RISK AND FINANCIAL ANALYSIS OF PUBLICLY TRADED BIOFUEL FIRMS

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Degree

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Dedication

I dedicate my work to Ganga Bista, Hemraj Bista, Bimala Bista, Birendra Basnet, Hemanta Basnet, Bhishma Raj Dahal, Amrit Shrestha, Sagar Dahal, L.N. Ojha, Seth Ingram, Brad Antone, Kumar Bolakhe, Binayak Kunwar, Suman Kshetri, Tongtong Li, Bowen Jiang, Lun Luo, Billie Ray, and Sam Gerloff.

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Abstract

This study analyzed the risk and financial performance of 22 publicly traded biofuel companies from 2018 to 2021. The analysis found that management, financing, biofuel policies, biofuel and feedstock markets, contracting, and general economic conditions were the most prevalent and significant risk factors for these companies. Primary biofuel (PB) companies, which had a higher percentage of biofuel revenues, were found to be more vulnerable to risks related to biofuels, while secondary biofuel (SB) companies were more susceptible to general business risks. Collaborative efforts among stakeholders could help mitigate these risks and support the growth of the biofuel industry.

The study also compared the financial performance of PB companies to those with smaller biofuel revenues (SB) using financial ratios, trend analysis, and analysis of stock returns. PB companies outperformed SB companies in profitability, liquidity, and efficiency ratios, with most ratios being highly volatile. There was an unexpected increase in profitability ratios for PB companies during 2020-2021, followed by a significant decline. PB companies had negative weighted average stock returns in the first two years of the study period but experienced a sharp reversal during the period of 2020 to 2021, likely due to the COVID-19 pandemic.

However, the study acknowledged potential sample selection bias since only publicly traded biofuel companies were included in the sample, which may not accurately reflect the performance of the entire biofuel industry. Future research could address this limitation by incorporating privately held biofuel firms into the sample.

Keywords: biofuel companies, risks analysis, prevalent and significant risks, financial ratios, trend analysis

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CHAPTER I

INTRODUCTION

1.1 Background

The increasing trend of fossil fuel consumption globally has raised concerns about the depletion of fossil fuels. Recent studies examining the fossil fuel consumption pattern have predicted that mainstream crude oil, at its present consumption rate, will not fulfill the worldwide demand in the next 50 years (Azari Marhabi et al., 2022). Fossil fuel combustion is one of the major sources of Greenhouse Gas (GHG) emissions. Climate change, primarily driven by the emission of GHG from the burning of fossil fuels, is widely regarded as one of the most pressing environmental concern in recent times (Siddik et al., 2021). GHG emissions are expected to rise in the coming years because of growing population and consumption of fossil fuels. This situation has required the gradual replacement of fossil fuels and the use of alternative fuels like biofuel (Altieri & Bravo, 2007; Huang et al., 2012). The Intergovernmental Panel on Climate Change (IPCC) has underscored the risks associated with climate change and recognized the gradual replacement of fossil fuels by renewable fuels to mitigate climate change (IPCC, 2014). Governments worldwide have implemented policies to transition from fossil fuels sector to renewable fuels using market-based mechanisms and command-and-control approaches (Campbell et al., 2018). Globally, more than fifty countries have developed biofuel policies and mandates to promote the transition of energy consumption in sectors like transportation, heating, and power from fossil fuels to renewable fuels like biofuel (Petersen, 2008).

In the United States, biofuels have emerged as a promising alternative source of energy because of their renewable nature. Biofuels reduce GHG emissions to the atmosphere and at the same time promote fuel security for a country. In addition, the biofuel industry can contribute to

socioeconomic development by creating jobs in the domestic market (McCarty & Sesmero, 2015). Several policies and mandates have been formulated and implemented to promote the biofuel industry in the US (Markel et al., 2018). The renewable fuel standard (RFS) was first started in 2005, and it expanded the way it is today as the second renewable fuel standard (RFS2) in 2007 (CRS, 2022). RFS2 is a federal program supervised by the US Environmental Protection Agency (EPA) that requires transportation fuel in US to contain a minimum volume of renewable fuel. EPA sets the limit for renewable fuels to be incorporated into transportation fuels in an increasing pattern each year and monitors the RFS2 compliance by tracking renewable identification numbers (RIN) (Markel et al., 2018). Although the RFS2 program has not been able to bring all the intended progress to the biofuel industry, it has stimulated the growth and development of the biofuel industry in the US (Markel et al., 2018). The biofuel industry has transformed in several ways from its beginning phase to the present. The first-generation biofuels like corn ethanol and sugarcane ethanol are the pioneers in the biofuel industry. The first-generation biofuels are extracted by fermentation or esterification of edible crops like sugarcane, corn, wheat, rapeseed, etc. For instance, ethanol can be obtained from the fermentation of corn or sugarcane and the esterification of crops like soybean or palm oil generates biodiesel. The easy availability of feedstock, efficient conversion technology, and biofuel-suitable government mandates and regulations encouraged the first-generation biofuel industry in the early 2000s leading to an ethanol boom during that period. However, the regular vehicle could only operate under E10 meaning the combination of fuel with 90% of regular gasoline and 10% of ethanol. Thus, the ethanol fuel market was already saturated by 2012. At the same time, public concerns regarding food insecurity, increasing food prices, competition with food crops, and concern about cost-effectiveness compared to their use as food shifted the attention of the stakeholders

towards other alternatives referred to as second and third generation biofuels (Ng et al., 2017; Voloshin et al., 2016). The second-generation biofuels include bioethanol and biodiesel obtained from non-edible feedstocks like woodchips, agricultural waste, jatropha, and switchgrass etc. Although the problem generated by first-generation biofuel is solved by second-generation biofuel, the availability of raw materials to produce second-generation biofuel is still a challenge. Several studies have explored feedstock availability, the scope of cultivating the feedstocks, the conversion processes, and the financial feasibility of producing second-generation biofuels as a challenge (Markel et al., 2018; McCarty & Sesmero, 2015; Miller et al., 2013; Ng et al., 2017). The third-generation biofuel is a current hot topic in the biofuel industry, and it uses microalgae and seaweeds to produce biofuel. It seems to be a promising alternative to first and second-generation biofuel because it does not compete with the farmland as it can be grown in saltwater and brackish water. Also, there is enormous potential to grow feedstock for third-generation biofuel. However, the economic viability of third-generation biofuels is still a major question.

1.2 Research Problem

Global warming and climate change resulting from carbon dioxide and GHG emissions by using fossil fuels is a growing concern. This situation has required the gradual replacement of fossil fuels and the use of alternative fuels like biofuel (Altieri & Bravo, 2007; Huang et al., 2012).

The recent advancements in electric vehicle technology, an alternative to conventional fossil fuels, have provided significant environmental benefits, particularly in terms of reducing greenhouse gas emissions. As a result, electric vehicles have gained increasing popularity and are now widely recognized as a more sustainable alternative to conventional gasoline-powered vehicles. Electric cars have made significant progress in recent years, with battery technology

improving rapidly, resulting in longer ranges and faster charging times. However, despite these advancements, the adoption of electric vehicles in some sectors, such as aviation, large transportation, and agriculture, has been slow. Biofuels remain relevant in these sectors due to the significant challenges facing the development of electric airplanes and electric large transportation vehicles.

Biofuel has advantages over conventional fossil fuel because of its renewable nature, lower GHG emissions, and promoting rural farm income (Altieri & Bravo, 2007). Thus, governments around the globe have made efforts to promote biofuel as an alternative to fossil fuels. The first-generation ethanol industry grew 10 fold during the 2000 to 2010 period (Lynd, 2017). However, the food vs fuel debate prompted the shift of biofuel industry's focus from first-generation ethanol to cellulosic biofuels arguably due to the large-scale availability of cheap, sustainable feedstock, and technology ready for use. However, the biofuel landscape did not turn out to be the way imagined by the policymakers. Several biofuel startups have failed and those that survived are focusing on other high value products than biofuels (Lynd, 2017). This could be attributed to the limited growth and development of the biofuel industry caused by the risks and uncertainties prevalent in the industry. Risks and uncertainties like high initial capital investment, rapid generation of novel technologies making the older ones less attractive, continuous adjustments and changes in biofuel policy, price variation, feedstock availability, among others, are major caveats discouraging investments in the biofuel industry and are downside for the growth of the industry (Miller et al., 2013). In addition, the irreversible nature of investment in biofuel combined with uncertain profitability from the investment has been identified as one of the major factors making investors hesitant to invest in biofuel ventures (Markel et al., 2018; McCarty & Sesmero, 2015).

This study seeks to evaluate the financial performance of firms in the biofuel industry and the risks faced by the biofuel firms. This study is of current relevance because the biofuel industry is still developing and transitioning to become a more economically viable and sustainable alternative to fossil fuel. Several biofuel startups have failed and filed for bankruptcy because of the high risks and lower returns associated with the biofuel industry. This context, therefore, requires conducting a financial analysis and identifying the drivers of profitability in the biofuel industry. Also, there has been limited research in the past identifying and evaluating the risk factors affecting the biofuel industry. Assessing the risks affecting the biofuel industry will help us understand the major caveats for the development of the biofuel industry and will provide the direction to mitigate those risks.

1.3 Significance of the Research

This study aims to identify and evaluate the major risks affecting the growth and development of the biofuel industry and assist policymakers and governments to develop an effective policy mix that could boost the biofuel industry. This study can contribute to the previous research by Pries et al. (2016) that identified the prevalence and significance of risks reported by publicly-traded biofuel companies. Unlike the previous research by Pries et al. (2016) that identified the prevalence and significance of risks for just one year, we identified the prevalence and significance of risks for four years (2018-2021). In addition, the sample companies used in our study are different than the previous study. The sample in the study by Pries et al. (2016) was identified by searching for terms like biofuel, ethanol, and biodiesel in the Electronic Document Analysis, and Retrieval system (EDGAR), and System for Electronic Document Analysis (SEDAR) databases. This study employed a different method to select the sample companies described in the data and method section. So, our study provides updated and

comprehensive results about the risks faced by the biofuel industry. In addition, we examine the financial performance of biofuel revenue dominant companies with the companies with less share of biofuel revenue. This could help us understand whether the investment in biofuel ventures is profitable to the investors.

1.4 Objectives of the Research

The objectives of this study are:

1. To identify and evaluate the risk factors faced by a sample of publicly traded biofuel firms from 2018 to 2021.

2. To analyze the financial performance of publicly traded biofuel firms from 2018 to 2021.

CHAPTER II

LITERATURE REVIEW

2.1 Literature Review for Risk Analysis

Any novel product or technology faces several challenges including cost, supply chain establishment, technical uncertainties, regulatory approval, political uncertainty, policy failures etc. (Dodd et al., 2018). In this section, we review studies relevant to our study about risks of the biofuel industry.

2.1.1 Biofuel Policies

Reducing dependency on foreign fuel along with environmental conservation is a general-purpose of government policies that intend to create a conducive environment for the growth of the biofuel industry. On the other hand, there is a growing concern that policy-level efforts for technological innovation are more focused on the economic aspects of the biofuel industry rather than environmental conservation (Costantini et al., 2015). Some studies examining the policy level efforts in the biofuel industry are discussed below.

Kesan et al. (2009) examined the impact of renewable fuel standard (RFS) on the growth and development of the US ethanol industry using data from 216 ethanol plants that entered the ethanol market after 2000. The study period ranged from 2000 to 2010. The analysis revealed that the RFS program contributes to increasing economies of scale and promoting the competitiveness of existing firms. The OLS regression using plant capacity as the dependent variable and RFS as the dummy, ethanol price, and number of ethanol plants in state as independent variables suggests a statistically significant relationship among them. This result stresses the importance of biofuel policy for the viability and growth of biofuel businesses.

A study by Naylor & Higgins (2017) examined the economic and policy factors that promote the expansion of biodiesel and studied the prospect of biodiesel growth in a low crude oil prices scenario. The authors used the case study method to explore the major biofuel-producing countries (Argentina, Brazil, Canada, Colombia, European Union, Indonesia, Malaysia, Thailand, and USA) as key elements for analysis. The key takeaways from the case studies were: 1) the expansion of biodiesel output in all the major producing countries was a result of explicit policy intervention, 2) vegetable oil prices have rarely been low enough for biodiesel to break even with conventional diesel in the absence of subsidies, 3) all large biodiesel producing countries use domestic agricultural commodities as the leading feedstock for biodiesel development, 4) The ratio of crude oil to vegetable oil prices influences the profitability of biodiesel investments, and provides an indication of the magnitude of government subsidies that will be needed to achieve biodiesel targets, and 5) The objectives that are often promoted to be a "win-win" strategy are frequently in conflict and have unintended consequences.

Similarly to Naylor & Higgins (2017), a study by Ebadian et al. (2020) evaluated the effectiveness of technology-push and market-pull policies to promote biofuels in 15 major biofuel producing countries. Technology-push policies are the policies that promote the early-stage research and development, demonstration, and commercialization of biofuel technology and reduce the financial burden at the initial phase of technology development. For example, rebates on R&D expenses, funding for construction of demonstration facilities, loan guarantee programs to reduce the risk of investment on commercial facilities, etc. On the other hand, market-pull policies are motivated to support matured technology and create demand for biofuels. Examples include blending mandates, fuel excise tax exemption, the tariff on imported ethanol, etc. The results revealed that biofuel policies are important for developing and growing

biofuel markets. In addition, countries with a policy mix of market-pull and technology push instruments were found to be more successful at increasing biofuel production.

2.1.2 Biofuel Industry Analyses

The biofuel industry is still a nascent industry that prioritizes research and development activities to solve the technical and economic challenges with biofuel production. First-generation ethanol, particularly corn ethanol, was the biofuel produced initially on a commercial scale to mitigate the environmental concerns raised by fossil fuels. Ethanol has been used to support the US fuel industry since the beginning of this century (Bothast & Schlicher, 2005). Governments and private stakeholders made several efforts for the growth of this industry in the early 2000s resulting in a boom in ethanol and other biofuel production. Tyner (2008) argued that the ethanol boom during that period was a consequence of fixed ethanol subsidies and the prospects relied upon the price of crude oil, the price of corn and distillers' grains, ethanol pricing, plant capital and operating costs, and biofuels mandates and policies. The ethanol market was already saturated by 2012 and hit the blend wall (E10) by producing more than 50 billion liters of corn ethanol (Peplow, 2014). The blend wall (E10) is the upper limit of the ethanol that can be consumed by the US fuel market. According to the E10, 10% of the ethanol can be mixed with regular gasoline and used to operate any vehicle without any modifications to the vehicle. This progress of the biofuel industry was considered an achievement until debates about food vs fuel surfaced. This debate along with less GHGs emissions by second-generation biofuel encouraged the shift of attention from first-generation ethanol to second-generation or advanced biofuels that are produced from non-food crops.

Extensive research based on techno-economic studies have been conducted to assess the feasibility of various conversion techniques and feedstocks for advanced biofuel production. A

study using three feedstock alternatives, brown grease, yellow grease, and carinata oil, analyzed the feasibility of catalytic hydrothermolysis (CH) aviation biofuel technology (McGarvey & Tyner, 2018). The results revealed that the venture was not financially viable without Renewable Identification Number (RINs) and Low Carbon Fuel Standard (LCFS) credits. Similarly, Mungodla et al. (2019) conducted a techno-economic analysis of second generation biofuels by sorting and analyzing the studies based on technology selection, feedstock availability and suitability, process simulation and economies. The results revealed that there is no generic answer to the feasibility of any technology at a commercial scale. The high initial capital investment in second-generation biofuel was attributed to the plant operations, production technology, and feedstock costs. Similarly, feedstock cost was found to be the most sensitive parameter among all plant parameters. Likewise, studies assessing environmental impact of the technology revealed that anaerobic digester performs superior in terms of environmental effects compared to thermochemical technologies. Aui et al. (2021) reported similar results from a meta-analysis of several techno-economic analyses for cellulosic ethanol production. The authors concluded government policies including financial incentives, biofuel mandates, and assistance programs are essential for the industry to thrive in the long run.

The price of feedstocks constitutes a major cost to biofuel production. The price uncertainties associated with biofuel are closely associated with the price of feedstocks and are a serious concern to the countries like U.S. and Brazil with large shares of biofuel in the energy market. Uddin et al. (2021) examined the impact of various financial and economic uncertainty factors like economic policy uncertainty, geopolitical risk, financial stress, and market volatility on the prices of ethanol in the US and Brazil suggesting that biofuel markets are sensitive to these uncertainties. However, as the industry matures, logistical and socio-economic challenges

tend to be important. A study to address the supply chain challenges in the biofuel industry was conducted by exploring the idea of Regional Biomass Processing Depots (RBPDs) (Eranki et al., 2011). The authors discussed RBPDs as the instrument that could bridge rural concerns like rural economics, food security, social issues, and environmental issues. Also, the concerns pertaining to biorefinery supply like homogenous feedstock, stable price of feedstocks, and low cost of transportation could be addressed. The addition of RBPDs in the industry would spread the capital costs of producing biofuels and thus reduce the risk to biorefinery and help achieve greater economic benefits.

2.1.4 Environmental and Social Concerns

There has been a growing environmental and social concern resulting from growth of biofuel industry. A study conducted by Martinelli & Filoso (2008) discussed the environmental and social issues associated with the expansion of sugarcane cultivation in Brazil for biofuel production. The authors question whether sugarcane ethanol can be considered a clean fuel, given environmental and social concerns. Environmental issues like soil degradation, deterioration of aquatic systems, nitrogen pollution, destruction of the riparian ecosystem, and environmental consequence of sugarcane burning were reported. Similarly, sugarcane burning and respiratory issues, and exploitation of cane cutters were reported as public health and social issues. The results are in line with the results reported by Mariacaa & Liorb (2010).

Similarly, biofuel production results in the tradeoff between the food and energy market. First-generation biofuel or conventional biofuel uses edible food crops like soybean, corn, rapeseed, etc. as the feedstock of biofuel production which could be used for food products. The data from 2016 reveals the U.S. as a major producer of ethanol contributing 58% of global ethanol and using up nearly 40% of corn (Uddin et al., 2021). Consumption of a very large

amount of food crops by the biofuel industry has the potential to drive the prices of food crops high. Thus, efforts have been made to encourage the production of advanced biofuel and gradually replace biofuel produced from food-based crops. In 2015, the European Union decided to put a cap on conventional biofuels at 7% of total biofuel production to minimize the number of food resources directed towards energy conversion. These decisions could be attributed somewhat to a negative perception of the public as biofuel production competes with the food industry (Stattman et al., 2018).

2.1.5 Biofuels Investment

The transition of biofuel firms from research and development to commercial production is highly contingent upon their ability to attract investors for the necessary financing to grow (Miller et al., 2013). First-generation biofuels on the other hand are found to be economically viable for very long time because of the support from the government in US. However, efforts have been made towards promotion of second-generation and third-generation biofuels to avoid the "food vs. fuel" debate in the global community. Investing in a biofuel firm poses a high risk from the investor's point of view because of several factors like high initial capital investment, continuous development of new technology, price uncertainty, and feedstock composition and availability. Although there are some policies to incentivize investment, the risk associated with starting a second-generation biofuel production plant is relatively high. Some existing regulatory and tax incentives for biofuel firms are Renewable Identification Number (RIN) pricing, cellulosic waiver credits, state and local level regulatory incentives (example: California's low carbon fuel standard enacted in 2007), and producer tax credit (Miller et al., 2013).

McCarty & Sesmero (2015) examined the importance of price risk and the irreversible nature of investment in a cellulosic biofuel plant. The analysis revealed uncertainty as a major

barrier to the entry of investors in the cellulosic biofuel industry. Petter & Tyner (2014) examined the impact of biofuel selling price and technical uncertainty on investment risk in a catalytic fast pyrolysis-derived biofuel production facility. The authors analyzed the effect of uncertainty associated with capital cost, hydrogen price, biofuel yield, feedstock cost, and biofuel selling price on the appeal of project investment to a private investor. Similarly, Miller et al. (2013) studied the investment risk in the second-generation biofuels industry. The research identified economic, rather than technical, barriers as the significant challenge for the commercial development of cellulosic biofuels. The authors concluded that the contemporary policy and market conditions are not promising enough to generate attractive returns, discouraging private investors to invest in the biofuel industry. The research suggested policy as an important element that could potentially reduce the risk of the second-generation biofuel industry. Revising the existing incentives to reduce risks for private investors could encourage private investment and speed up investment decisions.

2.1.6 PEST Analysis

Several studies in the past have employed Political, Economic, Social, and Technological (PEST) framework to assess the risks in several industries. Yakubiv et al. (2019) researched the strategic potential of bioenergy development in Ukraine using PEST analysis by surveying the existing agricultural enterprises, and potential producers of bioenergy. The authors reported that state incentives for bioenergy production could promote bioenergy development in Ukraine. In addition, the specification of the economic and legal framework for regulating producers of bioenergy would aid in renewable energy development. Igliński et al. (2016) also conducted a PEST analysis of the polish renewable energy sector and the results revealed that the renewable energy sector has potential for further growth in both the Łódzkie Voivodeship region and

Poland. Among the macroenvironmental factors, the economic factor was the most favorable, and technological factors were the least favorable. Similarly, Nunes et al. (2015) conducted a comprehensive PEST analysis of potential to replace fossil fuels, used traditionally, with biomass in the textile dyeing industry in Portugal. The study provided a framework for strategic management of macroenvironmental factors affecting the companies by reducing external dependence on fuels, creation and preservation of jobs, increasing competitiveness of the sector, use of local technology, and reduction of GHG. Zalengera et al. (2014) conducted a political, economic, social, technology, legal, and environmental (PESTLE) analysis - a modified form of the PEST framework that includes legal and environmental factors in addition to PEST factors- of the renewable energy sector in Malawi. The study outlined the contemporary energy situation in Malawi and data on renewable energy sources and technologies up to 2014 is presented. The authors concluded that holistic approaches are crucial for the progress of the renewable energy sector along with radical political and government decisions. Likewise, Kolios & Read (2013) discussed a broad analysis of renewable energy, particularly tidal energy, in the United Kingdom. The authors used PESTLE analysis to review the contemporary literature available in the relevant field. The findings revealed that many stakeholders were supportive of tidal energy, but at the same time are worried about relatively underdeveloped technology. These literatures discussed above support the use of PEST framework for assessing an industry – particularly, industries that are related to renewable energy or bioenergy- in the past and its usefulness in research.

A research in the past by Pries et al. (2016) explored the prevalence and significance of risks reported by publicly-traded biofuel companies for one year using the PEST framework. We also conducted risk analysis of sample biofuel companies. But this study is more comprehensive

and assesses risks faced by biofuel firms in three years (2018-2020). Risk assessment for multiple years will show the similarity of differences of the prevalence and significance of the risks. The findings could open multiple facets about the risks faced by biofuel industry and suggest changes that can be useful for coping with or mitigating those risks. In addition, the sample companies used in our study are different than the sample companies used by Pries et al. (2016).

2.2 Literature Review for Financial Analysis

It is crucial for firm stakeholders to understand the past, assess the current situation, and forecast the future of the firm financial performance. Financial analysis is a process of studying financial statements to assess and evaluate the performance and suitability of business, projects, or finance-related transactions and enable decision-makers to make sound decisions. There have been very few studies in the past related to the financial analysis of the biofuel or related industry (Barbosa et al., 2022; Hidayatno et al., 2012; Khanal et al., 2014; Rezec & Scholtens, 2017; Santis et al., 2016). In this section, we review studies relevant to our study about financial analysis of the biofuel industry and closely related industry like renewable energy. We attempt to conduct a financial analysis of publicly traded biofuel firms to contribute to the literature of biofuel finance.

2.2.1 Financial Analysis of Publicly Traded Biofuel Firms or Closely Related Firms

A study by Bacho & Murova (2017) examined the financial performance of 12 corn based ethanol companies in the US from 2009-2014. The authors used data from annual financial reports of the companies to calculate financial ratios related to profitability, asset turnover, leverage, liquidity and the operating margin. The authors compared the financial performance of

small (50 MGY[1]) and large (100 MGY) ethanol enterprises. The results revealed large ethanol enterprises are more profitable, have higher leverage, and higher operating margin compared to small ethanol enterprise. However, asset turnover and liquidity ratio were found to be comparable for small and large ethanol enterprises. The study also explored the factors affecting the profitability of the ethanol companies and found that year of operation, corn price, plant capacity, operating margin ratio, and leverage ratio were statistically significant factors that affect the profitability of the ethanol companies. Overall, the results of the study suggest that ethanol firms are gradually moving into the direction of positive returns of investment.

Biofuel firms have made efforts like mergers and acquisitions (M&As) to scale up and perform well in a highly competitive fuels market. Khanal et al. (2014) analyzed the impact of mergers and acquisitions (M&As) on the stock prices of publicly traded ethanol producing firms from 2010 to 2012 using an event analysis method in the US. M&As were attributed as an attempt by ethanol firms to capture the economies of scale and sustain in the adverse environment of the biofuel business. The results revealed that the market responded positively to the M&As. Biofuel firms can therefore improve their long run prospects by employing proper strategies and planning. A study by Rezec & Scholtens (2017) compared the performance of equity indices that try to capture renewable energy investments to the conventional benchmark indices. The authors used excess returns, standard deviations, and risk-adjusted Sharpe ratios to compare the performance. The results revealed that most of the renewable energy equity indices underperform their benchmarks and possessed significantly higher risk compared to the benchmarks. Thus, investing in equity indices of renewable energy was found to be unattractive from a financial perspective.

[1] Million gallons per year

Biofuels are promoted as a driver of sustainability because it reduces GHG emission and is a potential alternative to fossil fuels. A study by Santis et al. (2016) examined the financial performance, in terms of profitability, and liquidity ratios of the companies listed in the Corporate Sustainability Index (ISE) portfolio in comparison with the companies listed in the Sao Paulo Stock Exchange Index. The ISE index comprises companies committed to corporate sustainability and the Sao Paulo Stock Exchange index is representative of the Brazilian stock market. The profitability ratios used in the study were return on assets, return on equity, and return on investment. Similarly, the liquidity ratios used in the study were rapid liquidity, current liquidity, quick liquidity, and general liquidity. The data were subject to normality test using Kolmogorov-Smirnov test to assess the possibility of using parametric tests for statistical analysis. The data were not normally distributed suggesting the use of non-parametric tests, specifically the Kruskal-Wallis test, the median test, and Mann-Whitney U test. The results based on non-parametric analysis suggested that the groups of companies had a similar financial performance.

