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Angaben zur Veröffentlichung / Publication details:

Liu, Yang, Martin Blankenburg, and Mei Wang. 2023. "Earnings expectations of grey and green energy firms: analysis against the background of global climate change mitigation." *Energy Economics* 121: 106692. https://doi.org/10.1016/j.eneco.2023.106692.

Earnings expectations of grey and green energy firms: Analysis against the background of global climate change mitigation

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ARTICLE INFO

JEL:
Classification: G40
Q42
Q43
Keywords:
Conventional energy stocks
Renewable energy stocks
Earnings optimism
Earnings forecast errors
Behavioral finance

ABSTRACT

Promoting the adoption of green energy and reducing the consumption of conventional energy are becoming one of the most critical subjects in our society. Against this background, what are the investors' earnings expectations and how they form their expectations of green and conventional energy firms are still unclear. In this study, we aim to fill these gaps by systematically examining investors' earnings expectations of these firms from 1992 to 2016. We find that market participants are overly optimistic about the future earnings of both grey energy and green firms. However, the earnings optimism about these two types of firms is less potent than the market average. Besides, the earnings expectations of both firms exhibit time-varying pattern that investors are more optimistic after 2008. Surprisingly, no significant difference in earnings expectations between grey and green companies is identified in the studied period. Regression results indicate a positive relation between firm investment (profitability) and earnings optimism of green (grey) firms, indicating that investors overestimate different firm characteristics of these firms when forming their earnings expectations.

1. Introduction

In the early 1990s, the debate on climate change was limited to scientific discourses and the environmental awareness of the public about the need for green energy and clean technology was also very limited. However, since the United Nations Framework Convention on Climate Change in Rio in 1992, climate change mitigation and low-carbon and sustainable development have become one of the most critical subjects in society. More and more scientific evidence started to attest to the disastrous consequences of global warming, making the switch from traditional energy to green energy an emerging political and social agenda (Al Mamun et al., 2018). Over the last two decades, the potential and significance of cleaner energy and technology are becoming evident to the public (Zyadin et al., 2014). Thus, public awareness of the need for green energy has increased significantly in recent years (Kang et al., 2012).

With increasing awareness of environmental issues, there has been rising demand from investors for environmental-friendly business practices (Gadenne et al., 2009). Money flows into assets labeled as green or sustainable. The global annual investment in renewable energy capacity increased from 40.1 billion USD in 2004 to 282.2 billion USD in 2019, with a peak of 315.1 billion USD in 2017. The global renewable energy market was valued at 928.0 billion USD in 2017 and is expected to reach a valuation of 1512.3 billion USD by 2025, registering a compounded annual growth rate of 6.1% from 2018 to 2025 (Liu et al., 2021). In recent years, many countries have been working on promoting green finance. At the national level, central banks are making noises about prioritizing green investment and divesting fossil-based holdings (World Economic Forum, 2020). According to data compiled by Bloomberg Intelligence, the value of green and ESG funds traded on exchanges in 2017 reached a record of 41.6 billion USD. On the other side, it was estimated that by May 2018, 1048 institutions managing around 8.73 trillion USD have strategies limiting fossil fuel financing (Niyazbekova et al., 2021).

As reported by Bonaparte et al. (2017), investors' expectations of financial markets are dynamically influenced by the current political climate. Values, such as environmental and labor protection, may lead investors to overweight or underweight the stocks of companies associated with such issues. Thus, it can be expected that investors might gradually develop different expectations of firms in the green industry, i.e., renewable energy and clean technology sectors, and in the conventional energy sector, the so-called grey energy sector, in the last decades. However, previous studies related to firms in traditional and renewable energy sectors are carried out mostly on measuring the market

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connectedness between these two markets (Ferrer et al., 2018; Song et al., 2019; Uddin et al., 2019; Jiang et al., 2021) and studying the returns performance of stocks in these markets (King and Lenox, 2001; Boulatoff and Boyer, 2009; Tripathi and Bhandari, 2012; Flammer, 2013; Bildirici and Badur, 2019; Godil et al., 2020). It is well documented in previous studies, such as Brown et al. (1987), Dechow and Sloan (1997), Hong and Kubik (2003), Hughes et al. (2008) and Kothari et al. (2016), that market earnings expectations are, in general, optimistic. However, To the best of our knowledge, there is still no analysis conducted on investigating investors' earnings expectations of these two types of companies.

To fill this research gap, in this research, we systematically study investors' earnings expectations of firms in these two industries. As one important research stream, earnings expectations play key roles in solving the stock return puzzle and market anomalies (Lakonishok et al., 1994; Porta and Rafael., 1996; Skinner and Sloan, 2002; Doukas, 2002; Piotroski and Eric, 2012), understanding market sentiment (Hribar and McInnis, 2012), measuring the performance of the manager (Graham et al., 2005; Brauer and Wiersema, 2018), and analyzing the necessity of organizational or strategic change (Cyert and March, 1963). Using consensus analyst earnings forecast errors (EFEs), i.e., the difference between expected and actual earnings, to proxy investors' earnings expectations, we investigate whether investors are optimistic or pessimistic about future earnings performances of firms in grey energy and green branches and the changes in investors' earnings expectations over the studied period.[1] A strong positive EFE signals that investors hold optimistic earnings expectations, while a negative EFE indicates that the aggregated earnings expectation of investors is pessimistic. In addition, as mentioned beforehand, the market level earnings expectations are optimistic (Brown et al., 1987; Dechow and Sloan, 1997; Hong and Kubik, 2003). In this study, we further compare the earnings expectations of green and grey stocks with the market average to understand whether investors hold overly optimistic and pessimistic earnings expectations of these two types of companies.

Previous studies document that investors tend to be more optimistic about the future earnings performances of firms that have small sizes (Lys and Soo, 1995; Brown, 1997; Richardson et al., 1999; Easton and Sommers, 2007), low book-to-market ratios (Lakonishok et al., 1994; Porta and Rafael., 1996; Skinner and Sloan, 2002; Dechow and Sloan, 1997; Frankel and Lee, 1998), low profitability (Klein, 1990; Ali et al., 1992), high investment expenditures (Titman et al., 2004; Dehning et al., 2006; Gennaioli et al., 2016), young age (Ritter, 1991), less predictability (Das et al., 1998; Huberts and Fuller, 1995) and recent positive earnings surprises (So, 2013). However, these results are obtained by analyzing the pooled sample, lacking thus industry-specific analysis. In this study, we extend the existing literature by exploring how investors form their earnings expectations of green and grey energy firms by regressing the EFEs on firm characteristics. In particular, we focus on the relations between firm's profitability and investment expenditures and their EFEs for these two types of firms, respectively.

Traditional energy companies with long development history and well-established technologies are driven by profit. For these firms, profit is the pivotal variable that all proposed investments must meet profitability hurdle rates in order to be approved (Christophers, 2021). In contrast, as an emerging sector, the green industry requires significant investments to generate technological innovations, which are essential for the development of firms in this sector (Al Mamun et al., 2018). However, the entire innovation process is not only long, distinctive and fickle, but also involves uncertainties to be successful (Hsu et al., 2014). Thus, returns on investments in technological progress are volatile and low. Given the distinctive differences between these two industries, investors might form their earnings expectations in different ways such that they might overweight investment expenditures when facing green firms but not those grey industry corporates.

By constructing green and grey portfolios containing firms in conventional energy and green sectors, we systematically examine the earnings expectations, proxied by EFEs, of these two industries for the period from 1992 to 2016. We find that over the whole studied period, both grey and green portfolios have, on average, positive EFEs, indicating that investors are optimistic about the future earnings of corporates in these sectors. However, the magnitude of investors' earnings optimism about these two types of firms is significantly lower than the market average. Surprisingly, when comparing the EFEs between grey and green portfolios, we do not identify a significant difference. In addition, it is observed that the earnings optimism about green and grey energy companies shows time-varying pattern that investors become more confident about future earnings performances of green companies after 2008. Our regression results indicate a positive relationship between firm's profitability and EFE for conventional energy companies, indicating that investors hold more positive expectations about future earnings performances when grey energy firms are profitable. For green firms, however, this relation is not significant. In contrast, we identify that corporate investment expenditures have a significantly positive influence on investors when forming earnings expectations, indicating that investors are confident about the outcomes of the investments of green energy and clean technology companies.

Our study contributes to the energy economics and finance literature in a number of ways. First, to the best of our knowledge, this is the first study that systematically investigates investors' earnings expectations of conventional energy and green firms in a period when environmental protection is gradually more widely acknowledged by the public. As one of the basic principles of economics: expectations influence decisions, our findings can be used to explain investors' behaviors regarding these two types of firms (Gennaioli et al., 2016). Second, this research explores how investors form their earnings expectations when facing traditional energy and green companies. Therefore, our study can shed light on the discussion on relationships between EFE and firm characteristics by providing an industry-specific analysis, as previous studies focusing on this topic generally use the pooled sample. Our results clearly indicate that for grey and green energy companies, investors emphasize different firm characteristics in forming their earnings expectations, suggesting an industry-varying behavior of investors.

