Universidade do Minho
Escola de Economia e Gestão

Nuno Afonso Cruz Loureiro

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Master in Finance

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Professor Maria do Céu Cortez

DIREITOS DE AUTOR E CONDIÇÕES DE UTILIZAÇÃO DO TRABALHO POR TERCEIROS

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

Abstract

The fossil fuel divestment movement and its importance on climate change is a recent topic that has been attracting the interest of society. The purpose of this dissertation is to evaluate and compare the financial performance between a portfolio of fossil fuel stocks and a portfolio without fossil fuel stocks from February 2009 to January 2019. To evaluate the performance of the portfolios we use the four-factor model of Carhart (1997). With the objective to overcoming certain limitations of this model, we further evaluate portfolio performance with the conditional model developed by Christopherson, Ferson and Glassman (1998), which allows for time-varying risk and performance. In this model, we use two public information variables that represent the state of the economy.

Our results indicate that the investing in a fossil-free portfolio does not penalize investors relative to the benchmark. However, the fossil fuel portfolio outperforms the green portfolio regardless of the model used. Furthermore, we analyze the exposure of each portfolio to the risk factors and observe that the fossil-free portfolio is exposed to small caps.

Keywords: divestment; green energies; fossil fuels; portfolio performance; climate change.

Resumo

O desinvestimento em combustíveis fosseis e sua importância nas mudanças climáticas é um dos temas da atualidade. O objetivo desta dissertação é comparar o desempenho financeiro de uma carteira constituída apenas com ações de combustíveis fósseis e uma carteira sem ações de combustíveis fosseis para o período de Fevereiro de 2009 a Janeiro de 2019. Para avaliar o desempenho das carteiras, usamos o modelo de quatro fatores desenvolvido por Carhart (1997). Com o objetivo de ultrapassar algumas limitações do modelo anterior, avaliamos ainda o desempenho das carteiras com um modelo condicional desenvolvido por Christopherson, Ferson e Glassman (1998) que assume a variação temporal do risco e desempenho. Neste modelo, utilizamos duas variáveis de informação pública que representam o estado da economia.

Os nossos resultados indicam que investir numa carteira sem empresas de combustíveis fósseis não penaliza o desempenho relativamente ao mercado, embora a carteira de combustíveis fósseis tenha um desempenho superior ao da carteira verde em todos os modelos que implementamos. Adicionalmente, observamos a exposição de cada carteira aos fatores de risco, observando-se que a carteira sem empresas de combustíveis fosseis está exposta a empresas de pequena capitalização.

Palavras-chave: desinvestimento; energias verdes, combustíveis fosseis; desempenho de carteiras; mudanças climáticas

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1. Introduction

We live in a world where the consequences of climate change are more noticeable than ever. Melting ice and rising seas are becoming a problem in a lot of countries that lay near the oceans. Besides, the frequent waves of heat and droughts are affecting the regions more isolated from the oceans. There are many causes that can explain this phenomenon, but greenhouse gas emissions generated by fossil fuel production and use play a relevant role in global warming. In this context, there have been calls for a transition from carbon-intensive fossil fuels to renewable energy (Linnenluecke, Han, Pan and Smith, 2019). In this dissertation, we are going to focus on the financial impact of this trend and address fossil fuel divestment.

Our society relies heavily on fossil fuels, as it represents the main energy source used in the world. However, it is undeniable that burning fossil fuels is extremely harmful to the environment, being one of the main causes of climate change. Specifically, when fossil fuels are burned, carbon dioxide is released into the atmosphere. This will increase the concentration of carbon emission, which will affect the well-being of the planet. Thus, the over-consumption of fossil fuels is leading to serious environmental problems. For that reason, it is necessary to find a more ecological way of providing energy, leading to a more environmentally friendly world.

It is also important to acknowledge the growth of Socially Responsible Investments (SRI), before discussing fossil fuel divestment. Socially responsible investors use environmental, social and governance (ESG) criteria to evaluate companies they might be interested in. ESG criteria are based on three fundamental aspects of the company. First, the environmental criteria, which is associated to the environmental risks associated with the company. Second, the social criteria, which addresses the way how the company handles its stakeholders. Lastly, the governance criteria, that determines the transparency of the company.

The growth of SRI is not something new. For instance, according to Schueth (2003), in the United States, between 1995 and 1999, socially responsible portfolios grew from $162 billion to $1,5 trillion, which means an 800% growth in 4 years. According US SIF (2018), SRI is growing at a rate of 40% per year since 2016 and $12 trillion assets are being managed with ESG criteria.

Socially responsible investors take into account the social damage that is associated with the stocks that they invest in (Dam and Scholtens, 2015). They also may be willing to accept a lower financial return if an environmental gain can be reached.

It is undeniable that fossil fuel divestment is a hot topic nowadays in the media. The social media attention has influenced many companies to change their way of investing. This kind of attention was a result of several protests and campaigns in the past several years to persuade investors to stop owning shares of companies that are associated with producing fossil fuels (The Economist, 2015).

Fossil fuel divestment can be seen as a segment of SRI, in which investors creates portfolios in a way that prevents them from financing companies associated with oil, coal and gas. Those investors form portfolios of securities that are socially responsible, and thus also avoid fossil fuel stocks. Therefore, these SR investors will always have an ethical criterion when forming a portfolio. This kind of mindset is growing fast worldwide.

Figure 1 below shows precisely the kind of institutions that have been most influenced by these fossil-fuel divestment campaigns.

