The Determinants of Systematic Risk of Renewable Energy Firms

Lars J. Hesselink, Lammertjan Dam, and Wim Westerman

1 Introduction

In the last decade, global investments in energy capacity shifted from investing in fossil fuels to investing in renewable energy from naturally replenished natural resources, including biomass, waste-to-energy, geothermal, wind generation hydro-power, wave and tidal energy, biofuels and solar (New Energy Finance 2016). However, the risk–return relationship (Sadorsky 2012), on which investment decisions are based, is hard to assess in case of renewable energy investments. This relationship is important for managers when they value a private firm by discounting an investment's future cash flows with the weighted cost of capital. To calculate the equity component of this cost of capital, contemporary finance scholars focus on the systematic risk (beta) of public comparable firms (Damodaran 1999b). However, these are hard to be found and also comparable firm beta estimations do not reflect the opportunities and uncertainties in renewable energy investments (Menegaki 2008). Furthermore, beta estimations range from twice as risky as a well-diversified portfolio to half as risky (Sadorsky 2012; Donovan and Nuñez 2012; Bohl et al. 2013). So, there is a need to come up with common drivers that affect the systematic risk of renewable energy firms.

Sadorsky (2012) finds that oil returns positively influence the beta of renewable energy firms, but country-specific factors can also influence a renewable energy firm's beta. On the one hand, Inchauspe et al. (2015) find that renewable energy investments grew at different paces in different countries, and Donovan and Nuñez (2012) empirically find country differences in beta. On the other hand, the literature describes several country-dependent risk factors important to renewable energy firms (Popp et al. 2011; Barroso and Iniesta 2014; Kim et al. 2016). These country

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dependencies give rise to the idea that country-specific factors can influence the beta of renewable energy firms. However, these risk factors are not yet empirically tested as a determinant of a renewable energy firm's systematic risk. First, oil prices are likely to influence the beta of a country's renewable energy firms due to a substitution effect (Klevnäs et al. 2015). Second, a country's energy security influences the propensity to invest in renewable energy (Sen and Ganguly 2017). Third, a country's technological innovation potentially benefits renewable energy firms as innovation closes the price gap with fossil fuels (Khan et al. 2017). Fourth, literature documents on governmental policies as a means to reduce risk by securing cash flows in renewable energy investments (Sadorsky 2012). Therefore, the following research question is formulated: how do oil return, country-level net-imports, technological innovation, and environmental policies affect the beta of renewable energy firms?

An alternative to the static CAPM beta is the dynamic beta approach. This allows for beta to vary with a set of factors (Rosenberg and Marathe 1976). Our dynamic beta approach relates that systematic risk renewable energy firms vary with oil returns (Sadorsky 2012), and the level of a country's net-imports, technological innovation, and environmental policies. We employ a cross-country panel data set with 578 traded renewable energy firms over the period 2005–2016. We find that systematic risk, beta, is negatively influenced by oil returns and that country-level net-imports, and environmental policies discriminate risk between countries. Oil returns are the most dominant factor, a one standard deviation fluctuation in monthly oil prices leads to a fluctuation in beta of 0.17. Also, a one standard deviation difference in the level of net-imports and environmental policy affects beta with 0.14 and 0.09, respectively.

These results give insights on the beta of renewable energy firms. Macroeconomic factors influence the beta of the renewable energy sector and should not be forgone in comparable firm analysis. From here, country-specific factors help to convert the risk of comparable renewable energy firms abroad to the investment's country of interest. Also, this study provides insights on nonfinancial drivers (Trueman et al. 2000) of a renewable energy firm's beta and answers Sadorsky's (2012) call for further analysis of variables affecting the beta of such firms.

This chapter is structured as follows: Section 2 focuses on literature concerning beta estimation in renewable energy. From here, we derive hypotheses to answer the research question. Section 3 outlines the methodology and describes the data used. Section 4 presents the results and evaluates the hypotheses. Section 5 consists of a discussion and conclusion.