In addition to these academic contributions, our work has an essential real-world implication for managers in green and grey energy branches. It is reported that managers have great incentives to align firms' earnings with market expectations to protect their companies' stock prices by avoiding any negative earnings surprises, which could cause a severe slump in stock prices (Payne and Robb, 2000). Our study's results can help managers understand how market participants form their earnings expectations so that managers can effectively conduct earnings management to meet those expectations. This is especially critical for green firms who are heavy users of external financing (Kim and Park, 2016). If green firm managers continually fail to implement successful earnings managements, frequent negative earnings surprises might make investors vacillate to invest and deliver an image that investments in this industry are highly risky but profitable. Furthermore, our study provides investors with implications from the portfolio and risk management perspective. Our results show that investors are optimistic to green firms with higher investments, indicating that investors might overvalue the development potentials but neglect risks and uncertainties of these investments. Such high investment expenditures are likely to happen in the period when market conditions are favorable and external financing is sufficient. Therefore, investors should be more careful when forming their earnings

[1] The aggregated market-level investors' expectation of firm's future earnings performance is unobservable. However, as found by Elton et al. (1981), stock prices respond more to changes in analyst forecasts of earnings than they do to changes in earnings themselves. As a result, it has become standard in the industry to use the consensus analyst earnings forecasts to poxy the unobservable market expectations for firm earnings (Fried and Givoly, 1982).

expectations and investing in these stocks, especially in bullish markets.

The remainder of the paper is organized as follows. In the next section, we describe the sample data and the methodology deployed in this research. In the third section, we report our empirical results. In the fourth section, we discuss the key findings in this research. In the final section, we conclude the study and provide indications for future work.

2. Data and methodology

2.1. Data

Following Fama and French (2015), we select all NYSE, Amex, and NASDAQ stocks on both CRSP and Compustat with share codes 10 and 11. We obtain the annual data on firms' consensus analyst earnings forecasts, i.e., the average of all available analysts' earnings forecasts covering the stock, and actual earnings published in June in the form of earnings per share from the Institutional Brokers Estimate System (Doukas, 2002; Porta and Rafael., 1996).[2] Note that the analyst earnings forecasts are not available for all the firms. Furthermore, the data on corporate fundamentals are collected from the CRSP/Compustat Merged - Fundamentals Annual and Quarterly database. To ensure a fair comparison, we follow Piotroski and Eric (2012) and Hou et al. (2015) to exclude all financial firms and firms with negative or zero book-to-market ratios from the raw data sample.[3]

Exploring the relation between firm characteristics and EFE, we focus on classic corporate characteristics: firm size, book-to-market ratio, investment and profitability. The measures of these firm characteristics are calculated following Xing (2008), Novy-Marx (2013), Fama and French (2015) and Hou et al. (2015). Consistent with Fama and French (1993), the firm size (market capitalization of equity, ME) in June in year t, ME_t, is measured by the market value of outstanding shares at the end of fiscal year *t-1*. Firm value measured as book-to-market ratio (B/M) in June of year t, B/M_t, is defined following Fama and French (1993):

$$B\Big/M_t = \frac{BVCE_{t-1} + DT_{t-1} + ITC_{t-1} - BVPS_{t-1}}{ME_{t-1}} \tag{1}$$

where BV_{t-1}, DT_{t-1}, ITC_{t-1} and $BVPS_{t-1}$ are the book value of common equity (item 60), balance-sheet deferred taxes (item 74), investment tax credits (item 208), the book value of preferred stock at the end of fiscal year *t-1*. Depending on data availability, we use redemption (item 56), liquidation (item 10), or par value (item 130) to estimate the value of preferred stock (Xing, 2008; Fama and French, 1993). ME_{t-1} is the market capitalization of equity in fiscal year *t-1*.

In terms of firm investment measures, we focus on the investment-to-capital ratio (IK) of Xing (2008), the investment-to-asset ratio (IA) of Fama and French (2015), and the investment growth rate (IG) of Xing (2008). The IK in June of year t, IK_t, is derived as follows:

$$IK_t = \frac{CAPX_{t-1}}{PPENT_{t-2}} \tag{2}$$

where $CAPX_{t-1}$ is firm's capital expenditures (item 128) in the fiscal year *t-1* and $PPENT_{t-2}$ is the firm's net book value of property, plants, and equipment (item 8) in the fiscal year *t-2* (Xing, 2008). The IA of Fama and French (2015) in June of year t, IA_t, is defined as follows:

$$IA_t = \frac{AT_{t-1} - AT_{t-2}}{AT_{t-2}} \tag{3}$$

where AT_{t-1} and AT_{t-2} are total assets (item 6) in fiscal years *t-1* and *t-2* (Fama and French, 2015). The IG of Xing (2008) in June of year t, IG_t, is the ratio of capital expenditures (item 128) $CAPX_{t-1}$ and $CAPX_{t-2}$ in fiscal years *t-1* and *t-2* (Xing, 2008):

$$IG_t = \frac{CAPX_{t-1}}{CAPX_{t-2}} - 1 \tag{4}$$

The three firm profitability measures that are the focus of the current study are the gross profitability-to-asset ratio (GP) of Novy-Marx (2013), the operating profitability (OP) of Fama and French (2015), and the return-on-equity ratio (ROE) of Hou et al. (2015). GP in June of year t, GP_t, is derived as follows:

$$GP_t = \frac{REVT_{t-1} - COGS_{t-1}}{AT_{t-1}} \tag{5}$$

where $REVT_{t-1}$, $COGS_{t-1}$, and AT_{t-1} are the total revenue (item G321), the cost of goods sold (item 41), and the total assets in the fiscal year *t-1* (Novy-Marx, 2013). The OP in June of year t, OP_t, is defined as follows:

$$OP_t = \frac{REVT_{t-1} - COGS_{t-1} - XSGA_{t-1} - XINT_{t-1}}{BE_{t-1}} \tag{6}$$

where $REVT_{t-1}$, $COGS_{t-1}$, and BE_{t-1} are the total revenue, the cost of goods sold, and the book value of equity in fiscal year *t-1*. $XSGA_{t-1}$ is selling, general, and administrative expenses (item 132), and $XINT_{t-1}$ is total interest and related expenses (item 134) measured in fiscal year *t-1* (Fama and French, 2015). The last profitability measure in this study is the ROE of Hou et al. (2015). We use the annual equivalents of the variables for consistency with the frequency of all other constructed variables. Thus, the ROE in year t, ROE_t, is measured as follows:

$$ROE_t = \frac{IB_{t-1}}{BE_{t-2}} \tag{7}$$

where IB_{t-1} is the annual income before extraordinary items (item 18) in the fiscal year *t-1* and BE_{t-2} is the book value of equity observed at the end of the fiscal year *t-2* (Hou et al., 2015).

Following Piotroski and Eric (2012), we calculate the one-fiscal-year ahead EFE. Previous studies use share price as a scaling factor to measure earnings optimism (Chopra, 1998; Richardson et al., 2004). In this study, however, we scale forecast error by total assets per share. This is because the price level was unusually high during the 1990s, and it is likely that earnings optimism may appear to vanish during this period because of the scaling effect (Qian, 2009). The analyst earnings forecast errors in June of year t, EFE_t, are defined as follows:

$$EFE_t = \frac{Expected\ Earnings_t - Actual\ Earnings_{t+1}}{Total\ Assets\ per\ Share_t} \tag{8}$$

where $Actual\ Earnings_{t+1}$ is actual firm earnings observed in June of year $t+1$. $Expected\ Earnings_t$ is the consensus one-fiscal-year-ahead earnings forecast issued in June in year t. $Total\ Assets\ per\ Share_t$ is the total assets per share in June in year t. Following Novy-Marx (2013) and Fama and French (2015), the calculated EFEs are trimmed yearly at the 1% and 99% levels to remove the effect of outliers and data errors. Ultimately, we have 41,346 firm-year observations in our sample with complete data on all the firm characteristics. The sample period covers the years 1992 through 2016 when the market conditions were rather stable and less affected by those beyond market crises such as COVID-19 and the current Ukraine war, enabling us to have a clearer understanding on investors behaviors. Table A1 in Appendix provides full-sample descriptive statistics for all the calculated firm characteristics and EFE.

Based on this sample, we manually identify companies that engage in the green energy and technology fields to construct our green portfolio.

[2] Institutional Brokers Estimate System, I/B/E/S, is a database from the Refinitiv. It is an historical earnings estimate database containing analyst estimates for more than 20 forecast measures covering both U.S. and international companies.

[3] Firms with Standard Industrial Classification codes between 6000 and 6999.