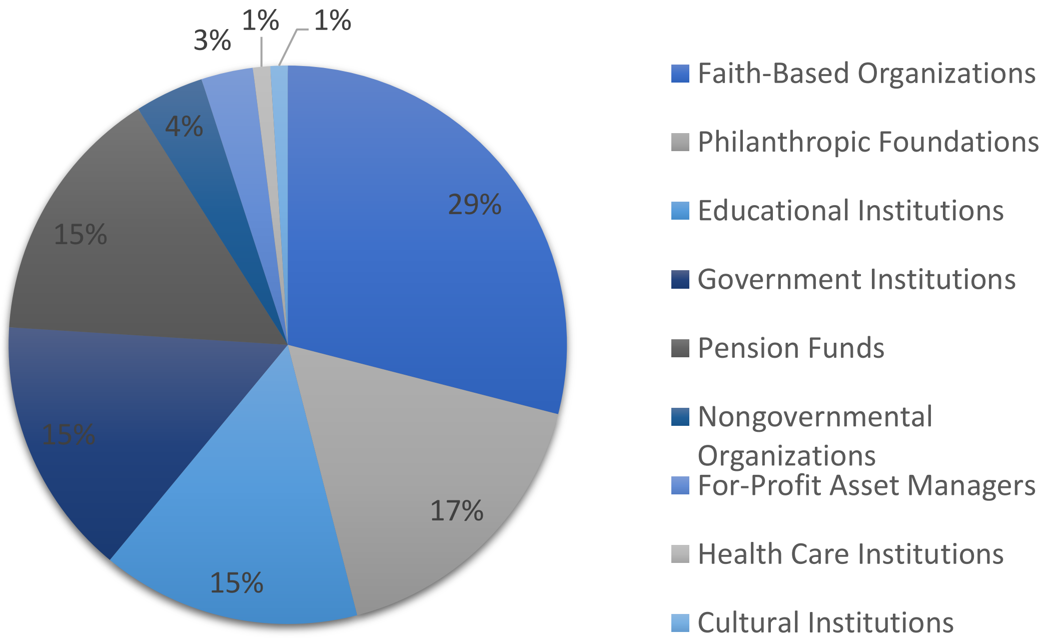

Figure 1: Types of divesting institutions

Source: Arabella Advisors (2016)

In general, the divestment movement has come a long way this decade. The number of institutions divesting is increasing each year. It is believed that the divestment made by some institutions influenced the share prices of fossil fuel companies and some researchers argue that fossil-free portfolios can outperform fossil fuel portfolios.

To sum, this reflects how much society nowadays is more concerned about climate change issues and is willing to invest in more environmentally friendly practices to protect the planet. In the past years, investing with environmental criteria has been growing fast. This is mostly because society´s social view has changed immensely in the last decades. Nowadays, many investors prefer to distribute their capital towards sustainable energy companies instead of investing in companies that are associated with oil, coal and gas.

The literature on the financial impact of fossil fuel divestment in portfolio performance is scarce. Trinks, Scholtens, Mulder and Dam (2018) compare the performance of portfolios with and without fossil fuel companies and find that excluding fossil fuel firms penalizes portfolio performance. However, the measures used to evaluate portfolio performance have some limitations, as they do not consider time-varying risk and performance.

The purpose of this dissertation is to evaluate the financial performance of U.S. portfolios by comparing one portfolio composed by fossil fuel stocks with a second portfolio that is divested from fossil fuel stocks. This second portfolio is formed by stocks of companies from different sectors that use energy in a clean way. We wanted to form a portfolio composed by companies that use clean energy in the most efficient way regardless of their sectors. We believe that comparing the fossil fuel portfolio with a portfolio composed by "clean" companies, which we call green portfolio, is a relevant topic, considering that we are facing a climate emergency (Ripple et al, 2020). We contribute to the literature by using robust models of performance measurement, namely conditional models, as developed by Ferson and Schadt (1996) and Christopherson, Ferson and Glassman (1998) to evaluate portfolio performance.

2. Literature Review

2.1. Ethical divestment

Ethical divestment occurs when private investors or institutional investors decide to sell stocks or debt from companies that are related with unethical behavior. An example of companies with this kind of activities are those in the 'sin' sector. These 'sin stocks' are associated to activities or products considered controversial or that violate ethical and religious standards, such as tobacco, alcohol and gambling, and are typically shunned by values-driven investors that use negative screens (Derwall, Koedijk and Ter Horst, 2011). However, there is evidence that portfolios of stocks of these companies can generate abnormal returns (Hong and Kacperczyk, 2009). Other examples of divestment are the divestment of fossil fuels stocks and chemicals to avoid the degradation of the environment.

2.2 Fossil fuel divestment

Burning fossil fuels is one of the main causes of climate change. For that reason, activists realized that it is necessary to increase public awareness about fossil fuel divestment. This awareness was highly influenced by Bill McKibben, who in 2012 published an article in the Rolling Stone Magazine entitled "Global Warming´s Terrifying New Math". He argued that people should understand the importance of divestment by pointing out that the rate of fossil fuel burning was five times greater than the "reasonable" amount at the time (McKibben, 2012). Many campaigns organized by a group called 350.org, made efforts to persuade institutions to divest some of their financial assets from the fossil fuel sector. The increasing debate about climate change and its causes made a huge impact on society. For example, in Australia divestment is strongly support by citizens and students who carry out campaigns in universities (Kemp, 2016). This is reflected worldwide as we see many institutions throughout the years who went on board with divestment, for instance large institutions such as Stanford University and Norway's sovereign-wealth fund (The Economist, 2015). Another example is the University of California that in 2015 sold 200 Million dollars in coal and oil holdings (Hiltzik, 2016). And the list goes on with many well-established institutions such as Rockefeller Brothers Fund and insurance company AXA, among others, who decided to divest from fossil fuels (Braungardt, Van den Bergh, and Dunlop, 2019). In 2018, Ireland was the first country that committed to divest from fossil fuels. The latest report by 350.org (2019) indicates that in September of 2019, $11 trillions of assets were divested from fossil fuels. More than 1100 institutions, from various types as shown in Figure 1, committed to divesting from fossil fuels. This represents a huge increase from 2014, when the assets committed were of $52 billion from 181 institutions. The great increase of institutions adopting divestment strategies shows how much this movement has grown around the world. And 70% of the institutions embraced with this cause are from outside of the United States. Although most of the institutions that embargo in the divestment are non-profitable, it is also reported that banks, such as Crédit Agricole and insurance companies, like AXA, have divested from fossil fuel investments.

2.2.1 Arguments in favor of fossil divestment

The most common argument for people to divest from fossil fuel stocks is the fact that this sector contributes to climate change. Since investing in fossil fuels harms the planet, some people argue that it puts people's life in danger (Moss, 2016). Therefore, investing in these stocks means an indirect contribution from investors to climate change. Divestment campaigns put pressure on banks and institutions to divest, which will affect the financing of fossil fuel companies. This will affect their exploration capacity and consequently reduce the supply of fossil fuels (Braungardt, Van den Bergh, and Dunlop, 2019).