2.2.2 Agribusinesses and Biofuels

The biofuel industry is a relatively immature sector and thus has a higher probability of economic and business fluctuations and unstable financial returns. A financial analysis of the integrated palm based biodiesel industry in Indonesia was conducted using a detailed bottom-up financial model (Hidayatno et al., 2012). The author analyzed the potential of establishing an integrated biodiesel industry, starting from the palm plantation to crude palm oil factory and finally to the biodiesel factory. The study concluded three major aspects of the industry. First, the biodiesel industry is not a profitable and attractive industry without government support like subsidies and incentives in market prices. Second, land productivity for palm and extraction of

palm oil and conversion to biodiesel are two major drivers of the cost in the industry. Third, social and environmental issues are equally important and inseparable along with the financial feasibility of the industry. The authors also suggested that government policies should encourage the establishment of integrated biodiesel industries in economically underperforming areas like non-forest or peatlands (Hidayatno et al., 2012).

A study by Barbosa et al. (2022) examined the strategies and public policies related to the sugarcane ethanol sector in Brazil by employing SWOT analysis with surveys (Delphi) and Analytic Hierarchy Process (AHP) multicriterial assessment. The SWOT analysis was conducted by studying the companies reports. Also, the authors assessed the status and strategic profile of the top 30 companies involved in sugar and ethanol energy operating in Brazil. The results suggested that expansive strategies like promoting R&D and innovation are preferred. The financial performance of the firms suggested that the sugarcane ethanol sector, in recent times, has experienced low profitability and high indebtedness. The financial performance of the firms was assessed using the qualitative information and the details from the industry reports instead of the traditional methods. The gathered information was then validated with the industry experts. The return from investment was 50% lower than the weighted average cost of capital (WACC) and average production growth was 20% lower than in the last 20 years. These results in Brazil, a major biofuel producing country, raises a question whether biofuel firms are as profitable as other businesses?

The biofuel industry is heavily dependent on the agriculture industry because the feedstocks like sugarcane and maize are used as raw materials in first-generation biofuel production and comprise a large share in the feedstock industry. We believe that the biofuel industry is somewhat comparable to the agribusiness industry because the raw materials used for

biofuel production are similar to agribusinesses. Katchova & Enlow (2013) compared the financial performance of publicly traded agribusiness firms to all firms from 1961 to 2011. The authors used profitability, liquidity, efficiency, solvency, and market financial ratios, and major accounts of the balance sheet and income statement to evaluate the financial performance of the two group of firms. The median value of financial ratios was used while comparing performances because financial ratios typically have outliers that skew the mean values (Trejo-Pech & DeLong, 2022). Agribusinesses outperformed all firms in terms of financial ratios related to profitability, liquidity, and market ratios. A DuPont analysis to compare the return on equity revealed that the higher return on equity for agribusinesses than the overall US market was due to higher asset turnover ratios. This indicates the higher operating efficiency of agribusinesses.

There has been limited research in the past that has examined the financial performance of biofuel firms. This study examines the financial performance of a sample of publicly traded biofuel companies by analyzing the financial ratios.

CHAPTER III

ANALYTICAL FRAMEWORK

3.1 Analytical Framework for Risk Analysis

3.1.1 Qualitative Content Analysis (QCA)

Qualitative content analysis is a tool for systematically describing qualitative material. In general, QCA is useful for describing qualitative material that requires input/interpretation from the individual analyzing the material to get meaning out of it. QCA involves previously assumed steps, regardless of material and research question, to follow and generate meaning out of it. The steps are: deciding the research question; identification and selection of material; developing a coding frame that comprises broad categories which may or may not incorporate subcategories within them; setting up the material into units of coding, and revising; discussions of the items revised; evaluating the coding frame in terms of consistency and validity; coding all the material, followed by revising and transforming the data for analysis and discussion; interpreting and presenting the findings (Schreier, 2012).

3.1.2 Financial Reporting

The annual report of a publicly-traded company is the primary formal means of communication with shareholders, investors, creditors, regulatory agencies, employees, and the general public (Lewis & Young, 2019). Traditionally, the quantitative metrics derived from financial statements like return on assets and return on equity, among others, were used as the basis for decision-making by accountants and economists. However, there has been growing discussion about limited insights provided by financial statements (Lewis & Young, 2019). The discussion revolves around the inability of the decision-makers to infer nuances solely relying on financial statements. The textual (qualitative) information available in a financial report is thus

thought to be equally important as financial statements and they both form integral components of the information that can be used for valuation, monitoring, and stewardship (Lewis & Young, 2019).

3.1.3 Corporate Risk Disclosure

Risk disclosure has been an important segment in the annual report of corporates because investors have started viewing sources of risk and uncertainty as a major component to be taken into consideration before investing. Risk is defined in its broadest sense as "the possibility of loss, injury, or other adverse or unwelcome circumstance" as this is how companies assess the risk they face (Pries et al., 2016, p. 94). The Securities and Exchange Commission (SEC) proposed to require disclosure of the risks associated with publicly-traded firms by including a section, risk factors, in their annual reports for "disclose risk factors that are specific to company or its industry and make an offering speculative or one of high risk"(Securities and Exchange Commission, 2005, p. 11). Beginning in 2005, this proposal came into effect and delineated the importance of risk factor disclosures as highly informative and important for investors in decision-making (Securities and Exchange Commission, 2005). Therefore, publicly traded companies disclose element of risks in their annual reports.

3.1.4 Risks Faced by the Companies

Companies face risks that are internal (linked to the operations and management of the company) and external (risks posed by other factors outside of the company) (COSO, 2004). The internal risks, based upon the value chain model, are categorized into two parts: (i) primary activities (inbound logistics, operations, outbound logistics, marketing and sales, and service) and (ii) support activities (firm infrastructure, human resource management, technology development, and procurement) (Porter, 1985). The assessment of the external risks to the

company can be done by the PEST (Political, Economic, Social, and Technological) framework, categorizing risks according to political, economic, social, and technological categories. The usefulness of this framework is based upon the assumption that a particular organization and its capacity to produce value is dependent on certain external and indirect circumstances that characterize a particular industry (Buchanan & Gibb, 1998). PEST analysis is a tool for understanding the strategic risk that operates by identifying changes in the firm's competitive position because of the external macro-economic conditions[2] (Sammut-Bonnici & Galea, 2014). PEST analysis is useful to understand a company, product, industry, business sector, or region/country and understand various macroenvironmental factors to be considered when assessing the growth or decline of a particular industry or market. These macroeconomic conditions generate variables that are beyond the control of a firm but pose significant control over the business. PEST is one of the important tools to assess the business position and ascertain the direction for the business to thrive in the marketplace and achieve true growth potential (Igliński et al., 2016). All the factors outside the organization's control can only be assessed and either attempt to prevent or react to the situation (Ward, 2005). Table 1 shows the major risk categories, according to Pries et al. (2016), included in the PEST framework for our study. All tables and figures are located at the end of the document in an appendix. Several studies have used this approach in the past to understand the various factors affecting the business (Igliński et al., 2016; Kolios & Read, 2013; Nunes et al., 2015; Yakubiv et al., 2019; Zalengera et al., 2014). Therefore, the PEST framework was utilized to assess risks reported by the sample of publicly traded biofuel companies.

[2] Macro-economic conditions are those influential events that do not limit themselves to small scope but rather broadly affect a regional or national economy.

3.2 Analytical Framework for Financial Analysis

The financial performance of companies can be examined by either the absolute performance or the relative performance in terms of financial ratios (Katchova & Enlow, 2013). Absolute performance can be employed to compare the firms only if they have similar scales of operation. Financial ratios, on the other hand, allow us to scale for factors like size and allow us to compare the financial performance of firms within an industry and across industries (Katchova & Enlow, 2013).

The financial analysis of our sample of biofuel companies includes five different types of financial ratios: profitability, liquidity, efficiency, solvency, cash-flows, and market-related ratios. These ratios were chosen to analyze the financial performance because these are the common financial ratio categories used to evaluate financial performance (Goldmann & Zawadzki, 2022; Katchova & Enlow, 2013; Trejo-Pech et al., 2023).

Profitability ratios reflect the net result of firm operations and financing decisions. A company must be profitable and ensure that shareholders are receiving appropriate benefits for its survival. We measure profitability using five popular specific indicators. Return on assets (ROA) evaluates a firm's performance in terms of total assets. Return on equity (ROE) evaluates a firm's performance in terms of total equity. Return on Capital (ROC) relates financial performance to capital components -the sum of equity and debt. The net margin ratio explores net income to total revenues. EBITDA margin[3] is the sum of EBIT[4] and depreciation and amortization divided by total revenues. Likewise, liquidity ratios discuss the ability of the firm to

[3] EBITDA margin is the earnings generated by the company before interest, taxes, depreciation, and amortization divided by the revenue.

[4] EBIT is the earnings generated by the company before interest, taxes.

pay off its debts maturing within a year. We use the current ratio to measure liquidity which is calculated by dividing the current assets by the current liabilities. Current assets typically consist of cash, accounts receivable, and inventories. Current liabilities include accounts payable, accrued expenses, and short-term loans. The current ratio above 1 indicates the ability of the firm to cover short-term liabilities.

Efficiency ratios measure how effectively the firm is managing its resources. We use asset turnover and inventory turnover ratios in our study. Asset turnover is total revenues to total assets. Inventory turnover is the total cost of goods sold to the average inventory. Solvency ratios examine the firm’s ability to meet its long-term debt obligations.

Market ratios examine the market performance of a company. We use the P/E ratio that examines the company’s market price per share to diluted earnings per share. Earnings per share (EPS) estimates the profits made by a company for each share of its stock. Stock returns estimate the profit or loss made by an investor on their investment in a particular stock over a period. The Altman Z-score helps to evaluate the company's financial health and potential risk of bankruptcy. Companies with score 3.0 and higher are considered financially healthy and low risk of bankruptcy. Cash flows ratio measures a company’s ability to generate and manage cash.

CHAPTER IV

MATERIALS AND METHODS

4.1 Sample Selection

An organized search was performed to identify publicly traded biofuel companies regardless of the country of origin. We utilized the North American Industry Classification System (NAICS), google scholar and journal articles, and Standard and Poor's as sources to identify those companies.

4.1.1 Using North American Industry Classification System (NAICS) and Industry Identification

The NAICS is a standard system for classifying business establishments into multiple groups based on the similarities of the production processes employed in the industry. NAICS is a joint effort of Statistics Canada, Mexico's Instituto Nacional de Estadística y Geografía (INEGI), and the US Economic Classification Policy Committee (ECPC) under the Office of Management and Budget (OMB). This system of classification came into practice to enhance uniformity and comparability for business statistics among North American countries. The 2017 NAICS has 20 sectors and 1,057 industries (NAICS, 2017).

NAICS codes[5] 324110 (Industry Name: Petroleum Refineries), 324199 (Industry Name: All Other Petroleum and Coal Products Manufacturing), 325193 (Industry Name: Ethyl Alcohol Manufacturing), and 325199 (Industry Name: All Other Basic Organic Chemical Manufacturing) were identified as the potential industries under which biofuel related companies could be grouped. We used Standard & Poor's COMPUSTAT, a database containing financial

[5] NAICS code is a six-digit code to categorize comparable industries.

information of publicly traded firms, to identify firms classified under these four NAICS codes. A total of 106 companies with these NAICS codes were available in the COMPUSTAT database. Since the four NAICS codes mentioned above contain firms from different industries (not only biofuel firms) we needed to identify biofuel firms among these 106 firms.

To identify what companies out of these 106 firms are biofuel firms (e.g., firms supplying feedstock, or involved in the production, logistics and storage, and distribution of biofuels), additional screening was performed. We used the companies' tearsheets[6] of the 106 firms and identified, according to the companies' description of business activities, the potential biofuel firms to include in our sample (we call this a preliminary list of biofuel firms).

We proceeded to download (from Capital IQ) and examine the most recent annual (10-K) and quarterly reports (10-Q) of firms in the preliminary list, and confirmed (e.g., further reduce the preliminary list) what companies were involved in biofuel production or the value chain of biofuel business (i.e., referred to as biofuel firms in this study).[7] In most cases, the "Item 1-Business" section of the annual reports disclosed the involvement of the firm in biofuel-related activities. A total of 19 companies were identified as biofuel companies after screening their most recent reports to investors. Table 2 provides the list of biofuel companies after the screening process. In addition, we conducted a systematic search of journal articles related to biofuel industries in google scholar to identify more companies in similar businesses besides the 19 already identified.

[6] A company tearsheet is a general summary of the business description of a company in Standard and Poor's Capital IQ. It was accessed through the University of Tennessee-Knoxville, library services.

[7] The annual (10-K) and quarterly reports (10-Q) were obtained from the S&P Capital IQ database (UT Library) under News, Events, and Filing section.

4.1.2 Google Scholar Search and Journal Articles

A systematic search in the google search engine, and specifically in google scholar, was done using the keywords “biofuel companies” and “biofuel industry” to identify companies involved in the biofuel business. To confirm whether the identified company is involved in the biofuel business, we repeated the same two steps screening process using S&P Capital IQ as we did for the companies obtained from NAICS. We identified seven additional companies after screening. Table 3 provides the list of additional companies identified from google searches and journal articles.

4.1.3 Standard and Poor's Quick Comparables

After obtaining the names of companies involved in biofuel business from NAICS, google search, and journal articles, “quick comparables,” an instrument of S&P Capital IQ, was used to identify other companies involved in a similar business, or peers. After identifying the companies, we followed the same two steps used for companies obtained from NAICS to screen them and confirm their involvement in the biofuel business. Table 4 provides the list of biofuel companies identified from the S&P Capital IQ quick comparable instrument, that are not listed in Tables 2 and 3.

Finally, the sample of firms for this study was prepared by compiling the companies from the above three sections. A total of 35 firms were selected by screening and removal based on the most recent annual reports (10K, 20-F for foreign companies) and quarterly reports (10Q). Table 5 provides a final sample of biofuel companies. All firms in Table 5 are biofuel firms with available financial statements and stock price data in Capital IQ. The last column of Table 5 provides a category for these firms based on the primary activity performed by the companies in the biofuel business. The categorization of the primary activity was done by carefully assessing

the business segment section of annual reports of the companies. The business segment of annual reports provides a brief overview of the company's main activities.

After retrieving the final list of sample companies, an attempt was made to explore the types of biofuels produced and categorize them based on the raw materials used for production (Generations of biofuels). The segments describing raw materials, products, and revenues in the annual reports were inspected for all the sample companies to collect information that can be used to categorize the sample companies based on the type of biofuel produced. The raw material section could not provide explicit information to categorize the companies. Although some companies were explicit about the products and had clear mentions such as "ethanol sales", and "biomass-based diesel sales", etc., in the revenues section, the remaining companies in the sample used generic terms like "biofuel sales", "fuel ingredients", etc. making it impossible to categorize the companies based on the type of biofuel produced.

4.2 Risk Analysis

4.2.1 Identification and Coding of Risks

The method used by Pries et al. (2016) was adopted in identifying and coding risk factors. However, this study is a more comprehensive risk assessment of publicly traded biofuel companies. Unlike the study by Pries et al. (2016) which assesses the risks for just one year – 2013 fiscal year, this study assesses the risks faced by publicly traded biofuel companies for three years from 2018 to 2020. Risks assessment for just one year may present risks observed in that particular year. Risk assessment for three years, on the other hand, may have some risks rectified and some novel risks observed.

In addition, our study comprises of 22[8] companies for the analysis which is different than those used by Pries et al. (2016) which used 26 companies operating in US and Canada. Furthermore, our study assesses the risks from the years 2018 to 2021, which provides us with current or recent risks faced by the biofuel companies. We used three criteria for selecting companies that will be used for risk assessment of the biofuel industry:

i. The company should be involved in the biofuel business for at least four years, from 2018-2021.
ii. The companies should have reported risk factors in their annual reports as required by the Securities and Exchange Commission (SEC).
iii. The companies should have their financial statements available in the Standard and Poor's database used in this study for financial analysis.

A total of 22 biofuel companies from Table 5 were selected for the risk assessment because only these 22 companies fulfilled our criteria. The risk segment in the annual report of the companies was used as the basis for obtaining specific data for risk analysis. The data for the risk analysis consisted of qualitative information about individual firm risk factors, as reported by the companies to the SEC. After collecting the data for risk analysis from the annual reports, the elements of risks reported were coded in a two steps hierarchy using a concept-driven approach. First, the broad risk categories were identified (Political, Economic, Social, Technological, Primary Activities, and Support Activities). Secondly, specific risks were

[8] Adecoagro S.A., Aemetis Inc., Alto Ingredients Inc., Archer-Daniels-Midland Company, Bunge Limited, Cardinal Ethanol LLC, Clean Energy Fuels Corp., Darling Ingredients Inc., Delek US Holdings Inc., Ecopetrol S.A., FutureFuel Corp., Gevo Inc., Granite Falls Energy LLC, Green Plains Inc., Green Plains Partners LP, Petróleo Brasileiro S.A. – Petrobras, Red Trail Energy LLC, Renewable Energy Group Inc., REX American Resources Corporation, Royal Dutch Shell plc, The Andersons Inc., Valero Energy Corporation.

identified for each broad category and coded by analyzing the descriptions for the risks in the annual report. In the process of qualitative risk assessment, coding changes were considered by creating a new specific risk category in the cases where novel specific risks that were out of the scope of previously set specific risk categories were identified. Table 6 shows an example of broad risk categories and specific risk factors reported by the biofuel companies in the risk factors section of annual reports.

4.2.2 Measures of Importance

The study employed two measures, prevalence and significance, to evaluate the seriousness of a particular risk to the sample biofuel companies, according to Pries et al. (2016). Prevalence measured how common is a particular risk in the sample of companies and was determined by the frequency of companies reporting a particular risk factor. For example, a prevalence score of 20 for biofuel regulation means 20 biofuel companies among the total of 22 sample companies reported biofuel regulation as a risk in their annual report.

Significance scores measured the severity of the particular risk in the industry. Significance was calculated by assigning significance scores to risks based on the order of reporting of risks in the annual reports For example, if four risks are reported in the annual report of a company, the first risk reported in the risk factors section of the annual report was assigned a score of 4, the second risk was assigned 3, the third risk was assigned 2, and the fourth risk was assigned 1. Also, the significance scores are assigned independently for each company and for each year. Significance score were assigned in such a way because companies are encouraged by securities regulator to report the individual risks in risk factors segment of annual reports in the order of priority or seriousness for the company (Pries et al., 2016; SEC, 2015). The risk that is most important to the company is reported first and the risk that is least important to the

company is reported last. Then, the significance scores were normalized by dividing the assigned scores by summed assigned scores for all the risks reported. Table 7 briefly presents an example of the process used for assigning and normalizing significance scores for the risks reported by a company.

The results of the risk analysis are presented graphically using a quadrant matrix with the prevalence of risk on the horizontal axis and the significance of the risk on the vertical axis. The lines passing across horizontal and vertical spaces in the figures are the average prevalence scores and average significance scores across all risks. The risks that are more important to the sample companies appear in the top-right corner of the figures and less important risks appear in the lower-left corner of the figures. The risks that appear in the lower right corner are prevalent but not significant, and the risks that appear in top left corner are significant but not prevalent.

4.3 Financial Analysis

4.3.1 Financial data

The financial data of the sample of biofuel companies were obtained from the Standard and Poor's database, accessed through the University of Tennessee at Knoxville, library services. The data comprised the items needed from the income statement, balance sheet, and statement of cash flows to compute the financial ratios for the analysis. Last twelve-month data (LTM) for each quarter were downloaded from Standard and Poor's database, starting from the first quarter of 2018 to the last quarter of 2021. This period was selected for the study because of two reasons. First, the financial data was available for only this period in the Standard and Poor's database. Second, we analyzed the annual reports of the sample companies during this period confirming their involvement in the biofuel business. The stock prices for most companies in the sample were obtained from COMPUSTAT/Capital IQ. The stock prices of the companies that

were not available in COMPUSTAT/Capital IQ were retrieved using google sheet and google finance[9]. The closing stock prices at the end of each quarter were used in the study. The formula used by Muhammad & Ali (2018) was employed for calculating stock returns.

The data was treated to remove observations for financial variables with zero or negative assets, equity, invested capital, or revenue from the database (Adams et al., 2019; Trejo-Pech et al., 2023). In addition, the data was winsorized at the 1% and 99% percentile to avoid the potential effect of outliers. Previous studies have suggested winsorizing as a common method used by majority of financial research to treat outliers (Adams et al., 2019; Trejo-Pech et al., 2023).

4.3.2 Classification of sample companies

A total of 22 sample companies were selected for risk assessment and financial analysis from the final sample of 35 biofuel companies. The sample companies were further classified into two categories: primary biofuels, and secondary biofuels. The information from the annual report of 2017 was used to classify the companies. The companies were classified as primary biofuels companies if their revenue from biofuels or closely related products exceeded 50% of the total revenue. In addition, in cases where quantitative data for biofuel sales were not available in the annual report, the companies were qualitatively classified after reading the annual reports. The author employed a conservative approach during this qualitative classification by classifying companies in "secondary biofuels" category if the annual report

[9] Google finance and google sheet were used as a tool to retrieve the stock prices of the biofuel companies – Ecopetrol, Shell plc, and Verbio. The function used to retrieve the stock price was (=GOOGLEFINANCE(Ticker, "close", "date") in a google spreadsheet.

lacked sufficient evidence[10] to justify the companies as primary biofuel firms. Out of 22 sample biofuel companies (ALL), 10 were classified as primary biofuels (PB), and 12 were classified as secondary biofuels (SB). The companies classified under the secondary biofuels category were consisted of companies involved in food and agribusinesses (Adecoagro SA, Archer-Daniels-Midland Company, Bunge Limited, Darling Ingredients Inc., The Andersons), crude oil business (Royal Dutch Shell plc, Petróleo Brasileiro S.A. – Petrobras, Valero Energy Corporation, Delek US holdings, Ecopetrol SA), renewable natural gas (Clean Energy Fuels corp.), and biofuel logistics (Green Plains Partners LP). The food and agribusiness dominant companies were probably looking to integrate biofuels and diversify their products. Similarly, the crude oil dominant companies were probably involved in the biofuel business to reduce their dependency on other biofuel companies and be self-dependent to meet the biofuel blending obligation as required by EPA in US and European Union (EU) in Europe. The sample companies were classified into two groups because we could not find any standard benchmark to compare their financial performance. Also, our classification is done in such a way that we can compare the financial performance of companies that are dominant in biofuel production (Primary Biofuels) and companies that have small share of biofuel business (Others). Table 8 lists the names of firms in the primary biofuel category. Table 9 lists the names of firms in the secondary biofuel category.

[10] The business section of the annual report describes the major products and services of the company. The qualitative assessment involved analyzing this section carefully and classifying the company as primarily biofuel, or others.

4.3.3 Financial performance analysis

The financial ratios and formulas to calculate the financial ratios used in our analysis are reported in Table 10. The formulas used to calculate the financial ratios are based on the guidelines of the Standard and Poor's database accessed through the University of Tennessee at Knoxville, library services. We conduct the following analyses to evaluate the financial performance of the sample of biofuel companies as done by Trejo-Pech et al. (2023): 1. Compare the financial ratios; 2. Conduct trend analysis of selected financial ratios; 3. Conduct trend analysis of cash flows; and 4. Analyze the stock returns of PB, SB, and ALL portfolio.

We use financial ratios to compare the financial performance of firms in the primary biofuel category to the firms in secondary biofuel category. The firms in the secondary biofuels category are used as the benchmark to compare the financial performance of primary biofuel firms. Histograms are used to visualize the probability distribution of financial data**.** Kolmogorov-Smirnov (KS) tests are used to statistically compare and confirm whether the data is normally distributed (Massey Jr, 1951). The null hypothesis (H_0) is that the data follows a normal distribution. Non-parametric tests are commonly used as a statistical technique for skewed or non-normal data to compare the two categories of companies. We use median test to test for difference in the financial ratios across the two categories, PB and SB (McKnight & Najab, 2010). The median test is used to test whether two groups differ in their median values. The null hypothesis for median test states that the groups being compared are sampled from populations with identical medians. On the other hand, the alternative hypothesis can take two forms: a two-tailed test where the medians of the two groups are different, or a one-tailed test where one group's median is greater than the other. The median test partitions two groups based on their observations relative to the median value of the combined dataset. Specifically,

observations that match the median of the combined dataset are removed, and the remaining data is divided into two groups: one containing values above the median and the other containing values below the median. To evaluate whether the observed frequencies in each group differ from what would be expected under a distribution that combines the two groups, the median test uses a Pearson's chi-squared test. This test calculates the chi-squared statistic, which is then compared to a chi-squared distribution to determine the p-value and the statistical significance of the results.

This research examines the financial ratios trend of companies in the biofuel industry from 2018 to 2021. The analysis focuses on three categories, namely PB, SB, and ALL, with ALL serving as the benchmark for comparing the financial performance of PB and SB firms. The study aims to provide an overview of how financial ratios change over time in the biofuel industry.

Moreover, the study investigates the stock returns of the three portfolios of companies over the same period. The stock returns for each year from 2018 to 2021 are assessed to determine whether there are significant variations in the performance of these portfolios over time. To benchmark the performance of the biofuel portfolios, the S&P 500, a commonly used benchmark in financial market research, is used to evaluate the stock returns of the three portfolios against the stock returns of the S&P 500. Furthermore, the study examines the stock returns of biofuel companies from the time of their Initial Public Offering (IPO[11]) to 2021 to ascertain whether these companies have experienced positive or negative stock returns over time.

