Determining the Performance of Renewable Energy Stocks: A Cross-Country Analysis

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ABSTRACT

We examine in this study the relationship between alternative-energy stock excess returns and a wide variety of firm- and country-level risk factors. We collect data for 186 companies, belonging to 5 major renewable energy indexes, from 29 countries over the period 2000-2015. We follow the methodology used by Boyer & Filion (2007) and employ a generalized least squared (GLS) panel model. The results suggest that market excess returns, the changes in company size, and a company's market-to-book value all have a significant, positive influence on alternative-energy stock value in all our specifications. The findings also imply that, in our sample, the alternative energy sector is riskier than the stock market as a whole. Oil price changes appear to have a weaker, but still a positive impact on clean-energy stock returns in specific time periods, whereas, surprisingly, natural gas prices do not appear to influence those returns. The changes in the percentage of electricity generated using renewable energies, GDP per capita, the input of manufacturing into a country's GDP, and pollution levels all appear to have a positive impact on renewable-energy stock prices. Finally, we find that the influence of interest rate changes varies (i) between developed and developing countries, and (ii) over the sample period which is largely due to the influence of the financial crisis.

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Determining the Performance of Renewable Energy Stocks: A Cross-Country Analysis

1. Introduction

Since the beginning of the industrial revolution in the 18th century, mankind has searched for an efficient source of energy to satisfy growing demand. Until recently fossil fuels such as oil were the preferred source of energy generation. However, recent concerns about the decline of oil reserves, coupled with rising energy demands and increased greenhouse gas emissions, have caused many governments to shift their interest to renewable energies.

Even though the volume of the known oil reserves rose by 0.9% between 2015 and 2016, the total reserves are sufficient for only 50.6 years (BP, 2017). Moreover, those reserves are located in a small group of countries. To be more specific, by the end of 2016, 85.7% of the world's proven reserves were contained in the OPEC countries (Algeria, Angola, Ecuador, Gabon, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela) (BP, 2017), and of these, 61.5% were concentrated in the Middle Eastern countries (OPEC, 2017). On the other hand, by the end of 2016 the largest oil consumers were the Pacific Asian countries (such as China and India) and the North American countries, consuming 35.25% and 23.69% respectively; yet these two regions have only 2.84% and 13.33% of the world's reserves (BP, 2017). Moreover, the Pacific Asian countries represent the fastest growing economic region while North America is the strongest economic region. This will result in even higher energy demands in these countries (Sadorsky, 2009b). In fact, according to BP (2017), the global power generation increase of 0.6% between 2015 and 2016 was driven mainly by non-OECD countries (which experienced a growth of 4.0%), and specifically by China (5.4%) and India (6.8%) (BP, 2017). This trend, in addition to the shocks in oil prices in recent years, led these high-consuming countries to search for a cheaper, renewable source of energy. In fact, renewable energies accounted for around 40% of the annual growth in global power generation by the end of 2016. Furthermore, the Asian Pacific countries saw an annual growth in renewable energy consumption of 27.86% (China 33.39%, India 29.16%) and the North American countries experienced a 15.72% growth between 2015 and 2016 (BP, 2017).

A second concern that many have raised recently is the rise in greenhouse gas emissions. As shown in Figure 1, carbon emissions started increasing at a high rate in 1983 and reached 9855 million metric tons of carbon by 2014 (a growth of 0.8% relative to the emissions in 2013) (Boden et al., 2017). As a result, different organizations and countries started to consider the possibility of enforcing new laws and regulations to reduce carbon emissions. For example, the United Nation's Intergovernmental Panel on Climate Change (IPCC) stated that enforcing a carbon price of $20 to $30 per ton either as a tax or a cap-and-trade system, will stabilize the CO_2 concentration in the air at an acceptable level by 2020 (Henriques & Sadorsky, 2008). This will enable low carbon generating companies to sell their remaining allowance of carbon emission to high carbon generating ones. Furthermore, it will force the high carbon generating companies to either cut their emissions or suffer higher costs (Henriques & Sadorsky, 2008). According to recent CO_2 emission statistics, it appears that some countries have successfully enforced regulations that enabled them to reduce their pollution levels. The average global growth in emissions between 2014 and 2016 was the lowest three-year growth rate since the period 1981-1983 (non-OECD countries experienced a 0.8% rise while OECD countries showed a decrease of 0.9% in emissions between 2014 and 2016) (BP, 2017). On an individual level, over the same interval, the United States saw its CO_2 emissions decline by 94.7 million tonnes (2%), China had a 41.4 million tonne decrease (0.7%) and Brazil showed a decline of 33.3 million tonnes (7%).

[Insert Figure 1 Here]

The recent rise in renewable energy generation coupled with the decline in CO_2 levels show that economies have started to shift their interests towards the clean energy sector. According to the *Global Trends in Renewable Energy Investment* report published in 2017, renewable energy attracted an investment of $241.6 billion in 2016, which was almost double the investment in fossil-fuel energy. The increase in global power from renewable sources in 2016 was 9% higher than the increase in the previous year. Furthermore, these investments increased the percentage of electricity generated using renewable sources by 1% in 2016 (11.3% in 2016 vs. 10.3% in 2015). This prevented the release of 1.7 gigatonnes of CO_2 (McCrone et al., 2017).

The aim of this study is to investigate the dynamics of alternative-energy stock prices by attempting to determine the different factors that influence those prices. Our main contribution to the existing literature is the inclusion of firm-specific factors, in addition to some additional country-specific factors that, to the best of our knowledge, were not investigated in previous research. We also extended the sample beyond that used in previous studies to include firms listed on 5 renewable energy indexes instead of just one (e.g. the WilderHill Clean Energy Index (ECO) in Henriques & Sadorsky (2008) and the WilderHill New Energy Global Innovation Index (NEX) in Inchauspe et al. (2015)). Finally, we extended the time period used to study the impact of different factors on clean-energy returns to 16 years (2000-2015).

The remainder of this paper is organized as follows. Section 2 (immediately below) presents a summary of previous studies related to the energy sector. Section 3 presents the data used in our study. Section 4 describes our research methodology and defines the variables used. Section 5 presents and discusses the results. Section 6 provides some additional tests to acquire more insight into the movements of alternative-energy stock returns. Finally, we conclude and discuss the limitations of this study in Section 7.

2. Literature Review

In recent years sustainable and green investments, including the alternative energies sector, have become an active area of research. However, most of the research done so far has examined the relationship between oil prices and stock returns in different countries.

A number of papers have focused on developed countries in attempting to define this relationship. For example, Jones and Kaul (1996) used a standard cash flow dividend valuation model to study the relationship between oil price shocks and stock returns for the United States (US), Canadian, Japanese and United Kingdom markets. Their results suggest that the US and Canadian stock markets were strongly influenced by oil shocks, whereas the effect was not that strong in the United Kingdom and Japanese markets. Sadorsky (1999) investigated the relationship between (i) US fuel oil prices, US industrial production, and the short-term interest rate and (ii) the S&P 500 using an unrestricted Vector Autoregression (VAR) model. He found that oil prices and oil volatility have an impact on S&P 500 stock returns. Faff and Brailsford (1999) examined the relationship between oil prices and Australian industry equity returns. Using an Arbitrage Pricing Theory (APT) model, they concluded that the effect of oil price shocks on equity returns depends on the particular industry concerned; they documented a positive relationship for the oil, gas and diversified resources industries, and a negative one for the paper and packaging, and transport industries. Hammoudeh & Li (2005) investigated the sensitivity of (i) Mexico's and Norway's stock returns and (ii) US oil and transportation industries' returns to oil prices using a Vector Error Correction (VEC) model. They found that both are sensitive to oil price changes with the US oil industry being the most sensitive. Park & Ratti (2008) studied the impact of oil price shocks on stock market returns for the United States and 13 European countries using a multivariate VAR model. They also documented a significant relationship between oil price volatility and stock returns, especially when using real world oil prices as opposed to national prices. Moreover, they found that the effect of oil price shocks varies from one country to another and that an increase in the price volatility depresses the stock returns for most European countries, while the opposite is seen for the United States. Diaz et al. (2016) examined the nature of the relationship between oil price volatility and stock returns for the G7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States). They employed a VAR model that included stock returns, oil price volatility using both world and national prices, interest rates and economic activity. As was the case for Park & Ratti (2008), Diaz et al. (2016) obtained a significant negative relationship between stock returns in the G7 countries and oil price volatility and found that world oil prices are more influential than national oil prices in terms of the effect on stock markets.

Other studies focused more on developing countries and markets. For example, Cong et al. (2008) tried to define the relationship between local oil prices and stock returns for the Chinese market using a multivariate VAR model that included interest rates and industrial production. They concluded that oil price shocks affect mostly the Chinese manufacturing and oil industries. Moreover, they found a significant relationship between oil price shocks and Chinese real stock returns, which suggests that the movement in exchange rates may be the reason for this result. Zhu et al. (2016) presented a more recent study on the same issue. They used a quantile regression approach for 14 Chinese industries and found (i) a positive and significant relationship between Chinese industries' returns and oil price shocks at the lower quantiles for each industry, and (ii) that the relationship may only exist during recessions. Le & Chang (2015) opted to examine the influence of oil prices on stock markets for three Asian countries: Japan, Malaysia, and Singapore. They used the Toda and Yamamoto (1995) causality approach and showed that oil price shocks have a positive impact on stock returns for all three markets. They also found that the magnitude of the impact differs from one country to another depending on the time and nature of the shock. Bouri (2015) chose oil importing countries in the MENA (Middle East and North Africa) region, namely, Lebanon, Jordan, Morocco, and Tunisia, to study the relationship between oil price volatility and stock returns around the time of the financial crisis. He employed an ARMAX-GARCH framework and found that the Jordanian stock market is the most likely market to be affected by oil price volatility, especially post-crisis. According to Bouri (2015), this may have been due to the higher number of GCC-country investors in the Jordanian market compared to the other markets in the study.

Finally, a number of researchers adopted a more global approach in their studies, examining both developed and developing countries simultaneously. For example, Maghyereh et al. (2016) used a directional connectedness measure to define the direction of risk spillover between oil price volatility and stock returns for 11 countries. They found a bi-directional risk spillover between oil price volatility and equity markets, with the risk transmission from oil prices to equity markets being the stronger. They further demonstrated that the direction of risk spillover varied over their sample period. Lastly, Reboredo & Ugolini (2016) included 3 developed economies (the United States, the United Kingdom, and the European Monetary Union) and the 5 BRICS economies (Brazil, Russia, India, China, and South Africa) to study the impact of oil price movements on the stock returns of the aforementioned countries using a quantile approach. Their results suggest that the impact of extreme oil price movements on stock returns was greater after the financial crisis than before the crisis, whereas small movements had no effect before nor after the crisis.