From a financial perspective, fossil fuel divestment can be beneficial as it excludes assets that can be stranded due to high climate and financial risks (Rezec and Scholtens, 2017; Henriques and Sadorsky, 2018; Hunt and Weber, 2019). The divestment on fossil fuel gives an opportunity to investors to re-invest in low-carbon companies. According to Arabella Advisors (2016), from 2010 to 2015 there was an increase of 20% on clean energy investments and a 4% increase from 2014 to 2015. This increase results from a number of institutions deciding to divest from fossil fuel and channeling their investments towards clean energy projects. Divestment can also have an educational impact. Universities can use divestment as a way to teach younger generations how to invest responsibly (Cleveland and Reibstein, 2015). This can be accomplished by urging students not only about the risks of climate change but also the negative externalities that fossil fuels have on the society.

Fossil fuel divestment fails on having a strong direct impact on public-traded companies and government entities. However, it has a several indirect impacts on different parts of the society. For instance, the cultural impact will change people's point of view about divestment. People take action by making divestment campaigns in order to raise the awareness about the fossil fuel consequences. This will have political impact, which will eventually lead to indirect financial impact (Bergman, 2018).

2.2.2 Arguments against fossil divestment

In contrast, some researchers argue that fossil fuel divestment does not have a climate impact and it is only being used as a way of creating political impact with no regards for the environment consequences. Moreover, Ritchie and Dowlatabadi (2015) analyzed some aspects of the divestment movement. They reported that divestment does not reduce the exposure to fossil fuel for institutional investors, because many green energies suppliers still rely on fossil fuels. There are fewer investment opportunities for green energies companies in comparison with fossil fuel companies, so there is a possible loss of diversification in stake. In fact, those that are not in favor of divestment argue that this kind of strategy will result in diversification costs. In general, investors will have fewer stocks to invest in, which may result in a more inefficient performance of the portfolio (Le Maux and Le Saout, 2004).

It is also important to understand the lack of direct impact that divestment has on the economy. According to Ansar, Caldecott and Tilbury (2013), the direct impact of divestment of fossil fuel companies on the economy is small. They argue that the amount of capital divested is not enough to affect shares prices and companies like ExxonMobil will not notice any reaction in their stocks.

2.3 Performance of fossil fuel firms vs non-fossil fuel firms

The increasing engagement to fossil fuel divestment strategies casts doubts on whether or not socially responsible investors would be losing returns in comparison with conventional investors. There is no consensus regarding the performance of portfolios when considering fossil fuels stocks divestment. On the one hand, some studies argue that a fossil fuel-free portfolio would outperform the market. For instance, Halcoussis and Lowenberg (2019) compare the rate of return of a fossil fuel-free portfolio with the S&P 500 index. They also compare a portfolio composed of fossil fuels stocks with the S&P 500. Their results show that the portfolio free of fossil fuels has a slightly higher rate of return than the overall market.

Moreover, Trinks, Scholtens, Mulder and Dam (2018) evaluate the performance of US portfolios with and without fossil fuel firms and find that fossil-free portfolios do not underperform the market, which could be explained by the "limited diversification benefits" that fossil fuel company stocks provide. Furthermore, during the first years of divestment campaigns, they noted that fossil fuel portfolios would underperform coal-free portfolios. Henriques and Sadorsky (2018) perform a comparison between three portfolios: one with fossil fuel companies and utilities, another with clean energy companies and another portfolio without fossil fuel companies, utilities and also without clean energy companies. The authors show that replacing fossil fuels and utilities with clean energy will result in a higher risk-adjusted return on the U.S market. Hunt and Weber (2019) also find that higher risk-adjusted performance of a portfolio reflecting divestment strategy. This type of evidence was also found by Hunt and Weber (2019), who analyze the effect of divestment strategies in the Canadian market and find that divestment leads to higher risk-adjusted returns.

Specifically focusing on the energy sector, Ng and Zheng (2018) compare the performance of US green and non-green energy portfolios and find that that green energy firms perform at least as well as non-green energy firms.

3. Methodology

To fulfill the objectives of this dissertation, two types of portfolios will be constructed. The first one is a fossil-free portfolio and the second one is a portfolio with fossil fuel stocks. The goal is to investigate the impact that divesting in fossil fuels will have on the financial performance of a portfolio.

To evaluate portfolio performance, we use a multi-factor model that captures recognized sources of systematic risk. The four-factor model developed by Carhart (1997) is given by:

$$r_{p,t} = \alpha_p + b_{p1}(r_{m,t}) + b_{p2}(SMB_t) + b_{p3}(HML_t) + b_{p4}(MOM_{p,t}) + \varepsilon_{p,t} \tag{1}$$

Where:

$r_{p,t}$: the excess return of fund p (over the risk-free rate);

$r_{f,t}$: risk-free rate;

$r_{m,t}$: the market excess return;

SMB_t (small minus big): difference in returns between a portfolio of small stocks and a portfolio of large stocks;

HML_t (high minus low): difference in returns between a portfolio of high book-to-market stocks and a portfolio of a low book-to-market stocks;

$MOM_{p,t}$(momentum): difference in the returns of a portfolio of a past winners and a portfolio of past losers;

$b_{p1}, b_{p2}, b_{p3}, b_{p4}$: factor coefficients;

$\varepsilon_{p,t}$: Error term;

α_p: Alpha of the portfolio.

Considering the limitations of the previous model, namely the fact that it assumes constant risk exposures over time, Ferson and Schadt (1996) develop a conditional of the model for evaluating performance. This model allows beta to vary over time according to public information variables that represent the state of the economy. In general, the model assumes that a set of predetermined variables (Z_{t-1}) will influence risk. Christopherson, Ferson and Glassman (1998) extended this model to allow both time-varying risk and performance, as follows:

$$r_{p,t} = \alpha_{0p} + \alpha'_p Z_{t-1} + \beta_{op} r_{m,t} + \beta'_p r_{m,t} Z_{t-1} + S_{op} SMB_t + S'_p SMB_t Z_{t-1} + h_{op} HML_t + h'_p HML_t Z_{t-1} + p_{op} MOM_t + p'_p MOM_t Z_{t-1} + \varepsilon_{p,t} \tag{2}$$

Where

α_{0p} : the fund average conditional performance measure;

Z_{t-1} : the vector of lagged information variables measured as deviations;

from their averages $(\mathrm{z_{t-1}} = \mathrm{Z_{t-1}} - \mathrm{E(Z)})$;

β'_p: The vector that measures the conditional beta in relation with the public information variables;

β_{op}: Average beta;

α_{0p} : Average alpha;

α'_p : Vector that measures the reaction of alpha to the public information variables;

4. Data

We start by identifying companies in that are fossil-fuel related and those that are not. To select fossil fuel companies, we identified in Datastream 372 US stocks belonging to the oil and gas sectors. Of those 372, we excluded 167 of them because of limited data on Datastream.