[11] Name and the year of IPO offering of the sample companies are in the parentheses. Adecoagro S.A. (2011), Aemetis Inc. (2006), Alto Ingredients Inc. (2005), Archer-Daniels-Midland Company (1980), Bunge Limited (2002), Cardinal Ethanol LLC (2014), Clean Energy Fuels Corp. (2007), Darling Ingredients Inc. (1994), Delek US Holdings Inc. (2006), Ecopetrol S.A.

CHAPTER V

RESULTS

5.1 Risk Analysis

The mean, maximum, and minimum of prevalence and significance measures of risks are presented in Table 11. Table 12 shows the prevalence and significance score of all specific risks used in the study. The mean prevalence and significance scores for each year in Table 11 are used to categorize whether a risk component represents a significant risk. Any risk with prevalence scores higher than the mean is referred to as a prevalent risk and any risk with significance score higher than mean is referred to as significant risk.

5.1.1 Political Risks

Figures 1 displays the prevalence and significance of risk factors under the political risks category reported by the ALL portfolio of sample biofuel companies from 2018 to 2021. The average prevalence scores for 2018, 2019, 2020, and 2021 are 13.92, 13.80, 14.00, and 13.40 respectively. The average significance scores for 2018, 2019, 2020, and 2021 are 0.056830, 0.056138, 0.056554, and 0.056368 respectively. In the political risk category, biofuel regulation (BFR) is the most significant risk in all three years. It is also the most prevalent risk for the sample companies in 2020 and 2021. However, Biofuel Regulation (BFR) is not the most prevalent in 2018 and 2019. Biofuel Regulation (BFR) includes risks like biofuel blend requirement, tax benefits, subsidies, incentives for biofuel production, etc., (Pries et al., 2016).

(2008), FutureFuel Corp. (2011), Gevo Inc. (2011), Granite Falls Energy LLC (2014), Green Plains Inc (2006), Green Plains Partners LP (2015), Petroleo Brasileiro S.A. – Petrobras (2000), Red Trail Energy LLC (2012), Renewable Energy Group Inc (2012), REX American Resources Corporation (1984), Royal Dutch Shell plc (1984), The Andersons Inc (1996), and Valero Energy Corporation (1982).

General Regulation (GNR) is the most prevalent risk in 2018 and 2019. General regulation (GNR), and Environmental, Health, and Safety (EHS) risks are prevalent in the biofuel industry but are of less significance than Biofuel Regulation (BFR). General Regulation (GNR) includes risks like laws, regulations, and mandates in general, which could adversely affect the operation of the company. Similarly, Environmental, Health, and Safety risk (EHS) includes risks related to the policies discussing GHGs emission, global warming, and laws and regulations governing the safety of the workers. International (INT) risk is neither significant nor prevalent in all three years. International (INT) is comprised of risks related to operating in a specific country or region. Similarly, Infrastructure (INF) is also neither significant nor prevalent risk in the political risk category in 2018 and 2019. Infrastructure includes risks associated with the infrastructure needed for transportation and logistics of biofuels.

5.1.2 Economic Risks

Figures 2 displays the prevalence and significance of risk factors under the economic risks category reported by the ALL portfolio of sample biofuel companies for 2021, 2020, 2019, and 2018. General Economic Condition (GEC) is found to be a prevalent and significant risk under the economic risk category for all four years of study. General Economic Condition (GEC) include risks like economic downturns, regional economic volatilities, seasonal fluctuations, etc. Markets-feedstock (MRF) is found to be a prevalent and significant risk in 2018 and 2019. Markets-feedstock (MRF) includes risks related to production, availability, supply, and pricing of feedstocks. Markets-biofuels (MRB) risk is not a prevalent risk but the most significant risk under the economic risk category in all four years. Markets-biofuels (MRB) include risks like demand, supply, and pricing of biofuels. Competition (COM) risk is related to competition with other related companies in production, marketing, and supply chain. Competition (COM) is

reported to be prevalent but not significant risk for sample biofuel companies in all four years. Markets-competing fuels (MRC) was not significant in all four years but a prevalent risk in 2019. Markets-competing fuels (MRC) include risks like demand, supply, and price of fossil fuels or other renewable energy that is a competition for biofuels. Stock (STR) risk is neither prevalent nor a significant risk across the sample of biofuel companies except 2019. Stock (STR) risk includes risks related to the stock market and shares available to the public. Markets-energy (MRE) risk is the least prevalent and not a significant risk to the sample of biofuel companies. It includes risks related to the price of energy like electricity or fossil fuels, used by the biofuel industry to run their operating facilities.

5.1.3 Social Risks

Figures 3 displays the prevalence and significance of risk factors under social risks category reported by the ALL portfolio of sample biofuel companies from 2018 to 2021. Both social risks, Public Perception (PUP) and Public Opposition (PUO), are neither prevalent nor significant in the sample biofuel. Public Perception (PUP) includes risks like consumer perception towards biofuels and reluctance to use biofuels. Public Opposition (PUO) includes risks like social movements by certain groups or the public and debates about “food vs fuel”.

5.1.4 Technological Risk

Figures 4 displays the prevalence and significance of risk factors under technological risks category reported by the ALL portfolio of sample biofuel companies for 2021, 2020, 2019, and 2018. Cybersecurity (CYS) is the only prevalent risk in the technological risk category in all four years. Cybersecurity (CYS) is the most important risk in this category and includes risks like security breaches, interruption of information systems, loss of company information, data theft, etc. Conversion Technology (CNT), Fuel Compatibility (FLC) and Intellectual Property

(INP) are in the lower left quadrant so technological risks in common are not prevalent and not significant. Conversion Technology (CNT) includes risks associated with rapid changes in the conversion technology -feedstock to fuel- adopted by the biofuel facilities. Fuel Compatibility (FLC) was not reported at all in 2019 by any sample companies. Fuel Compatibility (FLC) includes risks associated with blending and the feasibility of using biofuels as drop-in fuels. Intellectual Property (INP) includes risks like inability to protect intellectual property rights or patents associated with biofuel production technology.

The PEST analysis of risks in the biofuel industry reported political risks and economic risks as important risks to the sample companies. Political risks like Biofuel Regulation (BFR) and General Regulation (GNR), and economic risks like General Economic Conditions (GEC) and Markets-feedstock (MRF) are pronounced risks during the study period.

5.1.5 Primary Activities

Figures 5 displays the prevalence and significance of risk factors under primary activities risks category reported by the ALL portfolio of sample biofuel companies for 2021, 2020, 2019, and 2018. Profitable Operations (PRO) are the most important specific risks related to primary activities because they are highly prevalent and significant in the primary activities category. It includes risks related to the operational activities of companies to attain or maintain a profitable situation. Facilities Development (FTD) is neither prevalent nor significant risk in this category in 2018 and 2019. However, it is a significant risk in 2021 and 2020. Facilities Development (FTD) includes risks related to construction and setting up the biofuel facilities.

5.1.6 Support Activities

Figures 6 displays the prevalence and significance of risk factors under support activities risks category reported by the ALL portfolio of sample biofuel companies for 2021, 2020, 2019, and 2018. Risk management (RKM), Contracting (CON), and Financing (FIN) are present in the upper right quadrant in all four years, suggesting that these risks are prevalent and significant for the sample biofuel companies. Risk Management (RKM) includes risks like foreign currency exchange, natural disasters, pandemics, etc. Risk Management (RKM) is observed to be the most important risk among all the risk categories in all years because it is at the farthest top right corner location in the risk importance quadrant graph. Contracting (CON) includes risks associated with long-term contracts or agreements with partners and subsidiaries. Financing (FIN) related risks are challenges associated with obtaining funds to run the facilities and risks caused by contemporary financial arrangements. General Management (GNM) risks related to key personnel or employees, and general managerial issues are prevalent but not significant. Mergers and Acquisitions (MNA) risk is related to the past or future of the company because of mergers, acquisitions, divestitures, or joint ventures. This risk is neither prevalent nor significant.

As a summary, Table 13 displays the major risks that are prevalent and significant for all companies in the sample between 2018 and 2021. This enables us to identify whether any risks consistently remained significant over the years and whether some risks are more prevalent and significant in certain years than others. Political risk included Biofuel Regulation (BFR), which is a prevalent and significant risk throughout all years, while General Regulation (GNR) is only prevalent and significant in 2018 and 2019. Similarly, General Economic Condition (GEC) is a prevalent and significant risk throughout all years, whereas Markets-feedstock (MRF) is only prevalent and significant in 2018 and 2019. Social and technological risks did not have any

prevalent and significant risk factors. Likewise, primary activities and support activities risks reported the same prevalent and significant risks across all years.

5.2 Risk Analysis of Two Portfolios

A comparison is conducted by further categorizing the 22 sample biofuel companies into primary biofuels (PB) and secondary biofuels (SB) and performing the risk analysis. The basis used to classify the sample biofuel companies is the percentage of revenues from biofuels which is discussed in detail in the data and methods section. The sample companies are categorized into 10 PB companies and 12 SB companies. The mean prevalence scores for PB companies are 6.96, 6.96, 7.04, and 6.40 in 2018, 2019, 2020, and 2021 respectively. The mean significance scores for PB companies are 0.050991, 0.052777, 0.052836 and 0.053076 in 2018, 2019, 2020, and 2021 respectively. For SB companies, the mean prevalence scores are 6.96, 6.84, 6.96, and 7.04 in 2018, 2019, 2020, and 2021 respectively. The mean significance scores are 0.061460, 0.060723, 0.059935, and 0.059237 in 2018, 2019, 2020, and 2021 respectively.

5.2.1 Political Risks

Figure 7 shows the comparison for political risks. Biofuel Regulation (BFR) is still found to be prevalent and significant for PB companies. For SB companies, on the other hand, Biofuel Regulation (BFR) is not prevalent and significant. General Regulation (GNR), an important risk reported from previous analysis, is not prevalent and significant in PB companies. The term “previous analysis” is used to refer to the risk analysis comprising all 22 sample companies. General Regulation (GNR) is found to be prevalent and significant for SB firms. For PB companies, Infrastructure (INF) risk is neither prevalent nor significant consistent with previous analysis, but SB companies reported Infrastructure (INF) risk to be prevalent and significant.

5.2.2 Economic Risks

Figure 8 shows the comparison for economic risks. Markets-feedstock (MRF) and General Economic Conditions (GEC) are found to be prevalent and significant from previous analysis. Markets-feedstock (MRF) is found to be prevalent and significant for PB companies only. General Economic Condition (GEC) is prevalent and significant for SB but not for PB companies. In addition, Markets-biofuels (MRB), a specific risk found to be significant but not prevalent in previous analysis, is found to be both prevalent and significant for PB companies. But Markets-biofuels (MRB) risk is neither prevalent nor significant for SB companies. Stock-risk (STR), a specific risk found to be prevalent but not significant in previous analysis, is consistently prevalent for SB companies but not prevalent for PB companies. But it is found to be prevalent and significant in 2021 for PB companies. Markets-competing fuel (MRC) is prevalent for PB companies in 2018 and 2019 but not prevalent for SB companies in all four years. Market energy (MRE) and Competition (COM) are found to be consistent with the results of previous analysis for both portfolios.

5.2.3 Social Risks

Figure 9 shows the comparison for social risks. Social risks are found to have consistent results with previous analysis. Both Public Perception (PUP) and Public Opposition (PUO) are neither prevalent nor significant for both portfolio of companies.

5.2.4 Technological risks

Figure 10 shows the comparison for technological risks. Cybersecurity (CYS) is found to be consistent with previous analysis and is prevalent but not significant for both portfolios. Conversion Technologies (CNT), Intellectual Property (INP), and Fuel Compatibility (FLC) are neither prevalent nor significant in previous analysis. Intellectual Property (INP) is found to be

consistent with the results of previous analysis for both portfolios of companies. But Conversion Technologies (CNT) is observed to be a prevalent risk for PB companies. Although Fuel Compatibility (FLC) is found to be consistent with the results of previous analysis for PB portfolio, it is not reported at all by OT companies.

5.2.5 Primary activities risk

Figure 11 shows the comparison for primary activities risk. Profitable Operations (PRO) risk is found to be prevalent and significant risk in previous analysis. The results from the comparison test also reveal that Profitable Operations (PRO) is prevalent and a significant risk for both portfolios of companies. Facilities Development (FTD) is found to be significant but not prevalent in the years 2021 and 2020, and neither prevalent nor significant in 2018 and 2019 in previous analysis. The comparison test result revealed that Facilities Development (FTD) for PB portfolio is consistent with the previous analysis. For SB companies, Facilities Development (FTD) is neither prevalent nor significant in all years.

5.2.6 Support activities risk

Figure 12 shows the comparison for support activities risk. Risk Management (RKM), Contracting (CON), and Financing (FIN) are found to be prevalent and significant risks in previous analysis. The comparison test with both portfolios of companies revealed consistent findings with previous analysis. The comparison test for General Management (GNM) revealed consistent results with previous analysis and was found to be prevalent but not significant. Mergers and Acquisitions (MNA) are neither prevalent nor significant in previous analysis. The comparison test revealed Mergers and Acquisitions (MNA) to be prevalent for SB companies but not for PB companies.

Table 14 shows the prevalent and significant risks for primary biofuel companies. Table 15 shows the prevalent and significant risks for secondary biofuel companies. In summary, the risk assessment of biofuel companies has provided valuable insights by categorizing them into primary biofuel (PB) and secondary biofuel (SB) companies. This categorization has revealed differences in the prevalence and significance of risks between the two categories. Specifically, PB companies are more susceptible to risks directly related to biofuel, such as Biofuel Regulation (BFR), Market-biofuels (MRB), and Conversion Technologies (CNT). In contrast, SB companies are more vulnerable to general risks, such as General Regulation (GNR), General Economic Conditions (GEC), and Cybersecurity (CYS). These findings suggest that companies with a higher percentage of biofuel revenues (PB companies) are more severely affected by risks directly related to biofuels than those with lower percentages of biofuel revenues. Overall, this study provides a strong basis for understanding the risk factors that affect biofuel companies and the differences between primary and secondary biofuel companies.

5.3 Financial Analysis

The histograms revealed that the data are not normally distributed and are rather skewed. Figure 13 shows the histograms of selected financial ratios. The distribution of financial ratios is skewed rather than normal even though we treated the data to remove outliers. The KS test confirms that the data does not follow a normal distribution pattern. Thus, we use median values of financial ratios to compare across the firm categories instead of other measures of central tendency because financial ratios generally contain outliers that skew the mean values for the financial ratios (Katchova & Enlow, 2013; Trejo-Pech et al., 2023). The mode value, on the other hand, is not commonly used to compare financial ratios.

5.3.1 Median values of the financial ratios

Table 16 shows the median values of the financial ratios of PB companies, SB companies, and ALL companies from 2018 to 2021. In terms of profitability, PB companies outperformed SB companies except for the EBITDA margin. The median ROA was 6.0 percent for PB companies, and 4.0 percent for both SB and ALL companies. The median ROE was 12.0 percent for PB companies and 11.0 percent for both SB and ALL companies. The median ROI was 29.5 percent for PB companies, 27.0 percent for SB companies, and 28.0 percent for ALL companies. The median net income margin was 7.5 percent for PB companies, 4.0 percent for SB companies, and 5.0 percent for ALL companies. The median EBITDA margin was 10.5 percent for PB companies, 12.0 percent for SB and ALL companies.

PB companies outperform SB companies in terms of liquidity and efficiency ratio. The median current ratio is 3.220 for PB companies, 1.460 for SB companies, and 1.580 for ALL companies, suggesting that PB companies are in better position to pay off their short-term obligations than SB companies. The median asset turnover is 1.355 for PB companies, 0.850 for SB companies, and 1.040 for ALL companies. Similarly, the median inventory turnover is 8.850 for PB companies, 6.960 for SB companies, 7.185 for ALL companies. SB companies outperform PB companies in terms of solvency. The median total debt to equity ratio is 0.080 for PB companies, 0.730 for SB companies, and 0.520 for ALL companies. The lower total debt to equity ratio for PB companies could be attributed to the relatively immature stage of the biofuel venture, making banks or similar institutions skeptical to provide loans to PB companies. The median assets to equity ratio are 1.230 for PB companies, 2.460 for SB companies, 2.130 for ALL companies.

SB companies outperform PB companies in terms of market ratios. The median value of price to earnings ratio is 12.039 for PB companies, 17.279 for SB companies, and 15.808 for ALL companies. This result suggests that PB companies have the potential to generate the same amount of earnings by lower investment in PB companies as compared to SB companies. However, the lower P/E ratio also means that PB companies could be riskier than SB companies. The median value for EPS is 2.457 for PB companies, 2.138 for SB companies, and 2.225 for ALL companies.

PB companies outperform SB companies in terms of CFO to CAPEX and SB companies outperform PB companies in terms of CAPEX to D&A. The median value of CFO to CAPEX is 1.620 for SB companies, and 5.215 for PB companies meaning PB companies can easily cover the CAPEX by cash generated from operations. CFO is nearly three times higher than CAPEX in terms of PB companies. The median value of CAPEX to D&A is 0.900 for SB companies, and 0.550 for PB companies. This result suggests SB companies invest more than PB companies in relative terms of property, plant, and equipment (PP&E) and D&A. However, the CAPEX to D&A ratio is less than 1.0, which suggests those companies fail to replace their PP&E as much as the depreciated value of the PP&E.

5.3.2 Median test

Table 17 shows the results of the Median test comparing two groups of companies from 2018 to 2021. The median test is a non-parametric statistical test utilized to examine if two or more groups of observations have similar medians. This test serves as an alternative to the one-way ANOVA test, which presumes normal distribution and equivalent variances across groups. The objective of the median test is to compare the medians of the groups and investigate whether they are statistically different. The null hypothesis posits that the medians are equivalent across

all groups, while the alternative hypothesis proposes that at least one group has a different median.

The results obtained from the median test demonstrated that the median ROA, net income margin, current ratio, asset turnover, inventory turnover, total debt to equity, assets to equity, Altman Z, CFO to CAPEX, and CAPEX to D&A exhibit statistically significant differences. Hence, the PB companies and SB companies show considerable variations in the median values. Overall, the use of the median test has enabled a comprehensive evaluation of the data, leading to valuable insights into the performance of PB and SB companies.

5.3.3 Correlation Analysis of Profitability and Risk Estimates

Table 18 and 19 show the correlation analysis of profitability and risk estimates for the biofuel companies used in the study from 2018 to 2021. This analysis examines the relationship between profitability ratios (ROA, ROE, and ROI) and risk estimates (total debt to equity, political risk, economic risk, technological risk, primary activities risk, support activities risk, and Altman Z). All the profitability estimates are strongly and positively correlated with each other and are statistically significant. The correlation analysis revealed that there is a significant negative correlation between economic risk and profitability estimates for biofuel companies. This may be because economic risk captures factors like biofuel, feedstock, and energy markets, as well as general economic conditions, which have a direct impact on the profitability of the biofuel companies. The profitability of the biofuel companies is highly dependent upon the biofuel prices, price of competing fuels, cost of feedstocks, and general economic conditions. It is therefore reasonable that economic risk has a negative relationship with the profitability estimates. Political risk was found to have statistically significant and negative relationship with economic, technological, primary activities, and support activities risks. Social risk is not

correlated with the profitability estimates. Social risk captures the risk associated with public perception and opposition about the use of biofuels. The risk analysis revealed that these risk factors were not of much importance to the biofuel companies. So, that could be a reason for the lack of correlation between social risk and profitability estimates. However, social risk is found to have statistically negative relationship with total debt to equity, technological risk, and primary activities risk.

To recap, economic risk captures the state of biofuel, feedstock, fuels market, and general economic conditions and probably affects the profitability of biofuel businesses. Other risk factors are not found to have any relationship with the profitability estimates. Although these risk factors may indirectly affect biofuel companies, there was no discernible correlation between them and profitability estimates, except for economic risk, which was found to have a negative relationship.

5.3.4 Trend Analysis of selected financial ratios

Figure 14 shows the trend analysis of selected financial ratios of companies in the PB, SB, and ALL portfolio using median values from 2018 to 2021. ALL portfolio comprises all the 22 companies used for financial analysis. The profitability ratios of PB companies are highly volatile. SB companies and ALL companies have a comparable profitability performance throughout the study period. PB companies and SB companies are comparable in terms of profitability from the beginning to 2020. We can observe a rising trend in the profitability of PB companies beginning the 2020 to mid-2020 and PB companies outperforming SB and ALL companies in this period. The increasing trend of PB companies ceases after mid-2020 and starts decreasing until early 2021. The current ratio is highly volatile for PB companies and stable for SB and ALL companies. Similarly, PB companies are highly volatile in terms of efficiency ratios

as well. SB and ALL portfolio on other hand have fairly stable inventory turnover ratio but volatile asset turnover ratio.

The solvency ratios are fairly stable for all three portfolios, and SB companies continuously outperform PB and ALL companies. PB portfolio has the least total debt to equity ratio among all three portfolios. SB companies have a relatively higher proportion of equity in their capital structure as compared to PB companies. PB companies seem to have a low proportion of debt and a higher proportion of equity in their capital structure. In terms of asset to equity ratio, the assets of SB companies are more than two times the equity, which explains the resourcefulness of those companies but their high risk at the same time. PB companies have nearly equal asset value as their equity, which explains the less risky approach of PB companies to purchase their assets. The price to earnings ratio is highly volatile for all three portfolios of companies, and SB companies are comparable to ALL companies. The median EPS for all three portfolios is fairly stable throughout the study period except companies in PB portfolio are higher than SB and ALL portfolios at the start of the study period. Altman Z, a measure of financial distress, is found to be highly volatile for PB portfolio but fairly stable for the other two portfolios. Similarly, cash flow ratios are highly volatile for PB companies throughout the study period and SB and ALL companies are found to be fairly stable and consistent.

5.3.5 Stock returns of companies

The annual weighted average stock returns for PB, SB, and ALL portfolios are compared with a benchmark, the S&P 500 market index. The firm's total revenue was used as weights to calculate the weighted average. Figure 15 shows the weighted average stock returns of PB, SB, and ALL portfolios from 2018 to 2021. The X axis represents the rate of return, and the Y axis has the bar graphs for each portfolio. The S&P 500 index is used as a benchmark to compare the

stock return of the biofuel portfolios because it represents the overall stock market. The stock returns of all three portfolios are negative from 2018 to 2019. PB companies have higher negative returns compared to benchmark and other portfolios as well. The stock return of the PB portfolio is negative in the time period from 2019 to 2020 as well. On the other hand, the SB, ALL, and S&P 500 portfolios have positive stock returns in the same period. The stock returns from 2020 to 2021 are surprising because the PB portfolio has positive, and the highest stock returns compared to the other portfolios. From 2021 to 2022, all the portfolios have positive stock returns. The S&P 500 has the highest positive stock returns and the PB portfolio has the lowest positive stock returns. The weighted average stock returns from Initial Public Offering (IPO[12]) to Jan 1, 2022, revealed that the PB portfolio has a negative stock return. In contrast, SB and ALL portfolio have positive stock returns. This result suggests that companies that are primarily involved in the biofuel business are not performing well in relative to the whole market (i.e., S&P 500 index) from IPO to date.

[12] The process in which a private company sells its shares to the public for the first time.

CHAPTER VI

DISCUSSION

6.1 Discussion for Risk Analysis

Political risk comprises the risk related to biofuel policies and regulations, environmental regulations, international laws, and general regulations for the operation of a company. Biofuel regulation is one of the important risks in terms of prevalence and significance for the sample of biofuel companies analyzed in this study. A similar finding was reported by Pries et al. (2016) where biofuel regulation was found to be a prevalent and significant risk for a sample of 26 biofuel companies. Živković et al. (2017) also addressed the government's inconsistent policy for biofuels as a major problem in both the short and long term for the growth of the biofuel industry. Similarly, White et al. (2013) reported policy inconsistency as a challenge for the renewable energy sector. Potential investors, therefore, seek the assurance of long-term stable policies that minimize uncertainty to invest in the biofuel industry. Biofuel policies make high-cost biofuel to be competitive in the fuel market through economic incentives including subsidies, tariffs, and tax incentives.

Biofuel advocates argue biofuel is a vehicle for mitigating the effects of climate change because it reduces GHG emissions. Van der Horst & Vermeylen (2011) argue that biofuel policies are narrowly defined for energy security rather than environmental and social concerns. A review study of the Life Cycle Assessment (LCA) of biofuels by Jeswani et al. (2020) revealed that first and second-generation biofuels have lower GHG emissions than fossil fuels. However, there have been discussions regarding whether promoting the use of biofuels would result in an increase in greenhouse gas (GHG) emissions. Some argue that this could be the case,

leading to a debate on the potential effects of promoting biofuels. Large-scale mechanized monocultures using agrochemical inputs and, changing carbon-capturing forest land into feedstock cultivation are considered potential reasons behind increasing GHG emission that outweighs the benefits offered by biofuels (Altieri & Bravo, 2007).

The attractiveness of an industry as an investment option depends on the positive economic environment in which it operates. Intuitively, companies choose to operate in an economically favorable industry (Porter, 1980). The analysis identified risks specific to biofuels like markets for feedstocks, biofuels, energy, competing fuels, and general economic conditions. General economic conditions were found to be prevalent and significant risk in all years and markets feedstock was found to be prevalent and significant risk in 2018, 2019. Pries et al. (2016) also identified market feedstock as prevalent and significant risk. However, general economic conditions were not reported as prevalent and significant risk. The biofuel market is driven primarily by biofuel policies. For example, the RFS mandate requires a certain amount of renewable fuel to be mixed with fossil fuel before that can be sold in the fuel market. However, market price risk is still a problem even with several policies, mandates, tax exemptions, and tax credits favoring investors in the biofuel business (Ghoddusi, 2017). First-generation biofuels like ethanol from corn and sugarcane are matured technologies and are competitive with gasoline prices. But, in case of the second and third-generation biofuels, the high cost of production is often cited as the primary issue for not attaining profitability (Peng et al., 2020; Živković et al., 2017). Even though several subsidy programs, biofuel mandates, tax credits, and incentives are provided to the biofuel industry, advanced biofuel has not been profitable for investors. The cost of current technology adopted for feedstock cultivation and conversion to biofuel is also too high compared to fossil fuels, so biofuels fail to compete with fossil fuels in current market

conditions. Previous studies have therefore suggested future efforts to be directed towards research and development of low-cost, non-food feedstocks, efficient conversion technologies, etc. to reduce the biofuel production cost (Peng et al., 2020; Živković et al., 2017).