The previous paragraphs reviewed the literature on the impact of oil prices on stock returns. In contrast, little attention has been paid to the factors that determine energy stock returns. Boyer & Filion (2007) tried to determine the various factors that influence the returns of Canadian oil and gas companies. They used a generalized least squared panel model and concluded that the following factors all have a positive influence on oil and gas stock returns: Canadian market returns, increases in oil and gas prices, and growth in operational cash flows and proven reserves. In contrast, interest rates, volume of production of oil and gas and the weakening of the Canadian dollar relative to the US dollar all have a negative impact. Gupta (2016) also tried to determine the factors that can influence oil and gas companies' returns for a sample of 70 countries. He presented three distinct results: (i) oil prices positively influence the oil and gas companies' stock returns, whereas market stress, measured using the Market Dislocation Index (MDI), negatively influences these returns, (ii) sensitivity to oil price movements is higher for oil and gas firms located in high oil producing countries, and (iii) firms that are exposed to lower levels of competition in the oil and gas industry tend to be less sensitive to oil price decreases.

When it comes to alternative energy, to the best of our knowledge, most of the existing research examines the impact of different factors on the *consumption* of renewable energy. Sari et al. (2008) used the autoregressive distributed lag (ARDL) approach to define the relationship between industrial output and energy consumption (where the energy is generated using either fossil fuels or renewable sources) in the United States. Their results suggest that employment levels and industrial output have a long-term impact on energy consumption. Specifically, industrial production has a positive impact on hydroelectric, waste, and wind energy consumption, whilst labor has a negative impact on the consumption of these sources of energy. Sadorsky (2009b) studied the impact of CO_2 emissions, income (measured using GDP per capita) and oil prices on renewable energy consumption for the G7 countries. In another study, Sadorsky (2009a) investigated the impact of income on renewable energy consumption in emerging economies. He used a panel cointegration model and found in both studies that increases in income lead to increases in renewable energy consumption. Moreover, Sadorsky (2009b) showed that for the G7 countries, increases in CO_2 emissions have a positive impact on renewable energy consumption, while oil price increases have a negative impact. Apergis & Payne (2010) followed Sadorsky's (2009a, 2009b) work and examined the relationship between alternative-energy consumption and economic growth for the OECD countries. They also used a panel cointegration approach and found a positive relationship between renewable-energy consumption on the one hand and GDP per capita and labor force on the other. Moreover, they employed a Granger-Causality approach and showed a bi-directional causality between renewable-energy consumption and economic growth.

Although most studies have focused on energy *consumption*, nonetheless there are a few that have attempted to define the factors that affect alternative-energy *stock returns*. Henriques & Sadorsky (2008) attempted to define the relationship between alternative-energy stock prices and oil prices using a four variable VAR model that included, in addition to oil prices and renewable-energy firms' stock prices, technology stock prices and interest rates. Their results suggest that oil prices, technology stock prices and interest rate movements all have some power in explaining movements in alternative-energy stock prices (the correlation being positive in all cases); however, technology stock price movements have a higher impact than the other variables. Their study was then extended by Managi & Okimoto (2013) who accounted for structural changes by using a Markov-Switching VAR model. They found that after a structural change at the end of 2007, oil price movements had a strong positive impact on clean-energy stock returns. This study was then extended once again by Bondia et al. (2016) who used non-linear cointegration tests that allow for unknown structural breaks. This approach revealed the existence of two structural break points as opposed to the one found by Managi & Okimoto (2013). The study also revealed a short-term causality between (i) clean-energy stock prices and (ii) oil prices, technology stock prices, and interest rates.

Kumar et al. (2012) also used a VAR model to provide insight into the relationship between alternative-energy stock prices and oil price movements, adding another variable - the price of carbon emissions set by the European Union Emission Trading System under the cap-and-trade system. They also documented a relationship between movements in clean-energy stock prices and oil prices, technology stock prices and interest rates movements. However, they did not find a significant relationship between the price of carbon emissions and alternative-energy stock prices. Sadorsky (2012) used a different approach to study the impact of oil price volatility and technology stock price movements. He defined four different multivariate GARCH models and found, in line with Henriques & Sadorsky (2008), that both oil prices and technology stock price movements positively influence clean-energy stock prices, with technology stock price movements having a greater impact.

Wen et al. (2014) contributed to the literature by studying the return and volatility spillover effects between clean-energy and fossil-fuels stocks in the Chinese market. They used an asymmetric Baba–Engle–Kraft–Kroner (BEKK) model and documented significant return and volatility spillover effects between the two assets. Furthermore, they found that increases in alternative-energy (fossil-fuel) stock returns cause decreases in fossil-fuel (alternative-energy) stock returns. Reboredo (2015) used copulas to quantify the systematic risk between the oil market and the renewable-energy market. He concluded that oil price movements contribute to around 30% of alternative-energy firms' risk.

Finally, Inchauspe et al. (2015) proposed a multi-factor asset pricing model that included technology stock prices, oil prices and the MSCI World Index as the market index. This study also found a positive relationship between (i) the market and technology returns and (ii) the alternative energy returns, as well as a positive relationship between oil prices and clean energy returns. The former relationship has become stronger with time.

The previous research demonstrates that only a limited number of determinants of alternative-energy stock returns have been investigated. We believe that there are various additional factors, at country level and/or at firm level that influence alternative-energy stock returns. The present study attempts to address this gap in the literature by exploring the influence of a wide variety of risk factors on clean-energy stock prices.

3. Data

Our sample for this study consists of 186 alternative-energy companies, listed in five different indexes.[1] Our sample period is from 2000 to 2015 and we include firms from 29 different countries from around the world. We retrieved the list of companies in each index from Bloomberg along with their respective ISINs and CUSIPs where applicable. We then cleaned the list for duplicates and merged it with the list of companies available on the Compustat database using CUSIP for the North American firms and ISIN for the rest of the world. Table 1 presents a summary of how we constructed our sample. We also provide the list of firms included in this research in Table A1 and the list of countries in Table A2.

[Insert Table 1 Here]

Table 2 presents a description of the variables used in our study in addition to the different sources used to collect the data for each variable. We collected data on the monthly return for the companies in our sample, the monthly market return for each of the 29 countries, and the oil and natural gas prices were collected from Bloomberg, the firm-specific data were collected from Compustat, and the country-specific data were retrieved from the US Energy Information Administration (EIA) and World Bank. Our final sample consists of 2334 firm-year observations forming an unbalanced panel.

[Insert Table 2 Here]

[1] The five indexes used are Ardour Global Alternative Energy Index (AGIGL), WilderHill Clean Energy Index (ECO), WilderHill New Energy Global Innovation Index (NEX), S&P Global Alternative Energy USD Index (SPGTAE), and the S&P Global Clean Energy Index (SPGTCED).

4. Methodology

4.1 Definition of Variables and Hypotheses to be tested

4.1.1 Dependent Variable

Excess Return: We define our main variable as the annualized excess return of clean-energy firm *i* over the one-month US T-bill rate, collected from Kenneth French's data library (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/index.html). We use the US T-bill rate instead of each country's risk-free rate following the findings of Griffin (2002), which suggest that the use of either measure will yield similar results. We calculate *Excess Return* following the formulation of Boyer & Filion (2007) and Inchauspe et al. (2015). Firstly, we define the monthly return at month *t'* as follows (where *t'*-1 refers to the previous month):

$$ret_{t'} = \frac{price_{t'} - price_{t'-1}}{price_{t'}} \tag{1}$$

For a given firm, the *Monthly Excess Return*$_{it'}$ = $ret_{it'} - I_{t'}$, where $ret_{it'}$ represents the monthly return for firm *i* at month *t'* and $I_{t'}$ represents the risk-free rate. Finally, we annualize the monthly excess return of firm *i* at month *t'* as follows:

$$Excess\ Return_{it} = [(1 + Monthly\ Excess\ Return_{it'})^{12} - 1] \times 100 \tag{2}$$

4.1.2 Risk Factors

4.1.2.1 Common Factor

Market Excess Return: Following the work done by Sharpe (1964), Lintner (1965), Mossin (1966), and Merton (1973), we include market return as a risk factor. For each of the 29 countries included in our study, we construct this variable using the return of the index of the country in question (Table A2), as suggested by Griffin (2002), instead of using a global factor. Griffin (2002) states that country-specific risk factors have a higher explanatory power in the Fama and French three-factor model than global ones. The variable is calculated using the same steps as for *Excess Return*. We expect the variable to be positively correlated with the stock returns of alternative-energy companies because a country index that is doing well is likely to be a sign of a healthy economy.

4.1.2.2 Country-Specific Factors

All the country-specific changes are calculated following the method shown in equation (1) using annual data.

Oil Price Change: Various papers have examined the relationship between oil prices and stock returns in general, as well as energy stock returns in particular (e.g. Boyer & Filion, 2007;

Henriques & Sadorsky, 2008; Inchauspe et al., 2015; Bondia et al., 2016; and Reboredo & Ugolini, 2016). These studies found that movements in energy stock returns are related to movements in oil prices. Following Sadorksy (2001) and Boyer & Filion (2007), we use the *West Texas Intermediate (WTI)* barrel one-year futures because spot oil prices may be affected by random noise (Sadorsky, 2001). Additionally, the *WTI* is the most commonly used benchmark in the literature. We expect that changes in oil returns will be positively related to changes in alternative-energy stock returns, as higher oil prices incentivize individuals and countries to find a cheaper source of energy (Inchauspe et al., 2015).

Natural Price Change: Various studies, such as Boyer & Filion (2007), find that movements in natural gas prices affect the returns of the energy sector. To measure this variable, we use the *NYMEX Natural Gas* one-year futures index; we did this for the same reason that we chose futures prices to measure the price of oil. We expect natural gas changes to be positively related to alternative-energy returns following the same logic as that set out for oil prices.

Percentage of Generation Change: Various countries around the world are showing concerns about global warming and the increasing levels of pollution. Furthermore, with oil reserves concentrated in a small number of countries (Middle Eastern countries account for more than 50% of the world reserves (Sadorsky, 2009a)), many consumers are seeking new, non-pollutant, and renewable sources to generate energy. According to the International Energy Agency (IEA) (2007), renewable energy is expected to be the fastest growing form of energy generation between 2005 and 2030 (Sadorsky, 2009a). This makes the study of the influence of the percentage of energy generated using renewable sources on the stock prices of alternative-energy companies particularly interesting. A higher percentage of energy generation using renewable sources may suggest that alternative-energy technology firms will experience higher demand and attract a higher valuation. Thus we expect a positive relationship between the two variables.

GDP per Capita Change: Sadorsky (2009a) studied the effect of real GDP per capita on the renewable energy consumption for emerging economies, while Sadorsky (2009b) studied the same effect for the G7 countries and Apergis & Payne (2010), among other studies, considered OECD countries. All these studies found that an increase in real GDP per capita has a positive effect on the renewable energy consumption per capita. Therefore, we predict that the change in GDP per capita will be positively related to the stock returns of alternative-energy companies.

Inflation Rate Change: Inflation is considered to be a measure of the health of a country's economy. It tracks the price levels of goods and services, which reflects the purchasing power of a currency and this makes inflation rates one of the most significant performance metrics of an economy. Countries try to maintain a stable rate, which helps businesses to plan their future expenditure, as they can easily forecast future prices. Furthermore, inflation rates heavily influence other key parameters such as levels of employment. We expect that increases in inflation rate will have a negative impact on stock returns because they tend to drive a fall in the value of a currency and this may result in the collapse of an economy.

