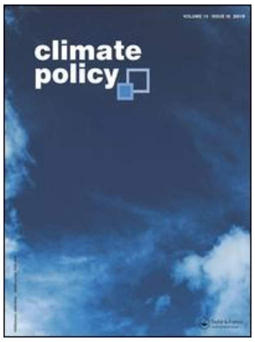

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The financial impact of fossil fuel divestment

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ABSTRACT
The fossil fuel divestment movement tries to increase awareness about the need for climate action and heralds divestment from fossil fuel producers as a means to combat climate change. Financial investors are increasingly showing interest in the non-financial impact of companies they invest in, i.e. responsible investing. However, they also want to be assured of sufficient returns and limited risks to support the living costs of their ultimate beneficiaries. In this context, we investigate the impact of divestment and the transition of the energy system on investment performance. We rely on an international sample of almost seven thousand companies and study a period of forty years. Further, we investigate scenarios with very different pathways to the transition of the energy system. We find that the investment performance of portfolios that exclude fossil fuel production companies does not significantly differ in terms of risk and return from unrestricted portfolios. This finding holds even under market conditions that would benefit the fossil fuel industry. We conclude that divesting from fossil fuel production does not result in financial harm to investors, even when fossil fuels continue to play a dominant role in the energy mix for some time.

Key policy insights

- Financing the exploration and exploitation of fossil fuel resources is increasingly being regarded as controversial, leading to divestment from this industry.
- Fossil fuel divestment does not seem to significantly harm financial investors and is not at odds with the fiduciary duty of institutional investors. This paves the way for more extensive initiatives to promote fossil fuel divestment.
- A smooth energy transition will most likely erode the profitability of fossil fuel firms and their ability to invest. Therefore, governments cannot rely on the fossil fuel industry to finance the energy transition.

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Climate change; divestment; energy system transition scenarios; fossil fuel; investors; stock market

1. Introduction

Most fossil fuel reserves should be left unused to not exceed the 2°C threshold beyond which dramatic climate change seems unavoidable (Meinshausen et al., 2009). This has motivated the advent of an advocacy network that encourages institutional investors to divest from their holdings of fossil fuel stocks (Ayling & Gunningham, 2017; Piggot, 2018). Oil and gas companies represent a substantial risk to the 2°C target because of their ability and intent to continue to explore for new fossil fuel sources (Heede & Oreskes, 2016). Previous studies have investigated overall climate risk (Carleton & Hsiang, 2016), issues related to governance (Gaulin & Le Billon, 2020; Newell & Simms, 2019; Piggot et al., 2018), the relationship between firms' operations and their contribution to climate change (Bang & Lahn, 2019; Heede, 2014; Hsiang et al., 2017), and bank sensitivity to losses from fossil fuel companies (Battiston et al., 2017). Given that financial investors are important players in

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shaping transformative change, it is crucial to account for their role in this respect as well (Crona et al., 2018; Steffen et al., 2018).

Some studies find that divesting from the production of fossil fuels has little impact on investors' financial performance (Trinks et al., 2018). Others suggest divestment either has a positive impact (Henriques & Sadorsky, 2018) or results in underperformance (Cornell, 2018). Public policy initiatives and NGOs are increasingly targeting institutional investors to move their funds out of the fossil fuel industry, in the hope that this will help reduce greenhouse gas (GHG) emissions.[1] Further, there is an increasing probability of legislation banning the use of fossil resources, in which case the majority of fossil fuel reserves may become stranded assets, i.e. assets that have suffered from unanticipated or premature write-downs, devaluations or conversion to liabilities. On the other hand, fossil fuel companies claim that the transition will take several decades and that fossil fuels will play a significant role in the meantime. The purpose of our study is to investigate what happens to investors' financial performance in scenarios of delayed and smooth energy system transitions. This complements the emerging 'divestment debate' by relating it to different pathways for the transition of the energy system. As such, this study is especially relevant for institutional investors and their stakeholders, as well as their regulators and supervisors.

We focus on the drivers of the performance of fossil fuel stocks, the impact on investment performance in the case of their divestment, and on how contraction and expansion of the fossil fuel industry relate to investment performance. More specifically, we aim to answer the following three questions:

(1) Are returns from investing in fossil fuel stocks different from those in other industries in terms of exposure to common risk factors?
(2) Are there implications for the financial performance of investment portfolios with and without fossil fuel stocks?
(3) What are the implications of a delayed versus smooth energy system transition on investment portfolio returns?

2. Materials and methods

We test the impact of excluding fossil fuel stocks from the investment universe by studying global stock returns at the industry level. The industry level is appropriate because it can be easily translated and implemented in an investment strategy, with no liquidity concerns, implying low transaction costs. Many providers offer industry-level portfolios, which makes it easy for an investor to implement the strategies we investigate. We use the industry indexes and returns provided by Refinitiv Eikon, a data provider, since they have a return history of more than 40 years, allowing for elaborate robustness analysis. These industry indices derive from the widely-used Industry Classification Benchmark (ICB) for classifying stocks. Our classification starts from the ten main industries with 6905 companies worldwide: basic materials (including coal mining), consumer goods, consumer services, financial, health care, industrial, oil and gas, technology, telecommunication, and utilities. Industry-level classification plays an important role in the practice of investment management. Many professional investment institutions follow industry classification in their investment processes by focusing on specific industries or by defining their asset allocations in terms of industry.