Our study identified technological risks as less important risks to the biofuel industry and rather emphasized support activities risks, political risks, and economic risks as important risks in the industry. Pries et al. (2016) also found technological risks as less important risks because the study did not report any risk that was both prevalent and significant. Hargadon (2011) observed similar results in a survey of 35 companies related to low-carbon innovation where risks in order of importance were policy uncertainty, market uncertainty, business feasibility, and technical uncertainty. The relative higher importance of political risks over technological risks could be attributed to subsidies, biofuel policies, and tax incentives provided by the government that reduces the cost of biofuel significantly and thus reduces the investment risk in biofuel venture (Sharma et al., 2020; Su et al., 2015).

The results of the study suggested social risks like public perception, and public opposition towards biofuel was relatively less important. Pries et al. (2016) also revealed that social risks are relatively less important. The food vs. fuel debate was considered the least important driver in the scale-up process of the US cellulosic biofuel industry (Chen & Smith, 2017). However, extreme land and income concentration, bulk unemployment, food insecurity, rural poverty, and mass migration are major social threats posed by the change in land-use patterns from food purposes to fuel purposes (Altieri & Bravo, 2007). The social impact of biofuel products and consumption in developed countries is relatively low because of the social policies designed to mitigate social issues. On the other hand, developing countries have established large-scale, export-oriented production systems which could yield positive social

impacts (Van der Horst & Vermeylen, 2011). It is thus reasonable that social risks were not reported as important risks because most of the companies in the study sample are operating in developed countries rather than developing countries.

The biofuel industry is still immature and has several managerial challenges ahead. The lack of capable managers to lead the biofuel industry by setting up the appropriate organizational structure, risk management, contracting and agreements, mergers and acquisitions, financing, etc. is potentially impeding the growth of the industry (Pries et al., 2016). The findings from the study suggests risk management, contracting, and financing as important risks for the sample companies both in terms of prevalence and significance. Pries et al. (2016) reported general management as prevalent and significant risk in addition to risk management, contracting, and financing. Miller et al. (2013) also believe the success of second-generation biofuel companies depends significantly on external financing since these are relatively in an immature stage. Highly profitable firms that have internally generated funds do not rely much on external financing (Demirgüç-Kunt & Maksimovic, 1998) but immature and unprofitable firms like biofuel firms probably need external financing for growth and development.

The inability of biofuel firms to obtain feedstocks in proper quantity and quality is one of the challenges for a profitable biofuel business. Bijman et al. (2009) identified contract farming as an option for reducing transaction costs and transaction risks for the supply chain of jatropha, an emerging biofuel crop, in Mozambique's biofuel industry. A similar assertion, by Yang et al. (2016), is that long-term contracts with farmers are critical to establishing perennial energy crops as feedstocks for the cellulosic biofuel industry. Vertical integration and contract with the independent farmer is a risk mitigation strategy resulting from risk-sharing in production and marketing, technological progress and innovation dissemination, consumer demand for a quality

product, and access to capital (Vukina, 2001). Although major efforts are aimed at achieving profitable business conditions, the biofuel industry should parallelly study the social concerns and try to solve those issues.

The categorization of biofuel companies into PB and SB has provided valuable insights into the different types of risks that these companies face. PB companies are those with a higher percentage of biofuel revenues, while SB companies have a lower percentage of biofuel revenues. The analysis has revealed that PB companies are more susceptible to risks directly related to biofuels. These risks include factors such as biofuel regulation, markets for biofuels, and conversion technologies. Because PB companies rely heavily on biofuels for revenue, any changes in these factors can significantly affect their operations and profitability. On the other hand, SB companies are more vulnerable to general risks that affect businesses across industries. These risks include factors such as general regulation, economic conditions, and cybersecurity. While these risks may also affect PB companies, SB companies may be more susceptible to them because they have a smaller portion of their revenue coming from biofuels. Overall, these findings suggest that the level of vulnerability to risks differs between PB and SB companies, with PB companies being more severely affected by risks directly related to biofuels. This categorization can help companies and investors better understand the risks associated with different types of biofuel companies and make more informed decisions about investments and operations.

6.2 Discussion for Financial Analysis

The financial analysis of the biofuel companies revealed that the median profitability estimates, ROA and ROE, of the sample of biofuel companies used in our study are higher compared to the profitability of publicly traded agribusinesses and all firms (Katchova & Enlow,

2013). However, a caveat of this comparison is that the estimates of profitability of biofuel companies used in our study are from 2018-2021, while for the publicly traded agribusinesses are from the 2008-2011 period, as reported by Katchova & Enlow (2013). Future studies may compare directly biofuel to other agribusinesses. A study by Bacho & Murova (2017) examined the financial performance of 12 corn-based ethanol companies in the US from 2009-2014. The small (50 MGY) and large (100 MGY) ethanol enterprises had an average ROE of 10.2% and 5.5% respectively. The result from our study revealed a higher mean ROE than these for all three portfolios. The mean ROE in our study is 16.5%, 12.3%, and 13.65% for PB, SB and ALL portfolios respectively. This suggests that biofuel companies are gradually getting more profitable compared to the past. The mean asset turnover ratio in our study is 1.083, 1.305, and 1.155 for PB, SB and ALL portfolios respectively. The mean asset turnover in the study by Bacho & Murova (2017) is 1.9497 and 1.9619 for small and large ethanol enterprises. This result suggests a lower asset turnover rate compared to the past.

Upon conducting a trend analysis of selected financial ratios, an intriguing pattern emerged, which showed a sudden surge in profitability ratios of primary biofuel (PB) companies between the years 2020 and 2021, followed by a sharp decline. The results are consistent with the higher profits generated by ethanol and biodiesel plants during the early 2020 and the decline at the end of 2020 (Irwin, 2021b, 2021a). This observation seems surprising given the adverse impact of the COVID-19 pandemic on many industries, including fossil fuel and biofuel businesses. Numerous studies have reported that the pandemic caused a significant reduction in demand and prices for biofuels and fossil fuels, primarily due to the temporary shutdown of a vast majority of businesses, and governments worldwide imposing lockdowns to mitigate the spread of the virus. As a result, transportation fuel consumption significantly decreased, leading

to a decrease in demand for biofuels and fossil fuels alike (Elleby et al., 2020; Irwin, 2020; Shadidi & Najafi, 2021).

The analysis of the stock returns of three portfolios comprising PB, SB, and ALL companies has revealed some interesting trends. First, PB companies displayed a significantly higher degree of volatility in their weighted stock returns as compared to SB and ALL portfolios. A similar result was obtained by Ellinger (2007) where 7 publicly traded ethanol companies had very volatile stock returns. Additionally, our study showed that PB companies have had negative weighted stock returns from their initial public offering (IPO) until January 1, 2022. This trend is consistent with a previous study conducted by Miller et al. (2013), which found that eight sample biofuel companies had negative stock returns from their IPO until September 4, 2013. The reason for this negative trend could be due to the use of second-generation biofuel technology, which was still in its nascent stage and required further development to improve its efficiency. Interestingly, a peculiar phenomenon emerged during the 2020-2021 period. The PB companies, which had previously shown negative weighted stock returns, experienced a sharp reversal in their fortunes and displayed very positive weighted stock returns. In contrast, SB and ALL portfolios showed negative weighted stock returns during this period. One of the probable reasons for this could be COVID-19 pandemic which occurred at the same period. The reason for this sudden shift in trend is not immediately clear, but it could also be attributed to various factors, such as changes in market dynamics, policy changes, or advancements in technology. Overall, these findings highlight the importance of closely monitoring the stock returns of companies operating in the biofuel industry, as they can exhibit significant fluctuations and trends over time.

CHAPTER VII

CONCLUSION AND POLICY RECOMMENDATION

This study focuses on the financial and risk analysis of a sample of publicly traded biofuel companies. The study specifically evaluated (i) the significance and prevalence of risks in the industry, and (ii) various financial metrics related to financial performance. The analysis of risk factors revealed that biofuel regulation, market biofuel, profitable operations, risk management, financing, and contracting were prominent sources of risk in the biofuel industry. The categorization of biofuel companies as PB or SB based on their percentage of biofuel revenues has revealed that PB companies are more vulnerable to risks directly related to biofuels, such as biofuel regulation and markets for biofuels, while SB companies are more susceptible to general business risks, such as economic conditions and cybersecurity. These findings can aid companies and investors in understanding the varying risks associated with different types of biofuel companies and making informed decisions about investments and operations. To address these risks, collaborative efforts could be made between government stakeholders, industry stakeholders, and researchers to establish stable and long-term policies and create market safety for biofuels. Moreover, stakeholders such as private equity investors, banks, and financing institutions could work together to minimize financing risks for biofuel production. These findings can provide a basis for developing policies that can mitigate risks and encourage the growth of the biofuel industry.

However, the study's limitations must be considered. The sample consists only of publicly traded biofuel companies, which can lead to a sample selection bias, known as survivorship bias, as private companies may face different risks and have different financial conditions. To overcome this limitation, future research could encompass both publicly traded

and private biofuel companies to provide a more comprehensive assessment of the industry's risks and profitability. Finally, the risk scores generated from this study can be used to understand the relationship with other financial ratios, and further research could explore these relationships.

The present study utilized the financial ratios analysis commonly used in the finance literature to assess the historical economic performance of biofuel companies. The investigation focused on comparing the financial performance of companies with a dominant share of biofuel revenues (PB companies) to those with a smaller percentage of biofuel revenues (SB companies) by utilizing SB companies as a benchmark. The S&P 500 market index was also used as a benchmark for examining the stock returns. The objective was to determine whether companies with higher biofuel revenues performed better financially than their counterparts with lower biofuel revenues. Descriptive statistics were employed to examine the financial ratios of the two groups of companies, revealing that PB companies outperformed SB companies in terms of profitability, liquidity, and efficiency ratios. A trend analysis of selected financial ratios indicated that most of the ratios were highly volatile, except for the total debt to equity and assets to equity ratios, which remained relatively stable compared to the other financial metrics used in the study. An abrupt increase in profitability ratios was identified in PB companies during 2020-2021, followed by a significant decline. The analysis of stock returns revealed that primary biofuel companies had negative weighted stock returns from their initial public offering until January 1, 2022, but experienced a sharp reversal in their fortunes during the 2020-2021 period. These counterintuitive results coincide with a major global event, the COVID-19 pandemic. The investigation highlights the importance of further exploring the performance of biofuel

companies during the pandemic period, as PB companies displayed comparatively better performance than other portfolios despite the volatility that could be attributed to several factors.

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APPENDIX

Table 1: Elements of the PEST analysis for risks in the biofuel industry

Political	**Economic**
i. Biofuel regulation - policies, subsidies, tariffs ii. Environmental and health safety iii. Infrastructure iv. International v. General regulation	i. Markets - feedstocks ii. Markets - biofuels iii. Markets - competing fuels iv. Markets - energy v. Competition vi. General economic conditions
Social	**Technological**
i. Public opposition ii. Public perception	i. Feedstock technologies ii. Conversion technologies iii. Fuel compatibility iv. Intellectual property v. Cybersecurity

Source: (Pries et al., 2016)

Table 2: Companies involved in biofuel business according to most recent annual and quarterly reports.

S.N.	Name of companies	Headquarters	Ticker	Stock Name	NAICS Code
1	Aemetis, Inc.	California, US	AMTX	NASDAQ	325193
2	Alto Ingredients, Inc.	California, US	ALTO	NASDAQ	325193
3	BP p.l.c.	London, the UK	BP	LSE	324110
4	Cardinal Ethanol, LLC	Indiana, US	CRDE	OTCPK	325193
5	Ecopetrol S.A.	Bogotá, Colombia	ECOPETROL	BVC	324110
6	FutureFuel Corp.	Missouri, US	FF	NASDAQ	325199
7	Gevo, Inc.	Colorado, US	GEVO	NASDAQ	325193
8	Granite Falls Energy, LLC	Minnesota, US	GFGY	OTCPK	325193
9	Green Plains Inc.	Nebraska, US	GPRE	NASDAQ	325193
10	Heron Lake BioEnergy, LLC	Minnesota, US	HLBY.L	OTCPK	325193
11	Lignol Energy Corporation	Vancouver, Canada	LECF.F	OTCMKTS	324199
12	Methes Energies International Ltd.	Nevada, US	MEIL	OTCMKTS	324199
13	Petróleo Brasileiro S.A.	Rio de Janeiro, Brazil	PBR	NYSE	324110
14	Red Trail Energy, LLC	North Dakota, US	REGX	OTCPK	325193
15	Renewable Energy Group, Inc.	Iowa, US	REGI	NASDAQ	324199
16	Renewable Fuel Corp	Nevada, US	RWFC	OTCPK	324199
17	REX American Resources Corporation	Ohio, US	REX	NYSE	325193
18	Royal Dutch Shell plc	The Hague, the Netherlands	RDSA	ENXTAM	324110
19	Valero Energy Corporation	Texas, US	VLO	NYSE	324110

Table 3: Biofuel companies identified from google search and journal articles.

S.N.	Name of companies	Headquarters	Ticker	Stock Name	References
1	Abengoa SA	Seville, Spain	ABG	BME	Pries et al. (2016)
2	Adecoagro S.A.	Luxembourg	AGRO	NYSE	Saravia-Matus et al. (2018)
3	Archer-Daniels-Midland Company	Illinois, US	ADM	NYSE	Khanal et al. (2014)
4	Bunge Limited	Missouri, US	BG	NYSE	Saravia-Matus et al. (2018)
5	Cosan S.A.	Sao Paulo, Brazil	CSAN3	BOVESPA	Pries et al. (2016)
6	Darling Ingredients Inc.	Texas, US	DAR	NYSE	Garten et al. (2017)
7	Green Plains Partners LP	Nebraska, US	GPP	NASDAQ	Google Search[13]
8	The Andersons, Inc.	Ohio, US	ANDE	NASDAQ	Khanal et al. (2014)
9	VERBIO Vereinigte BioEnergie AG	Zörbig, Germany	VBK.DE	XTRA	Google Search[14]

Table 4: Biofuel companies identified from S&P quick comparable instrument.

S.N.	Name of companies	Headquarters	Ticker	Stock Name
1	China Clean Energy Inc.	Fuqing, China	CCGY	OTCPK
2	Clean Energy Fuels Corp.	California, US	CLNE	NASDAQ
3	CropEnergies AG	Saxony-Anhalt, Germany	CE2	XTRA
4	Delek US Holdings, Inc.	Tennessee, US	DK	NYSE
5	Galp Energia, SGPS, S.A.	Lisbon, Portugal	GALP	ENXTLS
6	Global Bioenergies SA	Evry, France	ALGBE	ENXTPA
7	Neste Oyj	Espoo, Finland	NESTE	HLSE

[13] https://companiesmarketcap.com/biofuel/largest-companies-by-market-cap/
[14] https://companiesmarketcap.com/biofuel/largest-companies-by-market-cap/

Table 5: Sample of biofuel companies before filtering for risk and financial data availability

S.N.	Name of companies	Ticker	Stock Name	Country of Stock Exchange	*Classification*
1	Abengoa SA	ABG	BME	Spain	Production
2	Adecoagro S.A.	AGRO	NYSE	US	Production
3	Aemetis, Inc.	AMTX	NASDAQ	US	Production
4	Alto Ingredients, Inc.	ALTO	NASDAQ	US	Production and Marketing
5	Archer-Daniels-Midland Company	ADM	NYSE	US	Production
6	BP p.l.c.	BP	LSE	United Kingdom	Production
7	Bunge Limited	BG	NYSE	US	Production and Marketing
8	Cardinal Ethanol, LLC	CRDE	OTCPK	US	Production
9	China Clean Energy Inc.	CCGY	OTCPK	US	Production
10	Clean Energy Fuels Corp.	CLNE	NASDAQ	US	Production
11	CropEnergies AG	CE2	XTRA	Germany	Production
12	Cosan S.A.	CSAN3	BOVESPA	Brazil	Production, logistics, and Distribution
13	Darling Ingredients Inc.	DAR	NYSE	US	Production
14	Delek US Holdings, Inc.	DK	NYSE	US	Production
15	Ecopetrol S.A.	ECOPETROL	BVC	Colombia	Production
16	FutureFuel Corp.	FF	NASDAQ	U.S.	Production
17	Galp Energia, SGPS, S.A.	GALP	ENXTLS	Portugal	Production
18	Gevo, Inc.	GEVO	NASDAQ	US	Production
19	Global Bioenergies SA	ALGBE	ENXTPA	France	
20	Granite Falls Energy, LLC	GFGY	OTCPK	US	Production
21	Green Plains Inc.	GPRE	NASDAQ	US	Production
22	Green Plains Partners LP	GPP	NASDAQ	US	Storage and logistics,
23	Heron Lake BioEnergy, LLC	HLBY.L	OTCPK	US	Production and Marketing
24	Lignol Energy Corporation	LECF.F	OTCMKTS	US	

Table 5 Continued

25	Methes Energies International Ltd.	MEIL	OTCMKTS	US	Production, Marketing, and Feedstock supply
26	Neste Oyj	NESTE	HLSE	Finland	Production, Marketing and Distribution
27	Petróleo Brasileiro S.A. - Petrobras	PBR	NYSE	US	Production and Distribution
28	Red Trail Energy, LLC	REGX	OTCPK	US	Production
29	Renewable Energy Group, Inc.	REGI	NASDAQ	US	Production and Marketing
30	Renewable Fuel Corp	RWFC	OTCPK	US	Production, Blending, and Distribution
31	REX American Resources Corporation	REX	NYSE	US	Investment and Production
32	Royal Dutch Shell plc	RDSA	ENXTAM	Netherlands	Refining, Trading, and Marketing
33	The Andersons, Inc.	ANDE	NASDAQ	US	Production, marketing, and logistics
34	Valero Energy Corporation	VLO	NYSE	US	Production, and Marketing
35	VERBIO Vereinigte BioEnergie AG	VBK	XTRA	Germany	Production and Marketing

Table 6: Broad risk categories and specific risks

Risk category	**Abbreviations**	**Risk factors**	**Examples of risks from annual (10-K and 20-F) reports**
Political	BFR	Biofuel regulation	*"A change in government policies may cause a decline in the demand for our products."*
	EHS	Environmental, health, and safety	*"Concerns regarding the environmental impact of biofuel production could affect public policy which could impair our ability to operate at a profit and substantially harm our revenues and operating margins."*
	INT	International	*"A substantial portion of our assets and operations are located in India, and we are subject to regulatory, economic, and political uncertainties in India."*
	INF	Infrastructure	*"Our success depends on our ability to manage the growth of our operations."*
	GNR	General regulations	*"We could be adversely affected by violations of the U.S. Foreign Corrupt Practices Act."*
Economic	MRF	Markets-feedstock	*"Fluctuations in the price of corn and other feedstocks may affect our cost structure."*

Table 6 continued

	MRB	Markets-biofuels	*"Increased alcohol or essential ingredient production or higher inventory levels may cause a decline in prices for those products, and may have other negative effects, adversely impacting our results of operations, cash flows and financial condition."*
	MRC	Markets-competing fuels	*"Fluctuations in petroleum prices and customer demand patterns may reduce demand for renewable fuels and bio-based chemicals."*
	MRE	Markets-energy	*"Fluctuations in the price and availability of energy to power our production facilities may harm our performance."*
	COM	Competition	*"The industries in which we operate are extremely competitive. Many of our significant competitors have greater production and financial resources and could use their greater resources to gain market share at our expense."*
	GEC	General economic conditions	*"There is no public market for our units and no public market is expected to develop."*

Table 6 continued

	STR	Stock risk	*"Our quarterly operating results may fluctuate in the future. As a result, we may fail to meet or exceed the expectations of investment research analysts or investors, which could cause our stock price to decline."*
Social	PUO	Public opposition	*"Consumer resistance to the use of ethanol-based on the belief that ethanol is expensive, adds to air pollution, harms engines and/or takes more energy to produce than it contributes may affect the demand for ethanol."*
	PUP	Public Perception	*"Public perception, consumer acceptance and overall consumer demand for transportation fuel, any of which could negatively affect demand for fuel-grade ethanol and our results of operations."*
Technological	CNT	Conversion technology	*"We may not be able to successfully develop and commercialize our technologies, which may require us to curtail or cease our research and development activities."*
	FLC	Fuel compatibility	*"Demand for ethanol may not grow unless ethanol can be blended into gasoline in higher percentage blends for conventional automobiles."*
	INP	Intellectual property	*"We may be unable to protect our intellectual property."*

Table 6 continued

	CYS	Cybersecurity	*"Our information technology systems, processes, and sites may suffer interruptions, security breaches or failures that may adversely affect our ability to conduct our business."*
Primary Activities	FTD	Facilities development	*"We may not be able to recover the costs of our substantial investments in capital improvements and additions, and the actual cost of such improvements and additions may be significantly higher than we anticipate."*
	PRO	Profitable operations	*"We are currently not profitable and historically, we have incurred significant losses. If we incur continued losses, we may have to curtail our operations, which may prevent us from successfully operating and expanding our business."*
Support Activities	GNM	General management	*"Our Chief Executive Officer has outside business interests that could require time and attention."*
	RKM	Risk management	*"We may be subject to liabilities and losses that may not be covered by insurance."*
	FIN	Financing	*"Our business is dependent on external financing and cash from operations to service debt and provide future growth."*

Table 6 continued

CON	Contracting	*“We have entered into agriculture partnership agreements in respect of a significant portion of our sugarcane plantations.”*
MNA	Mergers and acquisitions	*"Our mergers, acquisitions, partnerships, and joint ventures may not be as beneficial as we anticipate."*

Table 7: Example of assigning and normalizing significance scores for the risks reported by a company.

Risks	**Assigned significance scores**	**Normalized scores**
A	4	0.4
B	3	0.3
C	2	0.2
D	1	0.1
Sum	10	1.0

Table 8: List of firms classified as Primary Biofuel (PB).

S.N.	**Primary biofuel**	**Ticker**	**N**
1	Aemetis, Inc.	AMTX	16
2	Alto Ingredients, Inc.	ALTO	16
3	Cardinal Ethanol, LLC	CRDE	16
4	FutureFuel Corp.	FF	16
5	Gevo, Inc.	GEVO	16
6	Granite Falls Energy, LLC	GFGY	16
7	Green Plains, Inc.	GPRE	16
8	Red Trail Energy, LLC	REGX	16
9	Renewable Energy Group, Inc.	REGI	16
10	REX American Resources Corporation	REX	16

Table 9: List of firms classified as Secondary Biofuel (SB).

S.N.	Secondary biofuel	Ticker	N
1	Adecoagro S.A.	AGRO	16
2	Archer-Daniels-Midland Company	ADM	16
3	Bunge Limited	BG	16
4	Clean Energy Fuels Corp.	CLNE	16
5	Darling Ingredients Inc.	DAR	16
6	Delek US Holdings, Inc.	DK	16
7	Ecopetrol S.A.	EC	16
8	Green Plains Partners LP	GPP	16
9	Petróleo Brasileiro S.A. - Petrobras	PBR	16
10	Royal Dutch Shell plc	SHEL	16
11	The Andersons, Inc.	ANDE	16
12	Valero Energy Corporation	VLO	16

Table 10: Financial ratios and formulas used in this study.

Categories	Financial ratios	Formulas
Profitability	Return on asset	(EBIT[15] * 0.625[16]) / ((Total $assets_{t-1}$[17] + Total $assets_{t-1}$[18]) / 2)
	Return on equity	$\frac{Net\ income}{Equity}$
	Return on capital	(EBIT* 0.625) / ((Total $capital_t$ + $(Total\ capital)_{t-1}$) / 2)
	Net margin	Net income / Total revenues
	EBITDA margin	(EBIT + D&A[19]) / Total revenues
Liquidity	Current ratio	Total current assets / Total current liabilities
Efficiency	Asset turnover	Total revenues / ((Total $assets_t$ + Total $assets_{t-1}$) / 2)
	Inventory turnover	Total cost of goods sold / (($Inventory_t$ + $Inventory_{t-1}$) / 2)
Solvency	Total debt to equity	Total debt / Total equity
	Assets to equity ratio	Average total assets/Average shareholder equity
Market	P/E[20] ratio	Market price per share[21]/Diluted EPS[22]

[15] Earnings Before Interest and Taxes (EBIT) is an account in the income statement. It is also referred to as operating income.
[16] 0.625 is used to encompass tax rate. The implicit tax rate is assumed to be 37.5%.
[17] t represents the current year.
[18] t-1 represents the previous year.
[19] D&A represent depreciation and amortization.
[20] Price to Earnings.
[21] Market value of a unit share of company stock.
[22] Diluted earnings per share, unlike earnings per share which takes into account only common shares, includes convertible bonds or convertible preferred stock along with common shares.

Table 10 continued

	EPS	Net income/Number of shares outstanding[23]
	Stock returns	ln (Price per share$_t$/Price per share$_{t-1}$)
Financial distress	Altman Z score	1.2 * ((Total current assets - Total current liabilities) / Total assets) + 1.4 * (Retained earnings / Total assets) + 3.3 * (EBIT / Total assets) + 0.6 * (Average market cap/ Total liabilities) + 1.0 * (Total revenues / Total assets)
Cash-flows	CFO to CAPEX[24]	Cash flow from operations (CFO)/ Capital expenditure (CAPEX)
	CAPEX to D&A[25]	Capital expenditure (CAPEX)/ Depreciation and amortization (D&A)

Note: The formulas presented in Table 10 are based on Standard and Poor's guidelines except for stock returns (Muhammad & Ali, 2018).

[23] Number of shares outstanding is the total company's shares hold by the shareholders.
[24] Cash flow from operations to capital expenditure.
[25] Capital expenditure to depreciation and amortization.

Table 11: Prevalence and significance measure for risks from 2018 to 2021.

	Year	**Min.**	**Mean**	**Max.**
Prevalence	2021	2	13.40	21
	2020	2	14.00	22
	2019	0	13.80	21
	2018	1	13.92	21
Significance	2021	0.025100	0.056368	0.153948
	2020	0.022001	0.056554	0.151037
	2019	0.000000	0.056138	0.146176
	2018	0.016667	0.056830	0.135918

Table 12: Prevalence and significance scores of specific risks.