Regarding non-fossil fuel firms, we used The Carbon Clean 200 (CC200) list of 2019 to identify clean energy companies. This list reports the 200 largest public companies ranked by green energy revenues. It uses negative proxies in order to exclude oil and gas companies. The companies who are on this list have 100% of the energy that they consume coming from renewable sources. From this list, we selected U.S. companies, resulting in 34 stocks. However, from those 34 we were not able to extract data from 2 of them so we ended up with 32 stocks.

From the Datastream database provided by Thomson Reuters, we extracted companies' monthly total return series from January 2009 to January 2019, and calculated returns in a discrete way.

Next, two portfolios were formed, the first one composed of fossil fuel-related companies and the second one is a portfolio formed with companies from various sectors, that use clean energy, which we call the green portfolio. In table 1 we present the companies that form the fossil-free portfolio and the sector that it belongs to. 1

Table 1 – Companies belonging to the fossil-free portfolio

Company	Sector
Alphabet	Communication Services
Cisco Systems Inc	Information Technology
HP Inc	Information Technology
Tesla Inc	Consumer Discretionary
CSX Corp	Industrials
Ecolab Inc	Materials
Ball Corp	Materials
Air Products and Chemicals Inc	Materials

[1] The list of the fossil-fuel companies is presented in Appendix 1.

Green Plains Inc	Energy
Acuity Brands Inc	Industrials
Emerson Electric Co	Industrials
McCormick & Company Inc	Consumer Staples
First Solar Inc	Information Technology
Workday Inc	Information Technology
Prologis Inc	Real Estate
Autodesk Inc	Information Technology
Republic Services Inc	Industrials
BorgWarner Inc	Consumer Discretionary
Renewable Energy Group Inc	Energy
Quanta Services Inc	Industrials
SunPower Corp	Information Technology
EMCOR Group Inc	Industrials
Pacific Ethanol Inc	Energy
Cree Inc	Information Technology
Owens Corning	Industrials
Avangrid Inc	Utilities
Itron Inc	Information Technology
Clearway Energy Inc	Utilities
Andersons Inc	Consumer Staples
Hubbell Inc	Industrials
Regal Beloit Corp	Industrials
Timken Co	Industrials

We also computed the difference portfolio, corresponding to the difference between the returns of the green portfolio and the fossil fuel portfolio. Table 2 describes the portfolios formed.

Table 2 –Summary of the portfolios used

Portfolio	Portfolio's description	Number of stocks
Fossil fuel Portfolios	It is an equally weighted portfolio is composed by NYSE and NASDAQ oil and gas stocks retrieved and identified in DataStream.	205
Green Companies Portfolio	The stocks were retrieved from DataStream and identified using the Carbon Clean 200 list. This list uses negative screens to exclude oil and gas companies.	32
Difference portfolio	This portfolio is formed by performing the subtraction between the green portfolio and the fossil fuel portfolio.	

As the market benchmark, we used two indexes: a general market index (Standard & Poor's composite 500) and a sector index (Standard & Poor's 500 Energy). Data on these indexes were collected from Datastream. The remaining risk factors, SMB, HML and MOM, as well as the risk-free rate, were collected from Kenneth's French website2.

Finally, for the conditional models, two public information variables were used: the dividend yield and the short-term rate. These variables were also used by Ferson and Warther (1996) for the US market. The dividend yield is based on the Dow Jones Industrials Average Index and retrieved from Datastream. The short-term rate is the monthly interest rate of the United States and was retrieved from the OECD database.

Both variables are lagged 1-month. Because these variables tend to have a higher level of correlation, they were stochastically detrended, as suggested by Ferson, Sarkissian and Simin (2003). The public information variables are also used in terms of their deviation from the mean.

2 http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/index.html

Table 3 presents the descriptive statistics of portfolio excess returns and of the variables involved in these regressions.

Table 3

This table shows the descriptive statistics of monthly excess returns of the equally weighted green and fossil fuel portfolios, the benchmarks used as the market risk factor, S&P Energy and S&P 500, the remaining Carhart four-factor model risk factors, SMB, HML and Mom and the public information variables used in the conditional models, dividend yield (DY) and short term interest rate (STR) both lagged 1-month.

VARIABLES	N	mean	p50	sd	min	max	kurtosis	skewness	jbera	p-value
Green	120	0.015	0.018	0.059	-0.168	0.188	3.908	-0.183	4.793	0.091
S&P Energy	120	0.005	0.012	0.057	-0.129	0.170	3.125	-0.180	0.729	0.69
Fossil Fuel	120	0.051	0.031	0.118	-0.171	0.511	5.091	1.120	46.94	6.4
S&P 500	120	0.012	0.015	0.039	-0.107	0.109	3.615	-0.370	4.637	6.4
SMB	120	0.001	0.003	0.024	-0.05	0.061	2.591	0.172	1.428	0.489
HML	120	-0.001	-0.003	0.025	-0.073	0.083	4.249	0.614	15.34	4.7
Mom	120	-0.268	0.002	0.047	-0.344	0.103	24.18	-3.361	2470	0
DY	120	0.00	-0.012	0.281	-0.764	1.483	10.43	1.237	306.8	2.4
STR	120	0.00	0.04	0.439	-1.680	0.752	8.001	-2.133	216	1.2

By comparing the results of the fossil fuel portfolio and the green portfolio, it is possible to see that the average excess return of the fossil fuel portfolio is 5.1% while the green portfolio has an average excess return of 1.5%. If we turn now to the values of the standard deviation, they show that the fossil fuel portfolio has a higher risk than the green portfolio, 11.8% and 5.9%, respectively. This means that the fossil fuel portfolio exhibits higher returns, but it also has a higher risk.

Furthermore, continuing the analysis of the descriptive statistics reported in table 3, the excess returns from both benchmarks are 1.2% and 0.53%, with the S&P 500 S&P Energy indexes, respectively. This is evidence that both the fossil fuel portfolio and green portfolio exceed both market indexes in terms of the mean average excess returns. The fossil fuel portfolio is the one with higher average excess returns among the portfolios and the market indexes. Table 3 also shows the descriptive statistics for the rest of the risk factors of the four-factor model of Carhart (1997) - SMB, HML and MOM - and for the public information variables (short-term interest rate and the dividend yield).