We adjust the ICB classification by relocating some subsectors of the main industries (see Appendix A1). There are two reasons for doing so. First, companies involved in the exploration and exploitation of fossil fuels currently are classified in two different industries, namely, the ICB industries of oil and gas and that of basic materials. Second, the ICB oil and gas industry also contains the sector of alternative energy stocks. Therefore, we replace the initial industry oil and gas with the newly created industry fossil fuels. Our fossil fuels index (FOS) consists of the sectors oil and gas producers and oil equipment and services from the oil and gas industry, and the subsector coal mining from the basic materials industry. This new index includes stocks of 327 international companies. We also create an adjusted basic materials index that is based upon the ICB basic material index, excluding stocks of firms involved in coal mining activities. We adjust the utilities index by adding the alternative energy sector, which is separated from the oil and gas industry. Finally, we also create a new index, the non-fossil fuels index (NOFOS), which has 6578 international constituents. This index is the complement of the fossil fuels index; it excludes the fossil fuel stocks from the overall sample. The weights for all components of these two indexes are based on their market capitalizations and rebalanced monthly.

The industry returns over the period 1973–2016 are shown in Figure 1. This reveals that the fossil fuel industry has the highest return. Excluding fossil fuel companies might therefore have a negative impact on overall portfolio performance as fossil fuel companies constitute about 6% of the global stock market value. We study the impact of their exclusion by comparing performance of a portfolio of global stocks (all industries), a portfolio excluding fossil fuel stocks (NOFOS), and a portfolio with fossil fuel stocks only (FOS). The strategy of separating out the fossil fuel industry is based on the idea that it is easier to address the industries that produce the resources responsible for CO_2 emissions rather than all the individual firms and households that consume fossil fuels: tracking down the production of fossil fuels is easier than tracking down its consumption throughout the entire economy. In addition, tracking down consumption as an investment strategy largely ignores the impact of fossil fuel consumption by households as end-users, and faces substantial problems with the lack of validated and independently audited and verified CO_2 equivalent emission data. Therefore, we adhere to the exclusion of firms engaged in the exploration and exploitation of fossil fuel and refrain from accounting for the input–output character of the use of fossil fuels.

Table 1 shows the summary statistics of the monthly total returns for the different industries and indexes from January 1973 to December 2016. They are in percentages and denominated in US dollars. Table 2 shows the average returns over a set of four different subperiods of eleven years each. In one subperiod, fossil fuels underperformed all industries, and in three subperiods they outperformed. This suggests that the choice of period is quite sensitive and motivates undertaking the analysis over a prolonged period of time.

In order to answer the first research question regarding returns from fossil fuel stocks, it is important to identify the sources of return explaining the differences between industries. If factors unique to the fossil fuel industry play a significant role in explaining the differences between industry returns, excluding fossil fuel stocks will result in lower returns for investors. We use the Fama and French (2015) model to explain the returns of the financial assets from a set of international common risk factors. The slope coefficients from this model measure the exposure of a stock to the common factors. Higher slope coefficients are usually associated with higher expected returns. The intercept of this regression model measures the risk-adjusted return. If the risk-adjusted return for fossil fuel stocks equals zero, it is safe to assume that there is no unique fossil fuel risk

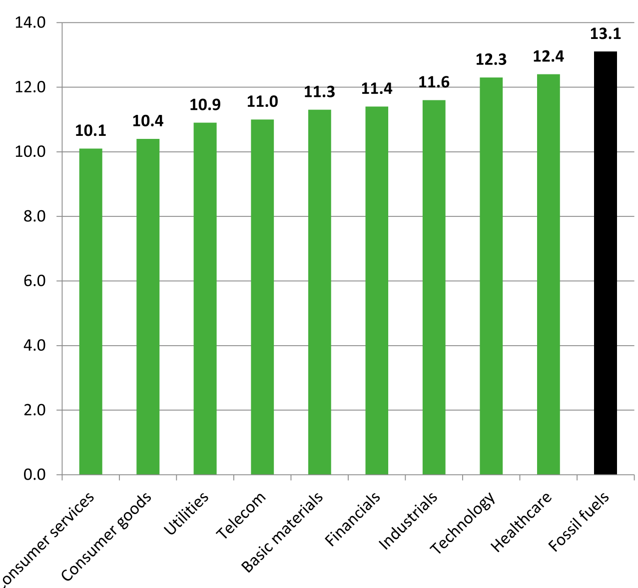

Figure 1. Summary statistics for the returns of industry indexes.