Specific risks	**Prevalence**			**Significance**		
	Min.	Mean	Max.	Min.	Mean	Max.
Biofuel regulation	16	17.00	19	0.074952	0.07769	0.07926
Environment, health, and safety	15	16.00	17	0.043591	0.04836	0.05215
Infrastructure	8	10.25	12	0.036030	0.03754	0.03893
International	13	13.25	14	0.044144	0.05314	0.06330
General regulation	17	18.5	20	0.050377	0.05952	0.06716
Markets-feedstock	13	14.5	16	0.064403	0.0685	0.07132
Markets-biofuels	11	12.25	14	0.079755	0.09631	0.11236
Markets-competing fuels	11	12.75	14	0.038348	0.04685	0.05239
Markets-energy	6	6.00	6	0.034756	0.04634	0.05174
Competition	17	17.75	19	0.045555	0.04904	0.05608
General economic conditions	16	17.75	20	0.073345	0.07513	0.07746
Stock risk	13	13.75	14	0.021238	0.02997	0.03589
Public opposition	5	6.00	7	0.022896	0.02441	0.0251
Public perception	10	10.75	12	0.035397	0.03742	0.04116
Conversion technologies	11	11.50	12	0.040084	0.04246	0.04521
Fuel compatibility	0	1.25	2	0.000000	0.02035	0.03323

Table 12 continued

Intellectual property	6	6.25	7	0.022001	0.026	0.03125
Cybersecurity	18	19.75	21	0.031850	0.03644	0.03930
Facilities development	9	9.75	11	0.040451	0.05352	0.06460
Profitable operations	18	20.25	22	0.086888	0.09889	0.11234
General management	16	16.75	17	0.041130	0.04218	0.04388
Risk management	20	21.00	22	0.135918	0.14677	0.15395
Financing	19	20.00	21	0.067879	0.08235	0.09702
Contracting	17	18.75	20	0.067872	0.07956	0.09096
Mergers and acquisitions	12	12.75	13	0.029682	0.03309	0.03560

Note: Specific risk factors under the political risk category: Biofuel regulation (BFR), environmental, health, and safety (EHS), international (INT), infrastructure (INF), and general regulations (GNR).

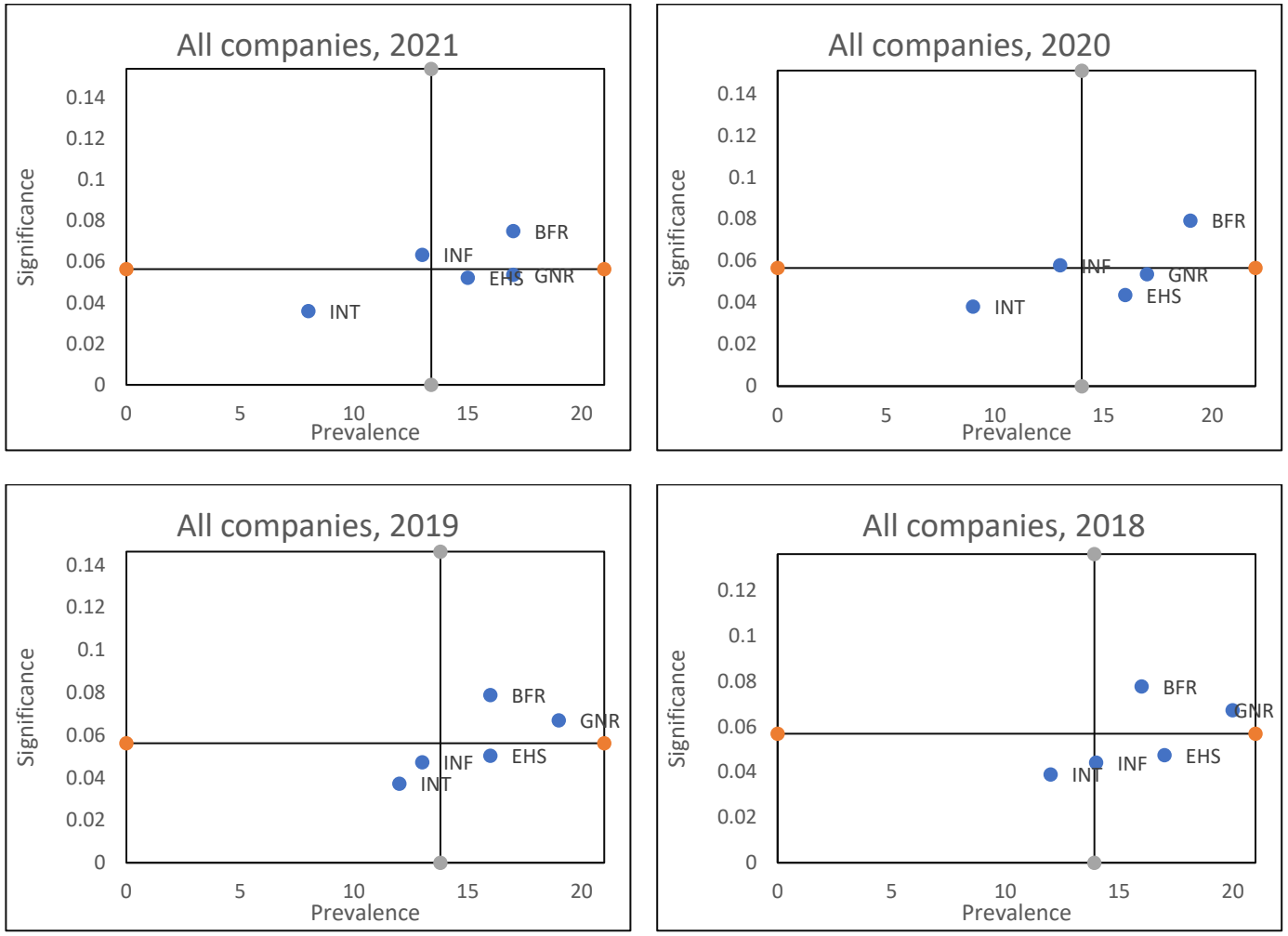


Figure 1: Prevalence and significance of political risks for all companies.

Note: Specific risk factors under the economic risk category: Markets: feedstock (MRF), markets-biofuels (MRB), markets-competing fuels (MRC), markets-energy (MRE), competition (COM), general economic conditions (GEC), and stock risk (STR).

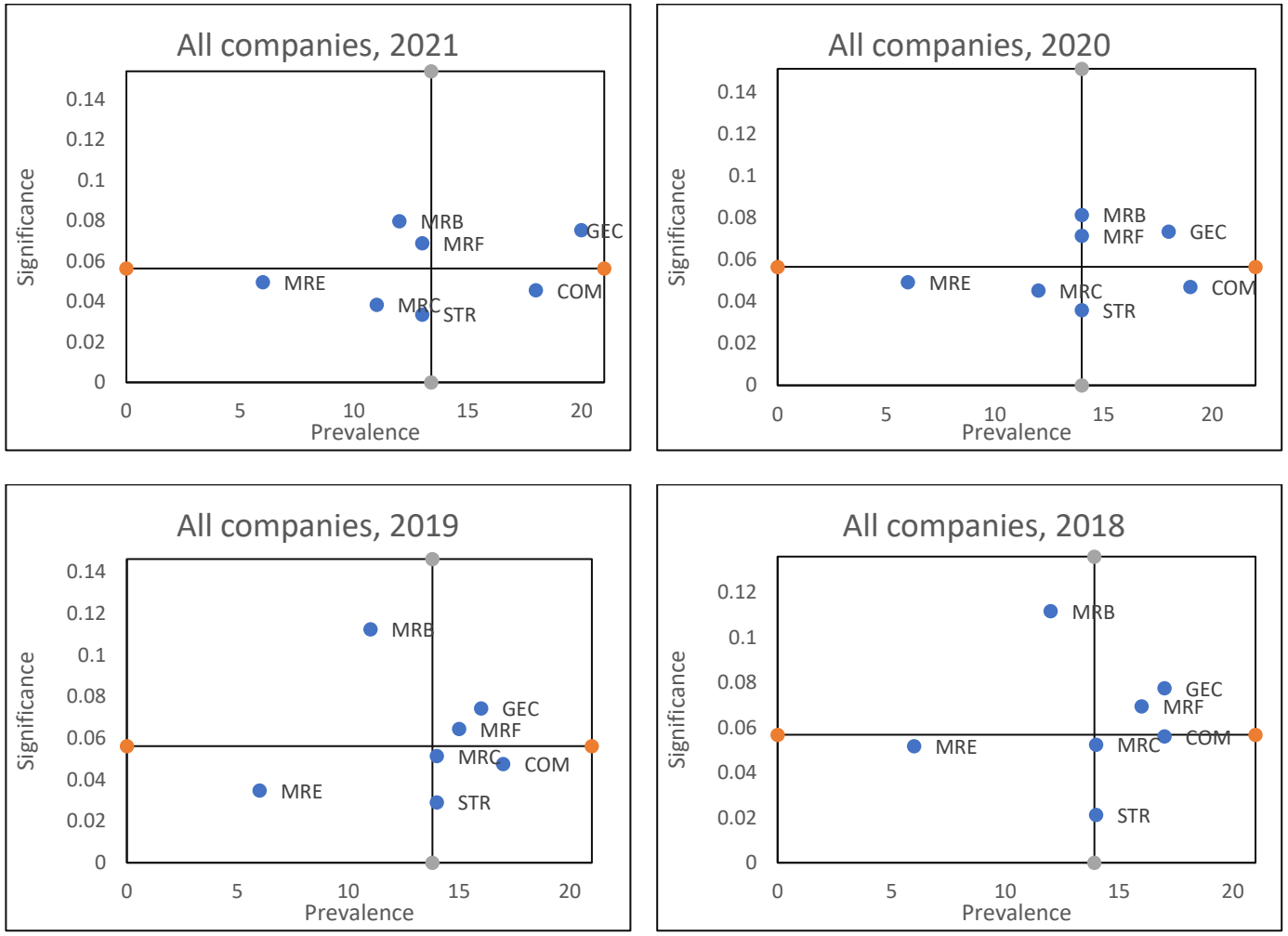


Figure 2: Prevalence and significance of economic risks for all companies.

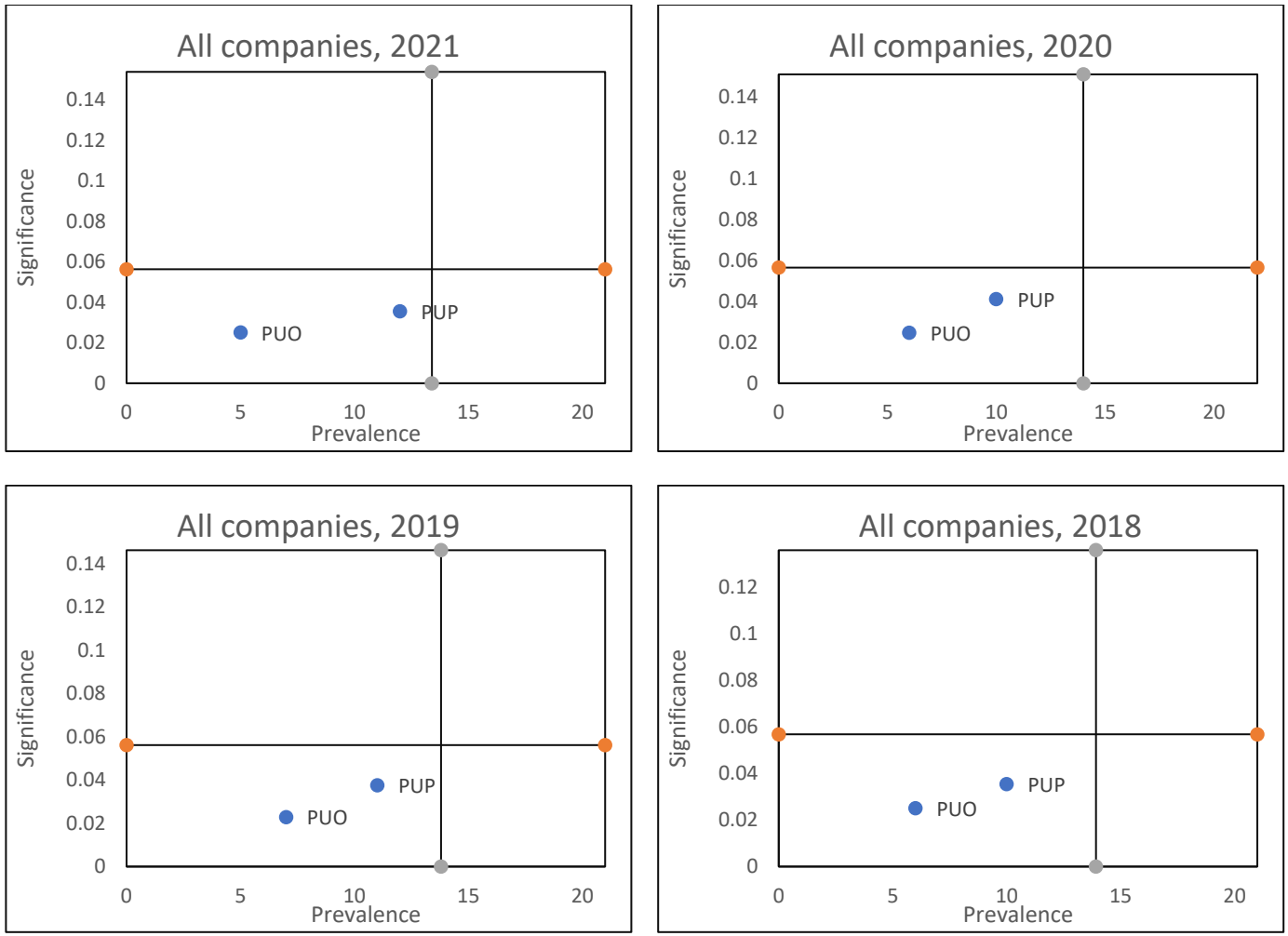


Figure 3: Prevalence and significance of social risks for all companies.

Note: Specific risk factors under the social risk category: Public opposition (PUO) and public perception (PUP).

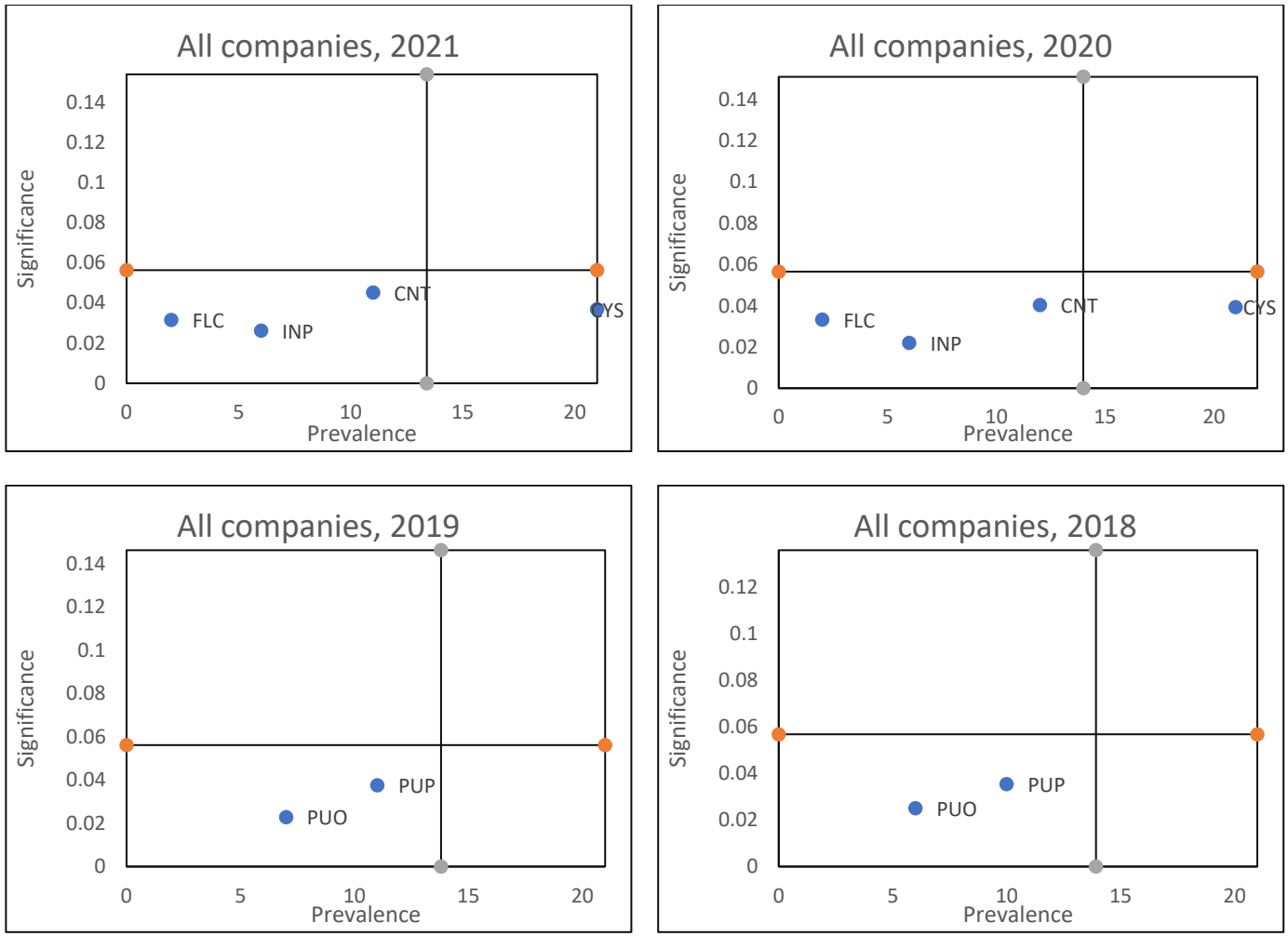


Figure 4: Prevalence and significance of technological risks for all companies.

Note: Specific risk factors under technological risk category: Conversion technology (CNT), fuel compatibility (FLC), intellectual property (INP), and cybersecurity (CYS).

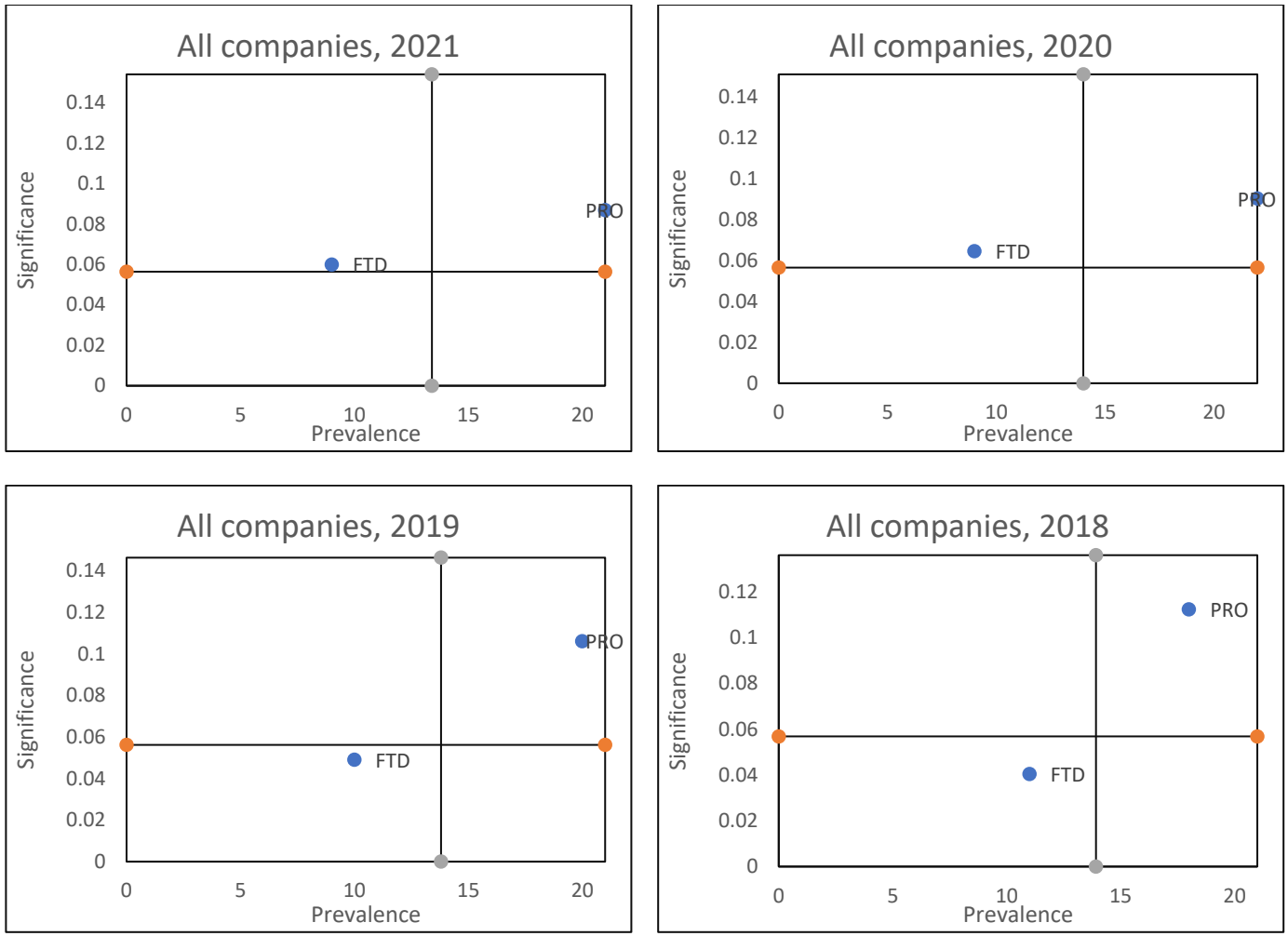


Figure 5: Prevalence and significance of risks reported in primary activities category for all companies.

Note: Specific risk factors under the primary activities risk category: Facilities development (FTD) and profitable operations (PRO).

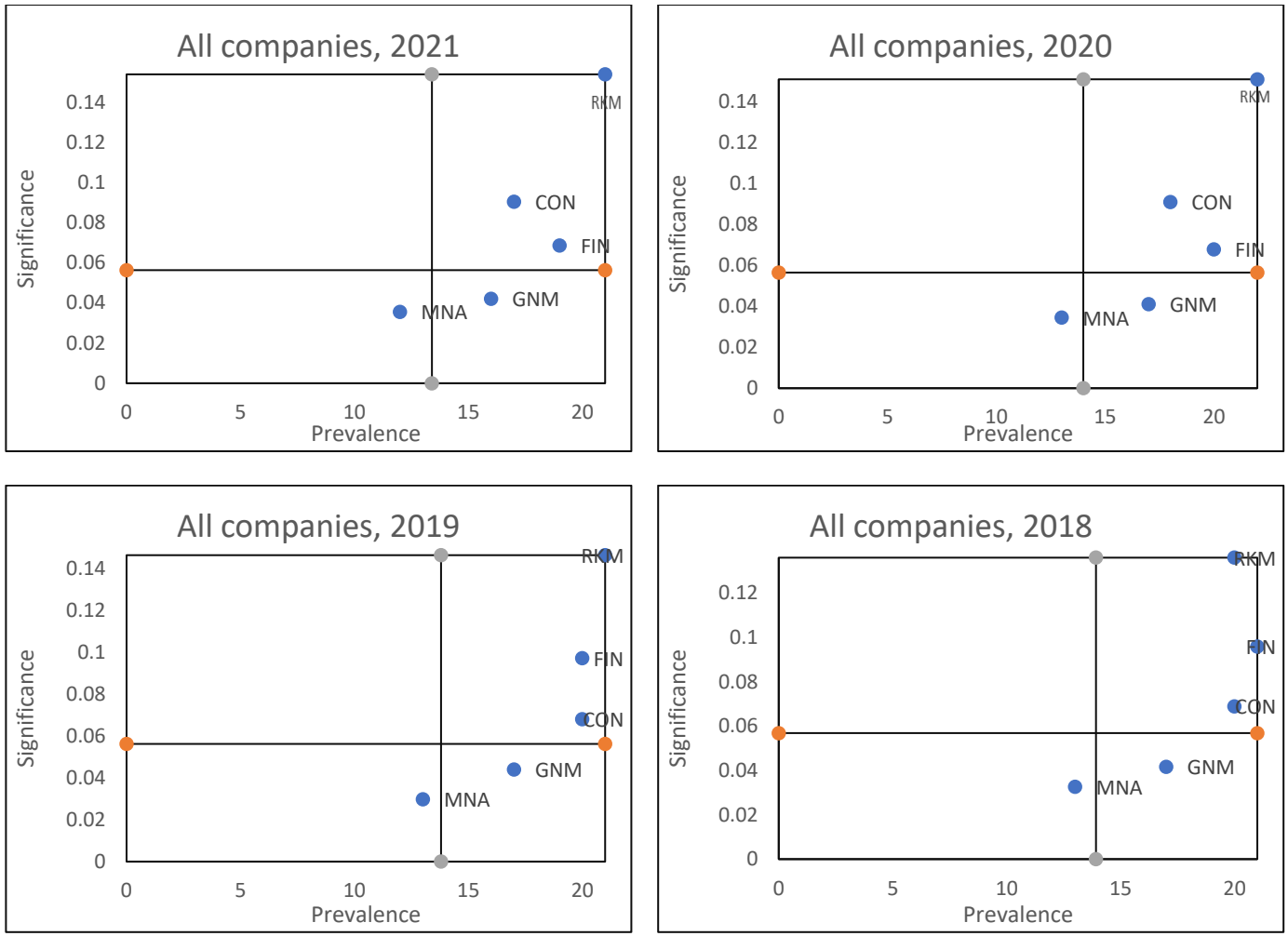


Figure 6: Prevalence and significance of risks reported in support activities category for all companies.