2 Literature Review

This literature review starts with an overview of investment decision-making based on the cost of capital. We describe limitations of the practitioner's method on renewable energy (hereafter RE) valuation. Given these limitations, we suggest an alternative solution based on evidence from the technology sector. We describe variables that affect the systematic risk of renewable firms. Lastly, the research framework is displayed.

2.1 Investment Decision-Making and the Cost of Equity Capital

The standard valuation approach is to discount an investment's future cash flows (DCF), based on a discount rate that represents the opportunity cost of making this investment (Koller et al. 2015). The discount rate is a percentage based on the weighted average cost (WACC) of debt and equity capital used. The cost of equity reflects the rate of return for the equity investor and the cost of debt the rate of return for the debt investor. To reflect benefits of the tax deductibility of interest, the cost of debt should be after corporate tax (Brotherson 2013).

The cost of equity is a challenging aspect of the WACC calculation (Donovan and Nuñez 2012). Sharpe (1964) and Lintner (1965) were the first to frame this cost of equity in their capital asset pricing model (CAPM). This model describes the cost of equity by means of a risk-free rate, a market risk premium, and a stock's sensitivity to the market index. This sensitivity is the stock's systematic risk, beta. Practitioners use the beta of comparable public firms (peers) to determine a private firm's cost of equity (Brotherson 2013; Koller et al. 2015). Thus, to arrive at the cost of equity for private RE firms, we need the beta of comparable listed RE firms.

2.2 Limitations to the Practitioner's Method in Renewable Energy Valuation

The practitioner's method faces limits in the case of valuing a private RE firm. One limitation concerns the estimation of the peer beta. There is little evidence on the systematic risk of RE firms because of the short-lived nature as an independent business (Donovan and Nuñez 2012). Thus, it is hard to find comparable listed firms with enough stock return observations to base beta on. Alternatively, accounting betas are used (Damodaran 1999a). However, in technology-based industries, such as the RE industry, nonfinancial data largely dominates the accounting information (Jorion and Talmor 2001). Also, historical information is likely to be less useful than in more established industries or even in non-high-tech industries (Trueman et al. 2000).

The limited evidence on the systematic risk of RE firms shows mutually deviating betas, since scholars use different samples and market index proxies. Table 1 provides an overview. Donovan and Nuñez (2012) fit CAPM-derived models for emerging markets' RE firms over the period 2006–2009. They find betas that range from 0.55 to 1.45 (Table 1). By using German data, Bohl et al. (2013) find a

Table 1 Literature on the systematic risk of renewable energy firms

Author(s)	Sample	Time-period	Market index	Beta	Research aim	Main finding
Donovan and Nuñez (2012)	Selected RE firms from China, Brazil, and India	2006–2009	Monthly return	1.30	Examining the key methodological challenges in determining the cost of equity for RE firms in emerging markets	For the multinational investor, RE possesses average market risk, but for the local investor market risk deviates between lower than average and higher than average. Thus, it is important to know who the marginal investor is
			MSCI-ASCI			
			China	0.82		
			Brazil	0.55		
			India	1.46		
Bohl et al. (2013)	ÖkoDAX Index and Renewable Energies Index	2004–2011	Monthly return CDAX	Time-varying, between 2.10 and 1.6	Examining the risk factors of RE stock returns, based on Carhart's four factor loadings	German RE stocks outperformed the market in 2004–2007, but this completely reversed in 2008–2011
Henriques and Sadorsky (2008)	Wilderhill Clean Energy Index firms	2001–2007	Monthly return S&P	1.40	Investigating the relationship between alternative energy stock prices, techno-logy stock prices, oil prices, and interest rates	Shocks to technology stock prices influence stock prices of alternative energy firms, however, oil prices only have a little significant impact
Inchauspe et al. (2015)	New Energy Global Innovation Index firms	2001–2014	MSCI Index	Time-varying between 0.9 and 1.2	Examining factors impacting the NEX and giving insights in the dynamic nature of these factors	The NEX is highly correlated with the MSCI, the technology stock index is an additional pricing factor and impact of oil prices on returns is weak. Time-varying coefficients illustrate changing relationships
Sadorsky (2012)	Wilderhill Clean Energy Index firms	2002–2007	Monthly return NYSE Index	1.96	Finding determinants of RE systematic risk	Increases in oil price returns increase the systematic risk of RE firms. Firm sales growth lowers the systematic risk