Notes: This figure presents the average of annual investment returns in percentages from January 1973 to December 2016 for Datastream industry indexes.

Table 1. Summary statistics for the returns of industry indexes.

	Mean	Median	Standard deviation
Fossil fuels (FOS)	1.03%	1.02%	5.64%
Basic materials	0.89%	1.08%	5.84%
Industrials	0.92%	1.22%	5.04%
Consumer goods	0.83%	0.98%	4.82%
Health care	0.98%	1.09%	4.05%
Consumer services	0.81%	0.96%	4.63%
Telecommunications	0.88%	0.79%	4.96%
Utilities	0.86%	0.86%	4.27%
Financials	0.90%	1.21%	5.52%
Technology	0.97%	1.01%	6.46%
Non-fossil fuels (NOFOS)*	0.85%	1.07%	4.53%
All industries	0.86%	1.07%	4.49%

Notes: This table presents the mean, median, and standard deviations of monthly returns in percentages from January 1973 until December 2016.
*All stocks excluding the fossil fuel stocks. See Appendix A1 for details regarding the composition of the industry indexes.

factor. Without a unique fossil fuel risk factor, the expected returns of fossil fuel stocks can be replicated with an appropriate portfolio of other industries having the same factor exposures.

We estimate the following version of the Fama and French (2015) model, where the return R_t on a portfolio in month t is explained by the following regression[2]:

$$R_t - R_{f,t} = \alpha + \beta_m(R_{m,t} - R_{f,t}) + \beta_s R_{s,t} + \beta_p R_{p,t} + \beta_i R_{i,t} + \epsilon_t, \tag{1}$$

where $R_{f,t}$ is the risk-free return, $R_{m,t}$ is the return on the market portfolio and $R_{s,t}$ is the return on the size factor. A positive coefficient for this factor implies that stocks behave like those of relatively small companies. Furthermore, $R_{p,t}$ is the return on the profitability factor, where a positive coefficient indicates that a stock behaves like a firm with high operating profitability. Finally, $R_{i,t}$ is the return on the investment factor, where a positive coefficient suggests that the firm is divesting or has a very low level of investment activity, and a negative exposure implies higher investment activity. These factors have been constructed by Fama and French (2015) and made available online.[3] Since these factors are available only starting from July 1990, Equation (1) is estimated using data from July 1990 to December 2016.

The second research question addresses the impact of excluding fossil fuel stocks on portfolio performance. We answer this question by comparing portfolios with and without fossil fuel stocks in terms of financial risk and return. In practice, portfolios with the same return may differ considerably in terms of total risk. Therefore, we use the Sharpe ratio (Sharpe, 1966) as the main evaluation criterion since it measures the return per unit of risk.

$$S = \frac{E(R - R_f)}{\sigma}, \tag{2}$$

Table 2. Average monthly returns over time.

	1973–1983	1984–1994	1995–2005	2006–2016
Fossil fuels (FOS)	1.04%	1.15%	1.40%	0.93%
Basic material	0.88%	1.22%	0.82%	0.77%
Industrials	0.92%	1.13%	0.90%	0.79%
Consumer goods	0.76%	1.12%	0.65%	0.73%
Health care	0.66%	1.52%	0.98%	0.80%
Consumer services	0.56%	1.32%	0.66%	0.66%
Telecommunications	0.82%	1.37%	0.66%	0.62%
Utilities	0.81%	1.43%	0.79%	0.57%
Financials	0.69%	1.62%	0.90%	0.62%
Technologies	0.85%	0.94%	1.28%	0.98%
Non-fossil fuels (NOFOS)*	0.73%	1.29%	0.80%	0.67%
All industries	0.76%	1.27%	0.84%	0.68%

Notes: This table presents the average monthly returns over individual industry indexes for four subperiods.
*All stocks excluding the fossil fuel stocks. See Appendix A1 for details regarding the composition of the industry indexes.

where σ is the standard deviation of the portfolio return. The numerator is the expected excess return (portfolio return over the risk free return). The Sharpe ratio provides a convenient way to compare portfolios that differ in terms of total risk. To test for the significance of the difference between two Sharpe ratios, we use the circular block bootstrap, with 10,000 replications and a block length of six months, which is in line with the literature.

As it is impossible to assess the impact of excluding fossil fuel stocks on portfolio performance for a potentially endless range of investment strategies, we examine only three basic strategies that are stylized representations of typical investment behaviour. The first strategy minimizes the total financial risk of a portfolio as measured by the standard deviation of returns. This strategy is representative of conservative investors who dislike risk and who profit most from diversification benefits. Eliminating fossil fuel stocks from the investment universe reduces the potential benefits of risk reduction due to diversification. Comparing the standard deviation of the minimum risk portfolio with and without fossil fuel stocks provides a clean measure of the higher financial risk due to lesser diversification opportunities. The second strategy relies on market capitalization weighting, which is by definition representative of the average investor. In addition, this strategy is also common among institutional investors and investors buying index-based investment products such as exchange traded funds (ETFs). The third strategy is equal weighting of the industries. This strategy is typically used by private investors.