5. Empirical results

In this section, we will analyze the performance of the fossil fuel portfolio and the green portfolio from February 2009 to January 2019. We start by presenting the results of the unconditional models followed by those of the conditional ones. Two benchmarks are used as the market, so the regressions are performed using a market index and a sector index.

5.1 Unconditional model

To evaluate the performance of the portfolios we use the four-factor model developed by Carhart (1997). As a proxy for the market portfolio, we are going to use two benchmarks. The first one is the S&P 500 index. This allow us to have a better understanding of how the performance of the overall market affects the portfolios returns and the level of correlation between the variation of the overall market and the variation of the portfolios. The second benchmark used is the S&P Energy index, which is a more specific market index formed by companies from the energy sector.

Firstly, we are going to analyze the unconditional model using the S&P 500 excess return as our market risk factor. Table 4 presents the results.

Table 4

This table reports the regression results of the equally-weighted portfolios using the four-factor model of Carhart (1997) considering data from 2009 to January 2019. In this regression, we use the S&P 500 as our market risk factor. Heteroskedasticidty and autocorrelation were tested by using the Breusch Pagan and the Breusch Godfrey tests. When there is both heteroskedasticity and autocorrelation, the Newey and West (1987) procedure is applied. If only heteroskedasticity is detected, we corrected it by using White robust models. P-values are in parenthesis. Difference is the portfolio that was constructed by subtracting the green portfolio with the fossil fuel portfolio.

VARIABLES	Green	Fossil Fuel	Difference
S&P 500	1.21376***	0.85539***	0.35837
	(0.000)	(0.001)	(0.28073)
SMB	0.53004***	0.83014**	-0.30010
	(0.000)	(0.035)	(0.42981)
HML	0.00909	0.08753	-0.07844
	(0.927)	(0.832)	(0.45289)
MOM	-0.13363**	-0.48909	0.35546
	(0.012)	(0.149)	(0.23933)
Alpha	-0.00050	0.03907***	-0.03957***
	(0.826)	(0.000)	(0.01032)
Observations	120	120	120
R-squared	0.84894	0.22411	0.03195

P-values in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In this regression the excess returns of the fossil fuel portfolio for the green portfolio are the dependent variable. The four-factor model risk factors developed by Carhart are the independent variables with the S&P 500 being our market risk factor. One of the portfolios is composed by fossil fuel stocks and the other one is formed only by stocks of green companies.

We can observe that the fossil fuel portfolio has a positive and statistically significant alpha, meaning that its performance is above the market. Regarding the green portfolio, the alpha of the green portfolio is negative, although not statistically significant. We thus conclude that it performs similar to the market. The alpha from the difference portfolio is -0.03957, and it is statistically significant at the 5% level. This leads to the conclusion that the green portfolio underperforms the fossil fuel portfolio.

The green portfolio has an explanatory power of 84.9%, this indicates the risk factors and the S&P 500 can explain more than 80% of the variation of the portfolio. However, for the fossil fuel portfolio the explanatory power of the model is much lower, 22.4%. In order to have a better understanding of how every risk factor is going to affect the variation of the portfolios it is necessary to analyze all the variables individually.

The market risk factor, S&P 500, is positively and statistically significant for both models. We can reject the null hypothesis at the 1% level of significance, which means that the coefficients of the variables are not equal to zero. The green portfolio has a greater exposure to the market risk factor since its coefficient of 1.213 is higher than the coefficient of 0.855 from the fossil fuel portfolio. There is a strong correlation between the variation of the market and the variation of the portfolios.

The results regarding SMB indicate that in both portfolios this small size effect is statistically significant. The betas are positive, which means that an increase on the SMB will lead to an increase in the excess return of the portfolios. Moreover, it shows that the portfolio is more exposed to small-cap stocks. The null hypothesis of no exposure to the SMB factor is rejected at the 5% level for the fossil fuel portfolio and at the 1% level for the green portfolio. The size factor coefficient is greater for the fossil fuel portfolio in comparison with the green portfolio, although the difference is not statistically significant, as we can conclude from the insignificant coefficient of the difference portfolio.

The HML or value premium is the spread in the returns between value companies and growth companies. Value companies have a high book-to-market ratio, while growth companies have a low book-to-market ratio. The coefficients of the HML are positive, but they are statistically insignificant for both portfolios.

The momentum factor represents the price movement of the stocks. Investors use this factor to identify the price trend of a certain stock. The results show that the momentum is not statistically significant for the fossil fuel portfolio. However, it is negative and statistically significant, at a level of 5%, for the green portfolio. The negative coefficient suggests that a variation of momentum factor has a negative correlation with the excess returns of the portfolio.

To sum up, the coefficients of the risk factors obtained with the S&P 500 benchmark show that both portfolios are exposed to small-cap stocks. Moreover, we could also conclude that the green portfolio has a greater exposure to the S&P 500 than the fossil fuel portfolio.

The regression results obtained when using the S&P 500 Energy as our benchmark are presented in Table 5. Both portfolios present positive and statistically significant alphas at a level of 1% implying that they both outperform the energy sector. However, the alpha of the fossil fuel portfolio is higher than the alpha of the green portfolio, as indicated by the statistically significant negative sign of the alpha of the difference portfolio. This is evidence that the fossil fuel portfolio shows higher abnormal returns than the divested portfolio.

As expected, the explanatory power of the fossil fuel portfolio increased with the use of the S&P Energy as our benchmark: it is now 34.7%. The opposite happened for the green portfolio, with the explanatory power now being 58.5%.

Table 5

This table reports the regression results of the equally weighted portfolios using the four-factor model of Carhart (1997). considering data from 2009 to January 2019. In this regression, we use the S&P 500 Energy index as our market risk factor. Heteroskedasticidty and autocorrelation were tested by using the Breusch Pagan and the Breusch Godfrey tests. When there is both heteroskedasticity and autocorrelation, the Newey and West (1987) procedure is applied. If only heteroskedastidcity is detected, we corrected it by using White robust models. P-values are in parenthesis. Difference is the portfolio that was constructed by subtracting the green portfolio with the fossil fuel portfolio.