To be included in the green portfolio, companies must have their primary business in green energy and technology fields.[4] Based on this criterion, we select 98 companies for the green portfolio with 1016 firm-year observations. In terms of the grey portfolio containing conventional energy companies, we also manually select all the firms with their business fields in the petroleum, gas and coal sectors from the sample. In total, we have 228 companies for the grey portfolio with 1578 firm-year observations. All the rest 38,752 observations left in the sample together construct the market portfolio, serving as a benchmark portfolio. In Table 1, we present the descriptive statistics on the firm characteristics and EFE for each constructed portfolio.

2.2. Methodology

We first investigate the pooled sample earnings expectations of all three portfolios from 1992 to 2016. As shown in Table 1, the EFEs of all the studied portfolios are not symmetrically distributed but positively skewed, implying that extreme observations can influence the mean value. Thus, we examine both the mean and median values of the EFEs. We compare the two energy portfolios with the market portfolio by conducting mean (*t*-test) and median (Kruskal-Wallis test) difference tests. However, the pooled sample analysis results can be misled by investors' excessive optimism/pessimism concentrated in specific years, and the potential time-varying patterns may be ignored in such examination (Doukas, 2002). Thus, we further conduct mean and median EFE difference tests between portfolios on an annual basis over the studied period to study whether the observed patterns of earnings expectations from the pooled sample analysis vary with the calendar year.

After examining the patterns of EFEs of green and grey portfolios, we follow Dehning et al. (2006) to conduct a firm-level ordinary least squares regression analysis to study the effects of different firm characteristics on the EFEs for each of the three studied portfolios. The test statistics are calculated using Newey and West (1987) standard errors to account for potential heteroskedasticity and autocorrelation. We first regress the EFE on firm size and B/M:

$$EFE_t^i = \alpha_i + \beta_1 log\left(ME_t^i\right) + \beta_2 B/M_t^i + \epsilon_{i,t} \tag{9}$$

where EFE_t^i is the earnings forecast error of firm i in year t, α is the intercept, $log(ME_t^i)$ and B/M_t^i are log market capitalization and book-to-market ratio of firm i in year t and ϵ is the error term.

Then, we regress the EFE on each of the three firm investment variables together with the firm size and value measures, respectively. By doing so, we are able to understand the information overlap among variables in the same category when comparing with the results of the following combined regression. This leads to the specification of the following three models:

$$EFE_t^i = \alpha_i + \beta_1 log\left(ME_t^i\right) + \beta_2 B/M_t^i + \beta_3 IK_t^i + \epsilon_{i,t}, \tag{10}$$

$$EFE_t^i = \alpha_i + \beta_1 log\left(ME_t^i\right) + \beta_2 B/M_t^i + \beta_3 IA_t^i + \epsilon_{i,t}, \tag{11}$$

$$EFE_t^i = \alpha_i + \beta_1 log\left(ME_t^i\right) + \beta_2 B/M_t^i + \beta_3 IG_t^i + \epsilon_{i,t} \tag{12}$$

where IK_t^i, IA_t^i and IG_t^i are investment-to-capital ratio, investment-to-asset ratio and investment growth rate of firm i in year t. After individual investment measure regressions, we run a combined investment variables regression:

$$EFE_t^i = \alpha_i + \beta_1 log\left(ME_t^i\right) + \beta_2 B/M_t^i + \beta_3 IK_t^i + \beta_4 IA_t^i + \beta_5 IG_t^i + \epsilon_{i,t}. \tag{13}$$

In terms of the effect of firm profitability on the EFE, similar to the investment variables case, we first conduct individual regression for each firm profitability measure:

$$EFE_t^i = \alpha_i + \beta_1 log\left(ME_t^i\right) + \beta_2 B/M_t^i + \beta_3 GP_t^i + \epsilon_{i,t}, \tag{14}$$

$$EFE_t^i = \alpha_i + \beta_1 log\left(ME_t^i\right) + \beta_2 B/M_t^i + \beta_3 OP_t^i + \epsilon_{i,t}, \tag{15}$$

$$EFE_t^i = \alpha_i + \beta_1 log\left(ME_t^i\right) + \beta_2 B/M_t^i + \beta_3 ROE_t^i + \epsilon_{i,t} \tag{16}$$

where GP_t^i, OP_t^i and ROE_t^i are gross profitability-to-asset ratio, operating profitability and return-on-equity ratio of firm i in year t. Subsequently, a combined regression model is defined:

$$EFE_t^i = \alpha_i + \beta_1 log\left(ME_t^i\right) + \beta_2 B/M_t^i + \beta_3 GP_t^i + \beta_4 OP_t^i + \beta_5 ROE_t^i + \epsilon_{i,t}. \tag{17}$$

At the end, we employ all the studied firm characteristics in one regression model, which is specified as following:

$$\begin{aligned} EFE_t^i = & \alpha_i + \beta_1 log\left(ME_t^i\right) + \beta_2 B/M_t^i + \beta_3 IK_t^i + \beta_4 IA_t^i + \beta_5 IG_t^i + \beta_6 GP_t^i \\ & + \beta_7 OP_t^i + \beta_8 ROE_t^i + \epsilon_{i,t}. \end{aligned} \tag{18}$$

3. Empirical results

3.1. Earnings forecast errors of market, conventional and renewable energy portfolios

Table 2 presents the pooled sample mean and median EFEs for market, grey and green portfolios. As shown, all the mean and median forecast errors listed in this table are positive, indicating that the earnings expectations of these three portfolios are generally optimistic. This finding is in line with many previous studies, indicating a prevalence of market earnings optimism (O'brien, Patricia C., 1988; Abarbanell, 1991; Das et al., 1998; Hong and Kubik, 2003; Hughes et al., 2008; Kothari et al., 2016). However, compared to the market portfolio, it is found that the expectations for future earnings of grey and green companies are significantly less optimistic. While the mean EFE for the market portfolio is 0.0137, they are 0.0075 and 0.0079 for green and grey portfolios. The highly significant *t*-statistics evidence the distinct differences. A similar picture can also be observed in the median analysis. In contrast, both mean and median differences in EFEs between conventional and renewable energy portfolios are nonsignificant, indicating that investors form similar earnings expectations about firms from these two sectors.

In Fig. 1, we illustrate the annual mean and median EFEs of the three portfolios from 1992 to 2016. The mean and median values for each portfolio are reported in Table A2 in Appendix. In Table 3, we list the pairwise annual mean and median differences in EFEs between market, grey and green portfolios. As shown in Fig. 1, before 2008, the market portfolio has generally larger mean and median EFEs than the other two portfolios, indicating that investors are less optimistic about the future earnings performances of firms in grey and green portfolios. This observation is evidenced by the results of mean and median differences tests listed in Table 3. From 1992 to 2007, the mean EFEs of green and grey portfolios are significantly smaller than those of the market portfolio for 10 and 11 out of 16 years, respectively. A similar pattern is observed in the median difference analysis. In 2008, peaks of both mean and median forecast errors for all the three portfolios are evident, implying that investors were still very optimistic in June 2008, shortly before the bankruptcy of Lehman Brothers in September. Especially, we observe strong surges of both mean and median EFEs for the conventional energy portfolio, which could be the result of the high oil price, i.e., 133.88 USD per barrel, in June 2008. After 2008, we observe that the EFEs of the two energy portfolios are at least indifferent to the market average for many years. In 2008 and 2014, we even observe that the grey portfolio has significantly larger mean and median forecast errors than the market portfolio. In terms of the green portfolio, only in 2010 do we observe that the market portfolio has significantly larger mean and median forecast errors. In the other eight years, both mean and

[4] The green energy and technology segments contain bioenergy and ethanol, geothermal energy, hydroelectric power, solar energy, wind power, *E*-mobility, fuel cell, energy storage and waste and pollution treatment sectors.

Table 1
Descriptive Statistics on all the Firm-level Corporate Characteristics and Earnings Forecast Error for Market, Grey and Green Portfolios.