To investigate the implications of different trajectories of energy system transitions for research question three, we proceed as follows: we use growth and decline in the number of operating oil rigs to create scenarios of delayed and smooth transition. Then, we compare the impact of the scenarios on key financial performance indicators, namely stock market returns, annual earnings growth, market value, and the price-earnings ratio[4] for the fossil and non-fossil fuel indexes.

3. Results

To answer the three research questions, we first analyse the differences between returns of fossil fuel stocks and other stocks. The outperformance of fossil fuel stocks (Figure 1) could be compensation for higher exposure to common risk factors or it could be unique to the fossil fuel industry. We use the Fama-French model to identify common risk factors and to estimate the risk-adjusted return (Fama & French, 2015). The common risk factors relate to the slope coefficients β of the regression line and the risk-adjusted return α is the intercept. We test the hypothesis that the slope coefficients and the intercept of the 327 fossil fuel stocks (FOS) and the 6578 non-fossil stocks (NOFOS) are equal.

Table 3 shows that the risk-adjusted returns of FOS are not significantly different from zero or from those of NOFOS. This is because the intercepts and differentials between the two groups do not appear to be significant.

Table 3. Risk-adjusted returns of fossil fuel stocks versus other stocks.

Variables	FOS[a]	NOFOS[b]	FOS − NOFOS
α	−0.0010	0.0008	−0.0018
	(0.0024)	(0.0008)	(0.0024)
β_m	1.097***	0.998***	0.0990
	(0.0612)	(0.0217)	(0.0608)
β_s	0.448***	−0.0645	0.512***
	(0.118)	(0.0417)	(0.117)
β_p	0.544**	−0.0343	0.578***
	(0.175)	(0.0620)	(0.174)
β_i	0.253*	−0.0941*	0.347**
	(0.126)	(0.0448)	(0.125)
Observations	318	318	318
R^2	54.7%	91.1%	9.20%

Notes: This table provides OLS estimates of the regression coefficients for the Fama and French (2015) model for the period July 1990 to December 2016. The model is specified as: $R_t - R_{f,t} = \alpha + \beta_m(R_{m,t} - R_{f,t}) + \beta_s(R_{s,t}) + \beta_p(R_{p,t}) + \beta_i(R_{i,t}) + \epsilon_t$. R_t is the return of the portfolio, $R_{f,t}$ is the risk-free rate, $R_{m,t}$ is the return on the market portfolio, $R_{s,t}$ is the return on the size factor, $R_{p,t}$ is the returns on the profitability factor, $R_{i,t}$ is the returns on the investment factor. The standard errors are in parentheses and *, **, and *** denote significance at the 10%, 5%, and 1% probability levels, respectively.

[a]Fossil Fuels Index; see Appendix A1 for the composition.

[b]Non Fossil Fuels Index; see Appendix A1 for the composition.

Therefore, we conclude that there is no unique component in fossil fuel returns. This implies that the returns from fossil fuel investing can be replicated with other industry returns (Fama & French, 2015). Further, Table 3 reveals that fossil fuel stocks have more exposure to the size factor, the profitability factor, and the investment factor. This implies that the higher returns for FOS are due to larger exposure to these common risk factors. Thus, when accounting for these factors, the fossil fuel industry no longer exhibits significant outperformance. This confirms earlier findings in the US (Trinks et al., 2018).

To answer our second question about the implications of divestment on portfolio performance, we proceed as follows: if investors divest fossil fuel firms from their portfolios, they limit the universe of investment objects. This reduces diversification opportunities, which could lead to a substantial increase in total risk. Therefore, we calculate the composition of the minimum risk portfolio including and excluding fossil fuel stocks to assess the impact of reduced diversification opportunities on portfolio risk (see Dam & Scholtens, 2015).

In Table 4, Panel A presents the average monthly return and standard deviation of the minimum risk portfolio for all industries and when excluding fossil fuel stocks. The average monthly return drops by two basis points when excluding fossil fuel stocks and the monthly standard deviation of returns increases by two basis points. From an economic perspective, these are marginal effects. We also calculate the Sharpe ratio for both portfolios and find small but statistically insignificant differences. Therefore, we can conclude that divestment from fossil fuels does not limit the diversification opportunities in terms of financial return and risk. We also investigate a market capitalization-weighted portfolio of the industry indexes including and excluding fossil fuels to assess the impact of the reduced investment universe on the average investor. As a robustness check, we also perform this analysis based on equally weighted portfolios, which is more representative for the private investor. Panel B of Table 4 shows that divesting from fossil fuel stocks also has a marginal impact on portfolio performance: a statistically insignificant difference of one basis point on a monthly basis. The equal-weighting strategy (in Panel C) generates similar results.