Manufacturing Change: Manufacturing and industrial production are closely related to energy. Thus businesses, and countries in general, have to closely monitor the relationship between manufacturing and its associated energy costs and to seek cheaper and more efficient sources of energy. In most cases, investing in renewable sources represents a long-term solution to a country's need to reduce both its energy costs and its dependence on foreign energy. Sari et al. (2008) found a positive relationship between energy consumption and industrial production when the energy source is hydro, waste, and wind, and a negative one when the energy source is fossil fuels. Thus, it is important to study the nature of the relationship between manufacturing and the stock returns of alternative-energy companies. We expect increases in manufacturing levels to have a positive effect on the returns.

Pollution Change: One of the most frequently discussed issues in recent years is global warming. Various countries have raised concerns about increasing rates of pollution and have often implicated the energy sector. We use the mean annual exposure of a country's population to PM2.5 pollution as a measure of pollution. This index is defined as the exposure of a country's population to polluting particles that measure less than 2.5 microns in diameter. The use of fossil fuels and coal to generate energy increases the emission of such particles, and this in turn is likely to lead to an increase in investment in renewable-energy technologies - both their development and consumption (Sadorsky, 2009b). Sadorsky (2009b) found that one of the major drivers for renewable-energy consumption in a panel of G7 countries is an increase in CO_2 emissions. Therefore, we expect that increases in pollution will have a positive impact on alternative-energy stock returns, as countries, businesses, and individual consumers will be compelled to use renewable sources to generate energy.

Interest Rate Change: Developing a new technology requires heavy investment. This will have a strong impact on the capital structure of the companies involved in the development of renewable-energy technologies. The use of debt to finance development is one of the solutions that renewable energy firms may adopt, making interest rates an obvious risk factor. (Boyer & Filion, 2007). A number of papers have documented the relationship between interest rates and stock returns such as Chen (1991), Sadorsky (2001), Henriques & Sadorsky (2008) and Bondia et al. (2016). Following their findings, we expect that interest rate increases will be negatively related to alternative-energy stock returns.

4.1.2.3 Firm-Specific Factors

All the firm-specific changes are calculated using the same approach as in equation (1) using annual data.

Total Assets Change: We use this variable as a measure of the change in a firm's size. We include it as a firm-specific risk factor following the work of authors such as Banz (1981), Roll (1981), Reinganum (1983), and Fama & French (1993). It reflects the difference between small and big firms with respect to their return generating process (Walker et al., 2014). The aforementioned studies documented a negative relationship between changes in the size of companies and their returns. However, such findings relate to size differences ***between*** companies, whereas our study relate to the effects of growth ***within*** individual firms. The growth of a firm may indicate that it is benefiting from the different opportunities it is presented with and it is generating higher returns. Thus, we expect that the increase in a firm's size will be positively related to its returns.

Capital Expenditures Change: This variable is used as a proxy measure of the growth opportunities of a firm. Theoretically small and new firms have higher growth potential than big and old ones and this affects their value (Morck et al., 1988). More specifically, given that high growth potential is valued by investors, it follows that this feature will be reflected in a firm's stock price. This theory is confirmed by McConnell & Muscarella (1985) who found, using an event study that investors react positively to the announcement of increases in planned capital expenditures and negatively to planned decreases. Thus, we expect that increases in capital expenditure will result in an increase in alternative-energy stock returns.

Market-to-Book Ratio Change: The market to book ratio is used as an indicator of a firm's maturity and growth opportunities (Chiek & Akpan, 2016). Moreover, this variable can be interpreted as a measure of a firm's exposure to risk; a low market-to-book value, for instance, may indicate that investors are not confident about the firm's growth prospects and may consider that it has high risk exposure. This will result in a high return (Fama & French, 1993; Walker et al., 2014). However, these conclusions were drawn from a market-to-book ratio differences ***between*** companies' analysis, whereas our study relate to the effects of growth in market value ***within*** individual firms. We expect this variable to be positively related to clean energy stock returns in the sense that a firm that is growing in market value will attract a higher revenue stream than a firm that is decreasing in value.

Long-Term Debt Change: The impact of leverage on stock returns may be significant, as shown in a variety of studies (e.g. Bhandari (1988); Lam (2002)). Moreover, the companies included in this study are involved in the development of new alternative-energy technologies, which requires high R&D investments. Hence, external financing is inevitable for these firms with debt being the most common method of financing. Thus, the study of the effect of debt on these firms' stock returns is particularly important. We expect that an increase in debt will have a negative impact on the stock returns of alternative-energy companies.

Earnings per Share Change: This variable is used as a proxy for changes in earnings, following Chiek & Akpan (2016). Pattell (1976) showed that when a firm voluntarily releases forecasts of earnings per share, the stock price exhibits a significant rise. This finding suggests that it might be worth investigating the relationship between stock returns and changes in earnings. We expect this relationship to be positive, as an increase in earnings per share shows that the company is in a good state. Therefore, investors will be more attracted to it, hence increasing its stock price and consequently its returns.

Capital Intensity Change: We use capital intensity as a measure of asset tangibility following the work of Konijn et al. (2011). Most of the firms in this study are involved in the development of new alternative-energy generation technologies, which means that these companies have higher intangible assets, such as patents and intellectual property, than other firms. These kinds of assets may be understated, which may affect the firm's value (Konijn et al., 2011). We expect a positive relationship between this risk factor and the stock returns of alternative-energy firms, as an increase in capital intensity may reflect an increase in intangible assets, and the latter may be viewed as the most important type of asset for these companies.

4.2 The Model

We based our methodology for this study on the work of Boyer & Filion (2007) and Inchauspe et al. (2015). They, in turn, based their model on the multifactor models used previously by Khoo (1994), Faff & Chan (1998), Faff & Brailsford (1999), Henriques & Sadorsky (2001), and Sadorsky (2001).

The main purpose of this study is to determine the factors that cause variation in the stock returns of alternative-energy firms. We start our analysis by quantifying the influence of country-specific factors on the stock prices. We use a generalized least squared (GLS) panel model, as it controls for potential heteroscedasticity and autocorrelation problems (Boyer & Filion (2007)).

Our first model is as follows:

$$\begin{gathered}Excess\ Return_{it} = \alpha_1 + \beta_1 Market\ Excess\ Return_{jt} + \ \beta_2 Oil\ Price\ Change_t + \\ \beta_3 Natural\ Gas\ Price\ Change_t + \ \beta_4 Percentage\ of\ Generation\ Change_{jt} + \\ \beta_5 GDP\ per\ Capita\ Change_{jt} + \ \beta_6 Inflation\ Rate\ \ Change_{jt} + \\ \beta_7 Manufacturing\ Change_{jt} + \ \beta_8 Pollution\ Change_{jt} + \ \beta_9 Interest\ Rate\ Change_{jt} + \epsilon_{it}\end{gathered} \quad (3)$$

where α_1 is a constant, *Excess Return*$_{it}$ is the annualized excess return of firm *i* over the one-month US T-bill rate at year *t*, $Market\ Excess\ Return_{jt}$ is the annualized excess return of the share index of country *j* over the one-month US T-bill rate at year *t*, *Oil Price Change*$_t$ is the oil change at year *t*, *Natural Gas Price Change*$_t$ is the natural gas change at year *t*, *Percentage of Generation Change*$_{jt}$ is the percentage of electricity generated using renewable resources change in country *j* at year *t*, *GDP per Capita Change*$_{it}$ is the Gross Domestic Product per Capita of country *j* at year *t*, *Inflation Rate Change*$_{jt}$ is the inflation rate change of country *j* at year *t*, *Manufacturing Change*$_{jt}$ is the percentage value added to country *j*'s GDP from the manufacturing industries' change at year *t*, *Pollution Change*$_{jt}$ is the pollution rate change of country *j* at year *t*, *Interest Rate Change*$_{\mathrm{jt}}$ is the interest rate change of country *j* at year *t*, and ϵ_{it} are the error terms.

Our second model aims to quantify the risk of firm-specific factors on the stock price. This translates into the following model:

$$Excess\ Return_{it} = \alpha_2 + \beta_{10} Market\ Excess\ Return_{jt} + \beta_{11} Total\ Assets\ Change_{it} + \beta_{12} Capital\ Expenditures\ Change_{it} + \beta_{13} Market - to - Book\ Ratio\ Change_{it} + \beta_{14} Long - Term\ Debt\ Change_{it} + \beta_{15} Earnings\ per\ Share\ Change_{it} + \beta_{16} Capital\ Intensity\ Change_{it} + \epsilon_{it} \quad (4)$$

where α_2 is a constant, *Excess Return*$_{it}$ is the annualized excess return of firm *i* over the one-month US T-bill rate at year *t*, $Market\ Excess\ Return_{jt}$ is the excess return of the share index of country *j* over the one-month US T-bill rate at year t, $Total\ Assets\ Change_{it}$ is the total assets change of firm *i* at year *t*, *Capital Expenditures Change*$_{it}$ is the capital expenditures change of firm *i* at year *t*, *Market-to-Book Ratio Change*$_{it}$ is the market-to-book ratio change of firm *i* at year *t*, *Long-Term Debt Change*$_{it}$ is the long term debt change of firm *i* at year *t*, $Earnings\ per\ Share\ Change_{it}$ is the earnings per share change of firm *i* at year *t*, *Capital Intensity Change*$_{it}$ is the capital intensity change of firm *i* at year *t*, and ϵ_{it} are the error terms.

Finally, we merge the country- and firm-specific variables to quantify simultaneously the risk of all the factors on the variation in stock prices of alternative-energy firms. The model for this step is as follows:

$$Excess\ Return_{it} = \alpha_3 + \beta_{17} Market\ Excess\ Return_{jt} + \beta_{18} Oil\ Price\ Change_t + \beta_{19} Natural\ Gas\ Price\ Change_t + \beta_{20} Percentage\ of\ Generation\ Change_{jt} + \beta_{21} GDP\ per\ Capita\ Change_{jt} + \beta_{22} Inflation\ Rate\ Change_{jt} + \beta_{23} Manufacturing\ Change_{jt} + \beta_{24} Pollution\ Change_{jt} + \beta_{25} Interest\ Rate\ Change_{jt} + \beta_{26} Total\ Assets\ Change_{it} + \beta_{27} Capital\ Expenditures\ Change_{it} + \beta_{28} Market - to - Book\ Ratio\ Change_{it} + \beta_{29} Long - Term\ Debt\ Change_{it} + \beta_{30} Earnings\ per\ Share\ Change_{it} + \beta_{31} Capital\ Intensity\ Change_{it} + \epsilon_{it} \quad (5)$$

4.3 Summary Statistics

Table 3 (Panel A) presents the summary statistics for the variables used in this study before winsorization and before calculating the changes. We winsorized the variables at the 5th and 95th percentiles to reduce the influence of outliers. The summary statistics for the variables after winsorization are presented in Table 3 (Panel B).