	ME	B/M	IK	IA	IG	GP	OP	ROE	EFE
Panel A: Market Portfolio									
Mean	4456.48	0.5872	0.2781	0.1747	0.3978	0.3758	0.2065	0.0658	0.0137
Minimum	1.41	0.0001	0.0022	−0.7820	−0.9812	−1.1430	−6.1398	−7.4820	−0.2868
25th Percentile	179.02	0.2670	0.1402	−0.0073	−0.1910	0.2123	0.1202	0.0155	−0.0033
Median	582.79	0.4524	0.2257	0.0780	0.1020	0.3496	0.2236	0.1054	0.0030
75th Percentile	2116.14	0.7367	0.3701	0.2154	0.5210	0.5187	0.3327	0.1876	0.0202
Maximum	715,599.80	23.90	1.1369	5.9462	17.89	1.3627	7.6287	4.5877	0.3949
Std. Dev.	18,930.48	0.6172	0.1887	0.4215	1.3665	0.2677	0.4700	0.4239	0.0503
Kurtosis	226.09	228.60	1.4450	30.57	46.45	2.1657	46.48	55.91	14.27
Skewness	12.24	9.7658	1.2523	4.3443	5.6683	0.1408	−1.3359	−3.4264	2.3682
Panel B: Grey Portfolio									
Mean	10,998.12	0.7510	0.2238	0.1850	0.3690	0.1770	0.2162	0.0969	0.0075
Minimum	9.7950	0.0021	0.0145	−0.6570	−0.8933	−1.1430	−6.1398	−1.7310	−0.1617
25th Percentile	333.18	0.4730	0.1079	0.0102	−0.1299	0.1082	0.1655	0.0374	−0.0043
Median	1413.40	0.6699	0.1747	0.0886	0.1371	0.1590	0.2302	0.0891	0.0014
75th Percentile	4841.10	0.9009	0.2899	0.2208	0.5124	0.2376	0.3231	0.1537	0.0135
Maximum	47,2518.7	8.5241	1.0754	3.3166	17.89	0.7729	7.6287	4.5877	0.3390
Std. Dev.	42,061.41	0.5077	0.1634	0.3961	1.1390	0.1459	0.5294	0.3232	0.0394
Kurtosis	60.46	53.79	3.7028	18.82	61.65	14.77	86.59	53.17	18.71
Skewness	7.3563	4.9537	1.7212	3.5936	6.1594	−1.4316	−3.0847	4.4036	2.5872
Panel C: Green Portfolio									
Mean	10,668.86	0.6060	0.1831	0.1337	0.2486	0.2546	0.2159	0.0771	0.0079
Minimum	3.1953	0.0157	0.0032	−0.4792	−0.9371	−0.4839	−4.3292	−3.1698	−0.2050
25th Percentile	284.49	0.3296	0.1001	−0.0010	−0.1350	0.1186	0.1446	0.0438	−0.0019
Median	948.15	0.5263	0.1564	0.0683	0.0888	0.2227	0.2124	0.0978	0.0010
75th Percentile	3894.88	0.7533	0.2311	0.1471	0.3784	0.3388	0.3180	0.1678	0.0105
Maximum	524,351.60	3.9944	0.9588	4.3871	14.25	1.3627	3.0995	2.4246	0.3930
Std. Dev.	44,174.03	0.4034	0.1207	0.3503	0.9001	0.1854	0.3621	0.2779	0.0365
Kurtosis	60.18	9.8420	5.6461	46.57	76.35	3.5083	55.40	38.73	25.38
Skewness	7.3680	2.2537	1.8392	5.5302	6.7155	1.3696	−3.1997	−1.8651	2.6198

Note: This table provides descriptive statistics on all the calculated firm-level corporate characteristics and analysts earnings forecast errors for each portfolio, i.e., market, renewable energy and conventional energy portfolios, for the period from 1992 to 2016. Std. Dev. stands for standard deviation and the kurtosis is the excess kurtosis.

Table 2
Pooled Sample Mean and Median Values of Earnings Forecast Errors for Market, Grey and Green Portfolios.

	Market	Grey	Green
Mean	0.0137	0.0075	0.0079
Mean Difference		0.0062***	0.0058***
(Market)		(6.06)	(4.96)
Mean Difference			−0.0004
(Grey)			(−0.26)
Median	0.0030	0.0014	0.0010
Median Difference		0.0016***	0.0020***
(Market)		(26.42)	(12.86)
Median Difference			0.0004
(Grey)			(0.18)

Note: This table presents the mean and median values of one-fiscal-year-ahead analyst earnings forecast errors for market, grey and green portfolios for the pooled sample from 1992 to 2016. In addition, we report the differences in means and medians between portfolios. The test statistics for the mean difference test (*t*-statistic) and median difference test (Kruskal-Wallis x^2) are reported in parentheses. ***, **, and * indicate significance at the 1% and 5% and 10% levels, respectively.

median differences of EFEs between these two portfolios are generally nonsignificant.

In terms of the EFE comparisons between grey and green portfolios, we are not able to draw any conclusion about a distinct difference in the EFE between them. In total 25 study years, the grey portfolio has significantly smaller median EFE than the green portfolio for eight years, whereas the opposite is observed for the other eight years. A similar pattern is also evident in the mean difference analysis. Notably, compared to market and green portfolios, both mean and median EFEs of the conventional energy portfolio fluctuate more strongly in the studied period. This could be resulted from the highly volatile oil prices in the examined period. In summary, the evidence suggests that the EFEs of grey and green portfolios exhibit time-varying behaviors. Consistent with pooled sample examination, we cannot observe a significant difference in EFEs between conventional and renewable energy portfolios in the annual analysis.

3.2. *Earnings forecast errors and firm characteristics*

In this section, we provide regression results of EFEs on firm characteristics for each of the three portfolios. The descriptive statistics and correlation matrices are listed in Table 1 and Table A3 in Appendix. Furthermore, we provide the results of mean and median difference tests for each studied firm characteristic in Table A4 in Appendix.

Table 4 presents the regression results for the market portfolio. In line with previous studies, the negatively significant coefficient on log *(ME)* in model (1) indicates that earnings optimism is negatively related to firm size (Lys and Soo, 1995; Brown, 1997; Richardson et al., 1999; Easton and Sommers, 2007). Additionally, the EFE is also negatively correlated with the *B/M*, implying that value firms receive less positive earnings forecasts than growth firms. This pattern is also reported in many previous studies, such as Porta and Rafael. (1996), Lakonishok et al. (1994), La Porta et al. (1997) and Skinner and Sloan (2002). Models (2)–(4) provide the regression results for each investment variable with the presence of log*(ME)* and *B/M*. As shown, all the three investment variables are positively significant at 1% level respectively, implying that corporate investment expenditures increase with the overestimation of future earnings. This result is consistent with numerous previous studies that also document a positive relationship

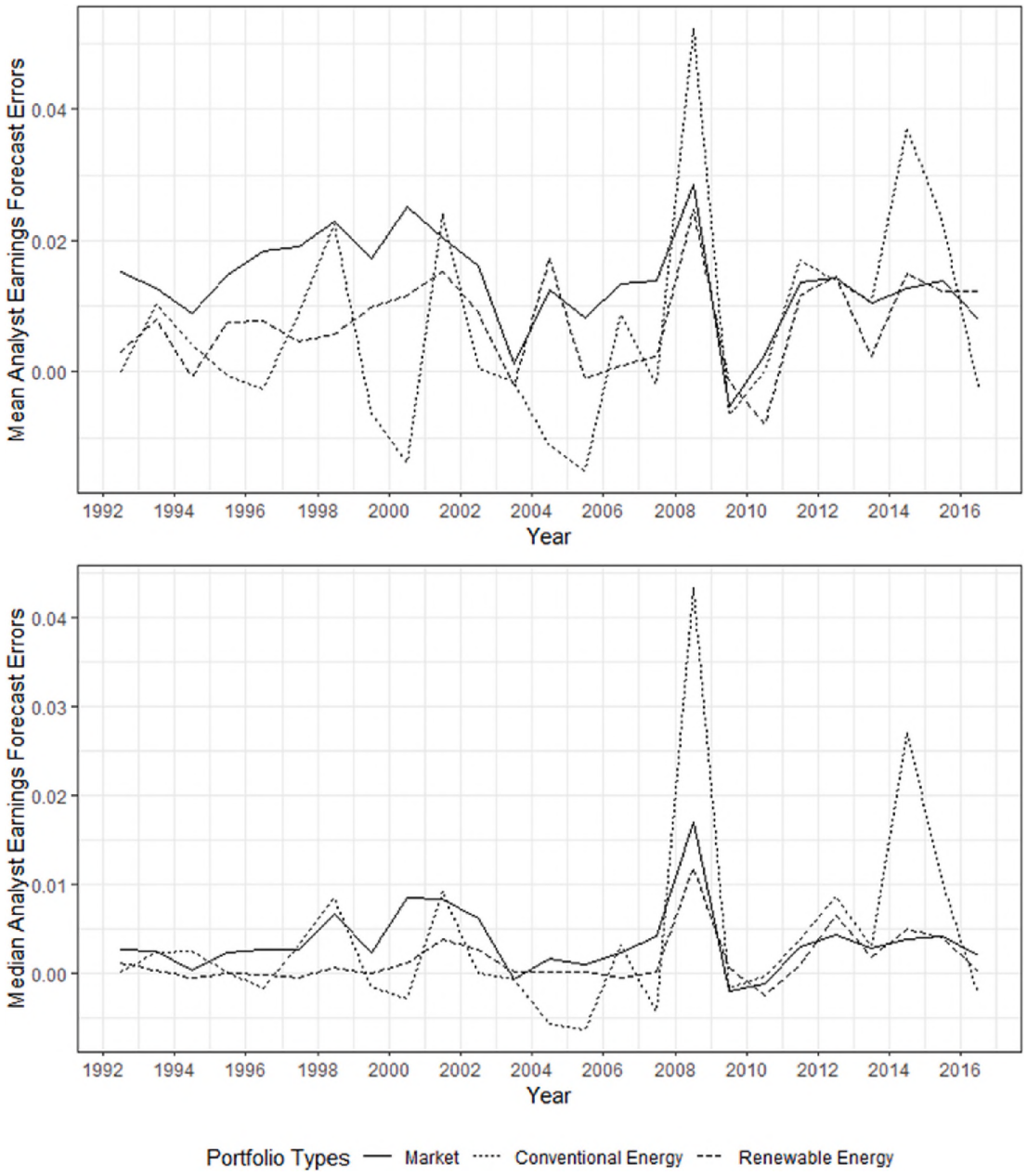

Fig. 1. Annual Mean and Median Values of Analyst Earnings Forecast Errors for Market, Grey and Green Portfolios from 1992 to 2016. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