To answer the third question about the role of divestment in different transition scenarios, the issue is to what extent historical returns will hold in the future. Investment returns are likely to vary due to changes in the future role of fossil fuels. Proponents of investment in fossil fuels argue that alternative sources of energy will only be available on a limited scale and/or may become available much later than might be desirable from a climate perspective (Fischell, 2015). They also argue that, even with abundant renewable energy sources, fossil fuels will remain important inputs for the chemical industry, among others (Cornell, 2018). In contrast, opponents argue that the economic viability of alternative energy sources is driving out fossil fuels and erodes the future profitability of the fossil industry (Ayling & Gunningham, 2017).

Although it is hard to forecast which reality will materialize (Bonan & Doney, 2018), we provide an analysis that enables investors to assess the impact of different scenarios on their portfolio. We use growth and decline in the number of oil rigs in operation to create scenarios based on historical returns. Figure 2 shows the number of oil rigs in operation, as reported by Baker Hughes, an oilfield service company. We model

Table 4. Stock market performance based on all assets including and excluding fossil fuel stocks.

	All stocks (All industries)	All stocks excl. fossil fuel (NOFOS)	Difference	*p*-value
Panel A: Minimum variance portfolio				
Average return	0.74%	0.72%	−0.02%	0.398
Standard deviation	3.03%	3.05%		
Sharpe ratio	0.168	0.162	−0.006	0.988
Panel B: Market cap-weighted portfolio				
Average return	0.70%	0.69%	−0.01%	0.577
Standard deviation	4.62%	4.63%		
Sharpe ratio	0.103	0.100	−0.003	0.996
Panel C: Equally weighted portfolio				
Average return	0.76%	0.74%	−0.02%	0.456
Standard deviation	4.44%	4.44%		
Sharpe ratio	0.119	0.116	−0.004	0.993

Notes: This table provides performance statistics based on average monthly returns from 1990 to 2016, the standard deviation of these returns, and the Sharpe ratio. For the average returns, the *p*-values are based on a paired *t*-test. For the Sharpe ratio, the *p*-values are based on a Jobson and Korkie (1984) test.

Figure 2. Number of oil rigs and economic contraction / expansion.

Notes: This figure shows the number of operational oil rigs worldwide from 1990 to 2017. The colour of the bar on the horizontal axis indicates a period of contraction (red) or expansion (green) based on the 12 months decline or growth in operational oil rigs. Source: Baker Hughes.

scenarios based on the trailing 12-month growth in the world count of global oil rigs. We assign months when the 12-month growth is negative to the scenario of ‘smooth energy transition’ and months with positive growth to ‘delayed energy transition’. We note three periods with a long-lasting and substantial decline in the rig count (contraction periods). The first period is during 1998–1999, the second during 2008–2009, and the most recent period is 2015–2016. We compare the impact of a smooth energy transition with a delayed energy transition on key financial performance indicators, namely stock market returns, annual earnings growth, market value, and the price–earnings ratio.

Table 5 reports the key characteristics of the financial performance variables for the FOS and NOFOS index in the smooth energy transition scenario (contraction phases) and in the delayed transition scenario (expansion phases). It shows that there are stark differences between the two portfolios in the different scenarios (we report the results from differences tests in Panel B). In particular, earnings growth is much lower during smooth transition than during delayed transition for both FOS and NOFOS. Further, the difference in earnings growth between the two scenarios is significantly greater for FOS than for NOFOS: The earnings growth in FOS changes dramatically, dropping from 23.7% in delayed transition to −8.4% in the smooth transition scenario. For NOFOS, the drop is much smaller but also substantial, namely from 15% to 1.1%. Thus, the impact of a change in the growth of the number of oil rigs has a significantly greater impact on the earnings growth of FOS than on NOFOS. In addition, we find the market value of FOS as a percentage of total market capitalization is significantly higher in the delayed transition scenario. Finally, we observe that the price–earnings ratio for FOS is somewhat higher during smooth transition. This ratio is a crude measure of how many years’ worth of current earnings a company will need to generate to arrive at its current market value.

Table 5 shows that NOFOS generates a 0.15% higher return on a monthly basis compared to FOS in the smooth transition scenario. With delayed transition, the return on FOS exceeds that of NOFOS by 0.45%.

Table 5. Financial impact of contraction and expansion phases in oil rig counts.

Panel A: Mean values

	Contraction phases (smooth transition)		Expansion phases (delayed transition)	
	FOS	NOFOS	FOS	NOFOS
Average monthly stock market return (%)	0.76	0.91	1.00	0.55
Earnings growth relative to last year's earnings (%)	−8.4	1.1	23.7	15.0
Market value as a % of total capitalization	7.7	92.3	8.6	91.4
Price–earnings ratio	17.9	20.4	16.6	20.6

Panel B: Differences

This panel reports the results from tests of the difference between the delayed (expansion) and the smooth (contraction) energy system transition scenarios and between fossil fuel versus non-fossil fuel indexes.