[Insert Table 3 Here]

The excess yearly return for the alternative-energy companies in our sample ranges from -69.4% to 201%, with a mean of 18.2% and a median of 4.5%. The numbers indicate that most of the companies in this sample have a positive excess return during the period studied. The market excess return varies between -8.45% and 19.0% with a mean of 0.84% and a median of -0.01%, which indicates that most of the economies used in this study generated positive returns on average between 2000 and 2015. Moreover, the markets appear to be less volatile (standard deviation = 5.24%) than the firms themselves (standard deviation = 67.9%). We also notice from Table 3, as well as from Figure 2 (which shows oil prices over our sample period), that oil prices fluctuate between $19.84 and $140 during the period studied, with a mean of $66.3. These fluctuations may be explained by various events that transpired during the sample period, as will be discussed in the results section. Natural gas prices also seem to fluctuate during the sample period, with a minimum of $1.96, a maximum of $13.9, and an average of $5.02 Table 3 and Figure 3). Finally, total assets, which are used in this study as a proxy for the firm size, vary between $0.027 billion and $55.029 billion with an average of $6.89 billion and a median of $ 0.83 billion. The numbers suggest that most of the firms that comprise our sample may be ranked as small to medium sized firms.

[Insert Figure 2 Here]

[Insert Figure 3 Here]

4.4 Correlation Matrix

In Table 4, we present the correlation matrix between the different variables used in our research. We can see that changes in oil prices and natural gas prices are positively associated with the returns of alternative-energy companies. Furthermore, in these univariate analyses, all of the correlation coefficients support our prediction for the relationship between the explanatory variable and excess returns, with the exception of the market-to-book value. Finally, most of the coefficients between explanatory variables are sufficiently small to suggest the absence of multicollinearity in our sample (Boyer & Filion, 2007).

[Insert Table 4 Here]

5. <u>Results and Discussion</u>

Table 5 presents the results for the three models presented in Equations (3) to (5). Firstly, we had to determine whether the use of panel data regression was necessary or whether a simple OLS regression would be sufficient by (i) testing for time effects and (ii) using the Breusch-Pagan Lagrange multiplier to test for random effects. The results suggested that the use of panel data techniques was required. We then invoked the Hausman test to determine whether we needed to use a fixed or random effects model and found that models (1) (The model using country-risk factors only) and (2) (The model using firm-risk factors only) required the use of a fixed effects model whereas model (3) (The model using both country and firm-risk factors) required a random effects model (Hausman test results are presented in Appendix B).

In general, the results demonstrate that most of the beta coefficients match our predictions concerning the direction of the relationship between the independent variable and excess stock returns. However, some of the coefficients are not significant in all three specifications. This may be due to the limited data that were available to use in our study.

5.1 <u>Country-Specific Factors</u>

Model (1) in Table 5 presents the results for the regressions of country-specific risk factors on alternative-energy firms' stock excess returns (Equation 3). In this specification, the market return, oil price change, and change in the percentage of energy generated using renewable sources are all significant at the 1% level, while the GDP and manufacturing changes are significant at the 10% level. The natural gas and pollution changes are not significant.

[Insert Table 5 Here]

Our first observation is that market returns have a positive impact on alternative-energy firms' stock returns. Furthermore, the coefficient on the market return, β, is larger than 1 (2.242) suggesting that alternative-energy firms are riskier than their respective markets. This finding can be explained by the nature of such firms; most of them are new, small companies that are involved in a new, risky sector. This result contrasts with the findings of Boyer & Filion (2007) in their study of the effect of common and fundamental factors on the stock returns of Canadian oil and natural gas companies; they find that those firms are less risky than the Canadian stock market.

Our second finding confirms our expectation that oil changes have a positive impact on alternative-energy returns. This result agrees with previous research (e.g. Inchauspe et al., 2015) and can be explained by the fact that increases in oil prices are likely to incentivize investors and governments to seek a cheaper, renewable source of energy (Bleischwitz & Fuhrmann, 2006; McDowall & Eames, 2006; Inchauspe et al., 2015). Moreover, oil changes appear to have a higher impact on alternative-energy stock returns than do natural gas prices (0.481 vs. 0.005). This result agrees with the findings of Boyer & Filion (2007) who posit the explanation that crude oil has a higher average production than natural gas and is more frequently used for producing energy. Therefore, oil prices have a higher impact on energy firms' stock prices in general and particularly in the case of alternative-energy companies (Boyer & Filion, 2007). A second explanation provided in Boyer and Filion (2007) is one originally suggested by Haushalter (2000), namely that energy firms are more likely to hedge against the volatility of natural gas prices than oil prices, which may explain the higher impact of oil changes on alternative-energy companies' excess return.

A surprising finding concerns the negative relationship between alternative-energy stock returns and the percentage of energy generated using renewable sources. One would expect that an increase in the use of renewable sources to generate energy implies that there is a high demand for the technologies being developed by the firms in our sample, which in turn will cause these firms to be highly valued by investors. Consequently, our result seems counter-intuitive. It may be a consequence of the fact that data on this variable were not available for some time periods in the sample; thus, the use of a more complete dataset may yield a different result.

A further anomaly is our finding that a 1% increase in GDP per capita changes results in a 0.78% decrease in alternative-energy stock returns, when the other variables are held constant. This result contradicts the findings of Sadorsky (2009a, 2009b) and Apergis & Payne (2010) who suggest that an increase in GDP per capita results in higher renewable-energy consumption which in turn might be expected to produce higher alternative-energy returns.

Our last finding consists of a positive relationship between manufacturing changes and alternative-energy stock returns. This result goes hand in hand with the findings of Sari et al. (2008). Their study suggests a positive relationship between renewable-energy consumption and industrial output. One would therefore expect an increase in manufacturing to result in higher renewable-energy stock returns.

5.2 Firm-Specific Factors

Model (2) in Table 5 presents the results for the effect of the firm-specific factors on alternative-energy stock returns. In this specification, the long-term debt change variable is significant at the 5% level, and the market excess return, size, and market-to-book ratio changes are significant at the 1% level.

In keeping with the previous model, the market excess returns prove to be positively related to the alternative-energy firms' returns, with a $\beta_{market} > 1$. This shows again that the alternative-energy firms included in our study are riskier than their respective markets.

The effect of changes in firm size (i.e. total assets) is also found to be positive; i.e. growth is positively correlated with stock returns. This finding may be associated with the age of the firms included in our sample. Most of these companies are relatively new and small firms, meaning that they have higher growth opportunities. As these firms grow in size, investors conclude that they may provide promising investment opportunities and thus value them more highly than firms that are growing more slowly or shrinking.

Various studies have found that company size is negatively related to stock returns (e.g. Banz (1981), Roll (1981), Reinganum (1983), Fama & French (1993), Drew & Veerarghavan (2002), and Maroney & Protopapadakis (2002), Farhan & Sharif (2015)), which may seem contradicting to our result. However, as discussed in the previous section, such findings relate to size differences ***between*** companies, whereas our findings relate to the effects of growth ***within*** individual firms. Thus, we conclude that while large firms tend to attract smaller stock returns than small firms, more rapidly growing firms attract higher returns than less rapidly growing firms.

Our next finding reveals a positive relationship between the market-to-book ratio changes and alternative-energy stock returns. The findings of much of the earlier research on this topic (e.g. Fama & French (1992, 1995), Barber & Lyon (1997), Malin & Veeraraghavan (2004)) may look contradicting to our result, but they relate, once more, to market-to-book ratio differences ***between*** companies, whereas our findings relate to the effects of growth in market value ***within*** individual firms. We show that a 1% increase in the market-to-book ratio changes result in a 0.64% increase in alternative-energy stock returns, with the influence of the other variables held constant. This means that investors consider a market-to-book ratio increase to be a sign of high growth prospects;

hence in our sample the greater the increase in the market-to-book ratio, the greater the benefit to firms in terms of their stock values.

Finally, our application of this model demonstrates a negative relationship between long-term debt changes and alternative-energy stock returns. This finding implies that investors lose faith in companies as they increase their long-term debt over the years. A possible explanation is that an increase in debt level may be interpreted by investors as a sign that a company is not generating enough income and benefit, or is not accessing sufficient profit-making opportunities, to finance its operations. This may dissuade investors from investing in these firms because they see a risk of debt overhang.

5.3 Country and Firm Factors Combined

In this section, we merge both the country- and firm-specific risk factors into one model. The results for this model are presented in Table 5, model (3).

The first observation for this model is the change in the sign and significance of the coefficients for both the percentage of energy generated using renewable sources and GDP per capita. Both coefficients in fact reverted to the expected sign, but they became insignificant. Also, the market excess return β is almost equal to 1, suggesting that the alternative-energy firms included in this study are as risky as their respective markets.

In the combined model, the coefficient of the size factor remains positive and significant confirming that for our sample, investors are tempted to invest in firms that grow in size. Similarly, the market-to-book ratio factor remains significant and positive reflecting investors' interest in companies whose value is increasing. Finally, we note that the pollution changes coefficient is on the border of significance with at the 5% level (p-value of 0.062). As expected, this relationship between increases in pollution and alternative-energy stock returns is positive. As mentioned in the previous section, Sadorsky (2009b) showed that increased CO_2 emissions per capita result in increased renewable-energy consumption. This increase means that the demand for alternative-energy technology grows, driving up company values and stock returns.

6. Additional Tests

In this section, we examine some additional risk factors that may affect alternative-energy stock returns. Potential shocks that occurred during the time frame of our sampling include the financial crisis of 2007-2009 and the drop in oil prices beginning in 2014. We sought to investigate whether these events might have influenced our findings by examining the data separately for different sub-periods as shown in Table 6. We also investigate in this section how the relationship between our risk factors and clean-energy stock returns differs between developed and developing countries. For the following investigations, we use the same equation as in model (3) (Eq. 5), but apply it only to the indicated specification.

[Insert Table 6 Here]

6.1 Financial Crisis 2007-2009

This crisis was considered by many as "the biggest financial crisis of the last 50 years" (Fahlenbrach, 2012). The crisis led to the collapse of many financial institutions, while others were bailed out by their respective governments (Beltratti & Stulz, 2012; Erkens et al., 2012). The ripple effects from these events spread to other sectors, and investors incurred large losses even in relation to investments that were supposed to be low risk (Fahlenbrach, 2012). This spillover effect was due mainly to the role that financial institutions played as intermediaries between lenders, investors and borrowers (Acharya et al., 2009). Clearly this financial turbulence might have influenced the effect of our risk factors on the behaviour of the alternative-energy market during this period.

Model (4) in Table 6 presents the results for the sub-period corresponding to the financial crisis (2007 – 2009). The β coefficients for the market returns, change in firm size, change in market-to-book ratio, and oil price changes are consistent with our previous findings; all are significant at the 1% level except for the market return which is significant at the 5% level. Furthermore, the interest rate change coefficient becomes significant in this specification (at the 10% level) and is negative. This result may be explained by the relationship between (i) stocks and bonds, and between (ii) bonds and interest rates, and by (iii) the movement of interest rates before and during this period. According to Bondia et al. (2016), bonds and stocks represent alternative investment vehicles and their movements are positively correlated with each other. However, the relationship between bonds yields and interest rates is negative. In this context, the negative coefficient in our results makes sense, especially for this particular sub-period. This finding also follows from the fact that between 2000 and October 2008, when the Federal funds and discount rates were fixed at 1% and 1.75% respectively, the market witnessed high movements in interest rates. The rates actually kept going down until they reached their lowest value in 2003 and then started rallying up to reach 5.25% until 2007 (Singh, 2017). This may have made the bond markets and consequently the stock markets more sensitive to the interest rate's movements - and this may explain the significance of this variable's negative coefficient for the 2007-2009 period in the specification.