between EFE and firm investment expenditures (Dehning et al., 2006; Titman et al., 2004; Gennaioli et al., 2016). In model (5) where the EFE is regressed on all the three investment measures, it is observed that the loading on the *IG* shrinks substantially and turns nonsignificant. In terms of the firm profitability measures, the result of model (6) shows that *GP* does not have any influence on earnings optimism. Consistent with previous studies, the results of models (7) and (8) suggest a negative correlation between EFE and firm profitability, indicating that investors are more optimistic about future earnings performances of less profitable firms (Klein, 1990; Ali et al., 1992). Surprisingly, in model (9), the coefficient on the *GP* becomes positively significant, while the coefficients on *OP* and *ROE* remain negatively significant. The result of the model (10) shows that only the coefficient on *IG* is nonsignificant at the conventional level, whereas the coefficients on all other firm characteristics are highly significant at 1% level. Moreover, the intercept size declines from models (1) to (10) but is significant across all the ten models, implying that the size of the unexplained earnings optimism in the market portfolio remains large. This observation provides evidence that investors' earnings optimism might be spontaneous.

In Table 5, we report the regression results for the grey portfolio. Similar to the market portfolio, the coefficients on *log(ME)* and *B/M* are consistently negatively significant for all the ten models, indicating that firm size and value have strong negative effects on EFEs of conventional energy companies. The results of models (2)–(4) suggest that the relationship between EFE and each investment factor is positively significant. However, in the combined model (5), we observe that none of the investment variables is significant at the conventional level. Recall that in the market portfolio, it is evident that the coefficients on *IK* and *IA* are highly significant. This observation indicates a considerable information overlap among the investment measures for the grey portfolio that investors do not distinguish the information conveyed from these investment factors in forming their earning expectations. In terms of the

Table 3
Mean and Median Differences of Analyst Earnings Forecast Errors between Market, Grey and Green Portfolios by Calendar Year.

	Market - Grey		Market - Green		Grey - Green		Observations		
	Mean Difference	Median Difference	Mean Difference	Median Difference	Mean Difference	Median Difference	Market	Grey	Green
1992	0.0155***	0.0025***	0.0122***	0.0015	−0.0033	−0.0010	1158	45	17
	(7.24)	(11.74)	(7.03)	(0.93)	(−1.55)	(1.86)			
1993	0.0025	0.0003	0.0047	0.0023	0.0022	0.0020	1233	51	19
	(0.71)	(0.17)	(0.89)	(0.44)	(0.36)	(0.12)			
1994	0.0048	−0.0022	0.0099***	0.0008	0.0051	0.0030***	1390	50	20
	(1.45)	(2.25)	(4.29)	(1.49)	(1.38)	(6.96)			
1995	0.0154***	0.0021***	0.0072*	0.0023	−0.0082*	0.0002	1573	55	21
	(5.58)	(8.41)	(1.72)	(0.29)	(−1.74)	(1.62)			
1996	0.0211***	0.0044***	0.0106**	0.0029	−0.0105*	−0.0015***	1711	60	21
	(7.28)	(25.37)	(2.24)	(0.48)	(−2.00)	(7.55)			
1997	0.0146***	−0.0005	0.0043***	0.0031*	0.0043	0.0036***	1738	57	23
	(2.75)	(0.62)	(3.48)	(2.82)	(0.81)	(7.03)			
1998	0.0004	−0.0019*	0.0171***	0.0059*	0.0167**	0.0078***	1885	63	28
	(0.07)	(2.84)	(4.41)	(3.80)	(2.62)	(12.92)			
1999	0.0235**	0.0038***	0.0074	0.0023	−0.0161	−0.0015*	1739	56	31
	(2.63)	(14.01)	(0.92)	(0.41)	(−1.37)	(3.05)			
2000	0.0392***	0.0113***	0.0135**	0.0072*	−0.0257***	−0.0041***	1614	52	30
	(7.46)	(45.49)	(2.47)	(3.40)	(−3.52)	(12.42)			
2001	−0.0036	−0.0009	0.0052	0.0045	0.0088	0.0054	1515	56	33
	(−0.66)	(1.14)	(0.98)	(0.72)	(1.19)	(1.80)			
2002	0.0158***	0.0061***	0.0070**	0.0035	−0.0088**	−0.0026**	1570	54	33
	(7.04)	(15.79)	(2.13)	(0.53)	(−2.40)	(6.00)			
2003	0.0029	0.0001	0.0036	0.0007	0.0007	−0.0008	1576	60	32
	(1.08)	(0.86)	(1.46)	(0.01)	(0.20)	(0.29)			
2004	0.0236***	0.0075***	−0.0049	0.0015	−0.0285***	−0.0060***	1611	62	35
	(9.14)	(36.20)	(−0.63)	(0.02)	(−3.52)	(15.61)			
2005	0.0231***	0.0073***	0.0091***	0.0008*	−0.0140**	−0.0065***	1609	63	35
	(5.27)	(29.01)	(2.70)	(3.27)	(−2.63)	(7.38)			
2006	0.0047	−0.0010	0.0123***	0.0028**	0.0076	0.0038**	1616	64	44
	(1.14)	(0.00)	(2.77)	(4.14)	(1.30)	(4.15)			
2007	0.0158***	0.0085***	0.0115***	0.0040**	−0.0043	−0.0045***	1551	73	46
	(2.99)	(26.01)	(3.99)	(4.69)	(−0.74)	(6.78)			
2008	−0.0138***	−0.0265***	0.0037	0.0052	0.0275***	0.0317***	1556	69	48
	(−3.82)	(19.34)	(0.61)	(0.47)	(3.24)	(11.80)			
2009	0.0013	−0.0005	−0.0038	−0.0027	−0.0051	−0.0022	1619	81	51
	(0.35)	(0.00)	(−0.57)	(2.00)	(−0.69)	(1.71)			
2010	0.0026	−0.0009	0.0108***	0.0014**	0.0082*	0.0023*	1536	71	56
	(0.75)	(0.05)	(2.71)	(4.65)	(1.64)	(2.77)			
2011	−0.0034	−0.0008	0.0021	0.0021	0.0055	0.0029	1494	69	54
	(−0.54)	(0.77)	(0.53)	(0.03)	(0.76)	(0.85)			
2012	0.0005	−0.0044	−0.0001	−0.0022	−0.0006	0.0022	1522	69	62
	(0.15)	(2.53)	(−0.02)	(2.15)	(−0.11)	(0.00)			
2013	−0.0001	−0.0002	0.0082**	0.0010	0.0083	0.0012	1476	72	65
	(−0.04)	(0.04)	(2.18)	(0.59)	(1.52)	(0.65)			
2014	−0.0243***	−0.0232***	−0.0021	−0.0021	0.0222***	0.0221***	1452	77	70
	(−3.85)	(51.09)	(−0.50)	(0.80)	(3.01)	(24.23)			
2015	−0.0090	−0.0060***	0.0016	0.0001	0.0106	0.0061**	1472	77	71
	(−1.55)	(12.55)	(0.25)	(0.04)	(1.26)	(5.69)			
2016	0.0014***	0.0044***	−0.0042	0.0018	−0.0146*	−0.0026*	1536	72	71
	(3.47)	(14.68)	(−0.53)	(1.58)	(−1.77)	(3.59)			

Note: This table presents the annual mean and median differences of one-fiscal-year-ahead analyst earnings forecast errors between the market portfolio and the grey and green portfolios for the period from 1992 to 2016. The test statistics for the mean difference test (*t*-statistics) and median difference test (Kruskal-Wallis x^2) are reported in the parentheses. In addition, we also list the number of observations in each portfolio for each year. ***, **, and * indicate significance at the 1% and 5% and 10% levels, respectively.

profitability measures, the loading on *GP* in model (6) is positive and significantly different from zero. This finding indicates that market participants are significantly more optimistic about the future earnings of conventional energy firms with higher gross profitability. This finding is consistent with the previous market portfolio analysis. Notably, in models (7) and (8), the coefficients on *OP* and *ROE* are both nonsignificant. In the combined model (9), the only significant coefficient is the one on *GP*. The results of model (10) show that, in addition to log*(ME)* and *B/M*, only the *GP* is significant at 5% level, indicating that among all the different investment and profitability variables, market participants tend to be more optimistic about future earnings performances when conventional energy companies exhibit higher gross profitability. Furthermore, it is observed that the intercepts in the conventional energy portfolio regressions are consistently smaller than they are in the market portfolio regressions, but the intercepts remain significantly positive across all the models, implying that investors' endogenous earnings optimism about grey energy companies is below the market average.