The MSCI (-ASCI = All Country World Index) is the Morgan Stanley Capital International on 23 developed and 24 emerging markets. The ÖkoDAX comprises the ten largest German RE firms, whereas the Renewable Energies Index is a bit broader with 23 firms. The CDAX is the composite index of all stocks traded on the Frankfurt Stock Exchange. The WilderHill Clean Energy Index compromises RE technology firms from the USA. The New Energy Global Innovation Index (NEX) is a well-diversified portfolio across RE subsectors and regions. See for more information the respective websites of the indices beta of 1.6, 1.65, and 2.10 for 2004–2007, the 2008–2011, and the full sample period, respectively. This evidence of a time-varying beta is backed up by a study of Inchauspe et al. (2015) on a well-diversified industry and country portfolio. The authors find a beta of 0.9 in 2003–2005 and a beta greater than 1.2 from 2013 and onwards. Inchauspe et al. (2015) also show similarities to Henriques and Sadorsky (2008) when studying market index, oil prices, and technology stock prices effects on the prices of RE stocks. Sadorsky (2012) studies mainly US technology-oriented RE firms. He finds that they are twice as risky as the market. Hence, a beta of 1.96 would be applicable.

Lastly, Menegaki (2008) argues that quality and market responsiveness of RE technologies cannot be modeled in terms of cash flows. Kim et al. (2016) join this view and argue that technological innovation and global climate change harm the definite cash flow assumption under the DCF method. As an alternative, they propose to use a real option valuation approach. So, questioning the overall DCF method also discredits the use peer betas, because the beta is central to the cost of equity calculation and in turn DCF calculation.

Taking into consideration the importance of the cost of equity and the "proven limitations" of the practitioner's method, Barroso and Iniesta (2014) argue not to reject it but instead to supplement it with techniques that more accurately assess and adjust to the reality of projects that generate uncertainties in some of their parameters (cf. Menegaki 2008; Kim et al. 2016).

2.3 Alternative Solution Based on the Evidence from the Technology Sector

Regressing the beta on variables other than accounting ratios can help to give insights on systematic risks of a novel industry, such as the RE industry. Central here is the relationship between technology stocks and RE stocks. Henriques and Sadorsky (2008) find a significant response of the RE index to technology index shocks. They argue that investors consider RE stocks closely related to technology sector rather than energy sector movements. Inchauspe et al. (2015) confirm this relation and ascribe this to the competition for the same inputs.

Another common factor is the limited availability of data. Jorion and Talmor (2001) acknowledge the limited availability of historical information and the domination of nonfinancial data in the early days of the technology sector and argue that "neither growth nor net income, nor cash flows, nor return on investment should be emphasized to the exclusion of other meaningful measures" (p. 13). The study by Sadorsky (2012) is the only one that researched the determinants of the systematic risk of RE firms. So, based on the similarities between the (early day) technology sector and the RE sector, this chapter advocates that non-accounting variables may be an important determinant of the systematic risk of RE firms.

2.4 *Determinants of Renewable Energy Systematic Risk*

Section 2.4.1 discusses a global factor that affects the systematic risk of RE firms, namely oil returns. Next, Sect. 2.4.2 discusses five country-specific factors that affect the systematic risk of RE firms, respectively energy import dependency, technological innovation, political risk, environmental policy stringency, and environmental policy stability.

2.4.1 A Global Factor Affecting the Systematic Risk of Renewable Energy Firms

The first potential determinant of RE systematic risk is global oil returns. Oil prices affect the costs of goods and services, impact inflation, and influence consumer confidence (Nandha and Faff 2008). In this way, oil returns affect stock prices, which ideally reflect "the market's best estimate of the future profitability of firms" (Jones and Kaul 1996, p. 24). So, increasing oil prices raise the cost of doing business and therewith affect equity returns of nonfossil fuel-related firms. Nandha and Faff (2008) find for 35 DataStream global industries that rising oil prices negatively impact on equity returns, except for oil, mining, and gas industries. Sadorsky (2012) tests the impact of oil returns on the systematic risk of mostly US tech-oriented RE stocks and finds a positive effect on the beta.