A final observation concerns the intercept. In this model, the intercept α represents the abnormal return of the alternative-energy stocks; for the financial crisis period, it is negative and statistically significant for this specification. This result agrees with the findings of Bohl et al. (2013) and Inchauspe et al. (2015). Both papers agree that prior to 2007, the alternative-energy sector had high expectations in terms of growth opportunities and government support. However, during and after the financial crisis, governments gave less support than was expected and this reduced investors' confidence in the development of the sector. This is consistent with the intercept value obtained in this model, which implies that when all the risk factors are at their mean level, the stock value returns are negative.

6.2 Before and After the Financial Crisis

We study in this specification the impact of our risk factors on alternative-energy stock returns for the years 2000 to 2006 and 2010 to 2015. The purpose is to compare the influence of our risk factors on stock returns during the financial crisis with their influence during the other years of the sample period.

Model (5) in Table 6 presents the results for this sub-period. We observe again that market returns, changes in firm size, and changes in market-to-book ratio are significant and positively correlated with alternative-energy stock returns. However, the interest rate risk factor in this specification is positively related to stock returns, contrary to the corresponding result obtained for the financial crisis specification. Our explanation for this difference is that firms and investors started hedging against interest rate movements after the financial crisis, which thus reduced the influence of rate movements on stock prices.

6.3 *Oil Price Drop 2014-2015*

Our final sub-period includes the years 2014 and 2015, which witnessed a huge drop in oil prices (Figure 2). This sudden drop was mainly due to the declining demand for oil from large economies like China, Russia, India and Brazil, facilitated by their move to renewable. The trend was reinforced by the tendency of producing countries (e.g. the United States, Canada, and especially Saudi Arabia) to create an oversupply of oil. The dramatic effect of these events on oil prices caused us to examine whether the relationship between our risk factors and alternative-energy returns was disturbed during this sub-period.

Model 6 in Table 6 presents the results for this specification. Our first observation is that the oil changes are not significant in this model, suggesting that investors became indifferent towards the low oil prices and that other factors (such as pollution) had a positive impact on alternative-energy stock returns. Indeed, pollution changes are once again significant and positively related to stock returns. This may be due to the increasing sensitivity of governments and individuals to the risks of global warming, and hence the rising levels of support for investment in more environment-friendly technologies.

Another observation concerns the market returns, change in firm size, and book-to-market changes, which are once again significant and positively related to stock returns. Furthermore, the manufacturing and long term debt changes become significant once again and have a positive and negative impact, respectively, on the alternative-energy stock returns, as was found in the previous specification (model (1) for the manufacturing changes and model (2) for the long term debt changes). An interesting result in this specification concerns the capital expenditure changes, which became significant in this specification. We found that as capital expenditures increase, the stock returns increase too. Investors presumably interpret capital expenditure increases as a sign of improved growth opportunities, which in turn benefit the companies in our sample through enhanced investment. We also note the positive impact on stock returns of increases in the percentage of energy generated from renewable sources. This result agrees with the reasoning we provided in our definition of variables and hypothesis to be tested section.

As in model 5, we find a positive relationship between the interest rate risk factor and stock returns in this period. As stated before, firms may have gained more insight into how to manage the risk of interest rate movements, perhaps assisted by the regulations that were imposed after the financial crisis (e.g. Dodd-Frank reforms). These changes may have contributed to our finding of a positive relationship between interest rate rises and stock returns.

We next consider the finding of a positive and highly significant relationship between inflation rate changes and alternative-energy stock returns. Our explanation for this result is that inflation rate increases may be interpreted as a tool for creating economic growth by governments. This would encourage investors to invest more in the various sectors of the economy including alternative-energy enterprises.

Finally, the intercept in this model (even though not significant) is once again positive. This means that an alternative-energy company whose country and firm-specific characteristics were all at the mean level would experience positive excess returns during the period of 2014-2015. This agrees with the findings of Inchauspe et al. (2015) who showed that the alternative-energy sector started to generate positive returns after 2013. As stated by Bürer & Wüstenhagen (2009), investors are more likely to invest in the renewable energy sector following environment-friendly reforms implemented by governments. This may explain the increase in excess returns for the clean-energy sector given that a number of 'green' reforms and environmental laws were adopted by different governments during this period.

6.4 Developed vs. Developing Countries

[Insert Table 7 Here]

We compare in this specification the impact of our risk factors on the renewable-energy stock returns for a sub-sample of developed countries (Table 7, Model 7) *versus* a sub-sample of developing countries (Table 7, Model 8). We try in this part to have more insight about the differences in behavior of our country- and firm-risk factors in different economies. We base our classification of developed and developing countries on the *World Economic Situation and Prospects 2017* published by the *United Nations* in 2017 (Table A2).

From Table 7, we note that in general that our risk factors have a similar impact on clean-energy stock returns in both developed and developing countries. Moreover, the results in this specification are consistent with our findings in Model (3).

In both models (7) and (8) in Table 7, changes in firm size and in market-to-book ratio are significant and positively influence with renewable-energy stock returns. The changes in debt are significant for developed countries and have a negative impact and insignificant for the developing countries' firms. The market excess return coefficient is also still positive and almost equal to 1. We conclude then that the clean-energy sector is as risky as the market for both developing and developed economies. The oil price changes are positively correlated to the renewable-energy returns for both country classifications. Furthermore, developed countries appear to be more affected by oil prices fluctuations than developing countries ($\beta_{oil,developed} = 0.206\ vs.\ \beta_{oil,developing} = 0.134$). Manufacturing changes appear to have a negative and significant impact on renewable- energy firms in developed countries, and are insignificant for the developing countries. Finally, interest rate changes appear to have positive impact on developed countries' clean-energy firms and a negative one on the developing countries clean-energy firms. This indicates that investors in developed countries view interest rate movements as an opportunity to invest more and generate more benefit, whereas investors in developed countries are more careful when dealing with interest rates movements.

Conclusion

For many years, oil and fossil fuels have been the main source of energy worldwide. However, following worldwide economic growth and increases in global energy demands, governments have become increasingly concerned about the limited fossil-fuel resources available to mankind and the harmful greenhouse emissions resulting from their use. This has encouraged various countries, together with investment agencies, to shift their interest towards clean and renewable sources of energy. This situation encouraged us to examine the dynamics and performance of green energy stocks worldwide.

In this study, we have addressed the relationship between alternative-energy stock returns and various risk factors for the period between 2000 and 2015 for companies listed in five main alternative-energy indexes. We followed Boyer & Filion's (2007) methodology and used a GLS cross-sectional time series linear model to study these relationships, examining the influence of both country-level and firm-level risk factors on stock returns. Some of our findings are in line with the literature, whilst others provide some new insights into the behaviour of clean-energy returns and their determinants.

We document a positive and significant relationship between alternative-energy returns and market returns generally, and we find that $\beta_{market} \geq 1$ in all our model specifications. We conclude that market returns have a strong influence on determining the value of alternative-energy stocks and that the alternative-energy sector is riskier than the market in general. We also find a significant and positive relationship with the size of firms and book-to-market changes risk factors throughout our sample period and for different specifications.

An increase in oil prices seems to have a positive and significant impact on alternative-energy stock returns in some periods, and insignificant in others. This result broadly agrees with the existing body of work dedicated to this issue. On the other hand, natural gas changes seem not to affect renewable-energy stock returns in any of the specifications used in this study. Country-level risk factors also were significant in some periods and insignificant in others, which may be explained by the laws, regulations, and reforms implemented by governments during the studied period.

Finally, we document similar behavior to Inchauspe et al.'s (2015) findings concerning alternative-energy sector abnormal returns, namely the generation of positive excess returns prior to the financial crisis and after 2013, and negative returns in the period between 2007 and 2013. We invoke Bohl et al.'s (2013) and Inchauspe et al.'s (2015) reasoning in explaining this result.

The results of this study complement existing research into the factors that affect alternative-energy stock prices. We examine factors that were addressed in previous studies and add others, in particular a number of firm-specific variables that have not been investigated to date. We believe that our findings will contribute to the understanding of the dynamics of alternative-energy stock prices. However, we recognise that this study has some limitations that should be addressed in future investigations. In particular, we consider that the use of a longer time period would provide a clearer and more reliable assessment of the impact of the variables included in this study. In addition, the inclusion of measures of governmental environment policies and regulations might well help to explain some of the variance in clean-energy stock prices that could not be captured in the models included in this study.

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Tables and Figures

Tables

Table 1: Data Collection

We report in this table our methodology for constructing our sample. We started by collecting the constituents of five main alternative-energy indexes, which provided us with 324 companies. Second, we deleted 115 duplicate firms that were listed in two or more indexes to keep only one observation for each firm. Finally, we deleted 23 companies for which data were not available on Compustat. Our final sample was composed of 186 clean-energy companies.

	Firms
Alternative Energy Companies from Bloomberg	324
Less	
Duplicate Firms	115
Firms with No Data in Compustat	23
TOTAL	186

Table 2: Description of Variables

This table presents a brief description of the variables used in this study in addition to the sources used to obtain data for each variable.

Variable	**Source**	**Description**
Excess Return	*Bloomberg*	Excess return of a firm *i* over the one month US T-bill rate.
Market Excess Return	*Bloomberg*	Market return for country *j* index over the one month US T-bill rate.
Total Assets	*Compustat*	Total assets of firm *i* which represents the firm size
Capital Expenditures	*Compustat*	Capital expenditures of firm *i* which represents its investment opportunities.
Market-To-Book Ratio	*Compustat*	Market to book value of firm *i*.
Long-Term Debt	*Compustat*	Long term debt of firm *i* which represents the firm leverage.
Earnings Per Share	*Compustat*	Earnings per share of firm *i*.
Capital Intensity	*Compustat*	Capital Intensity of firm *i* defined as the ratio of total property plant and equipment to the total assets.
Oil Price	*Bloomberg*	Oil Prices
Natural Gas Price	*Bloomberg*	Natural Gas Prices
Percentage of Generation	*U.S. Energy Information Administration (EIA)*	Percentage of energy generated using renewable sources of country *j*.
GDP Per Capita	*World Bank*	Gross Domestic Product per Capita of county *j*.
Inflation Rate	*World Bank*	Inflation rate of country *j*.
Manufacturing	*World Bank*	The percentage of value added to the country *j*'s GDP from the manufacturing industries.
Pollution	*World Bank*	Mean annual concentration of PM2.5 in country *j*'s air.
Interest Rate	*World Bank*	Interest rate of country *j*.

Table 3: Summary Statistics

We report in this table the summary statistics for our variables before calculating the changes, and before (Panel A) and after winsorizing (Panel B) each one at the 5th and 95th percentiles to reduce the influence of outliers. Looking at Panel B, we notice that the excess yearly return for the alternative-energy companies in our sample has a mean of 18.2% and a median of 4.5%, which may indicate that most of the companies in this sample have a positive excess return during the period studied. The market excess return varies has a mean of 0.84% and a median of -0.01%, which indicates that most of the economies used in this study generated positive returns on average between 2000 and 2015. Also, the market appears to be less volatile (standard deviation = 5.24%) compared to the alternative energy firms (standard deviation = 67.9%).