In Table 6, we list the regression results for the green portfolio. Similarly, in model (1), we observe that both firm size and B/M negatively correlate with the EFE. The coefficients on both variables are statistically significant at 1% level. Surprisingly, as shown in model (2), the coefficient on B/M turns nonsignificant with the presence of the IK. This finding indicates that for green firms, the factor B/M provides the information of IK in the regression. Thus, B/M loses its ability to explain EFE when regressed with IK. In model (3) where the IA is added to the regression, all the firm characteristic factors are significant. The result of model (4) indicates that the IG is not significantly correlated with EFEs

Table 4
Regression Results for the Market Portfolio.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Intercept	0.0504***	0.0373***	0.0478***	0.0477***	0.0372***	0.0511***	0.0486***	0.0480***	0.0440***	0.0333***
	(0.0016)	(0.0012)	(0.0011)	(0.0016)	(0.0017)	(0.0020)	(0.0015)	(0.0015)	(0.0018)	(0.0019)
log(ME)	−0.0046***	−0.0040***	−0.0046***	−0.0044***	−0.0040***	−0.0047***	−0.0041***	0.0041***	−0.0038***	−0.0034***
	(0.0002)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
B/M	−0.0111***	−0.0091***	−0.0103***	−0.0105***	−0.0088***	−0.0112***	−0.0111***	−0.0112***	−0.0108***	−0.0087***
	(0.0009)	(0.0004)	(0.0004)	(0.0008)	(0.0008)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0008)
IK		0.0285***			0.0233***					0.0196***
		(0.0014)			(0.0021)					(0.0022)
IA			0.0097***		0.0070***					0.0073***
			(0.0006)		(0.0009)					(0.0009)
IG				0.0025***	0.0006					0.0006
				(0.0003)	(0.0004)					(0.0004)
GP						−0.0016			0.0069***	0.0059***
						(0.0017)			(0.0017)	(0.0017)
OP							−0.0092***		−0.0065***	−0.0059***
							(0.0013)		(0.0014)	(0.0014)
ROE								−0.0108***	−0.0083***	−0.0073***
								(0.0013)	(0.0014)	(0.0014)
Adj. R^2	0.03	0.05	0.04	0.04	0.05	0.03	0.04	0.04	0.05	0.06
Observations	38,752	38,752	38,752	38,752	38,752	38,752	38,752	38,752	38,752	38,752

Note: This table presents the regression results of earnings forecast errors on corporate characteristics for the market portfolio for the period from 1992 to 2016. The *t*-statistics for the coefficients are calculated based on the Newey-West standard errors, which are reported in parentheses. ***, **, and * indicate significance at the 1% and 5% and 10% levels, respectively.

Table 5
Regression results for the grey portfolio.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Intercept	0.0254***	0.0186***	0.0219***	0.0204***	0.0172***	0.0210***	0.0253***	0.0254***	0.0200***	0.0128**
	(0.0059)	(0.0053)	(0.0060)	(0.0062)	(0.0054)	(0.0062)	(0.0060)	(0.0059)	(0.0058)	(0.0053)
log(ME)	−0.0014**	−0.0012**	−0.0013**	−0.0011*	−0.0010*	−0.0014**	−0.0014**	−0.0014**	−0.0013**	−0.0009*
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0005)	(0.0005)
B/M	−0.0106***	−0.0094***	−0.0095***	−0.0092***	−0.0085***	−0.0094***	−0.0105***	−0.0105***	−0.0093***	−0.0076***
	(0.0025)	(0.0024)	(0.0025)	(0.0025)	(0.0024)	(0.0025)	(0.0025)	(0.0025)	(0.0024)	(0.0023)
IK		0.0194**			0.0077					0.0055
		(0.0083)			(0.0107)					(0.0108)
IA			0.0107***		0.0047					0.0048
			(0.0038)		(0.0029)					(0.0030)
IG				0.0051**	0.0039					0.0040
				(0.0023)	(0.0028)					(0.0028)
GP						0.0195**			0.0253**	0.0230**
						(0.0088)			(0.0101)	(0.0101)
OP							0.0009		−0.0030	−0.0020
							(0.0026)		(0.0031)	(0.0031)
ROE								0.0015	0.0002	−0.0026
								(0.0053)	(0.0061)	(0.0063)
Adj. R^2	0.02	0.03	0.03	0.04	0.04	0.02	0.02	0.02	0.02	0.04
Observations	1578	1578	1578	1578	1578	1578	1578	1578	1578	1578

Note: This table presents the regression results of earnings forecast errors on corporate characteristics for the grey portfolio for the period from 1992 to 2016. The t-statistics for the coefficients are calculated based on the Newey-West standard errors, which are reported in parentheses. ***, **, and * indicate significance at the 1% and 5% and 10% levels, respectively.

of green firms. As expected, with the presence of the IK, B/M is not significant in the combined model (5). Furthermore, IG is also not significant at the conventional level. The results of models (6) to (9) provide obvious evidence that there is no correlation between EFE and firm profitability performance for green companies. In the final model (10), it is evident that EFEs of green companies are significantly correlated only with firm size and investments, namely IK and IA but not with B/M. Notably, after controlling the effects of all the firm characteristics, the intercept in model (10) turns indifferent from zero, indicating that investors' earnings optimism about green companies generally comes from the overestimation of firms' investment expenditures.

4. Discussion

Our research yields many meaningful and useful insights. In this section, we discuss the key findings of this research.

First, we find that the earnings optimism of both green and grey portfolios exhibits time-varying pattern. After the 2008 Global Financial Crisis (GFC), we observe that the EFEs of grey and green portfolios are generally indifferent from the market average EFE, indicating that investors hold market average earnings expectations of companies in both portfolios. For the green portfolio, the reason behind could be the increasing environmental awareness of investors and the globally increasing investment in renewable energy sector after 2008. As mentioned beforehand, investors' expectations of financial markets are dynamically influenced by the current political climate. Even most sophisticated market participants, such as hedge fund managers, change their expectations as a response to the changing political landscape (Zuckerman, 2009). In recent years, the increasing number of calls, whether from the media, government or corporations, appeal to make responsibility for environmental protection an integral part of investment decision-making (Boulatoff and Boyer, 2009). Combating climate

Table 6
Regression Results for the Green Portfolio.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Intercept	0.0304***	0.0153*	0.0286***	0.0259***	0.0144*	0.0259***	0.0305***	0.0299***	0.0237***	0.0120
	(0.0077)	(0.0083)	(0.0079)	(0.0100)	(0.0084)	(0.0100)	(0.0074)	(0.0071)	(0.0081)	(0.0093)
log(ME)	−0.0022***	−0.0019**	−0.0022***	−0.0021**	−0.0018**	−0.0021**	−0.0024***	−0.0021***	−0.0019***	−0.0019***
	(0.0008)	(0.0008)	(0.0008)	(0.0009)	(0.0008)	(0.0009)	(0.0006)	(0.0007)	(0.0007)	(0.0007)
B/M	−0.0112***	−0.0065	−0.0100***	−0.0095**	−0.0056	−0.0095**	−0.0110***	−0.0114***	−0.0094**	−0.0047
	(0.0035)	(0.0041)	(0.0035)	(0.0041)	(0.0041)	(0.0041)	(0.0037)	(0.0036)	(0.0039)	(0.0044)
IK		0.0527***			0.0473**					0.0495***
		(0.0189)			(0.0198)					(0.0191)
IA			0.0086**		0.0067*					0.0067*
			(0.0040)		(0.0036)					(0.0036)
IG				0.0091	0.0014					0.0018
				(0.0092)	(0.0017)					(0.0017)
GP						0.0091			0.0115	0.0020
						(0.0092)			(0.0103)	(0.0099)
OP							0.0031		0.0041	0.0092
							(0.0083)		(0.0082)	(0.0079)
ROE								−0.0042	−0.0094	−0.0068
								(0.0090)	(0.0080)	(0.0077)
Adj. R^2	0.02	0.05	0.02	0.02	0.05	0.02	0.02	0.02	0.02	0.05
Observations	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016

Note: This table presents the regression results of earnings forecast errors on corporate characteristics for the green portfolio for the period from 1992 to 2016. The t-statistics for the coefficients are calculated based on the Newey-West standard errors, which are reported in parentheses. ***, **, and * indicate significance at the 1% and 5% and 10% levels, respectively.

change and promoting green energy and clean technology are becoming one of the major political issues worldwide that requires global solidarity. Thus, investors might believe that investments in green assets are the "right thing to do" as they are affected by their surrounding environment. In such circumstances, investors tend to be more optimistic about green firms to justify their decisions on such investments.