The relation of oil prices to a broader sample of RE firms can be various. Gogineni (2010) finds that industries do not rely evenly on oil as an input to conduct business. Consequently, stock prices of less oil-reliant firms are less influenced by oil price increases relative to a broad market index. This results in a lower beta for RE firms, because RE operations rely less on oil. Second, RE is a substitute for oil, and especially for fuels and coal (Klevnäs et al. 2015; Khan et al. 2017). So, if oil price increases reduce the demand for oil (Gogineni 2010), RE is perceived as more attractive (Khan et al. 2017). Vice versa, RE becomes less attractive when oil prices decrease and a RE firm's beta is expected to increase. This chapter goes with the second view: RE firm returns are less sensitive than the market to oil price increases and RE acts as a substitute for fossil fuels. Thus, oil returns and a RE firm's beta are negatively related.

H1: A price increase [decrease] in oil leads to a lower [higher] beta for RE firms

2.4.2 Country-Specific Factors Affecting the Systematic Risk of RE Firms

Country level compound annual growth rates in RE investments range from 17% to 57% over the period 2004–2011 (Inchauspe et al. 2015) and studies (Table 1) show mutually deviation betas. Also, the literature describes several country-dependent risk factors important to RE firms (Popp et al. 2011; Barroso and Iniesta 2014; Kim et al. 2016). This gives rise to the idea that, on top of oil, country-specific factors can influence the beta of RE firms.

Energy Import Dependency

The objective of countries to reduce uncertainty in energy supply (Sen and Ganguly 2017) reduces the systematic risk of RE firms. However, this reduction depends on the proportion of a country's energy imports. Based on a literature study, Vivoda (2009) holds that one way to secure a country's energy supply is to diversify sources from where oil is imported. However, diversification does not reduce oil price volatility. Hence, the higher the level of energy imports the larger the magnitude of oil price volatility.

Various empirical studies find negative effects of oil price volatility on economic activity of net-oil importing countries—Hamilton (2003) on nonlinear effects on the GDP growth, Cuñado and Pérez de Gracia (2005) on the consumer price index (CPI) and production in Asian countries, Gronwald (2008) on U.S. GDP growth, consumer- and import prices, and Álvarez et al. (2011) on European and Spanish CPI. Hence, the higher the level of imports the higher the impact of oil price volatility becomes. The adverse effects of oil price volatility ask for a solution to curb their impact on economic activity. Here, RE's hedging role serves as a solution. Rentschler (2013) simulates oil price volatility and finds that increasing the share of RE avoids GDP losses.

Therefore, a country's pursuit of energy independence creates a favorable environment for RE firms. It secures their cash flows. From here, investors reward RE firms with a lower risk perception. Vice versa, RE firms do not face this lower risk perception in countries with greater domestic energy resources. Thus, there is a negative relationship between energy imports and the systematic risk of RE firms. Hence, higher net energy imports decrease the beta of RE firms.

H2: Investing in a country which is relatively more dependent on energy imports [exports] decreases [increases] the beta for RE firms

Technological Innovation

Literature acknowledges the importance of technology in the RE sector, but has not yet examined technological innovation as a determinant of systematic risk of RE firms. Empirically, papers focus on the explanatory power of technology stock return on RE stock return (Henriques and Sadorsky 2008; Inchauspe et al. 2015), on the effect of technological innovation on the use of RE technologies (Popp et al. 2011) and on the diffusion of these technologies (Verdolini and Galeotti 2011). Theoretically, papers put forward the uncertainty from cost fluctuations in the RE sector (Barroso and Iniesta 2014), security of demand for RE because of digitalization (Khan et al. 2017) and cost competitiveness with fossil fuels due to technological innovation (Popp et al. 2011). In sum, there is evidence that technological innovation plays an important role within the RE sector.