VARIABLES	Green	Fossil Fuel	Difference
S&P Energy	0.60168***	1.04314***	-0.44146**
	(0.000)	(0.000)	(0.19746)
SMB	0.60694***	0.46142	0.14552
	(0.000)	(0.247)	(0.43054)
HML	-0.08086	-0.32776	0.24690
	(0.632)	(0.438)	(0.45678)
MOM	-0.24423***	-0.43322**	0.18899
	(0.005)	(0.046)	(0.23341)
Alpha	0.01064***	0.04416***	-0.03352***
	(0.004)	(0.000)	(0.00972)
Observations	120	120	120
R-squared	0.58504	0.34679	0.05912

P-values in parentheses
*** p<0.01, ** p<0.05, * p<0.1.

Just like in the previous regression, the coefficient associated to the market index

(S&P 500 Energy) is statistically significant. In this analysis, the fossil fuel portfolio is more exposed to the S&P Energy index than the green portfolio, as the coefficient of the difference portfolio is negative and statistically significant.

The SMB factor is not statistically significant for the fossil fuel portfolio, but it is for the green one. In fact, the green portfolio is the only one that is exposed to small-cap stocks.

The HML factor continues to be statistically insignificant for both portfolios, so we cannot reject the null hypothesis that this coefficient is equal to zero.

Finally, the momentum factor is negative and statistically significant for both portfolios: for the green portfolio at the 1% level and for the fossil fuel at the 5% level. However, the negative coefficient shows that this factor will have a negative impact on the portfolios.

All in all, it is possible to conclude that both benchmarks are useful in explaining the variation of returns of both portfolios. The regression results involving the S&P 500 and the one involving the S&P 500 Energy show that the former has a greater influence on the portfolios than the latter. Although the explanatory power of the model is reduced, the green portfolio tends to perform better when compared against the S&P 500 Energy. Moreover, the difference portfolio from both regressions allow us to conclude that the fossil fuel portfolio outperforms the green portfolio.

5.2 Conditional model

In this section we will report the performance of our portfolios by using the conditional model of Christopherson, Ferson and Glassman (1998). This model was chosen because it uses time-varying conditional alphas and betas. In general, the model assumes that a set of predetermined variables will influence systematic risk and performance. This will allow us to have more accuracy in our regressions and, hopefully, help us explain with more efficiency the variation of the portfolios.

Additionally, we performed a Wald test in the conditional models. This test helped us understand if the public information variables add value to the explanation of the portfolios. In addition, the values of the coefficients allow us to understand better the impact that each variable has on the variation of the portfolios excess return.

Just as we did with the unconditional models, we perform the regressions with the S&P 500 and S&P 500 Energy.

Table 6

Reports the results of the regression for the equally weighted portfolio with the S&P 500 as our benchmark and using the extended conditional model by Christopherson, Ferson and Glassman (1998) during the period from February 2009 and January 2019. The public information variables used are the short-term interest rate (STR) and dividend yield (DY). Heteroskedasticidty and autocorrelation were tested by using the Breusch Pagan and the Breusch Godfrey test. If both heteroskedasticity and autocorrelation are detected the Newey West (1987) procedure is applied. If only heteroskedasticity is detected, we corrected it by using White (1980) robust models. *W1*, *W2* and *W3* correspond to the p-value of the Wald test for the null hypothesis that the coefficients of the conditional alphas, the conditional betas and the conditional alphas and betas, respectively, are jointly equal to zero. Difference is the portfolio that was constructed by subtracting the green portfolio with the fossil fuel portfolio.

VARIABLES	Green	Fossil Fuel	Difference
STRt1	0.00336	-0.00581	0.00917
	(0.636)	(0.854)	(0.03187)
DYt1	-0.02193**	-0.04901	0.02708
	(0.043)	(0.308)	(0.04822)
S&P 500	1.25337***	0.96442***	0.28895
	(0.000)	(0.001)	(0.29505)
S&P500*STRt1	-0.23277	0.25861	-0.49138
	(0.189)	(0.743)	(0.79291)
S&P500*DYt1	0.53786**	-0.57885	1.11671
	(0.049)	(0.632)	(1.21549)
SMB	0.54686***	0.60707	-0.06021
	(0.000)	(0.179)	(0.45215)
SMB*STRt1	-0.35075	1.46007	-1.81081*
	(0.128)	(0.156)	(1.03041)
SMB*DYt1	0.17624	-3.58339**	3.75964**
	(0.655)	(0.044)	(1.77108)
HML	-0.01742	0.10700	-0.12442
	(0.875)	(0.829)	(0.49775)
HML*STRt1	0.38773	0.95415	-0.56642
	(0.115)	(0.383)	(1.09886)
HML*DYt1	-0.40966	1.85269	-2.26235
	(0.477)	(0.471)	(2.58418)
MOM	-0.12192	-1.02781***	0.90590**
	(0.119)	(0.004)	(0.34943)
MOM*STRt1	0.00054	-0.01978	0.02032
	(0.997)	(0.978)	(0.71860)
MOM*DYt1	0.07260	-0.18266	0.25526
	(0.641)	(0.793)	(0.70015)
Alpha	-0.00155	0.03828***	-0.03983***
	(0.506)	(0.000)	(0.01048)
Observations	120	120	120
R-squared	0.86529	0.32291	0.15702
W1	0.2159	0.1819	0.1277
W2	0.1247	0.5651	0.8012
W3	0.2545	0.1382	0.1296

P-values in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Similar to the results reported in table 4, the performance of the green portfolio is neutral and the fossil fuel portfolio has a positive and statistically significant alpha at a level of 1%. The regression results using the S&P 500 are presented in table 6. As expected, the conditional model showed a slightly greater coefficient of determination in comparison with the non-conditional model using the S&P 500, in table 3. The additional variables improved the explanatory power of the model. The SMB risk factor is positive statistically significant for the green portfolio, at a level of 5%, which indicates exposure to small-cap stocks. The HML factor continues to be statistically insignificant for both portfolios.

In contrast to what we observed in table 4, the momentum risk factor has a statistically significant impact on the fossil fuel portfolio instead on having on the green one. Since the coefficient is negative, it means that these portfolios are more exposed to stocks with poor performance in the recent past.

There is only one public information variable that has a significant impact on returns - the dividend yield. This variable has a negative impact on the returns of the green portfolio, at a level of significance of 5%. This means that a higher dividend yield causes lower excess returns for the green portfolio. The short-term interest rate presents little evidence of explaining the variation in portfolio performance.