	Delayed vs smooth		FOS vs NOFOS	
	FOS[a]	NOFOS[a]	Delayed[b]	Smooth[b]
Average monthly stock market return (%)	0.282	0.878	0.071*	0.437
Earnings growth relative to last year's earnings (%)	0.000***	0.000***	0.036**	0.000***
Market value as a % of total capitalization	0.011**	0.490	0.000***	0.000***
Price–earnings ratio	0.239	0.456	0.000***	0.000***

Notes: FOS is the Fossil Fuels Index; NOFOS is the Non-Fossil Fuels Index; see Appendix A1 for details regarding the composition of the industry indexes

[a]This column presents the p-values for the Mann-Whitney U test.

[b]This column presents the p-values for the Wilcoxon matched pairs signed-rank test.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Only the latter differential is (marginally) significant. To assess the nature and statistical relevance of these differences, we estimate the Fama–French model. The regression results in relation to investment performance are in Table 6.

Table 6 shows that neither the FOS nor the NOFOS indexes exhibit statistically significant risk-adjusted returns, irrespective of the scenario. This implies that risk-adjusted returns are not different from zero in either scenario, despite the fact that the nature of the exposure to asset pricing factors dramatically differs in these two scenarios. Table 6 also reveals substantial differences between the exposures to common risk factors in the two scenarios. More specifically, exposure to the profitability factor is much higher for the FOS during delayed transition. This is very plausible, given the way oil companies exploit and explore fields. We assume that oil companies tend to exploit those fields with lower operating costs first. They will expand their capacity with fields that have higher marginal operating costs only when oil prices rise above these costs. The profit margins on the existing fields with low operating costs become highly profitable during delayed transition and increasing oil prices. In addition, exposure to the investment factor is much higher for FOS than for NOFOS during smooth transition, indicating that fossil fuel firms reduce investments or even divest in this scenario (Table 7).

Next, we calculate the impact of excluding fossil fuel stocks from the investment universe on portfolio performance by comparing portfolios. For each scenario and each investment strategy, we calculate the average return, standard deviation, and the Sharpe ratio. For each scenario and investment strategy, we also calculate the difference between the return of a portfolio with (all industries) and without fossil fuel stocks (NOFOS). Although the returns in the smooth transition scenario are lower than the returns in delayed transition, we find that, regardless of the scenario, the differences between portfolios with and without fossil fuel stocks are very small and statistically insignificant. Even in the delayed transition scenario, the impact of restricting the universe to NOFOS is only a few basis points and statistically insignificant. The risk-adjusted returns in the two scenarios are statistically indistinguishable from zero. However, the exposure to common risk factors is very different in smooth and delayed transition, witnessed by the fact that the slope coefficient for the profitability factor is higher in a delayed than in a smooth transition. Furthermore, the coefficient for the investment factor is lower in the delayed transition scenario. In other words, fossil fuel stocks represent firms that are less profitable and less able to invest during a smooth energy transition.

Table 6. Risk-adjusted returns and factor exposure during periods of expansion and contraction.

Panel A: Regression coefficients in a contraction scenario			
Variables	FOS	NOFOS	FOS − NOFOS
α	−0.0032	0.0003	−0.0034
	(0.0039)	(0.0015)	(0.0036)
β_m	1.0848***	1.0330***	0.0518
	(0.1091)	(0.0414)	(0.1019)
β_s	0.3256	−0.1309	0.4565**
	(0.2147)	(0.0815)	(0.2007)
β_p	0.1846	0.1691	0.0155
	(0.2998)	(0.1138)	(0.2802)
β_i	0.5962**	−0.0602	0.6564***
	(0.2349)	(0.0891)	(0.2196)
Observations	126	126	126
R^2	0.510	0.886	0.110
Panel B: Regression coefficients in an expansion scenario			
Variables	FOS	NONFOS	FOS − NOFOS
α	0.0003	0.0011	−0.0008
	(0.0030)	(0.0010)	(0.0031)
β_m	1.0911***	0.9837***	0.1074
	(0.0728)	(0.0245)	(0.0747)
β_s	0.5659	−0.0613	0.6272***
	(0.1431)	(0.0482)	(0.1468)
β_p	0.8437***	−0.1348*	0.9785***
	(0.2203)	(0.0742)	(0.2260)
β_i	0.0561	−0.0932*	0.1493
	(0.1490)	(0.0502)	(0.1529)
Observations	192	192	192
R^2	0.591	0.929	0.130

Notes: This table presents the regression coefficients from estimating the Fama and French (2015) model on monthly excess returns. The model is specified as $R_t - R_{f,t} = \alpha + \beta_m(R_{m,t} - R_{f,t}) + \beta_s(R_{s,t}) + \beta_p(R_{p,t}) + \beta_i(R_{i,t}) + \epsilon_t$.
FOS is the Fossil Fuels Index; NOFOS is the Non-Fossil Fuels Index; see Appendix A1 for details regarding the composition of the industry indexes
Standard errors in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 7. Impact of eliminating fossil fuel stocks on diversification opportunities and portfolio performance during smooth and delayed energy system transitions.