Note: Specific risk factors under the support activities risk category: General management (GNM), risk management (RKM), financing (FIN), contracting (CON), and mergers and acquisitions (MNA).

Table 13: Prevalent and significant risks for all companies.

	Prevalent and significant risks for all companies			
Risk categories	**2018**	**2019**	**2020**	**2021**
Political	GNR, BFR	GNR, BFR	BFR	BFR
Economic	GEC, MRF	GEC, MRF	GEC	GEC
Social				
Technological				
Primary Activities	PRO	PRO	PRO	PRO
Support Activities	RKM, FIN, CON	RKM, FIN, CON	RKM, FIN, CON	RKM, FIN, CON

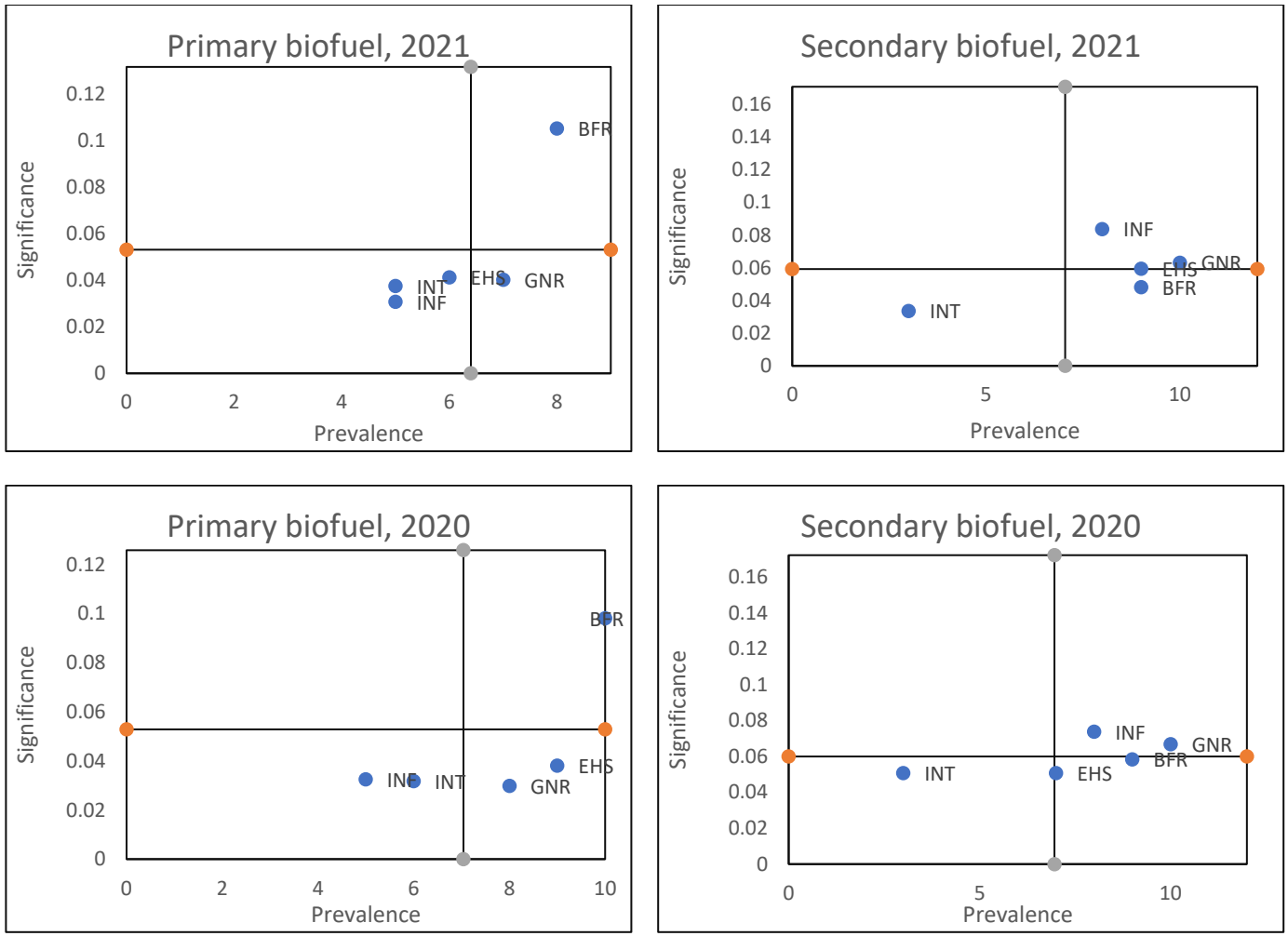


Figure 7: Comparison of political risks between primary biofuel and secondary biofuel companies.

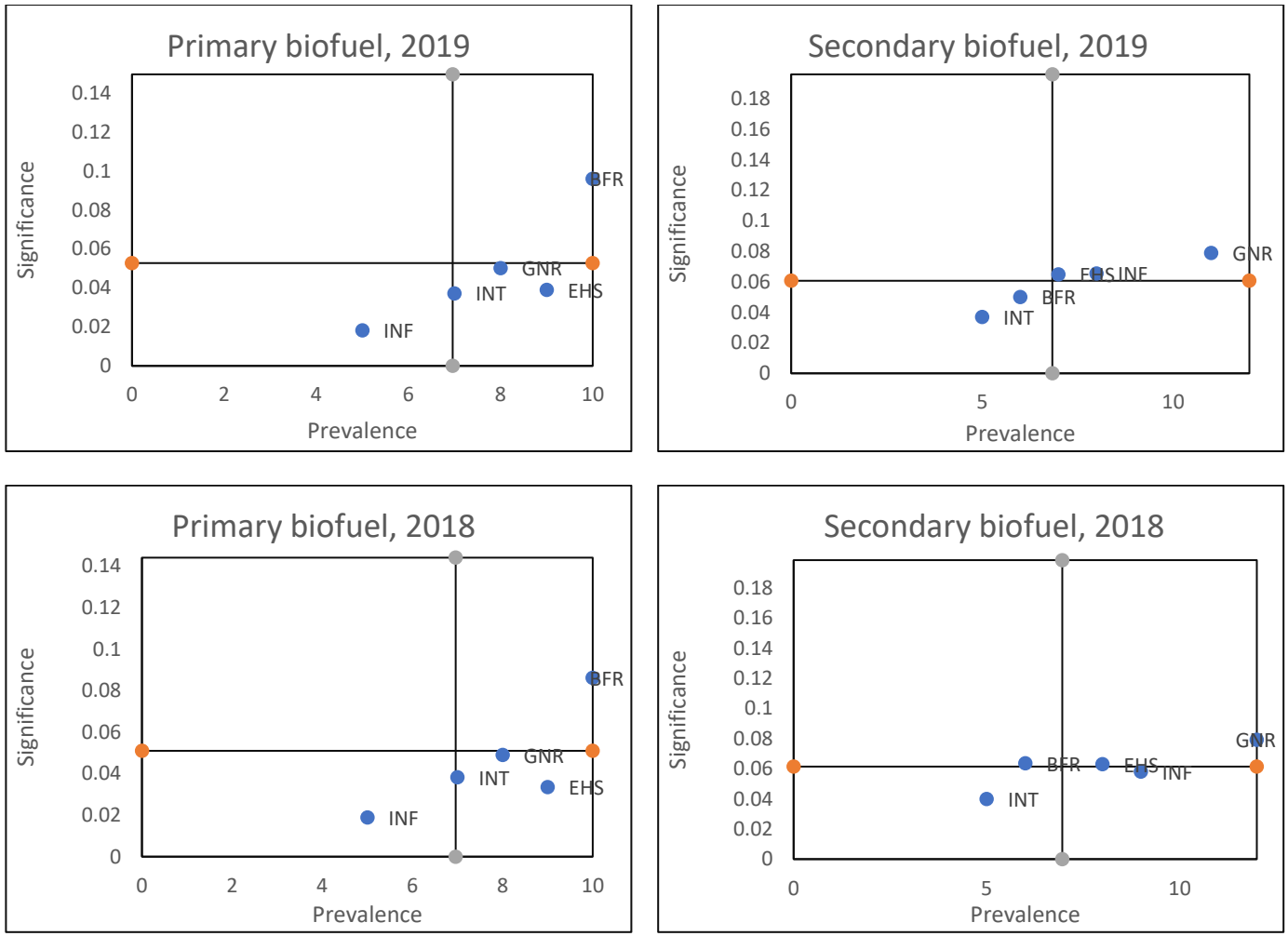


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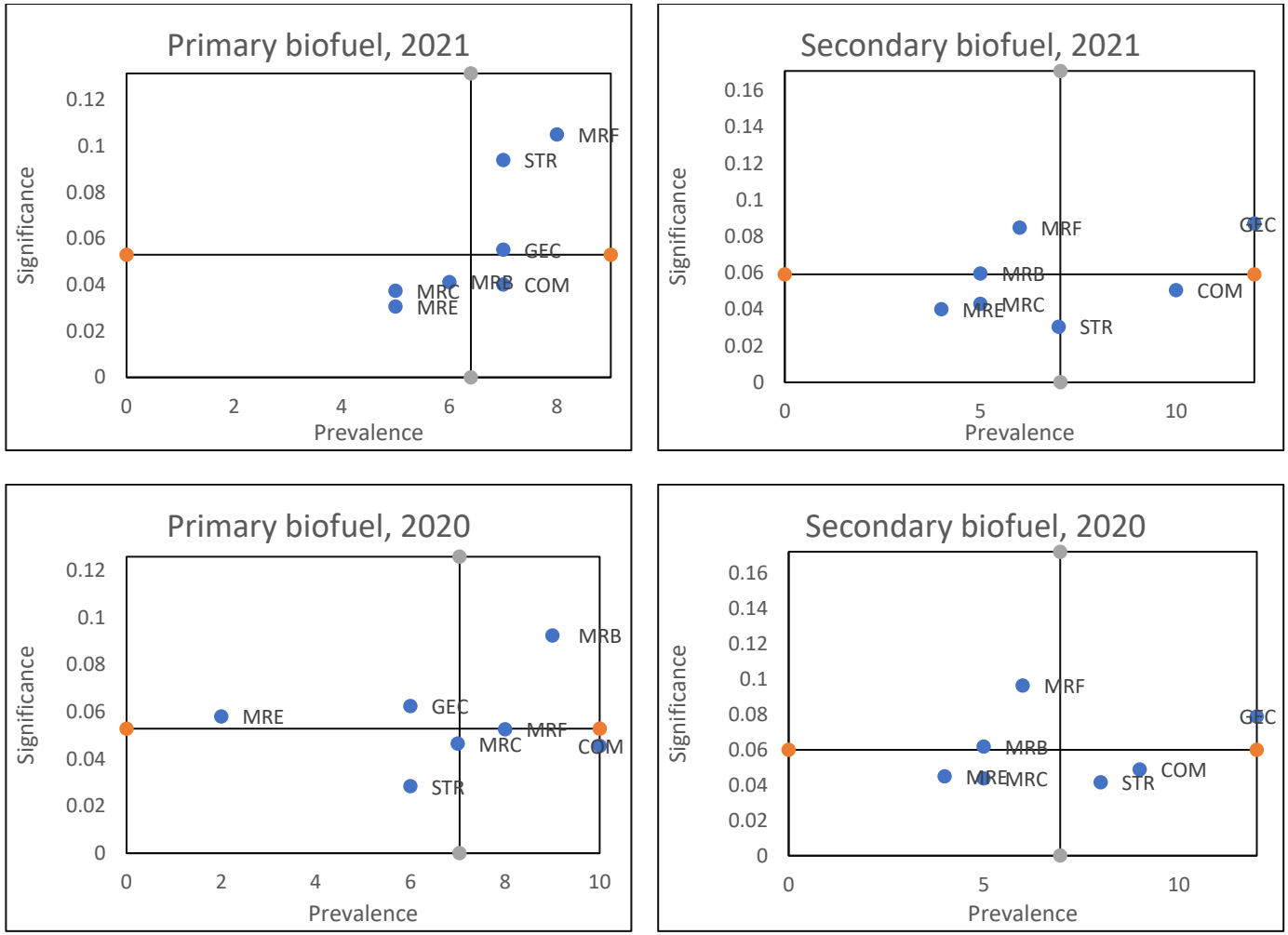


Figure 8: Comparison of economic risks between primary biofuel and secondary biofuel companies.

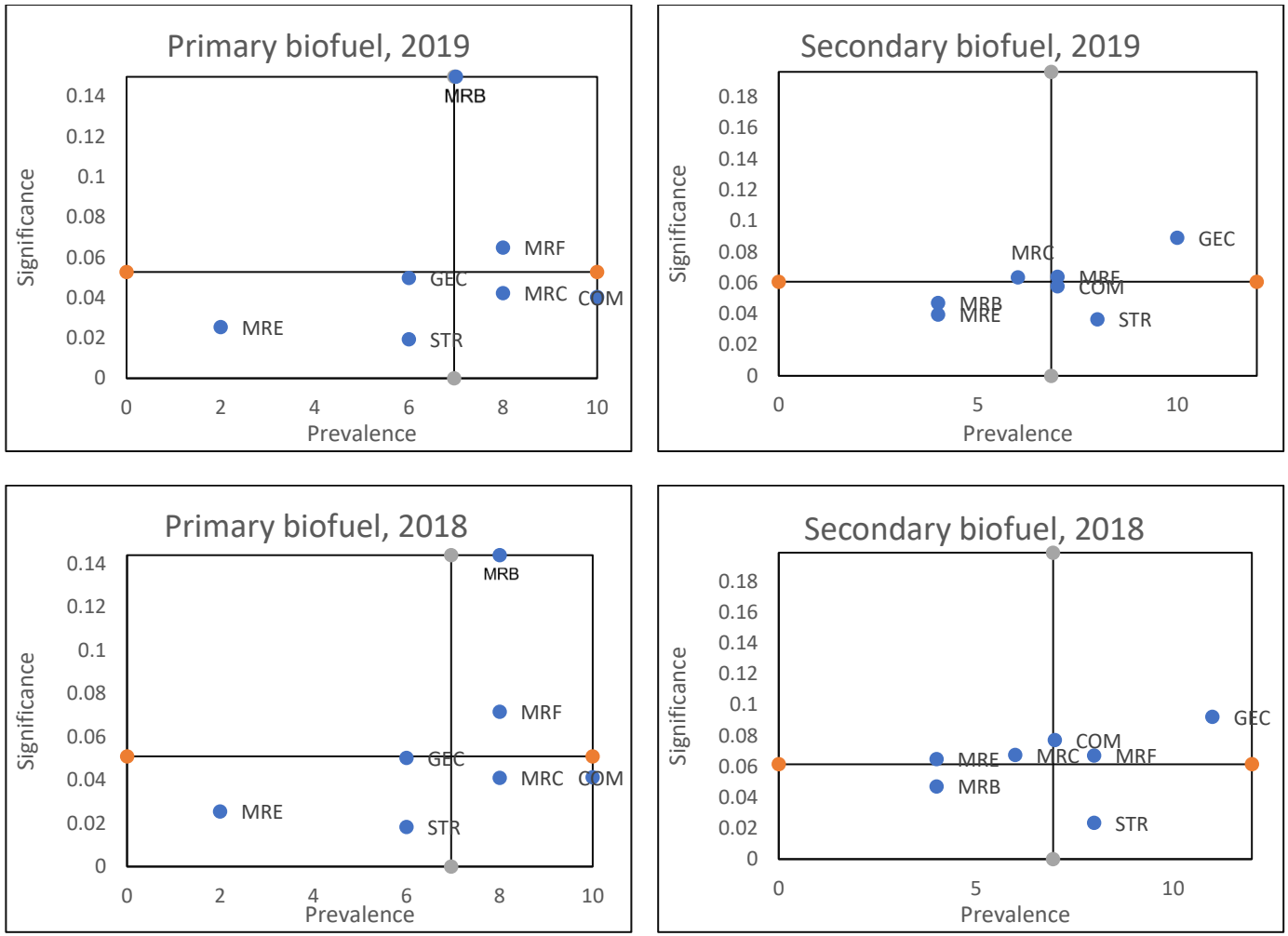


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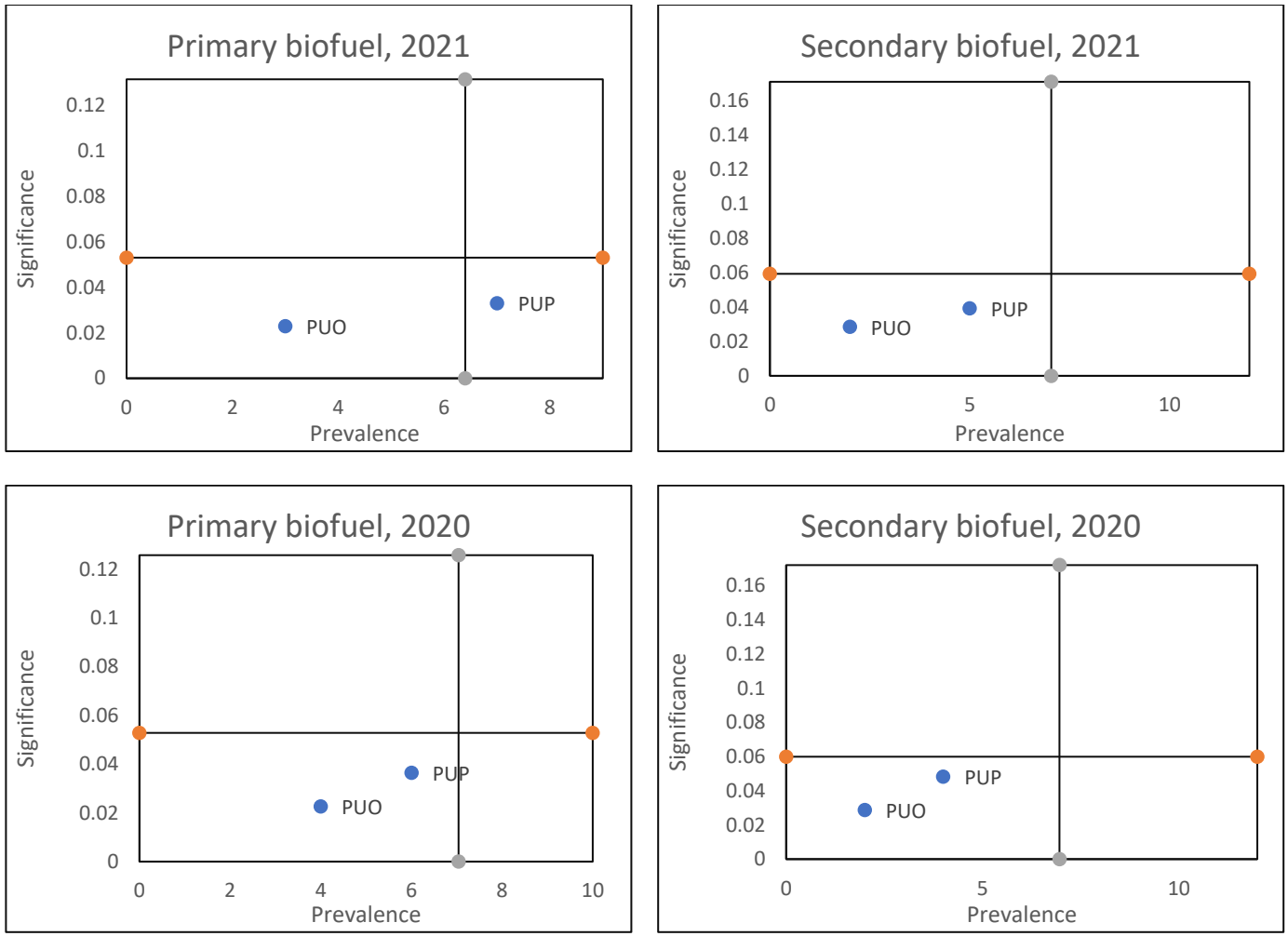


Figure 9: Comparison of social risks between primary biofuel and secondary biofuel companies.

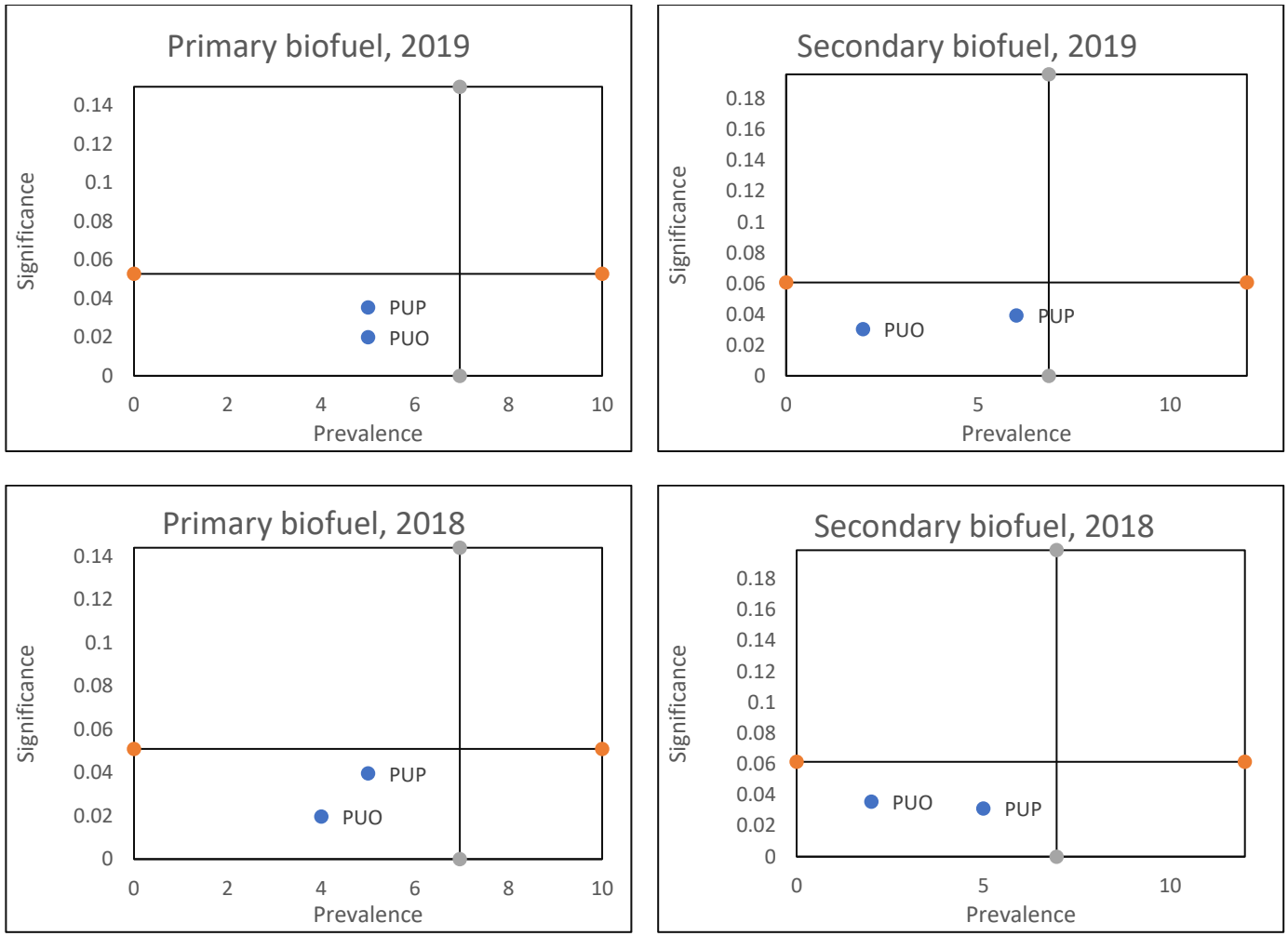


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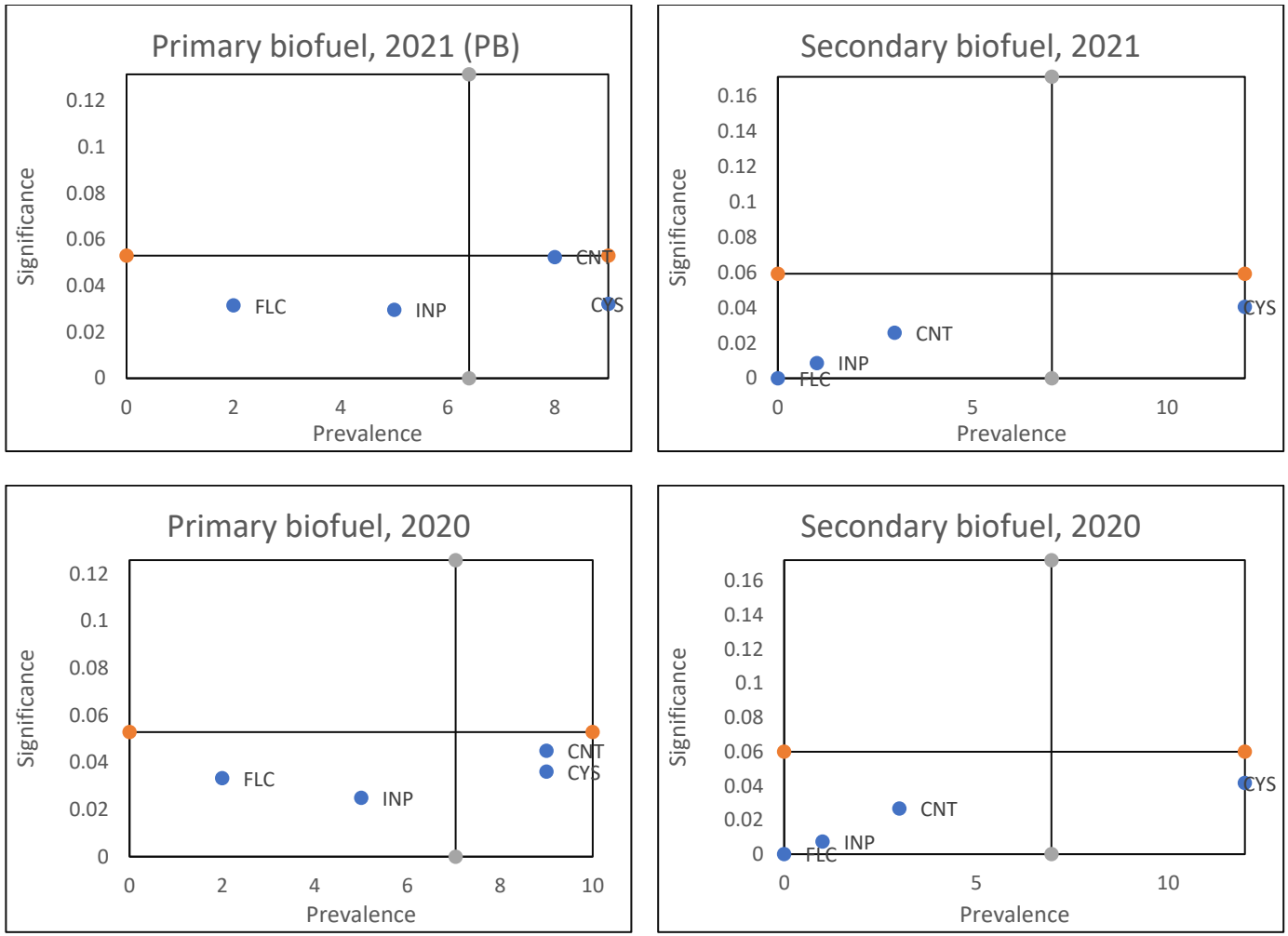


Figure 10: Comparison of technological risks between primary biofuel and secondary biofuel companies.