Panel A

Variables	**N. Obs.**	**Mean**	**Standard Deviation**	**Minimum**	**Median**	**Maximum**
Excess Return (%)	2023	18.204	67.909	-69.396	4.496	201.269
Market Excess Return (%)	2224	0.838	5.239	-8.452	-0.010	19.028
Total Assets (Millions Of $)	2304	10434.8	32283.98	0.029	830.28	352894
Capital Expenditures (Millions Of $)	2265	594.973	1745.737	0	40.587	18313.87
Market-To-Book Ratio	2037	5.257	44.235	-957.310	1.405	1150.404
Long-Term Debt (Millions Of $)	2304	2658.132	8436.319	0	100.265	94422.77
Earnings Per Share ($)	2130	-4.955	314.609	-47.57	0.179	951.582
Capital Intensity Ratio	2299	0.270	0.278	0	0.171	1.734
Oil Price ($)	2334	66.299	27.025	19.84	61.05	140
Natural Gas Price ($)	2334	5.023	2.299	1.959	4.405	13.921
Percentage of Generation (%)	2107	17.709	19.363	0.003	10.879	99.879
GDP Per Capita ($)	2334	35865.52	17234.83	958.012	39677.20	102910.4
Inflation Rate (%)	2334	2.126	1.837	-4.480	2.069	25.296
Manufacturing (%)	2139	16.119	7.824	1.189	13.517	36.927
Pollution	2139	17.081	15.568	5	10.44	57.2
Interest Rate (%)	1966	3.623	5.523	-4.339	2.840	48.340

Panel B						
Variables	**N. Obs.**	**Mean**	**Standard Deviation**	**Minimum**	**Median**	**Maximum**
Excess Return (%)	2023	18.204	67.909	-69.396	4.496	201.269
Market Excess Return (%)	2224	0.838	5.239	-8.452	-0.010	19.028
Total Assets (Millions Of $)	2304	6892.91	14597.56	27.018	830.279	55092
Capital Expenditures (Millions Of $)	2265	427.414	936.399	0.401	40.587	3554
Market-To-Book Ratio	2037	2.862	4.267	0.195	1.405	18.634
Long-Term Debt (Millions Of $)	2304	1777.86	84167.91	0	100.265	15758
Earnings Per Share ($)	2130	0.618	1.476	-1.867	0.179	4.428
Capital Intensity Ratio	2299	0.264	0.262	0.003	0.171	0.821
Oil Price ($)	2334	66.299	27.025	19.84	61.05	140
Natural Gas Price ($)	2334	5.023	2.299	1.959	4.405	13.921
Percentage of Generation (%)	2107	17.709	19.363	0.003	10.879	99.879
GDP Per Capita ($)	2334	35558.1	16364.29	3471.25	39677.2	56115.72
Inflation Rate (%)	2334	2.092	1.536	-0.653	2.069	5.263
Manufacturing (%)	2159	16.119	7.824	1.189	13.517	36.927
Pollution	2139	17.111	15.475	7.2	10.44	56.48
Interest Rate (%)	1966	2.999	2.209	-1.061	2.840	8.236

Table 4: Correlation Matrix

We report in this table the Pearson/Spearman correlation coefficients between each risk factor and the renewable-energy stock excess return, and between each pair of risk factors.

		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Excess Return	**1**															
Market Excess Return	**2**	0.142														
Oil Price Change	**3**	0.269	0.052													
Natural Price Change	**4**	0.127	-0.040	0.480												
Total Assets Change	**5**	0.220	0.015	0.059	-0.051											
Capital Expenditures Change	**6**	0.064	0.002	-0.025	-0.092	0.461										
Market-To-Book Ratio Change	**7**	0.691	0.118	0.221	0.118	0.105	0.004									
Long-Term Debt Change	**8**	-0.009	0.036	-0.047	-0.095	0.319	0.164	-0.024								
Earnings Per Share Change	**9**	0.012	0.018	-0.076	-0.071	0.072	0.083	-0.031	-0.002							
Capital Intensity Change	**10**	-0.081	0.062	0.066	-0.038	-0.080	0.301	-0.070	0.118	-0.023						
Percentage of Generation Change	**11**	-0.105	-0.023	-0.069	-0.094	-0.073	-0.061	-0.133	0.029	-0.016	0.054					
GDP Per Capita Change	**12**	0.052	0.116	0.058	-0.012	0.224	0.174	0.027	0.105	0.052	0.135	-0.093				
Inflation Rate Change	**13**	-0.091	-0.030	-0.211	0.018	-0.035	0.035	-0.089	-0.019	0.027	0.027	0.039	0.091			
Manufacturing Change	**14**	0.013	-0.034	0.006	0.016	0.102	0.098	0.011	0.018	0.018	-0.012	0.039	0.156	-0.112		
Pollution Change	**15**	0.023	0.014	-0.133	0.140	-0.021	0.040	0.026	0.008	0.043	-0.008	0.090	0.029	0.179	0.087	
Interest Rate Change	**16**	-0.016	-0.057	0.028	0.108	-0.003	0.046	-0.029	0.033	-0.066	0.014	-0.135	-0.035	0.076	0.098	-0.199

Table 5: Summary of Regression Results for Models (1), (2), and (3)

This table presents the results for our main regressions models. In model (1), we study the effects of country-related risk factors on the excess returns of renewable-energy firms. In model (2), we investigate the effect of firm-related risk factors on the returns. Finally, model (3) combines both country and firm risk factors to quantify the risk of all risk factors on clean-energy returns, as a robustness test.

Dependent Variable: Excess Return			
	Country Specific Factors (1)	Firm Specific Factors (2)	Country and Firm Factors Combined (3)
Intercept	21.678***	0.125	0.665
	(0.000)	(0.917)	(0.753)
Market Excess Return	2.242***	1.062***	0.994***
	(0.000)	(0.000)	(0.000)
Total Assets Change		0.432***	0.305***
		(0.000)	(0.003)
Capital Expenditures		-0.006	-0.0004
Change		(0.713)	(0.980)
Market-To-Book Ratio		0.640***	0.578***
Change		(0.000)	(0.000)
Long-Term Debt Change		-0.039**	-0.022
		(0.025)	(0.190)
Earnings Per Share Change		0.002	0.010
		(0.747)	(0.283)
Capital Intensity Change		0.023	-0.061
		(0.772)	(0.612)
Oil Price Change	0.481***		0.219***
	(0.000)		(0.000)
Natural Price Change	0.005		-0.200
	(0.562)		(0.623)
Percentage of Generation	-0.745***		0.016
Change	(0.000)		(0.901)
GDP Per Capita Change	-0.781*		0.023
	(0.087)		(0.917)
Inflation Rate Change	-0.004		-0.008
	(0.793)		(0.499)
Manufacturing Change	1.358*		-0.267
	(0.051)		(0.531)
Pollution Change	1.169		1.286*
	(0.407)		(0.062)
Interest Rate Change	-0.031		0.016
	(0.407)		(0.578)
R-Squared	8.80%	54.89%	51.91%
Model's P-Value	0.000	0.000	0.000
N. Obs.	1392	1637	1088

*** Significant At 99% Confidence Level
** Significant At 95% Confidence Level
* Significant At 90% Confidence Level
Numbers Between Parenthesis Represent the P-Values

Table 6: Summary of Regression Results for Models (4), (5), and (6)

This table presents the results for additional test models. In model (4), we investigate the effects of our risk factors on the excess returns of renewable-energy firms during the financial crisis period. In model (5), we exclude the financial crisis period to study the risk factors on the returns. Finally, we determine in model (6) the influence of our risk factors on clean-energy stock returns during the most recent oil price drop period (2014-2015).

	Dependent Variable: Excess Return		
	2007-2009 (4)	2000-2006 and 2010-2015 (5)	2014-2015 (6)
Intercept	-13.428**	1.571	28.839
	(0.031)	(0.529)	(0.246)
Market Excess Return	1.074**	0.951***	2.862***
	(0.035)	(0.003)	(0.007)
Total Assets Change	0.363***	0.254*	0.489**
	(0.002)	(0.063)	(0.022)
Capital Expenditures	-0.044	0.021	0.073*
Change	(0.358)	(0.503)	(0.086)
Market-To-Book Ratio	0.616***	0.548***	0.793***
Change	(0.000)	(0.000)	(0.000)
Long-Term Debt Change	0.005	-0.026	-0.121***
	(0.858)	(0.246)	(0.004)
Earnings Per Share Change	0.015	0.006	0.002
	(0.411)	(0.564)	(0.940)
Capital Intensity Change	0.072	-0.131	-0.433
	(0.655)	(0.360)	(0.200)
Oil Price Change	0.278***	-0.003	0.217
	(0.007)	(0.964)	(0.874)
Natural Price Change	-0.067	0.048	0.744
	(0.684)	(0.275)	(0.562)
Percentage of Generation	0.177	-0.005	2.660***
Change	(0.568)	(0.966)	(0.002)
GDP Per Capita Change	0.649	0.213	1.121
	(0.184)	(0.478)	(0.361)
Inflation Rate Change	-0.037	-0.004	0.624***
	(0.362)	(0.803)	(0.001)
Manufacturing Change	-0.159	-0.104	10.903**
	(0.887)	(0.859)	(0.033)
Pollution Change	-0.475	0.190	9.936***
	(0.824)	(0.844)	(0.004)
Interest Rate Change	-0.095*	0.055*	1.550***
	(0.086)	(0.085)	(0.000)
R-Squared	75.02%	43.97%	85.65%
Model's P-Value	0.000	0.000	0.000
N. Obs.	241	847	76

*** Significant At 99% Confidence Level
** Significant At 95% Confidence Level
* Significant At 90% Confidence Level
Numbers Between Parenthesis Represent the P-Values

Table 7: Summary of Regression Results for Models (7) and (8)

This table presents the results for the Additional Tests Models (7) and (8). In model (7), we investigate the effects of our risk factors on the excess returns of renewable-energy firms for the developed countries. In model (8), we investigate the effects of our risk factors on the excess returns of renewable-energy firms for the developing countries.