	Returns in smooth transition scenario (with falling rig numbers)				Returns in delayed transition scenario (with rising rig numbers)			
	All industries	All excluding fossil fuels (NOFOS)	differ-ential	p-value	All industries	All excluding fossil fuels (NOFOS)	differ-ential	p-value
Panel A: Minimum Variance Portfolio								
Average return	0.59%	0.59%	−0.00%	0.964	0.83%	0.80%	−0.02%	0.346
Standard deviation	3.19%	3.20%	0.26%		2.93%	2.94%	0.28%	
Sharpe ratio	0.123	0.123	−0.001	0.999	0.303	0.296	−0.009	0.987
Panel B: Market Cap-Weighted Portfolio								
Average return	0.94%	0.96%	0.02%	0.470	0.55%	0.53%	−0.03%	0.401
Standard deviation	4.49%	4.45%	0.26%		4.70%	4.71%	0.37%	
Sharpe ratio	0.166	0.170	0.003	0.997	0.071	0.065	−0.006	0.993
Panel C: Equal-Weighted Portfolio								
Average return	0.94%	0.96%	0.01%	0.698	0.64%	0.60%	−0.04%	0.324
Standard deviation	4.28%	4.27%	0.40%		4.23%	4.09%	0.39%	
Sharpe ratio	0.173	0.177	0.004	0.995	0.087	0.079	−0.008	0.843

Notes: This table presents the average return, the standard deviation of monthly returns and the Sharpe ratio of the different portfolios over the period 1990–2016. The Sharpe ratio is calculated as $E(R - R\_f)/\sigma$. The reported p-values are respectively based on a standard t-test on the differences in means and a circular block bootstrap, with 10,000 replications and a block length of six months.

4. Discussion and conclusion

We study the impact of fossil fuel divestment on investors' financial performance by investigating almost seven thousand international companies over a forty-year period and try to answer three questions. First is whether returns from investing in fossil fuel companies differ from those in other industries in terms of financial risks. Here, it shows that the returns of fossil fuel stocks are not significantly different from those of other stocks. We find that the former are more exposed to the size, profitability and investment factor than the latter. This means that the strategy of investing in fossil fuel stocks is relatively more exposed to stocks with a small market capitalization, to firms that show high profitable earnings and to firms with low investments. This implies that the higher absolute returns for fossil fuel stocks over prolonged periods of time is due to the financial risk involved and that the higher return compensates for this risk.

The second question is about the implications for investment performance if an investor divests from fossil fuel stocks. In this regard, we find that screening out fossil fuel stocks has no significant impact on the return and the risk of a global well-diversified portfolio of industry indexes. From this, we conclude that divestment from fossil fuel companies does not influence total financial risk for the investor.

The third and last question is interested in the investment implications of a delayed or a smooth transition of the energy system from fossil fuel-based to renewables-based. This is motivated by the fact that we want to find out how investment portfolios might behave under different scenarios regarding the transition of the energy system. The scenarios are based on the trailing 12-month growth in world count of global oil rigs. In this regard, we find that, regardless of the scenario, the differences between portfolios with and without fossil fuel stocks are statistically insignificant.

These findings relate to the fact that exclusion of fossil fuel stocks involves a relatively limited reduction of the investment universe (Bello, 2005), that they significantly correlate with other stocks (Trinks et al., 2018), and that a host of other financial instruments can replicate the properties of such assets (Fama & French, 2015). The stylized observation that fossil fuel companies tend to outperform the market ignores the fact that this outperformance reflects more exposure to common risk factors.

From the perspective of national GHG reduction policies, our findings provide room for stricter policies to promote fossil fuel divestment. We show that fossil fuel divesting does not conflict with the fiduciary duty of institutional investors, which might provide them with an argument to invest in fossil fuel stocks for the sake of financial returns and lower risk. It also paves the way for more extensive initiatives to promote fossil fuel divestment. National governments may decide to support these without harming the financial interests of investors. This could be done by creating mandatory divestment policies for specific groups of investors, such as pension funds. This avoids the risk of stranded assets, which could threaten pensions in the future. Fossil fuel divesting is currently only done by a limited group of investors on a voluntary basis. While its effectiveness as a tool to curb GHG emissions has not been proven yet, it is most likely to become effective when supported by a substantial cohort of investors (Heinkel et al., 2001). The results from our study neutralize the arguments that fossil fuel divesting is detrimental for financial returns and that divestment would penalize, for instance, retirees, who depend on investment returns in funded pension schemes.