According to the results given by the Wald test, for both portfolios we cannot reject the null hypothesis for Wald 1 meaning that there is no evidence of time-varying alphas. The same is observed with Wald 2, suggesting that there is no evidence of time-varying betas. The results of using the conditional model with the S&P Energy index are presented in table 7. Similar to what we observed when we used the S&P 500 Energy in the unconditional model, in table 7 we see that both portfolio alphas are positive and statistically significant at a level of 1%. The R^2 is higher when compared with the non-conditional using S&P 500 Energy but is smaller if we compare with the conditional regression using the S&P 500.

Table 7

Reports the results of the regression for the equally-weighted portfolio with the S&P 500 Energy as our benchmark and using the extended conditional model by Christopherson, Ferson and Glassman (1998) during the period from February 2009 and January 2019. The public information variables used are the short-term interest rate (STR) and dividend yield (DY). Heteroskedasticidty and autocorrelation were tested by using the Breusch Pagan and the Breusch Godfrey test. If both heteroskedasticity and autocorrelation are detected the Newey and West (1987) procedure is applied to correct the model. If only heteroskedasticity is detected, we corrected it by using White (1980) robust models. *W1*, *W2* and *W3* correspond to the p-value of the Wald test for the null hypothesis that the coefficients of the conditional alphas, the conditional betas and the conditional alphas and betas, respectively, are jointly equal to zero. Difference is the portfolio that was constructed by subtracting the green portfolio with the fossil fuel portfolio.

VARIABLES	Green	Fossil Fuel	Difference
STRt1	-0.01400	-0.01206	-0.00194
	(0.160)	(0.660)	(0.02905)
DYt1	0.00442	-0.05924	0.06366
	(0.776)	(0.169)	(0.04545)
S&P Energy	0.69456***	0.97979***	-0.28523
	(0.000)	(0.000)	(0.21020)
S&P EnergySTRt1	-0.39479**	0.12447	-0.51926
	(0.033)	(0.806)	(0.53735)
S&P EnergyDYt1	0.18224	0.37718	-0.19493
	(0.562)	(0.664)	(0.91899)
SMB	0.58429***	0.27395	0.31035
	(0.00)	(0.542)	(0.47577)
SMB*STRt1	-0.79807**	0.47110	-1.26916
	(0.031)	(0.641)	(1.06869)
SMB*DYt1	0.38391	-2.84840*	3.23231*
	(0.527)	(0.091)	(1.77243)
HML	-0.30793*	-0.39147	0.08354
	(0.070)	(0.401)	(0.49349)
HML*STRt1	-0.86815***	0.32711	-1.19526
	(0.006)	(0.702)	(0.90664)
HML*DYt1	-0.69724	0.03273	-0.72997
	(0.321)	(0.987)	(2.05248)
Mom	-0.01828	-0.70605**	0.68777*
	(0.882)	(0.039)	(0.35920)
Mom*STRt1	-0.46588*	-0.14382	-0.32206
	(0.066)	(0.836)	(0.73544)
Mom*DYt1	-0.39876*	-0.40492	0.00615
	(0.095)	(0.537)	(0.69421)
Alpha	0.00937***	0.04251***	-0.03313***
	(0.007)	(0.000)	(0.00996)
Observations	120	120	120
R-squared	0.68567	0.39571	0.16559
W1	0.0004	0.7319	0.2285
W2	0.3658	0.3334	0.3780
W3	0.0008	0.5822	0.2192

P-values in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Once again, the SMB factor is positive and statistically significant at a level of 1% for the green portfolio, meaning that the portfolio is exposed to small-cap stocks.

Moreover, HML factor is negative and statistically significant at a level of 10% for the green portfolio. This is the first time that this factor is statistically significant in any of the models we performed. The negative coefficient of -0.30, suggests that the green portfolio tends to be exposed to growth stocks.

The momentum factor, just like we have observed before on table 6, only has a statistically significant impact on the fossil fuel portfolio. However, the negative impact is lower than it was on the regression done with the S&P 500 index, with the coefficient decreasing from -1.02 to -0.706.

The Wald test provides us similar results for the fossil fuel portfolio as we have seen on table 6. We are not able to reject the null hypotheses that the alphas and betas are jointly equal to zero. However, for the green portfolio we are able to reject the null hypothesis that the coefficients of beta are jointly equal to zero.

6. Conclusions

In summary, with this dissertation, we aimed to provide a better understanding about fossil fuel divestment and its consequences. This is a hot topic nowadays and has several recent studies addressing the topic. On the one hand, some researchers prefer to focus more on the financial consequences of divestment. On the other hand, others prefer to emphasize the environmental consequences of divesting raising awareness about divestment and its importance in combating climate change.

In our study, we decided to focus on the financial consequences of divesting. We have managed to form two portfolios, one consisting of fossil fuel stocks and another of fossil-free companies, in particular, companies that use clean energy. The period time we used for our analysis was from February 2009 to January 2019. Our aim was to compare both portfolios and figure it out which had the best performance. To help us compare both portfolios we created another portfolio – the difference portfolio - that results from the subtraction between the green portfolio and the fossil fuel portfolio. To evaluate portfolio performance, we used the four-factor model developed by Carhart (1997). However, considering the limitations presented by the previous model we also used the conditional model of Christopherson, Ferson and Glassman (1998) model to allow both time-varying, risk and performance. In our conditional models, we used two public information variables that represent the state of economy. These variables were the short-term interest rate and the dividend yield. We contribute to the literature by using robust models of performance measurement, as previously mentioned.

Taken together, the results we gathered from both conditional and non-conditional models show that the alpha of the fossil fuel portfolio was always positive and statistically significant at a level of 5%. When using the market index as the benchmark, the green portfolio performs neutral and the fossil-free portfolio exhibits positive performance. When using the sector index, both portfolios outperform the sector-. However, the performance of the fossil fuel portfolio is always higher than that of the green portfolio, regardless of the benchmark used.

Furthermore, the results from the market factor document positive and statistically significant coefficients at a level of 5%, for both portfolios. This means that a change in the return of the indexes translates into a positive variation for the portfolios. In general, for both portfolios, the S&P 500 Energy reports the highest coefficients. This may be explained by the fact that both portfolios are composed of energy stocks, so the correlation is bigger.

The findings of our study indicate that the green portfolio is exposed to small-cap stocks. This is shown by the fact that the SMB factor has a positive and statistically significant impact for the green portfolio whatever model is used. The fossil fuel portfolio is more exposed to the momentum factor. This factor has a negative impact on the variation of the fossil fuel portfolio. The HML factor does not add much explanatory power to the returns of both portfolios, since the only coefficient that is statistically significant is only significant at a level of 10%. There is no evidence of time-varying alphas and betas in for the fossil fuel portfolio This means that this model does not add much explanatory power to the variation of excess returns for the fossil fuel portfolio. However, the results show that for the green portfolio there is evidence of time-varying betas. This means that the public information variables have an impact on the variation of the green portfolio's excess return.