Dependent Variable: Excess Return		
	Developed Countries (7)	Developing Countries (8)
Intercept	3.147	-7.319
	(0.106)	(0.220)
Market Excess Return	0.949**	0.956***
	(0.016)	(0.001)
Total Assets Change	0.234*	0.445***
	(0.066)	(0.000)
Capital Expenditures Change	0.001	-0.010
	(0.982)	(0.766)
Market-To-Book Ratio Change	0.517***	0.691***
	(0.000)	(0.000)
Long-Term Debt Change	-0.031*	0.009
	(0.072)	(0.777)
Earnings Per Share Change	0.002	0.018
	(0.893)	(0.176)
Capital Intensity Change	-0.200	0.239
	(0.180)	(0.120)
Oil Price Change	0.206***	0.134*
	(0.000)	(0.088)
Natural Price Change	-0.056	0.054
	(0.241)	(0.563)
Percentage of Generation Change	0.124	-0.153
	(0.439)	(0.461)
GDP Per Capita Change	0.275	-0.205
	(0.362)	(0.506)
Inflation Rate Change	-0.011	0.001
	(0.439)	(0.984)
Manufacturing Change	-0.965*	0.690
	(0.051)	(0.464)
Pollution Change	1.400	0.944
	(0.112)	(0.581)
Interest Rate Change	0.122***	-0.055*
	(0.010)	(0.097)
R-Squared	43.07%	72.52%
Model's P-Value	0.000	0.000
N. Obs.	813	275

*** Significant At 99% Confidence Level
** Significant At 95% Confidence Level
* Significant At 90% Confidence Level
Numbers Between Parenthesis Represent the P-Values

Figures

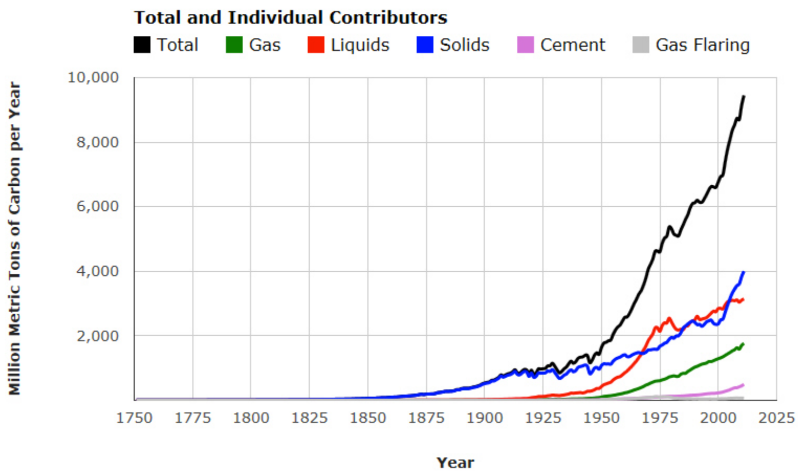

Figure 1: Yearly Carbon Emissions between 1750 and 2014. Source: Boden et al. (2017).

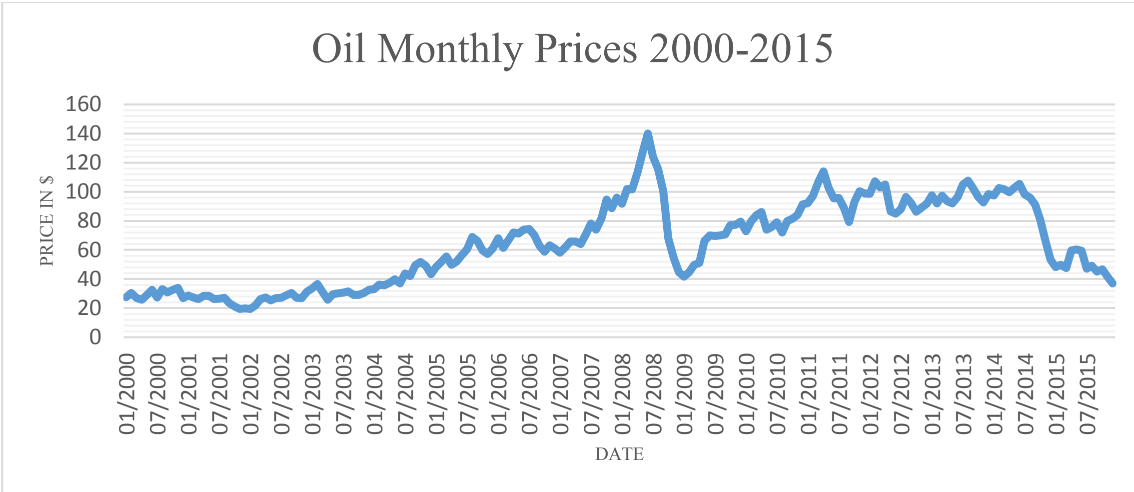

Figure 2: Monthly Oil Prices in US Dollars between 2000 and 2015. Source: Bloomberg.

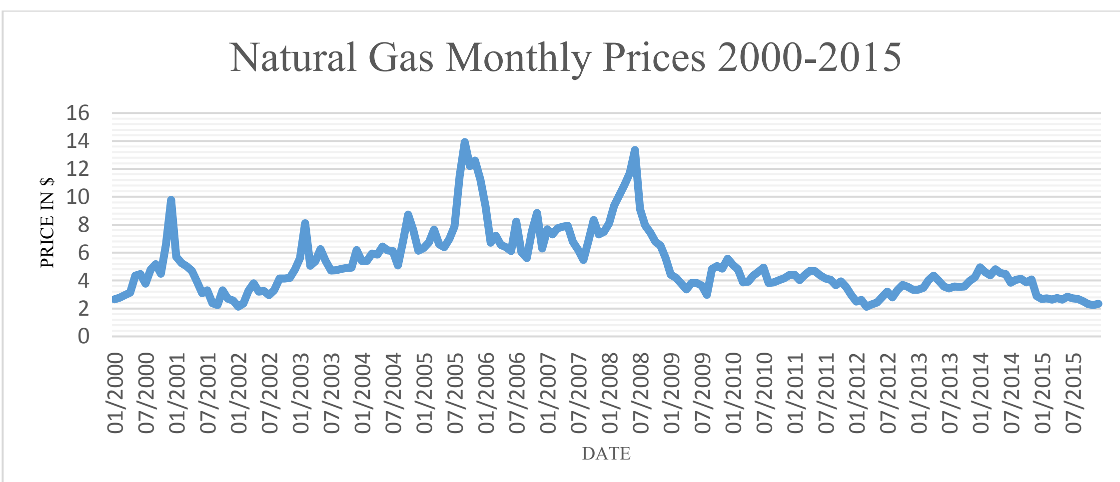

Figure 3: Monthly Natural Gas Prices in US Dollars between 2000 and 2015. Source: Bloomberg.

Appendices

Appendix A

Table A1: List of the Firms Used in the Study and their Respective Countries

Name	Country
VERBUND AG	Austria
SAO MARTINHO SA	Brazil
CIA ENERGETICA DE MINAS GERAIS	Brazil
CIA PARANAENSE DE ENERGIA	Brazil
BALLARD POWER SYSTEMS INC	Canada
CANADIAN SOLAR INC	Canada
HYDROGENICS CORP	Canada
WESTPORT FUEL SYSTEMS INC	Canada
SOCIEDAD QUIMICA Y MINERA DE CHILE SA	Chile
CHINA EVERBRIGHT WATER LTD	China
BYD CO LTD	China
DONGFANG ELECTRIC CORP LTD	China
SHANGHAI ELECTRIC GROUP CO LTD	China
CHINA LONGYUAN POWER GROUP CORP LTD	China
CGN POWER CO LTD	China
HAITIAN ENERGY INTERNATIONAL LTD	China
SHUNFENG INTERNATIONAL CLEAN ENERGY LTD	China
DAQO NEW ENERGY CORP	China
JA SOLAR HOLDINGS CO LTD	China
JINKOSOLAR HOLDING CO LTD	China
KANDI TECHNOLOGIES GROUP INC	China
TRINA SOLAR LTD	China
YINGLI GREEN ENERGY HOLDING CO LTD	China
VESTAS WIND SYSTEMS A/S	Denmark
DONG ENERGY A/S	Denmark
NOVOZYMES A/S	Denmark
FORTUM OYJ	Finland

CAVERION CORP	Finland
ALBIOMA SA	France
ELECTRICITE DE FRANCE SA	France
FUTUREN SA	France
BLUE SOLUTIONS	France
ENERGIEKONTOR AG	Germany
CAPITAL STAGE AG	Germany
NORDEX SE	Germany
SMA SOLAR TECHNOLOGY AG	Germany
PNE WIND AG	Germany
VERBIO VEREINIGTE BIOENERGIE AG	Germany
MANZ AG	Germany
CROPENERGIES AG	Germany
SOLARWORLD AG	Germany
E.ON SE	Germany
OSRAM LICHT AG	Germany
UNIPER SE	Germany
TERNA ENERGY SA	Greece
C P NEW ENERGY	Hong Kong
SINGYES SOLAR	Hong Kong
CONCORD NEW ENERGY GROUP LTD	Hong Kong
COSLIGHT TECH	Hong Kong
UNITED PHOTOVOLTAICS GROUP LTD	Hong Kong
HUANENG RENEWABLES CORP LTD	Hong Kong
CHINA EVERBRIGHT INTERNATIONAL LTD	Hong Kong
CANVEST ENVIRONMENTAL PROTECTION GROUP C	Hong Kong
C TRANSMISSION	Hong Kong
TITANS ENERGY	Hong Kong
COMTEC SOLAR SYSTEMS GROUP LTD	Hong Kong
GCL-POLY ENERGY HOLDINGS LTD	Hong Kong
SOLARGIGA ENERGY HOLDINGS LTD	Hong Kong

TIANNENG POWER INTERNATIONAL LTD	Hong Kong
WASION GROUP HOLDINGS LTD	Hong Kong
XINYI SOLAR HOLDINGS LTD	Hong Kong
SKY SOLAR HOLDINGS LTD	Hong Kong
KINGSPAN GROUP PLC	Ireland
SOLAREDGE TECHNOLOGIES INC	Israel
FALCK RENEWABLES SPA	Italy
EREX CO LTD	Japan
ODELIC CO LTD	Japan
KANSAI ELECTRIC POWER CO INC/THE	Japan
KURITA WATER INDUSTRIES LTD	Japan
GS YUASA CORP	Japan
TAKUMA CO LTD	Japan
ELECTRIC POWER DEVELOPMENT CO LTD	Japan
TOKYO ELECTRIC POWER CO HOLDINGS INC	Japan
JGC CORP	Japan
MITSUBISHI HEAVY INDUSTRIES LTD	Japan
MITSUBISHI ELECTRIC CORP	Japan
MEIDENSHA CORP	Japan
HANWHA Q CELLS CO LTD	Korea, Rep.
KOREA ELECTRIC POWER CORP	Korea, Rep.
PHILIPS LIGHTING NV	Netherlands
CONTACT ENERGY LTD	New Zealand
MERIDIAN ENERGY LTD	New Zealand
MERCURY NZ LTD	New Zealand
REC SILICON ASA	Norway
ENERGY DEVELOPMENT CORP	Philippines
GP BATTERIES INTERNATIONAL LTD	Singapore
SAETA YIELD SA	Spain
EDP RENOVAVEIS SA	Spain
GAMESA CORP TECNOLOGICA SA	Spain

IBERDROLA SA	Spain
SOLARIA ENERGIA Y MEDIO AMBIENTE SA	Spain
NIBE INDUSTRIER AB	Sweden
GURIT HOLDING AG	Switzerland
MEYER BURGER TECHNOLOGY AG	Switzerland
ADVANCED LITHIUM ELECTROCHEMISTRY CO LTD	Taiwan
EVERLIGHT ELECTRONICS CO LTD	Taiwan
EPISTAR CORP	Taiwan
E-TON SOLAR TECH CO LTD	Taiwan
GINTECH ENERGY CORP	Taiwan
GREEN ENERGY TECHNOLOGY INC	Taiwan
SOLARTECH ENERGY CORP	Taiwan
NEO SOLAR POWER CORP	Taiwan
DANEN TECHNOLOGY CORP	Taiwan
GIGASOLAR MATERIALS CORP	Taiwan
SINO-AMERICAN SILICON PRODUCTS INC	Taiwan
SIMPLO TECHNOLOGY CO LTD	Taiwan
MOTECH INDUSTRIES INC	Taiwan
SOLARTRON PCL	Thailand
SUPERBLOCK PCL	Thailand
SPCG PCL	Thailand
EKARAT ENGINEERING PCL	Thailand
ENERGY ABSOLUTE PCL	Thailand
AKENERJI ELEKTRIK URETIM AS	Turkey
AMEC FOSTER WHEELER PLC	United Kingdom
RICARDO PLC	United Kingdom
DIALIGHT PLC	United Kingdom
CERES POWER HOLDINGS PLC	United Kingdom
AFC ENERGY PLC	United Kingdom
DRAX GROUP PLC	United Kingdom
UTILITYWISE PLC	United Kingdom