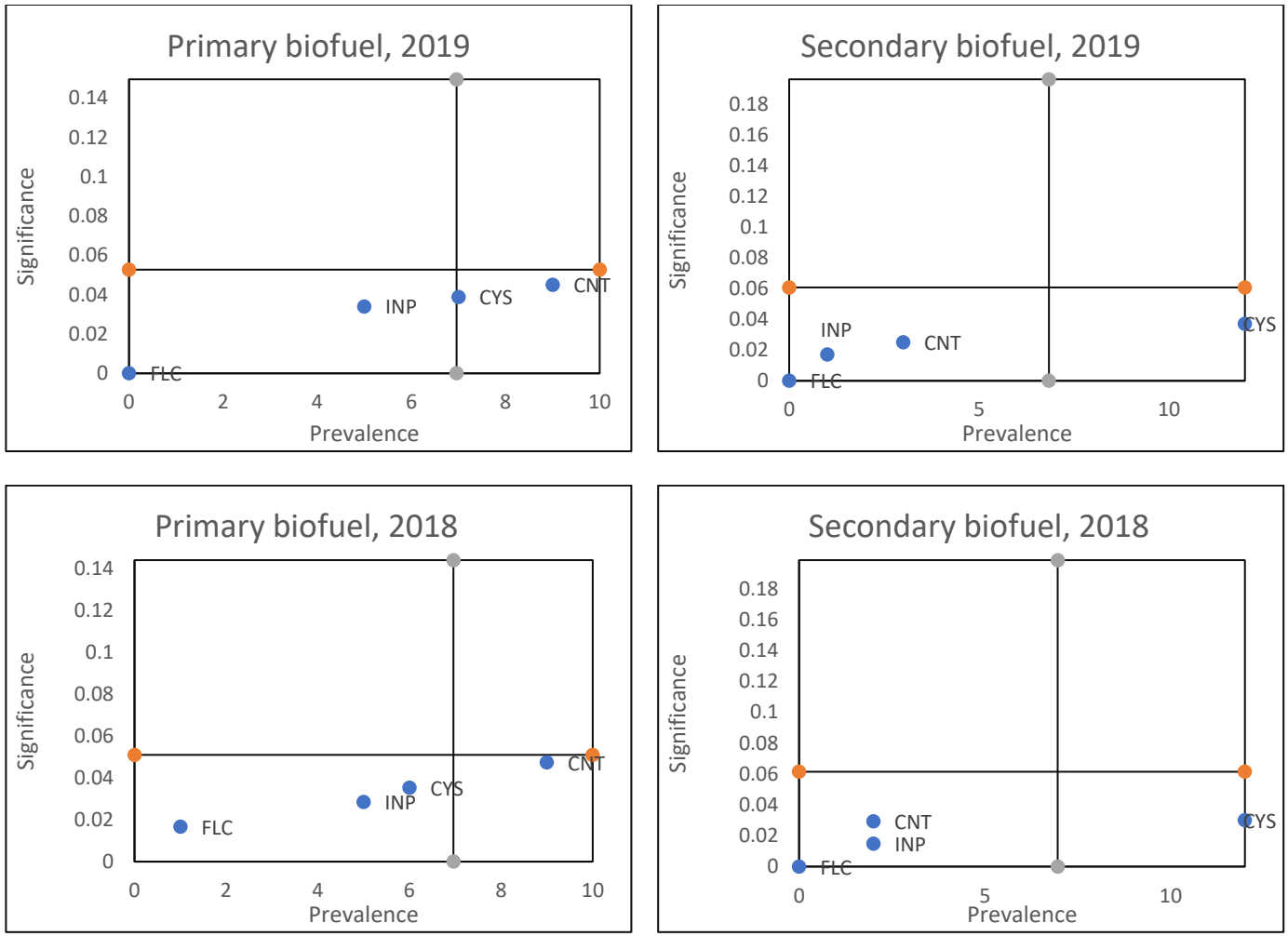


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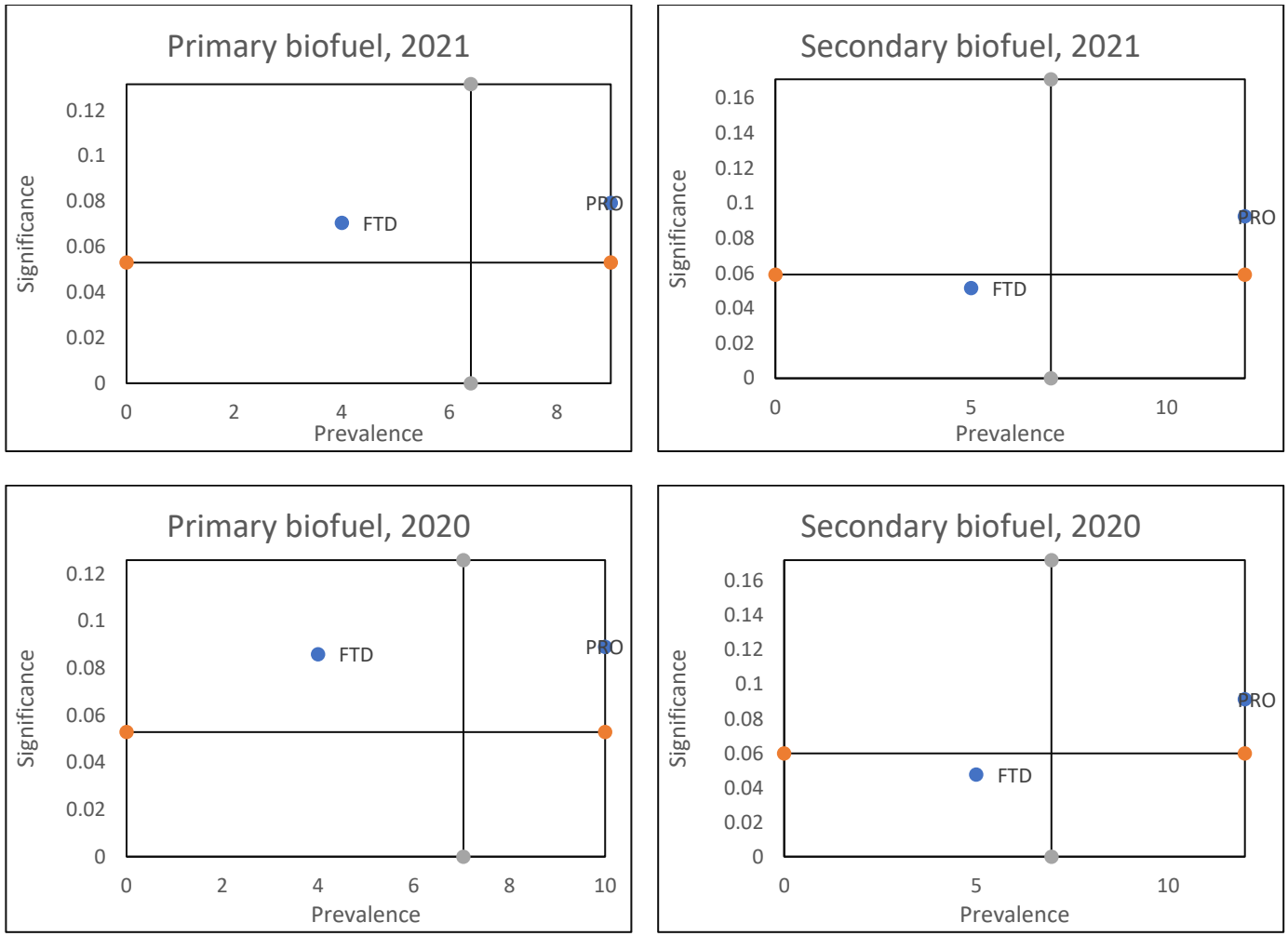


Figure 11: Comparison of primary activities risks between primary biofuel and secondary biofuel companies.

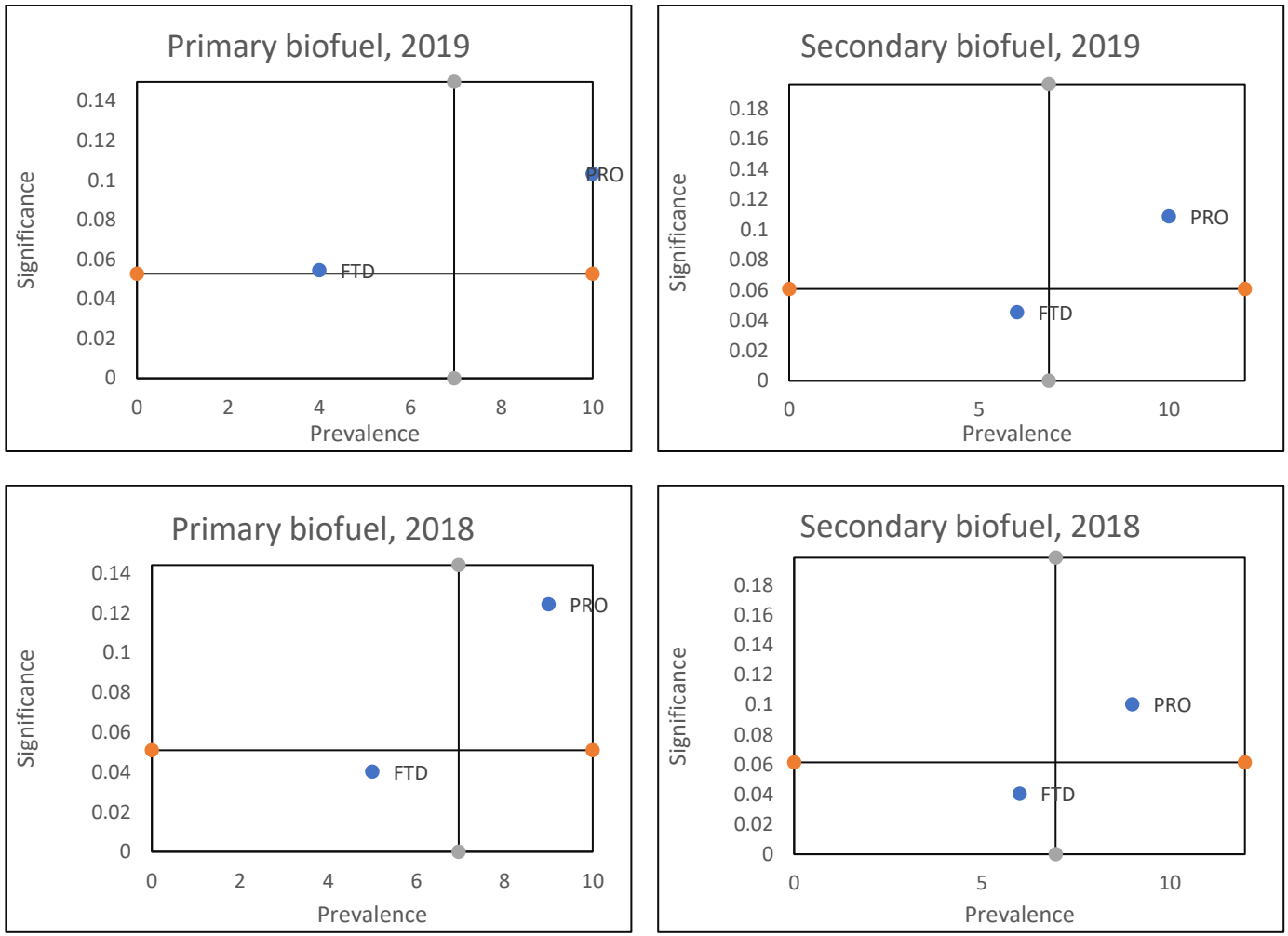


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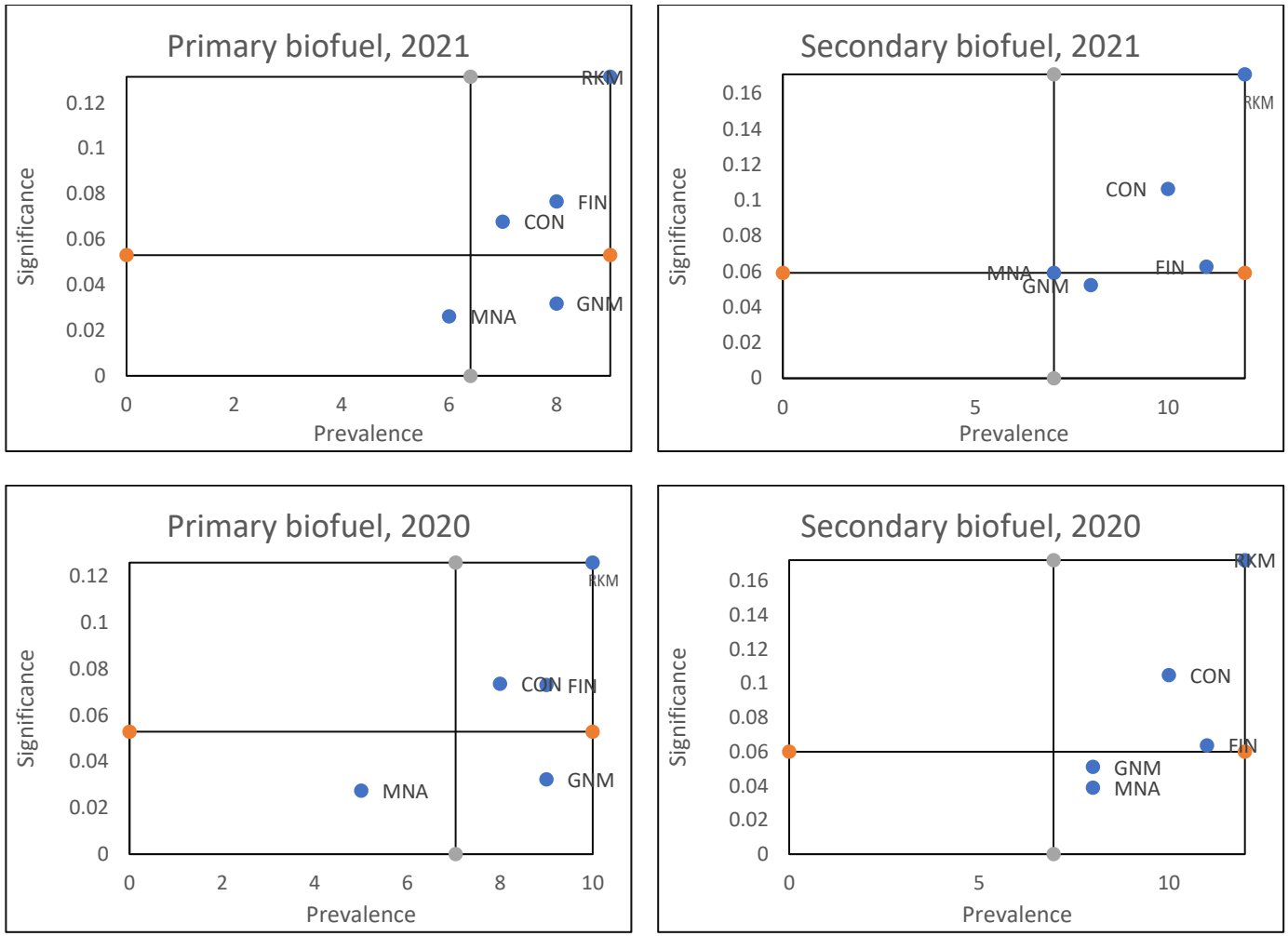


Figure 12: Comparison of support activities risks between primary biofuel and secondary biofuel companies.

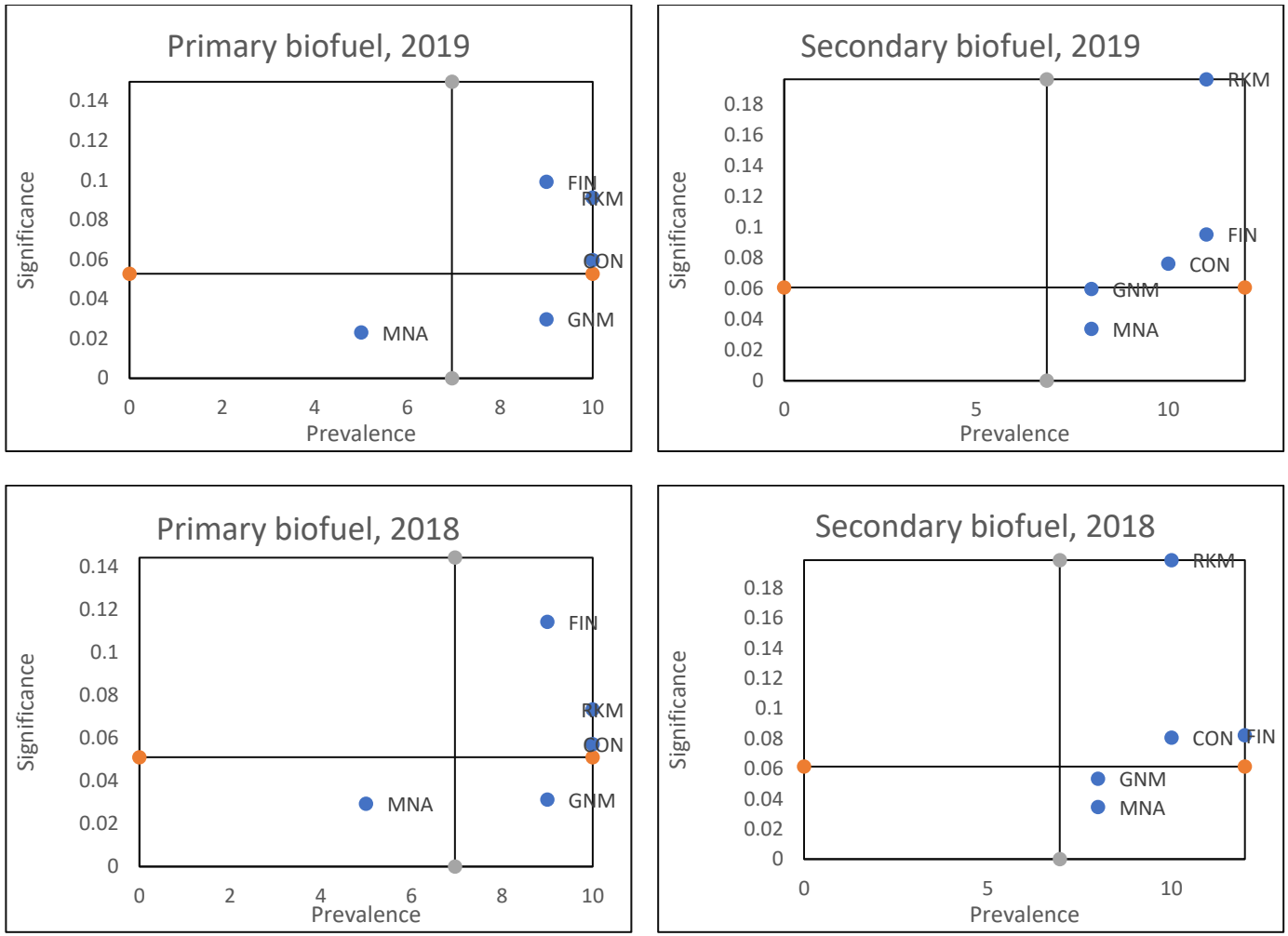


Figure 12 continued.

Table 14: Prevalent and significant risks for Primary Biofuel (PB) companies.

	Prevalent and significant risks for primary biofuel (PB) companies			
Risk categories	**2018**	**2019**	**2020**	**2021**
Political	BFR	BFR	BFR	BFR
Economic	MRB, MRF	MRB, MRF	MRB	MRF, STR, GEC
Social				
Technological				CNT
Primary Activities	PRO	PRO	PRO	PRO
Support Activities	RKM, FIN, CON	RKM, FIN, CON	RKM, FIN, CON	RKM, FIN, CON

Table 15: Prevalent and significant risks for Secondary Biofuel (SB) companies.

	Prevalent and significant risks for secondary biofuel (SB) companies			
Risk categories	**2018**	**2019**	**2020**	**2021**
Political	GNR, EHS	GNR, EHS, INF	GNR, INF	GNR, EHS, INF
Economic	GEC, MRF	GEC, MRF	GEC	GEC
Social				
Technological				
Primary Activities	PRO	PRO	PRO	PRO
Support Activities	RKM, FIN, CON	RKM, FIN, CON	RKM, FIN, CON	RKM, FIN, CON

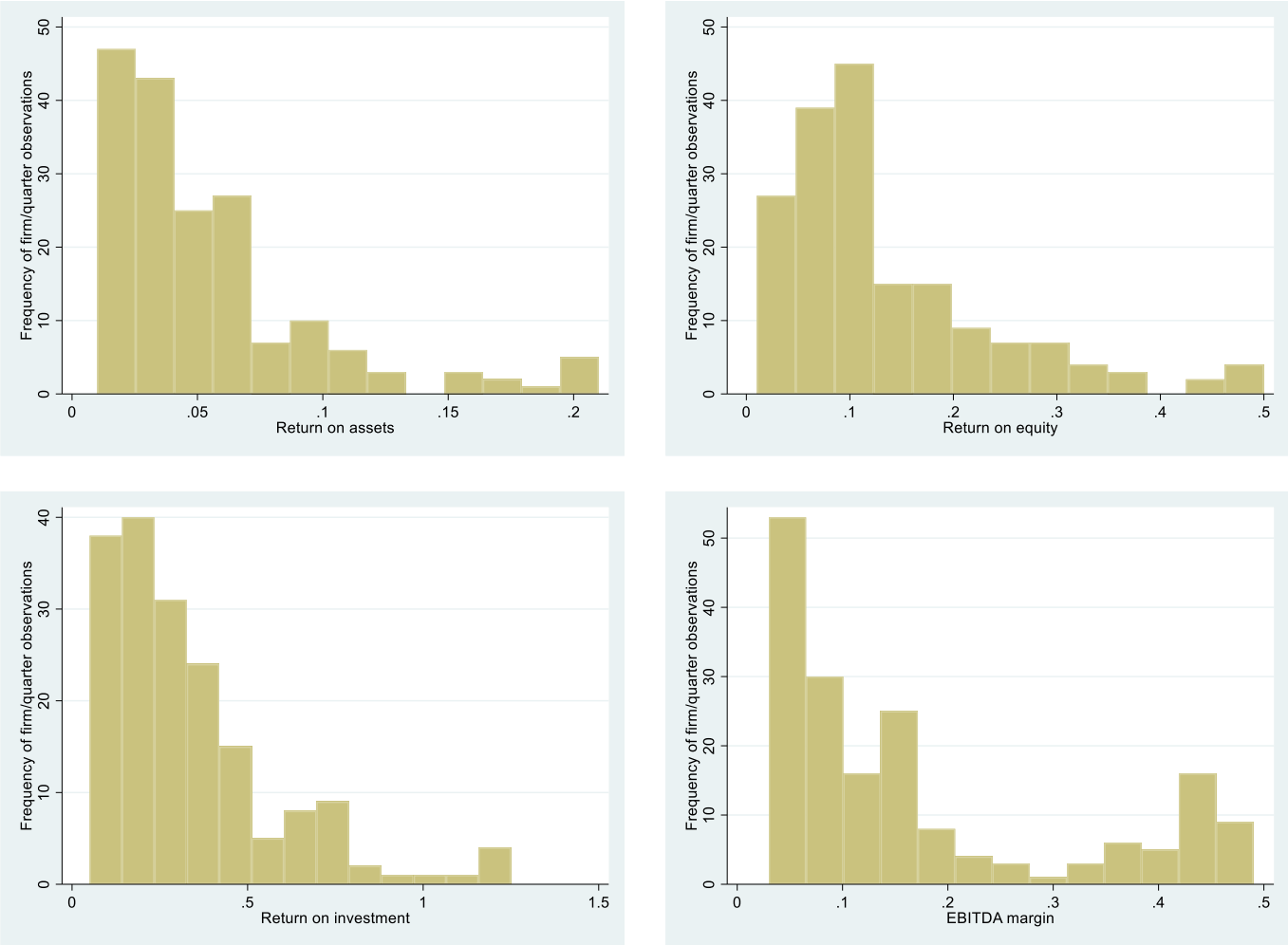
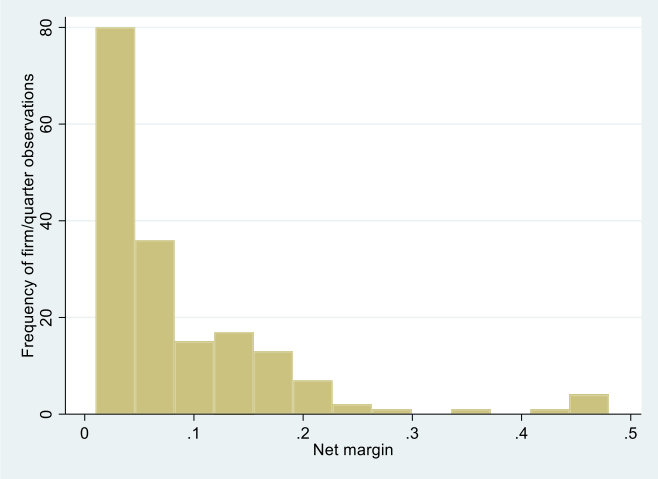
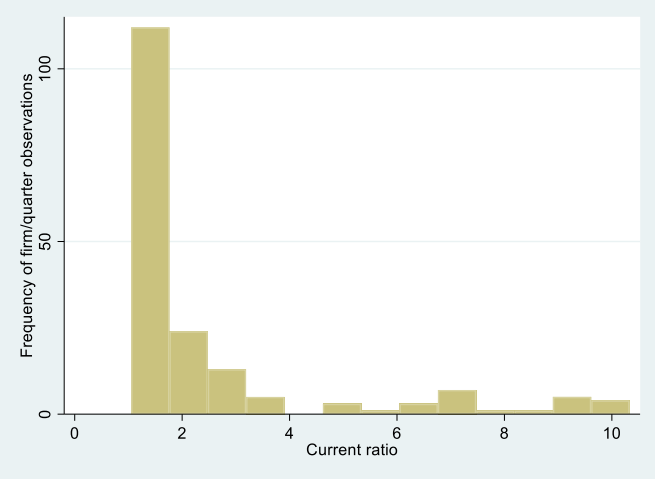
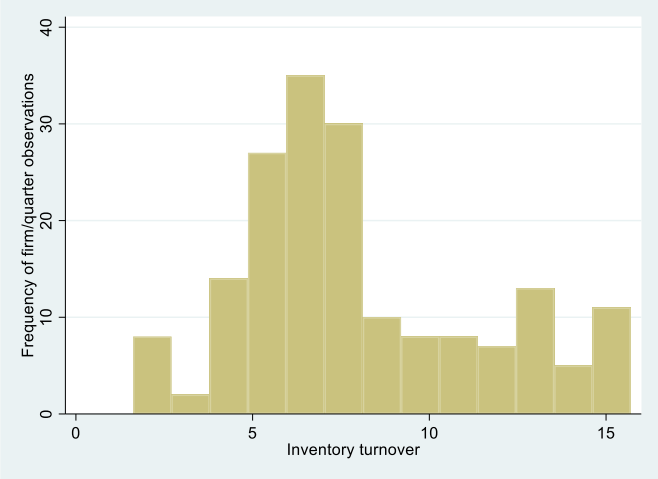


Figure 13: Histograms of the selected financial ratios.