Ultimately, as we said previously, this dissertation investigates the differences in the financial performance between the fossil fuel portfolio and the green portfolio. After analyzing all the models and the descriptive analysis of the variables, we observe that all the alphas from the difference portfolios are statistically significant at a level of 1%. It is clear to conclude that the fossil fuel portfolio outperforms the green portfolio, and, in the end, divestment has a negative financial impact.

Our findings differ from recent studies. For instance, Trinks, Scholtens, Mulder and Dam (2018) found an underperformance of fossil fuel portfolio in comparison with fossil-free portfolios. However, this was only visible for a short period of time, when the fossil fuel prices were down. Another example is Henriques and Sadorsky (2018), who concluded that it is possible to have higher-adjusted returns by divesting in fossil fuel and including clean energy.

Our work has some limitations, such as the fact that the stocks that were used to create the fossil fuel portfolio are only from oil and gas companies. This is a clear limitation since it does not include coal stocks, which is an important fossil fuel. Another possible limitation is the difference on the number of stocks that each portfolio has. The fossil fuel has 205 stocks, while the green portfolio has 32.

Based on the results there are some recommendations we would like to suggest for future research namely extending this research to other regions, for example Europe, and compare the results.

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Appendix

Appendix 1- List of fossil fuel companies

Companies		
Domination Resources Black Warrior Trust	Cross Border Resources	Gase Energy
Infinity Energy Resources	Sentry Petroleum	Evolution Petroleum
Chelsea Oil and Gas	Concho Resources	HyperDynamics
Callon Petroleum Company	Mogul Energy International	Tianci International
Royale Energy	Alamo Energy	Diamondback Energy
Deep Well Oil & Gas	Avoca	West Texas Resources
Aztec Oil & Gas	Comstock Resources	Freestone Resources
Kodiak Energy	Approach Resources	Western Midstream Partners
County Line Energy	SRC Energy	New Source Energy Partners
Axis Energy	Daleco Resources	Parsley Energy
Houston American Energy	Panhandle Oil & Gas	Montage Resources
Victory Oilfield Tech	EOS Petroleum	Viper Energy Partners
Erin Energy	BP Prudhoe Bay Royalty Trust	Empower Clinics
Cygnus Oil & Gas	Cabot Oil & Gas	Pioneer Natural Resources
Mexco Energy	Torchlight Energy Resources	ConocoPhillips
Cimarex Energy	Blue Dolphin Energy	EQT
Treasure Island Royalty Trust	Range Resources	CHEVRON
Delta Oil & Gas	Lilis Energy	EXXON MOBIL
Daybreak Oil & Gas	White Label Liquid	Occidental Petroleum
Devon Energy	Marathon Oil	HESS
New Frontier Energy	Abraxas Petroleum	Murphy Oil
Chancellor Group	Solar Integrated Roofing	Noble Energy
Spindletop Oil & Gas	Minerco	North European Oil
Reserve Petroleum Company	Gulport Energy	Tellurian
Contango Oil & Gas	FieldPoint Petroleum	Antero Resources
Sky Petroleum	Striker Oil & Gas	California Resources
Whiting Petroleum	Laredo Oil	Barnwell Industries
Britannia Mining	Octagon 88 Resources	Apache

Osage Exploration and Development	Petro River Oil	EP Energy
W&T Offshore	Adino Energy	Texas Pacific Land Coast
Highpoint Resources	Providence Resources	Southwestern Energy
Strata Oil & Gas	Tengasco	Marine Petroleum Trust
Brinx Resources	Allied Energy	PDC Energy
C2E Energy	PostRock Energy	Central Natural Resources
American Energy Group	Pioneer Oil & Gas	Tidelands Royalty Trust
Eurasia Energy	Eca Marcellus Trust I	Dorchester Minerals
Camber Energy	Pharmagen	Sabine Royalty Trust
Index Oil & Gas	Qep Resources	U.S Energy
Green Technology Solutions	Oasis Petroleum	ZaZa Energy
Denbury Resources	Hugoton Royalty Trust	PrimeEnergy Resources
Gran Tierra Energy	Black Ridge Oil & Gas	Mesa Royalty Trust
Arkose Energy	Hinto Energy	San Juan Basin Royalty Trust
Century Petroleum	SandRidge Mississipian	Permian Basin Royalty Trust
MNP Petroleum	Unit Group	Yuma Energy
Great Eastern Energy	VOC Energy	Earthstone Energy
Cross Timbers Royalty Trust	Kosmos Energy	Coastal Caribbean Oils & Minerals
Eagle Ford Oil & Gas	Abby Inc	Global Wholehealth Partners
T-Rex Oil	WPX Energy	Black Stone Minerals
United American Petroleum	Polar Petroleum	Petroshare
Arkanova Energy	SandRidge Permian Trust	Rosehill Resources
Geopetro Resources	Chesapeake Granite Wash	Centennial Resource Development
Northern Oil and Gas	Puissant Industries	SilverBow Resources
SM Energy	Bonanza Creek Energy	Norris Industries
Vaalco Energy	Mid-Con Energy Partners	Titan Energy
Chesapeake Energy	Altex Industries	Sandridge Energy
Continental Resources	Permianville Royalty Trust	Exctraction Oil & Gas
Rock Energy Resources	Sanchez Energy	Amplify Energy
Sanchez Midstream Partners	Laredo Petroleum	Penn VA
Trillion Energy International	Graphene & Solar Technologies	Goodrich Petroleum
Empire Petroleum	Whiting USA Trust II	Jagged Peak Energy

Redhawk Holdings	Nevtha Capital Management	Kimbell Royalty Partners
MV Oil Trust	Matador Resources	Perkins Oil & Gas
Holloman Energy	Texas South Energy	Ultra Petroleum
Zion Oil & Gas	SandRidge Mississipian Units	Alta Mesa Resources
Devmar Equities	Pacific Coast Oil	Chaparral Energy
EOG Resources	Norstra Energy	Falcon Minerals
ERHC Energy	Trek Resources	Magnolia Oil & Gas
Ring Energy	Enable Midstream Partners	PermRock Royalty Trust
Talos Energy		