Another reason is the increasing investment worldwide in green firms in the last decades. The all-asset class global annual new investment in the renewable energy sector increased from 177.9 billion USD in 2008 to 238.5 billion USD in 2010. Then, the investment level remained above 230 billion USD annually with a peak of 317.3 billion USD in 2015. Especially, the global research and development investment in renewable energy raised significantly after 2008 (Ajadi et al., 2019). Thus, as a heavy user of external financing, green firms are receiving sufficient financial supports for their developments. Starting in 2008, the first commitment period of the Kyoto Protocol entered into effect. Many countries started to issue their renewable energy promotion projects or revise their ongoing projects. For instance, as a participating country in the Kyoto Protocol, Germany introduced the 2009 amendment of her Renewable Energy Sources Act. This amendment provided the most substantial financial support among all the amendments to promote the private adoption of renewable energy production (Yang et al., 2021). Such national-level supporting programs help green energy and clean technology companies realize their commercial potential. As a result, investors hold more positive earnings expectations of the firms in the green portfolio in recent years, as earnings from these firms tend to be safer when external financial supports are adequate and stable.

However, increasing environmental awareness of investors and national-level financing projects for the first and second commitment periods of the Kyoto Protocol are clearly not the reasons behind the increasing confidence in the earnings performances of conventional energy firms. There must be other reasons. Our previous regression analysis shows that investors make more optimistic earnings expectations when conventional energy firms are profitable. As found by Wattanatorn and Kanchanapoom (2012), oil prices have a significant positive impact on the profits of companies in the energy sector. Thus, dynamic conventional energy prices should be the key factor for the increasing earnings optimism regarding grey energy firms.

The supply and demand conditions strongly dominate the energy commodity market, determining the fundamental values of these commodities' prices (Su et al., 2017). The GFC in 2008 illustrates how powerful the effect of a sharp drop in the demand for these commodities on the price of them. For instance, the demand for crude oil plummeted, causing a fall in the price of oil from 134 USD per barrel in June 2008 to 39 USD in February 2009. However, when it became clear in 2009 that the collapse of the global financial system was not imminent, the demand for oil recovered to levels prevailing in 2007, and the price of oil stabilized near 100 USD per barrel (Baumeister and Kilian, 2016). With the recovery of the US and global economies and positive economic outlooks, the increasing demand for energy commodities further pushed the price of these resources in the post-GFC period. In addition, several political events, such as the Libyan uprising in 2011 and tensions with Iran in 2012, were also associated with an oil price increase in this period. Thus, from mid-2009 to 2015, the crude oil price was significantly higher than in the period prior to the 2008 GFC. However, from 2015, due to the surplus of the crude oil and the fall in demand across the commodity markets, oil price started to fall. In January 2016, the Brent crude oil price dropped below 30 USD per barrel. Consequently, as shown in Table 3, in 2016, both the mean and median EFEs of the grey portfolio are significantly smaller than the market portfolio.

Another important finding of this study is that investors show different behaviors when forming earnings expectations of firms in green and grey portfolios. They are more optimistic about future earnings when grey energy firms are profitable. However, when it comes to green firms, investors are more confident about firms with larger investment expenditures.

It is well documented that a positive relation exists between firms' investment expenditures and earnings expectations. In particular, the progress in green energy and clean technology firms requires significant investment to generate innovations. Such innovations are the major source of competitive advantage for green firms, as these firms create value for customers through these innovations (Lin et al., 2006). Thus, green firms with higher investment expenditures are likely to have greater investment opportunities, which create technological advantages and innovations. Additionally, due to the long, sophisticated and uncertain innovation process, green firms rely strongly on external financing (Kim and Park, 2016). When green firms have higher investment expenditures, it may signal that the capital markets, which provide financing for the investments, have greater confidence in these firms and their management (Titman et al., 2004). The endorsement of institutional investors makes investors expect that the future earnings of these corporates will be enhanced. However, it should be noted that investors

generally stay away from capital-intensive fundamental innovations (Rajan, 2012). Therefore, the observed investors' behavior in forming earnings expectations of green firms should be also influenced by investors' cognitive bias that they are irrational and make systematic mistakes when processing information. They tend to underreact to negative news and overreact to positive news about green energy and clean technology industry in the current society where environmental awareness is promoted, when forming their expectations (Bondt and Werner, 1992; Easterwood and Nutt, 1999). Given these facts, green firms with larger investment expenditures should be viewed favorably by investors.

In terms of firms in the grey portfolio, it is found that investors are more optimistic when these companies are profitable. Different from the green energy and clean technology industry, grey energy industry is characterized by its high sunk costs and volatile output prices. Under such huge uncertainty and sunk costs, investors are reluctant to invest or only invest low (Dixit and Pindyck, 1994). As pointed out by Scott (2008), the oil industry earns a lot less than some other major industries. American Petroleum Institute reports that her members earn about 8.3 cents per USD invested, compared to 18.4 cents for pharmaceutical manufacturers and 19.1 cents for beverage and tobacco producers. Hvozdyk and Mercer-Blackman (2010) systematically investigate the determinants of the investment in the oil industry. They find that investment in the oil industry is positively correlated with oil price and profits. Since profits are correlated with output price, investors decide to invest in the oil industry mainly based on the firm's profitability. In summary, oil and gas industry profit margins are an important variable for those considering energy investments. Thus, if conventional energy firms perform profitably, investors tend to give more optimistic earnings forecasts.

The identified difference in forecasting earnings of green and grey companies further indicates that the formation of investors' earnings expectations might be industry-specific. In an emerging industry, such as the green energy and clean technology industry, investors are more future-oriented, valuing companies with higher investment expenditures. In contrast, in a mature industry, such as the traditional energy industry in this research, investors focus more on the current operating performance of the firms.

5. Conclusion

The current study systematically investigates the earnings expectations of conventional energy and green corporates covering 1992 through 2016 when combating climate change gradually became one of the most important topics in our society. The key findings of our research are summarized as follows. First, we find that investors hold positive earnings expectations about conventional energy and green stocks during the studied period. However, the earnings optimism about these stocks is significantly less potent than the market average. Second, the annual EFE analysis results indicate that the EFEs of both grey and green portfolios exhibit time-varying behavior. Before 2008, it is evident that the EFEs of these two portfolios are, in general, significantly smaller than the market portfolio, whereas the differences in EFEs become nonsignificant afterward. Third, we do not identify any significant difference in the EFEs between the green and grey portfolios in the period when the voice of climate change mitigation was louder and louder. During the total 25 sample years, the grey portfolio has a significantly smaller median EFE than the green portfolio for eight years, whereas the opposite is observed for the other eight years. A similar pattern is also evident in the mean difference analysis. Fourth, we find that conventional energy companies with higher profitability, i.e., GP, should receive more optimistic earnings expectations, whereas investors are more confident about future earnings when green firms have higher investment expenditures. Last but not least, it is observed that after controlling the effects of all the firm characteristics, the unexplained EFE is the largest for the market portfolio, while it is not significantly different from zero for the green portfolio.

To the best of our knowledge, this study is the first focusing on this research topic. In addition to many meaningful insights, we provide some implications for the real-world practice and the future research. First, it is reported in the literature that managers have strong incentives to achieve the expected earnings to protect companies' stock prices (Beneish, 2001). This is especially important for managers of grey and green energy firms, as the stock prices of these types of companies are more volatile than average stocks (Kumar et al., 2012). Furthermore, these companies' earnings also involve many uncertainties, such as technological development and oil price. In this research, we illustrate how investors form their earnings expectations which could help managers conduct efficient earnings management. In addition, our results show that the earnings expectations of green firms show time-varying pattern and investors are more optimistic to green firms with higher investments. Such high investment expenditures are likely to happen in bullish markets with high market sentiment and adequate external finances. However, it must be borne in mind that investments involve uncertainties and sufficient financing resources do not guarantee any success of innovations. Therefore, it is advisable that investors should be more careful when forming their earnings expectation and investing in these stocks in bullish market, avoiding falls in stock prices due to negative earnings surprises.

The first implication for future study is based on the limitation of our current study that the sample period does not cover more recent periods such as the trade war between China and the US, COVID-19 and even the current Ukraine war. Further studies should cover these periods to examine how investors forming their earnings expectations of stocks in green and grey portfolios in turbulent periods. Another suggestion for future study is that many previous studies, such as Lakonishok et al. (1994) and La Porta (1996), already document that earnings optimism is closely related to stock returns. Thus, future studies that aim to explain the returns of conventional and renewable energy stocks should also consider the effect of earnings optimism on the stock returns of these firms.

CRediT author statement

Yang Liu: Conceptualization, Methodology, Data curation and preparation, Empirical analysis, Writing original draft. Martin Blankenburg: Data curation and preparation, Literature reviewing. Mei Wang: Supervision.

Appendix A. Appendix

Table A1
Descriptive statistics on the firm-level corporate characteristics and earnings forecast error for the full-sample.

