primary Energy Source / Mix
VWS	Vestas Wind Systems	Denmark	Tech / Manufacturing	**100% Renewable** (Wind Turbines)
EDPR	EDP Renováveis	Spain	Renewable Utility	**~99% Renewable** (Wind & Solar)
ORA	Ormat Technologies	USA/Israel	Renewable Utility	**100% Renewable** (Geothermal)
BLX	Boralex Inc.	Canada	Renewable IPP	**100% Renewable** (Wind, Hydro, Solar)
INE	Innergex Renewable	Canada	Renewable IPP	**100% Renewable** (Hydro, Wind)
VER	Verbund AG	Austria	Utility	**~95% Renewable** (Hydro Power)
NEE	NextEra Energy	USA	Integrated Utility	~60% Renewable/Nuclear (World's largest wind owner)
IBE	Iberdrola S.A.	Spain	Integrated Utility	~70% Zero Emission (Wind leader)
ENEL	Enel S.p.A.	Italy	Integrated Utility	~65% Zero Emission (Aggressive coal phase-out)

Annex 3

Table 8. Sample Companies: Capitalization, Indices, and Market Position

Company Name	Ticker	Approx. Market Cap (USD)*	Primary Index	Leadership Position / Niche
TRADITIONAL ENERGY (TRAD)				

Exxon Mobil Corp.	XOM	~$520 B	S&P 500 (USA)	Largest non-government integrated oil company in the western world.
Chevron Corp.	CVX	~$280 B	S&P 500 (USA)	Second-largest US oil major; leader in Permian Basin production.
Shell plc	SHEL	~$210 B	FTSE 100 (UK)	World’s largest trader of Liquefied Natural Gas (LNG).
TotalEnergies SE	TTE	~$160 B	CAC 40 (France)	Most diversified European major; significant investments in LNG and multi-energy.
ConocoPhillips	COP	~$130 B	S&P 500 (USA)	World's largest independent "Pure-Play" Exploration & Production (E&P) firm.
BP plc	BP	~$100 B	FTSE 100 (UK)	Historical "Supermajor"; leader in deepwater extraction and trading.
Petrobras	PBR	~$95 B	Bovespa (Brazil)	Global leader in ultra-deepwater and pre-salt oil extraction technology.
Equinor ASA	EQNR	~$80 B	OBX (Norway)	Largest gas supplier to Europe (post-2022); leader in floating offshore wind dev.
EOG Resources	EOG	~$70 B	S&P 500 (USA)	Technological leader in hydraulic fracturing (fracking); largest shale oil producer.
Eni S.p.A.	ENI	~$50 B	FTSE MIB (Italy)	Italian energy giant; leader in African energy exploration.
Occidental Petroleum	OXY	~$50 B	S&P 500 (USA)	Major Permian Basin producer; leader in Enhanced Oil Recovery (EOR) & Carbon Capture.

INNOVATIVE ENERGY (INNOV)				
NextEra Energy	NEE	~$150 B	S&P 500 (USA)	World’s largest generator of renewable energy from the wind and sun.
Iberdrola S.A.	IBE	~$85 B	IBEX 35 (Spain)	Europe's largest electricity utility by market cap; pioneer in global wind farms.
Enel S.p.A.	ENEL	~$70 B	FTSE MIB (Italy)	Largest European utility by customer base; aggressive decarbonization strategy.
Vestas Wind Systems	VWS	~$30 B	OMX Copenhagen	Global #1 manufacturer of wind turbines (Onshore & Offshore) by installed capacity.
Verbund AG	VER	~$26 B	ATX (Austria)	One of Europe’s largest producers of electricity from hydropower.
EDP Renováveis	EDPR	~$15 B	PSI 20 (Portugal)	Top-4 global wind energy producer; pure-play renewable spin-off of EDP Group.
Ormat Technologies	ORA	~$4.5 B	S&P MidCap 400	Global leader in geothermal energy generation and recovered energy generation.
Boralex Inc.	BLX	~$2.5 B	TSX (Canada)	Canada's largest independent producer of onshore wind power.
Innergex Renewable	INE	~$1.5 B	TSX (Canada)	Specialized independent producer of hydroelectric, wind, and solar energy.

**Note: Market Capitalization figures are approximate averages for the 2023–2024 period, converted to USD. Inclusion in major indices (S&P 500, FTSE 100, etc.) serves as a proxy for stock liquidity and institutional relevance.*

Annex 4

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	Model G (Yearly Interactions)
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Intercept	18.377***
	(1.880)
is_renewable	-12.659***
	(2.625)
C(Year)[T.2012]	-1.365
	(0.928)
C(Year)[T.2013]	-4.615***
	(1.478)
C(Year)[T.2014]	-7.086***
	(2.067)
C(Year)[T.2015]	-20.223***
	(2.250)
C(Year)[T.2016]	-25.698***
	(1.778)
C(Year)[T.2017]	-15.763***
	(1.907)
C(Year)[T.2018]	-6.788**
	(2.745)

C(Year)[T.2019]	-7.363***
	(2.595)
C(Year)[T.2020]	-30.329***
	(6.312)
C(Year)[T.2021]	-14.611***
	(5.410)
C(Year)[T.2022]	11.515*
	(6.947)
C(Year)[T.2023]	8.560**
	(3.464)
C(Year)[T.2024]	-2.369
	(2.965)
is_renewable:C(Year)[T.2012]	-4.121
	(2.722)
is_renewable:C(Year)[T.2013]	-4.002
	(4.976)
is_renewable:C(Year)[T.2014]	6.667**
	(2.922)
is_renewable:C(Year)[T.2015]	19.866***
	(3.829)
is_renewable:C(Year)[T.2016]	28.595***
	(3.821)
is_renewable:C(Year)[T.2017]	20.312***

	(4.009)
is_renewable:C(Year)[T.2018]	12.002***
	(4.075)
is_renewable:C(Year)[T.2019]	9.660***
	(3.470)
is_renewable:C(Year)[T.2020]	30.981***
	(6.658)
is_renewable:C(Year)[T.2021]	14.316**
	(5.987)
is_renewable:C(Year)[T.2022]	-12.832
	(7.907)
is_renewable:C(Year)[T.2023]	-7.332
	(4.855)
is_renewable:C(Year)[T.2024]	4.367
	(3.347)
R-squared	0.386
R-squared Adj.	0.370
N	1100
R2	0.386

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Standard errors in parentheses.

* p<.1, ** p<.05, ***p<.01