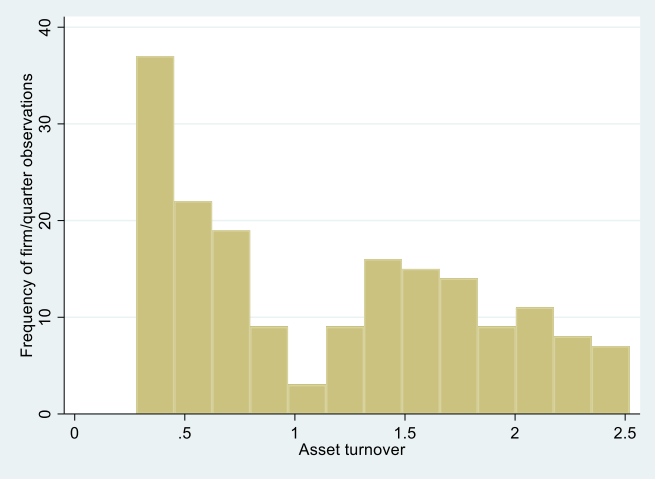


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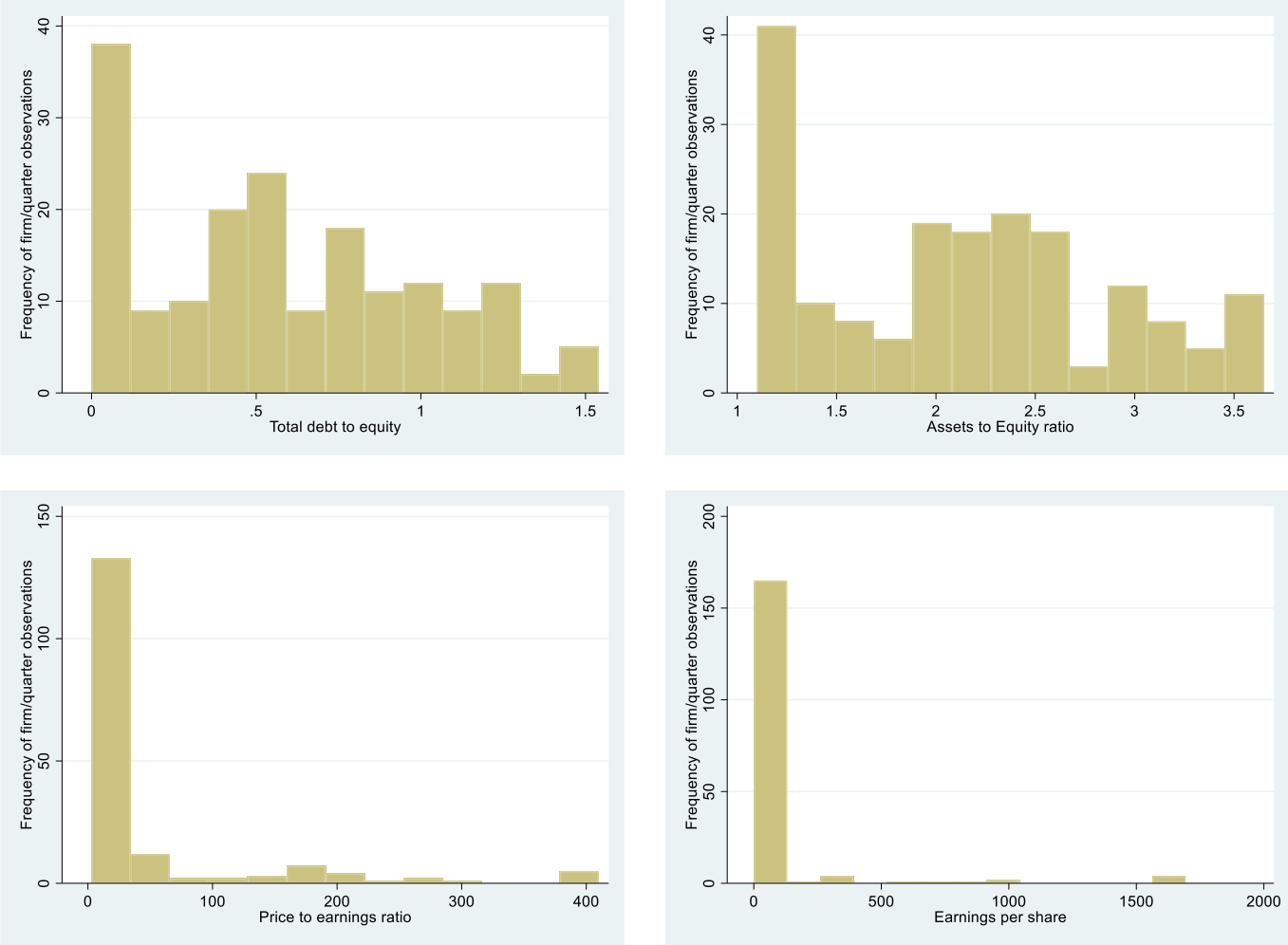
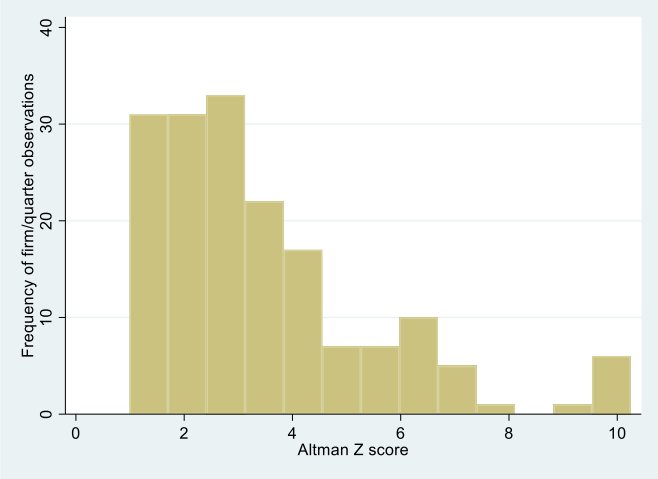
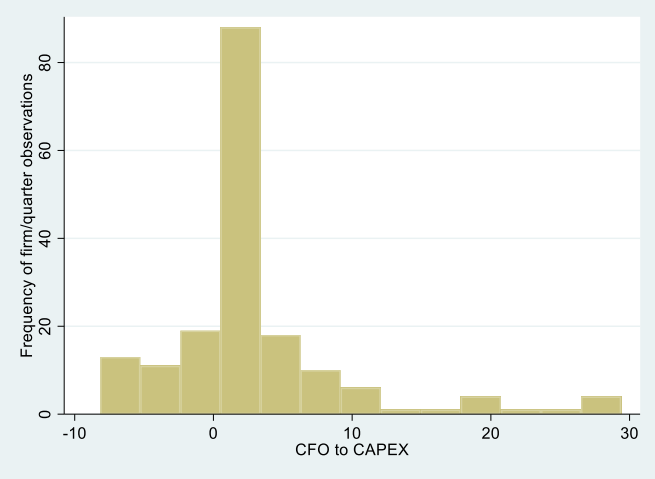


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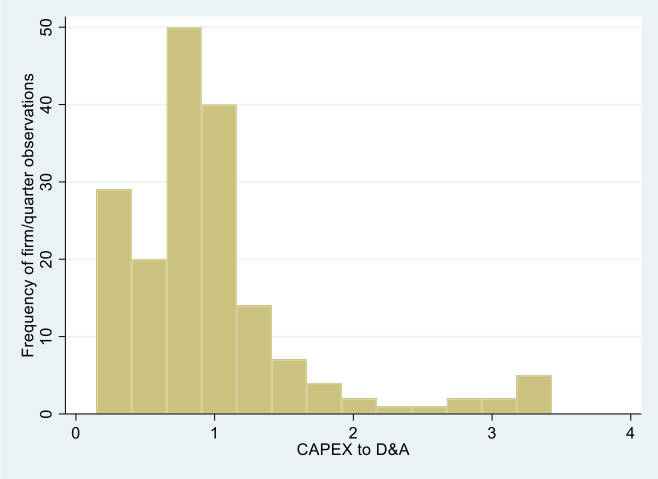


Figure 13 continued.

Table 16: Median values of the financial ratios from 2018 to 2021.

Financial Ratios	**Median**		
	PB	**SB**	**All**
ROA	0.060	0.040	0.040
ROE	0.120	0.110	0.110
ROI	0.295	0.270	0.280
Net income margin	0.075	0.040	0.050
EBITDA margin	0.105	0.120	0.120
Current ratio	3.220	1.460	1.580
Asset turnover	1.355	0.850	1.040
Inventory turnover	8.850	6.960	7.185
Total debt to equity	0.080	0.730	0.520
Assets to equity	1.230	2.460	2.130
P/E ratio	12.039	17.279	15.808
EPS	2.457	2.138	2.225
Altman Z	5.780	2.430	2.930
CFO to CAPEX	5.215	1.620	1.970
CAPEX to D&A	0.550	0.900	0.880

Table 17: Median test to compare PB companies and SB companies from 2018 to 2021.

Financial ratios	**Median test (p-value)**	**Difference (PB-SB)**
ROA	0.071*	0.02
ROE	0.351	0.01
ROI	0.290	0.025
Net income margin	0.014**	0.035
EBITDA margin	0.514	-0.015
Current ratio	0.000***	1.76
Asset turnover	0.033**	0.505
Inventory turnover	0.079*	1.89
Total debt to equity	0.000***	-0.65
Assets to equity	0.000***	-1.23
P/E ratio	0.182	-5.24
EPS	0.833	0.319
Altman Z	0.000***	3.35
CFO to CAPEX	0.000***	3.595
CAPEX to D&A	0.012**	-0.35

Note: PB is the portfolio of companies in primary biofuel category and SB is the portfolio of companies in others category. *** represents 1% level of significance, ** represents 5% level of significance, and * represents 10% level of significance.

Table 18: Correlation analysis of profitability and risk estimates of sample biofuel companies from 2018 to 2021.

	ROA	ROE	ROI	Total debt to equity	Political risk	Economic risk
ROA	1.000					
ROE	0.869***	1.000				
ROI	0.976***	0.895***	1.000			
Total debt to equity	-0.112	-0.070	-0.040	1.000		
Political risk	0.124	0.105	0.161**	0.032	1.000	
Economic risk	-0.280***	-0.190**	-0.295***	-0.115	-0.177**	1.000
Social risk	0.116	0.026	0.077	-0.334***	0.323***	-0.310***
Technological risk	0.096	0.022	0.026	-0.529***	-0.261***	0.014
Primary activities						
risk	0.080	0.096	0.079	0.076	-0.462***	-0.159**
Support activities						
risk	0.069	0.031	0.093	0.330***	-0.247***	-0.714***
Altman Z	0.082	0.072	0.022	-0.688***	0.114	0.262***

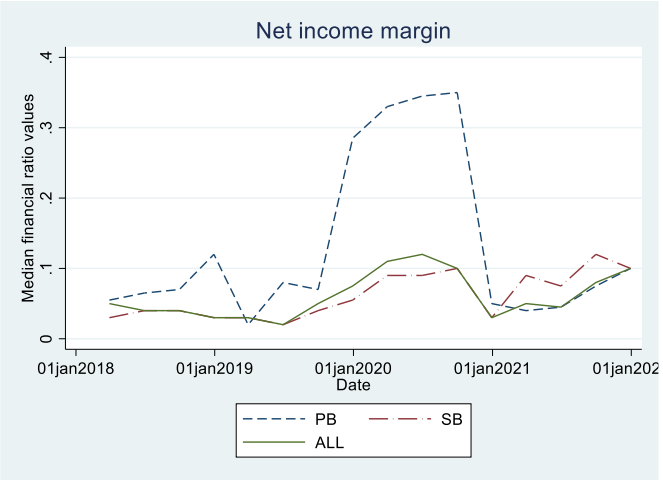
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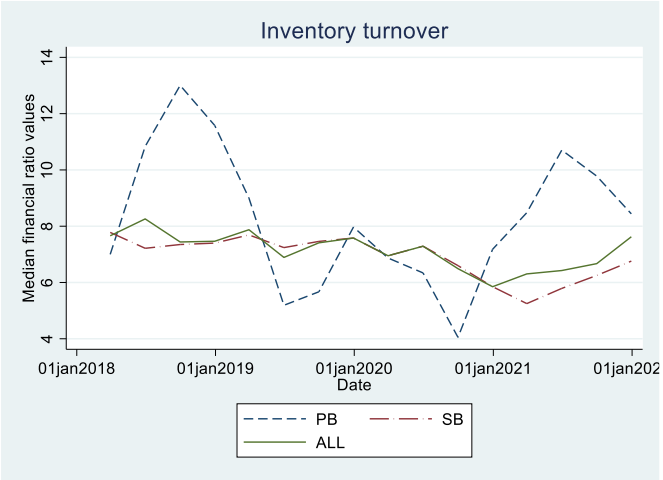
	Social risk	Technological risk	Primary activities risk	Support activities risk	Altman Z
Social risk	1.000				
Technological risk	-0.193**	1.000			
Primary activities risk	-0.294***	-0.036	1.000		
Support activities risk	0.106	-0.139*	-0.072	1.000	
Altman Z	0.213***	0.361***	-0.189**	-0.433***	1.000

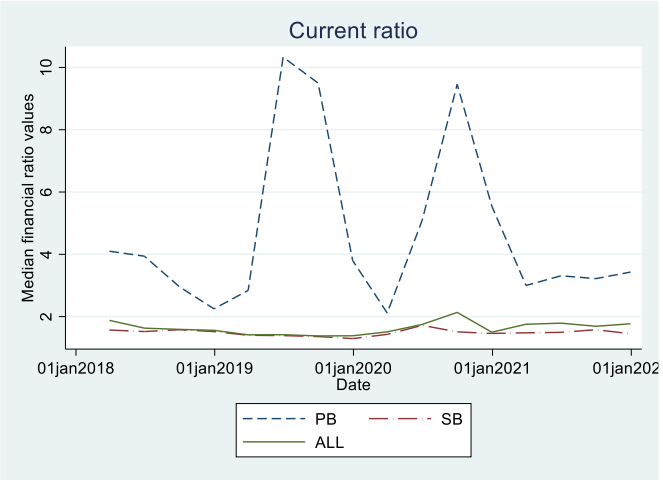
*, **, *** represents statistically significant result at 10%, 5%, and 1% level of significance respectively



Figure 14: Trend analysis of financial ratios, median values from 2018 to 2021.







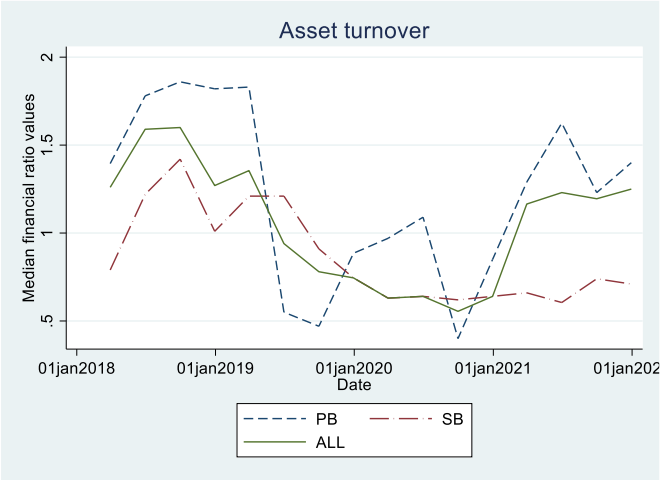
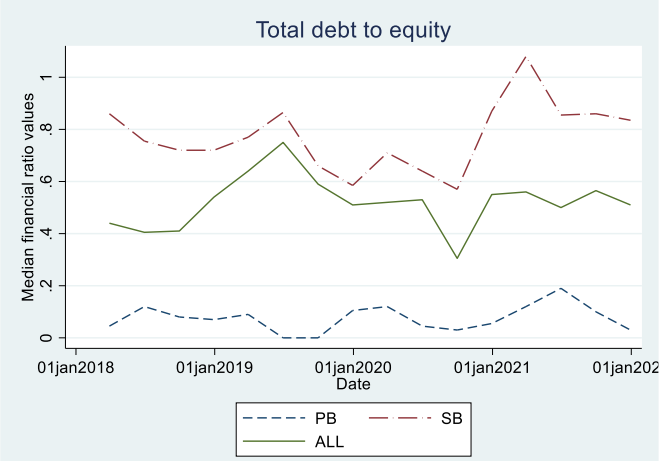
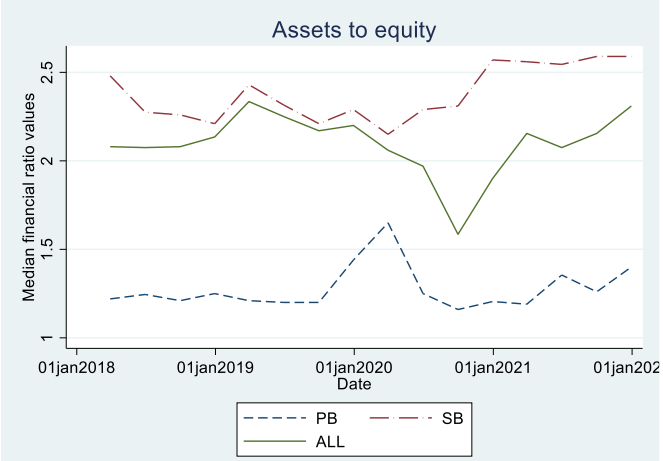


Figure 14 continued.







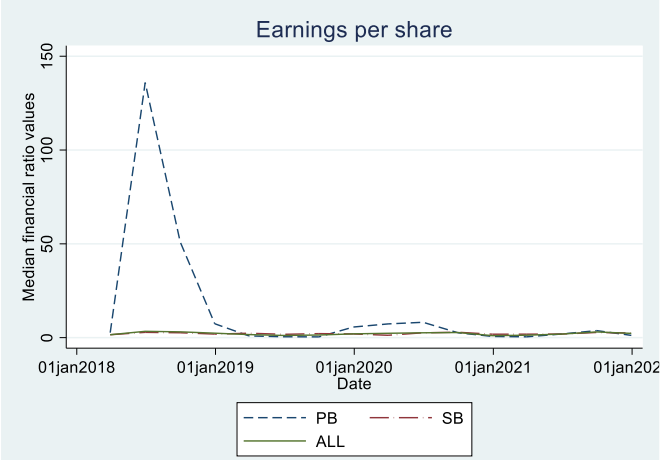
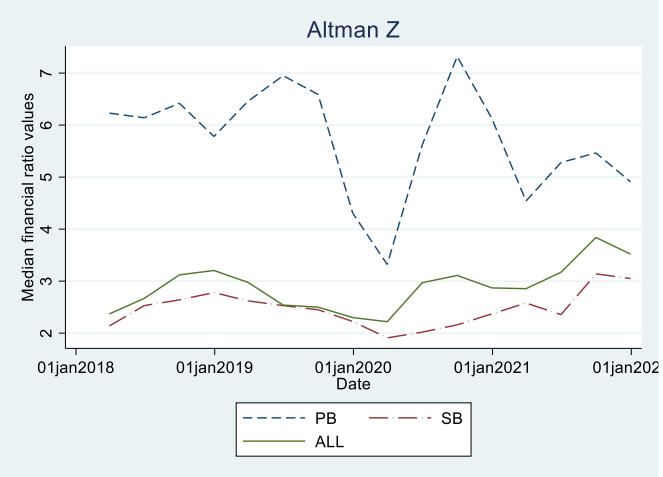
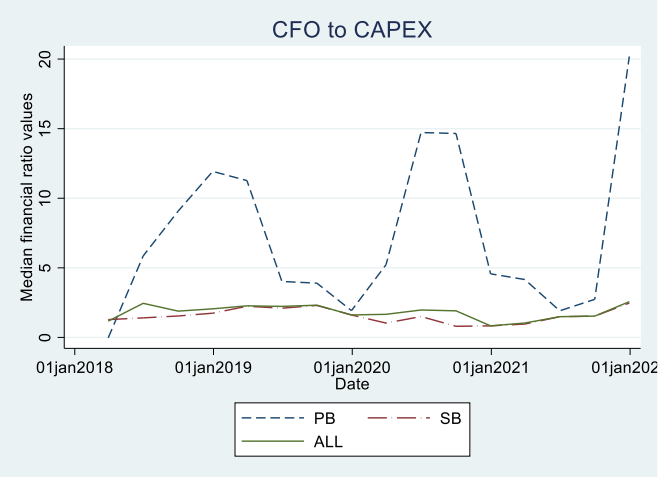


Figure 14 continued.





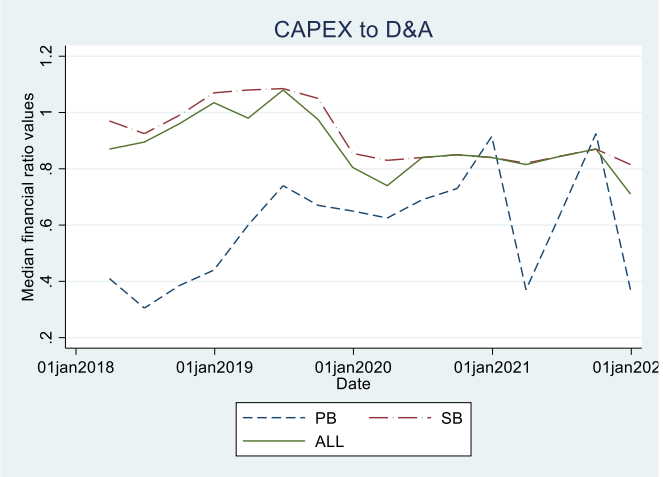


Figure 14 continued.



Figure 15: Average stock returns of PB, SB, ALL portfolio compared to S&P500 from 2018 to 2021.

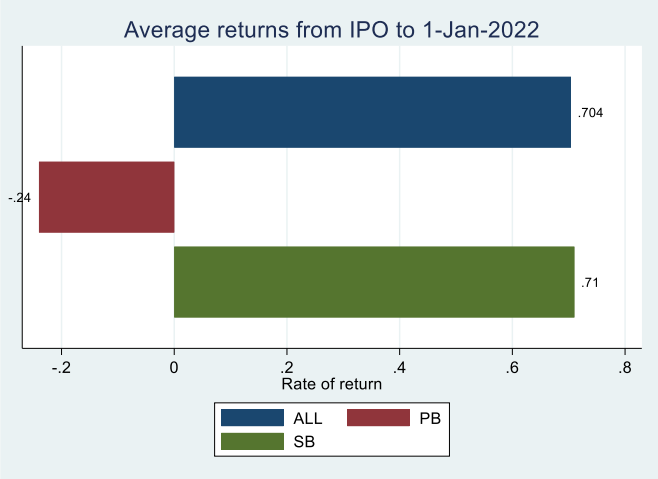


Figure 15 continued.

VITA

Bishal Bista is a master's candidate at the University of Tennessee, Knoxville. He was born in Dailekh, Nepal, on July 14th, 1998. He has a Bachelor of Science in Agriculture from Agriculture and Forestry University, Nepal. After being motivated by his advisor and friends, he decided to pursue graduate school. He was admitted as a graduate research assistant in the Department of Agricultural and Resource Economics in the University of Tennessee, Knoxville. His research interests include agribusiness finance, renewable fuels, and agribusiness management. He fulfilled his course requirements with A's in all the coursework and he is expected to graduate on May of 2023.