A second policy implication is that national governments should not count on the fossil fuel industry to finance the low carbon transition: in a smooth energy transition, fossil fuel companies will lose their profitability and ability to invest. While this should not be very surprising in itself, it also implies that fossil fuel companies are not very likely to finance the energy transition. Divesting from fossil fuel stocks will not be a substitute for national government climate policies. Therefore, national governments should be expected to play an active role in financing the energy transition, and should not be misguided by the optimism expressed by some oil companies as to their future role in alternative energy generation. However, divestment may increase the cost of exploiting fossil fuels (see Curran (2020) for a case study of the Carmichael coal mine in Australia), thus making zero or low GHG emission alternatives relatively cheaper. We also observe that both the profitability and investment activity by fossil fuel companies decrease substantially during a smooth energy transition. A related issue – but one we do not address in our study – is the question of a just transition (leaving no one behind) as divesting will have consequences for employment in the fossil fuel industry and its supply chain.

Our results closely align with those of Henriques and Sadorsky (2018) and Trinks et al. (2018) who have a similar objective, but rely on different research designs and samples. The major contribution of our paper is that we include an analysis of what could happen with divested portfolios under different scenarios regarding the transition of the energy system. Our results do not confirm the pattern arising from previous studies (Ayling & Gunningham, 2017; Battiston et al., 2017; Cornell, 2018), which conclude, among other things, that divestment from fossil fuels has a dramatic impact on portfolio performance. The explanation is that our analysis provides a more relevant factor model for explaining returns and the ability of our approach to identify (the lack of) a return component unique for fossil fuels.

Beyond divestment, there are alternatives for investors to show their concern over climate change: they can engage and use their shareholder rights to convince management to change course in the direction of non-fossil fuel resources or they can invest in renewable and more sustainable energy technologies (Scholtens, 2014). However, the assessment of the most beneficial strategy from a climate change perspective is outside the scope of this paper. Further, divesting from fossil fuel stocks does not guarantee that global warming will not go above the 2°C threshold and/or that dramatic and irreversible changes to ecosystems will not occur (Steffen et al., 2018). But divestment will help change the mindset in the required direction of reducing the use of fossil fuels, and does not financially hurt investors and their beneficiaries.

Notes

1. For an overview of fossil fuel supply side initiatives, see Gaulin and Le Billon (2020).
2. For a description of the construction of the factors we refer to the technical Appendices A2 and A3 of this paper and to Fama and French (2015).
3. https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/index.html.
4. This ratio between the stock price of the company and its earnings per share. It shows the expectations of the market and is the price that has to be paid per unit of expected earnings.

Disclosure statement

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Appendix. Technical details on data collection and methodology

A1. Definition and composition of new industry indexes

This tables reports how we transform the original ICB industry classification to our new industry definition:

New industry definition	# Constituents	Link with original ICB industry	(Sub)sector
Fossil fuels (FOS)	327	Oil and Gas	Oil and gas producers (sector)
		Basic resources	Oil equip. and serv. (sector)
			Coal (subsector)
Basic materials	460	Basic materials	All (sub)sectors except for coal
Industrials	1297	Industrials	Unchanged
Consumer goods	914	Consumer goods	Unchanged
Health care	402	Health care	Unchanged
Consumer services	900	Consumer services	Unchanged
Telecom	153	Telecom	Unchanged
Utilities	332	Utilities	All (sub)sectors
		Oil and gas	Alternative energy
Financials	1731	Financials	Unchanged
Technology	389	Technology	Unchanged
Non-fossil fuels (NOFOS)	6578	All non-fossil fuel stocks	

A2. Monthly rebalancing

For each (adjusted) industry index we calculate a monthly return based on the market cap weighted components of each index. The market cap weighting is updated on a monthly basis. Both the information on returns and the market capitalizations is retrieved from Eikon Refinitiv. The returns are measured in terms of US dollar.

A3. Implementation of the Fama and French (2015) model

The Fama and French (2015) model proposes five factors to explain cross-sectional differences between stock returns. Following the suggestion in Fama and French (2015), we dropped the so-called HML factor after performing a factor redundancy test. The remaining four factors are: the return on the market portfolio (R_m), the return on the size factor (R_s), the return on the profitability factor (R_p), and the return on the investment factor (R_i). The return on the market portfolio is the market capitalization weighted average return of all stocks in the market. The size factor s is also known as the Small minus Big (SMB) factor. It is calculated as the difference between the return on a portfolio of small-cap stocks and large cap stocks. The profitability factor p is defined by Fama and French as the Robust minus Weak (RMW) factor, which is calculated as the difference in return between a portfolio of highly profitable firm and low profitable firms. The investment factor i is defined as the Conservative minus Aggressive factor (CMA), which is calculated as the difference in return between a portfolio of firms with a low level of investment activity including divesting firms and a portfolio of firms with a high level of investment activity.

A4. Implementation of the minimum risk portfolio

The minimum risk portfolio is a natural measure of the risk reduction potential in a universe of risky assets. It is constructed without the need to estimate expected returns and is based on the covariance matrix of returns only. The minimum variance portfolio w for period t is calculated using the following expression:

$$w_t = \frac{\Omega^{-1}\iota}{\iota'\Omega^{-1}\iota}, \tag{A1}$$

where Ω is the historical covariance matrix estimated over the estimation period $t-1$ preceding the time of portfolio construction and ι is a vector of ones.