AVX CORP	United States
ACUITY BRANDS INC	United States
ADVANCED ENERGY INDUSTRIES INC	United States
AIR PRODUCTS & CHEMICALS INC	United States
AMERESCO INC	United States
AMERICAN SUPERCONDUCTOR CORP	United States
AMTECH SYSTEMS INC	United States
AMYRIS INC	United States
BWX TECHNOLOGIES INC	United States
BADGER METER INC	United States
CECO ENVIRONMENTAL CORP	United States
CALGON CARBON CORP	United States
CLEAN ENERGY FUELS CORP	United States
CODEXIS INC	United States
COVANTA HOLDING CORP	United States
CREE INC	United States
DOMINION RESOURCES INC/VA	United States
DUKE ENERGY CORP	United States
EL PASO ELECTRIC CO	United States
ENERGY FOCUS INC	United States
ENERGY RECOVERY INC	United States
ENERSYS	United States
ENERNOC INC	United States
ENPHASE ENERGY INC	United States
ENTERGY CORP	United States
ESCO TECHNOLOGIES INC	United States
EXELON CORP	United States
FIRST SOLAR INC	United States
FIRSTENERGY CORP	United States
FRANKLIN ELECTRIC CO INC	United States
FUEL TECH INC	United States

FUELCELL ENERGY INC	United States
GENERAL CABLE CORP	United States
GENTHERM INC	United States
GREEN PLAINS INC	United States
HANNON ARMSTRONG SUSTAINABLE INFRASTRUCT	United States
HEXCEL CORP	United States
ITRON INC	United States
IXYS CORP	United States
LSI INDUSTRIES INC	United States
MAXWELL TECHNOLOGIES INC	United States
NEXTERA ENERGY INC	United States
ORION ENERGY SYSTEMS INC	United States
ORMAT TECHNOLOGIES INC	United States
PG&E CORP	United States
PACIFIC ETHANOL INC	United States
PATTERN ENERGY GROUP INC	United States
PLUG POWER INC	United States
POWER INTEGRATIONS INC	United States
POWER SOLUTIONS INTERNATIONAL INC	United States
PURE CYCLE CORP	United States
QUANTA SERVICES INC	United States
RENEWABLE ENERGY GROUP INC	United States
RENTECH INC	United States
SILVER SPRING NETWORKS INC	United States
SUNPOWER CORP	United States
SUNRUN INC	United States
TPI COMPOSITES INC	United States
TERRAFORM GLOBAL INC	United States
TERRAFORM POWER INC	United States
TERRAVIA HOLDINGS INC	United States
TESLA MOTORS INC	United States

UNIVERSAL DISPLAY CORP	United States
VEECO INSTRUMENTS INC	United States
VICOR CORP	United States
VIVINT SOLAR INC	United States

Table A2: List of the Countries Included in this Study with their Respective Indices and Classifications

Country	Bloomberg Index Ticker	Classification
Austria	ATX Index	Developed
Brazil	IBOV Index	Developing
Canada	SPTSX Index	Developed
Chile	IGPA Index	Developing
China	SHSZ300 Index	Developing
Denmark	KAX Index	Developed
Finland	HEX Index	Developed
France	CAC Index	Developed
Germany	DAX Index	Developed
Greece	ASE Index	Developed
Hong Kong	HSI Index	Developing
Ireland	ISEQ Index	Developed
Israel	TA-125 Index	Developing
Italy	FTSEMIB Index	Developed
Japan	NKY Index	Developed
Korea, Rep.	KOSPI Index	Developing
Netherlands	AEX Index	Developed
New Zealand	NZSE Index	Developed
Norway	OSEAX Index	Developed
Philippines	PCOMP Index	Developing
Singapore	STI Index	Developing
Spain	IBEX Index	Developed
Sweden	SAX Index	Developed
Switzerland	SMI Index	Developed
Taiwan	TWSE Index	Developing
Thailand	SET Index	Developing
Turkey	XU100 Index	Developing
United Kingdom	ASX Index	Developed
United States	SPX Index	Developed

Appendix B

Table B1: Hausman Test for Model 1

This table presents the results for the Hausman Test for model (1) (country-specific factors). Following the results of this test, we used the fixed effects panel model.

	Coefficients			
	(b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
Market Excess Return	2.242	1.867	0.375	0.169
Oil Price Change	0.481	0.473	0.008	0.010
Natural Price Change	0.005	-0.004	0.010	0.012
Percentage of Generation Change	-0.745	-0.644	-0.101	0.0560
Gdp Per Capita Change	-0.781	-0.173	-0.607	0.214
Inflation Rate Change	-0.004	-0.014	0.010	0.004
Manufacturing Change	1.358	1.085	0.272	0.167
Pollution Change	1.169	1.996	-0.827	0.478
Interest Rate Change	-0.0315	-0.040	0.008	0.013
	χ^2 = 26.84			
	Prob>χ^2= 0.001			

Table B2: Hausman Test for Model 2

This table reports the results for the Hausman Test for model (2) (firm-specific factors). Following the results of this test, we used the fixed effects panel model.

	Coefficients			
	(b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
Market Excess Return	1.062	1.037	0.024	0.065
Total Assets Change	0.432	0.407	0.025	0.013
Capital Expenditures Change	-0.006	-0.005	-0.001	0.002
Market-to-Book Ratio Change	0.640	0.634	0.005	0.003
Long-Term Debt Change	-0.039	-0.038	-0.001	0.003
Earnings per Share Change	0.002	0.004	-0.002	0.001
Capital Intensity Change	0.023	-0.007	0.030	0.011
	χ^2 = 12.78 Prob>χ^2= 0.078			

Table B3: Hausman Test for Model 3

This table reports the results for the Hausman Test for model (3) (country and firm specific factors combined). Following the results of this test, we used the random effects panel model.

	Coefficients			
	(b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
Market Excess Return	1.151	0.994	0.157	0.108
Total Assets Change	0.221	0.219	0.001	0.010
Capital Expenditures Change	-0.031	-0.020	-0.011	0.010
Market-to-Book Ratio Change	0.319	0.305	0.013	0.021
Long-Term Debt Change	-0.002	0.000	-0.002	0.005
Earnings per Share Change	0.576	0.578	-0.002	0.006
Capital Intensity Change	-0.021	-0.022	0.001	0.004
Oil Price Change	0.008	0.010	-0.002	0.002
Natural Price Change	-0.031	-0.061	0.030	0.026
Percentage of Generation Change	0.014	0.016	-0.002	0.031
GDP per Capita Change	0.180	0.023	0.157	0.140
Inflation Rate Change	-0.010	-0.008	-0.002	0.003
Manufacturing Change	-0.288	-0.267	-0.021	0.137
Pollution Change	1.427	1.286	0.141	0.306
Interest Rate Change	0.005	0.016	-0.011	0.008
	$\chi^2 = 10.30$ Prob>χ^2= 0.801			

Table B4: Hausman Test for Model 5

This table reports the results for the Hausman Test for model (5) (time period including 2000-2006 and 2010-2015). Following the results of this test, we used the random effects panel model.

	Coefficients			
	(b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
Market Excess Return	1.127	0.951	0.176	0.136
Total Assets Change	-0.035	-0.003	-0.032	0.022
Capital Expenditures Change	0.044	0.048	-0.005	0.010
Market-to-Book Ratio Change	0.263	0.254	0.009	0.027
Long-Term Debt Change	0.025	0.021	0.005	0.006
Earnings per Share Change	0.550	0.548	0.002	0.008
Capital Intensity Change	-0.022	-0.026	0.004	0.005
Oil Price Change	0.004	0.006	-0.002	0.003
Natural Price Change	-0.151	-0.131	-0.019	0.036
Percentage of Generation Change	-0.008	-0.006	-0.002	0.041
GDP per Capita Change	0.513	0.213	0.300	0.197
Inflation Rate Change	-0.006	-0.004	-0.002	0.004
Manufacturing Change	-0.047	-0.105	0.057	0.193
Pollution Change	0.420	0.190	0.229	0.412
Interest Rate Change	0.044	0.055	-0.011	0.011
	χ^2 = 13.27 Prob>χ^2= 0.581			

Table B5: Hausman Test for Model 7

This table reports the results for the Hausman Test for model (7) (the Developed Countries Specification). Following the results of this test, we used the random effects panel model.

	Coefficients			
	(b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
Market Excess Return	1.083	0.949	0.134	0.156
Total Assets Change	0.252	0.234	0.019	0.028
Capital Expenditures Change	-0.001	0.001	-0.001	0.007
Market-to-Book Ratio Change	0.511	0.517	-0.006	0.008
Long-Term Debt Change	-0.027	-0.031	0.005	0.005
Earnings per Share Change	0.001	0.002	-0.001	0.003
Capital Intensity Change	-0.167	-0.200	0.033	0.036
Oil Price Change	0.212	0.206	0.006	0.013
Natural Price Change	-0.070	-0.056	-0.014	0.012
Percentage of Generation Change	0.092	0.124	-0.032	0.044
GDP per Capita Change	0.374	0.275	0.099	0.118
Inflation Rate Change	-0.013	-0.011	-0.003	0.004
Manufacturing Change	-0.939	-0.965	0.027	0.175
Pollution Change	1.641	1.400	0.241	0.393
Interest Rate Change	0.108	0.122	-0.014	0.013
	χ^2 = 8.90 Prob>χ^2= 0.883			

Table B6: Hausman Test for Model 8

This table reports the results for the Hausman Test for model (8) (the Developing Countries Specification). Following the results of this test, we used the random effects panel model.

	Coefficients			
	(b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
Market Excess Return	1.105	0.956	0.149	0.136
Total Assets Change	0.444	0.445	-0.002	0.030
Capital Expenditures Change	-0.008	-0.010	0.003	0.006
Market-to-Book Ratio Change	0.696	0.691	0.005	0.010
Long-Term Debt Change	0.001	0.009	-0.009	0.005
Earnings per Share Change	0.016	0.018	-0.003	0.004
Capital Intensity Change	0.232	0.239	-0.006	0.035
Oil Price Change	0.133	0.134	-0.001	0.021
Natural Price Change	0.054	0.054	0.000	0.014
Percentage of Generation Change	-0.067	-0.153	0.086	0.047
GDP per Capita Change	-0.071	-0.205	0.134	0.117
Inflation Rate Change	-0.002	0.001	-0.002	0.004
Manufacturing Change	0.755	0.690	0.065	0.296
Pollution Change	1.065	0.944	0.121	0.464
Interest Rate Change	-0.054	-0.055	0.001	0.010
	χ^2 = 10.35 Prob>χ^2= 0.797			