	ME	B/M	IK	IA	IG	GP	OP	ROE	EFE
Mean	4858.80	0.5939	0.2737	0.1741	0.3930	0.3652	0.2071	0.0673	0.0133
Minimum	1.41	0.0001	0.0022	−0.7820	−0.9812	−1.1430	−6.1398	−7.4820	−0.2868
25th Percentile	184.56	0.2731	0.1371	−0.0063	−0.1868	0.1994	0.1233	0.0172	−0.0032

(*continued on next page*)

Table A1 (*continued*)

Median	606.91	0.4629	0.2209	0.0780	0.1030	0.3367	0.2238	0.1043	0.0028
75th Percentile	2231.10	0.7465	0.3635	0.2134	0.5161	0.5059	0.3315	0.1861	0.0197
Maximum	715,599.80	23.90	1.1369	5.9462	17.89	1.3627	7.6287	4.5877	0.3949
Std. Dev.	21,299.85	0.6098	0.1873	0.4190	1.3491	0.2657	0.4700	0.4175	0.0496
Kurtosis	200.29	225.61	1.5557	30.49	47.47	2.1856	49.35	56.70	14.61
Skewness	12.00	9.6057	1.2825	4.3423	5.7164	0.1962	−1.4557	−3.3005	2.3915

Note: This table provides descriptive statistics on all the calculated firm-level corporate characteristics and one-fiscal-year-ahead analyst earnings forecast errors for all the 41,346 companies in the final sample during the period from 1992 to 2016. Std. Dev. stands for standard deviation and kurtosis is the excess kurtosis.

Table A2
Annual mean and median values of analyst earnings forecast errors of market, grey and green portfolios.

	Mean			Median		
	Market	Grey	Green	Market	Grey	Green
1992	0.0153	−0.0002	0.0031	0.0027	0.0002	0.0012
1993	0.0128	0.0103	0.0081	0.0026	0.0023	0.0003
1994	0.0090	0.0042	−0.0009	0.0004	0.0026	−0.0004
1995	0.0148	−0.0006	0.0076	0.0023	0.0002	0.0000
1996	0.0184	−0.0027	0.0078	0.0028	−0.0016	−0.0001
1997	0.0191	0.0088	0.0045	0.0027	0.0032	−0.0004
1998	0.0228	0.0224	0.0057	0.0067	0.0086	0.0008
1999	0.0172	−0.0063	0.0098	0.0024	−0.0014	0.0001
2000	0.0252	−0.0140	0.0117	0.0085	−0.0028	0.0013
2001	0.0204	0.0240	0.0152	0.0084	0.0093	0.0039
2002	0.0162	0.0004	0.0092	0.0062	0.0001	0.0027
2003	0.0013	−0.0016	−0.0023	−0.0005	−0.0006	0.0002
2004	0.0124	−0.0112	0.0173	0.0018	−0.0057	0.0003
2005	0.0081	−0.0150	−0.0010	0.0011	−0.0062	0.0003
2006	0.0133	0.0086	0.0010	0.0023	0.0033	−0.0005
2007	0.0139	−0.0019	0.0024	0.0042	−0.0043	0.0002
2008	0.0285	0.0523	0.0248	0.0170	0.0435	0.0118
2009	−0.0053	−0.0066	−0.0015	−0.0020	−0.0015	0.0007
2010	0.0026	0.0000	−0.0082	−0.0011	−0.0002	−0.0025
2011	0.0136	0.0170	0.0115	0.0031	0.0039	0.0010
2012	0.0143	0.0138	0.0144	0.0044	0.0088	0.0066
2013	0.0106	0.0107	0.0024	0.0029	0.0031	0.0019
2014	0.0128	0.0371	0.0149	0.0039	0.0271	0.0050
2015	0.0139	0.0229	0.0123	0.0042	0.0102	0.0041
2016	0.0081	−0.0023	0.0123	0.0021	−0.0023	0.0003

Note: This table presents the annual mean and median values of one-fiscal-year-ahead analyst earnings forecast errors for market, grey and green portfolios for the period from 1992 to 2016.

Table A3
Firm characteristics correlation matrices for market, grey and green portfolios.

	ME	B/M	IK	IA	IG	GP	OP	ROE
Panel A: Market Portfolio								
ME	1.00							
B/M	−0.2656	1.00						
IK	−0.1485	−0.1721	1.00					
IA	0.0091	−0.1179	0.2319	1.00				
IG	−0.0855	−0.0728	0.4229	0.3077	1.00			
GP	−0.0258	−0.1338	0.1375	−0.0668	−0.0665	1.00		
OP	0.2362	−0.0648	−0.1298	0.0142	−0.0745	0.3532	1.00	
ROE	0.1979	−0.0670	−0.0864	−0.0484	−0.0705	0.3181	0.5840	1.00
Panel B: Grey Portfolio								
ME	1.00							
B/M	−0.1629	1.00						
IK	−0.1073	−0.1583	1.00					
IA	−0.0247	−0.1241	0.2129	1.00				
IG	−0.0792	−0.1063	0.3598	0.4786	1.00			
GP	0.0224	−0.2012	0.0725	0.1258	0.0527	1.00		
OP	0.0944	−0.0709	−0.1134	0.1239	0.0149	0.5469	1.00	
ROE	0.1648	−0.1351	−0.0628	0.2548	0.0628	0.3730	0.5923	1.00
Panel C: Green Portfolio								
ME	1.00							

(*continued on next page*)

Table A3 (*continued*)

	ME	B/M	IK	IA	IG	GP	OP	ROE
B/M	−0.3277	1.00						
IK	−0.0157	−0.2616	1.00					
IA	0.0545	−0.1557	0.1102	1.00				
IG	−0.0468	−0.1104	0.3849	0.2224	1.00			
GP	−0.0645	−0.3276	0.2668	−0.0334	−0.0242	1.00		
OP	0.2514	−0.1475	−0.1849	0.0191	−0.1485	0.3442	1.00	
ROE	0.2767	−0.1682	−0.1117	0.0496	−0.0548	0.3481	0.4811	1.00

Note: This table reports the correlations between corporate characteristics that are used in the regression for each of the three portfolios.

Table A4
Mean and median values of firm characteristics for market, grey and green portfolios.

	Market	Grey	Green
Panel A: ME			
Mean	4456.48	10,998.12	10,668.86
Mean Difference		−6541.64***	−6212.38***
(Market)		(−6.15)	(−4.47)
Median	582.79	1413.40	948.15
Median Difference		−830.61***	−365.36***
(Market)		(236.80)	(73.16)
Panel B: B/M			
Mean	0.5872	0.7510	0.6060
Mean Difference		−0.1638***	−0.0188
(Market)		(−12.45)	(−1.44)
Median	0.4524	0.6699	0.5263
Median Difference		−0.2175***	−0.0739***
(Market)		(460.06)	(35.72)
Panel C: IK			
Mean	0.2781	0.2238	0.1831
Mean Difference		0.0543***	0.0950***
(Market)		(12.86)	(24.31)
Median	0.2257	0.1747	0.1564
Median Difference		0.0510***	0.0693***
(Market)		(164.47)	(301.78)
Panel D: IA			
Mean	0.1747	0.1850	0.1337
Mean Difference		−0.0103	0.0410***
(Market)		(−1.00)	(3.66)
Median	0.0780	0.0886	0.0683
Median Difference		−0.0106***	0.0097***
(Market)		(10.49)	(8.48)
Panel E: IG			
Mean	0.3978	0.3690	0.2486
Mean Difference		0.0288	0.1492***
(Market)		(0.98)	(5.13)
Median	0.1020	0.1371	0.0888
Median Difference		−0.0351**	0.0132
(Market)		(6.59)	(0.88)
Panel F: GP			
Mean	0.3758	0.1770	0.2546
Mean Difference		0.1988***	0.1212***
(Market)		(50.76)	(20.29)
Median	0.3496	0.1590	0.2227
Median Difference		0.1906***	0.1269***
(Market)		(1374.70)	(356.77)
Panel G: OP			
Mean	0.2065	0.2162	0.2159
Mean Difference		−0.0097	−0.0094
(Market)		(−0.72)	(−0.81)
Median	0.2236	0.2302	0.2124
Median Difference		−0.0066***	0.0112
(Market)		(13.05)	(0.00)
Panel H: ROE			
Mean	0.0658	0.0969	0.0771
Mean Difference		−0.0311***	−0.0113
(Market)		(−3.69)	(−1.26)
Median	0.1054	0.0891	0.0978
Median Difference		0.0163***	0.0076
(Market)		(9.78)	(0.60)

Note: This table shows the mean and median values of the studied corporate characteristics for market, grey and green portfolios for the period from 1992 to 2016. In addition, we report the differences in means and medians and the corresponding mean and median difference tests for each firm characteristic between

portfolios. The test statistics for the mean difference test (*t*-statistic) and median difference test (Kruskal-Wallis x^2) are reported in parentheses. ***, **, and * indicate significance at the 1% and 5% and 10% levels, respectively.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.eneco.2023.106692.

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