This role is not yet translated into a determinant of systematic risk. However, most of the energy-related innovations are carried out in a few countries and the diffusion of technological innovation for RE cannot be taken for granted in all countries (Verdolini and Galeotti 2011). Thus, there is an unequal effect on systematic risk of RE firms between countries. Verdolini and Galeotti (2011) model the probability that an innovation generated in country *j* becomes available in country *i*. They find that most innovations never cross a country's border, but if an innovation crosses the border, geographical distance is not significant anymore.

On the one hand, costs of RE are likely to decrease in the future, but this is most likely in countries with high technological development. Consequently, this competitive advantage decreases the systematic risk for RE firms residing in countries with a higher technological innovation, relative to firms from countries with a lower technological innovation. On the other hand, investing in energy systems results in irreversible investments (Verdolini and Galeotti 2011). This creates a "lock-in" in the chosen technology, despite further technological RE innovation (Foxon 2007). From here, unequal diffusion of technology results in unequal risk distribution. Consequently, RE firms in countries with high technological development are more likely to face these breakthroughs, which create a source of long run risk (Hsu 2010).

This chapter goes with the view that the cost-reducing effect of technological innovation outweighs the effect of technological breakthroughs as a source of long run risk. Potential breakthroughs nowadays are likewise to ones that could have happened 10 years ago. Thus, there is a negative relationship between technological innovation and the beta of RE firms.

H3: The higher (lower) the technological innovation in a country the lower (higher) the beta of RE firms

Political Risk, Environmental Policy Stringency, and Environmental Policy Stability

The United Nations induced an international agreement to reduce emissions, the Kyoto Protocol (UNFCCC Protocol 1997), to commit its member countries to adopt RE practices. Subsequently, countries employ various RE policies. Popp et al. (2011) distinguish between "R&D, investment incentives (e.g., risk guarantees, grants, and low-interest loans), tax incentives (e.g., accelerated depreciation), tariff incentives (e.g., feed-in tariffs), voluntary programs, obligations (e.g., guaranteed markets and production quotas), and tradable certificates" (p. 649).

Authors point to the implications of their research for governmental policies on RE. The same survey among 60 private equity investors conducted in 2007 and 2010 gives insights on the right policies to mitigate investment risk (Bürer and Wüstenhagen 2009; Hofman and Huisman 2012). Popp et al. (2011) uses a sample of 26 OECD countries over the period 2011. He finds that governmental policy, proxied by ratification of the Kyoto Protocol and two specific policies, enhance RE investment. Moreover, the majority of the real option literature focusses on feed-in tariffs as the main market uncertainty (Kim et al. 2016). In sum, different types of research link RE investments to environmental policies. However, none of them examines if these policies reward RE firms in that country with a lower systematic risk.

The governmental environmental policies affect the systematic risk of RE firms in three ways: (1) the policies create a predictable demand (Sadorsky 2012), (2) the policies reduce the costs of renewable relative to fossil fuels by penalizing firms that pollute the environment and by including favorable tariffs (Kim et al. 2016), and (3) uncertainty in environmental policies poses a risk on RE investments. From here, strict environmental policies in a country would exert a positive effect on future profitability of RE firms (Bohl et al. 2013). Stringent environmental policies reduce systematic risk, but loose environmental policies do increase it.

An issue is how environmental policy stringency depends on political stability. Fredriksson and Svensson (2003) study a sample of 31 countries and cannot reject that the marginal effect of political instability on environmental policy is zero. Political risk in its broadest meaning is the adverse effect on the value of an investment, as a consequence of government actions, or imperfections of a country's executive, legislative, or judicial institutions, or internal and external conflicts (Bekaert et al. 2016). This chapter tests the effect of country's political risk on the systematic risk of RE firms, the effect of environmental policy stringency on systematic risk and the combined effect (here after environmental policy stability) on systematic risk.

Countries with a low political risk do not necessarily have stringent environmental policies and vice versa. In countries with stringent policies but high political risk, investors still perceive a higher risk. If not including the combined effect, this results in a downward biased estimate of beta because of stringent environmental policies, while neglecting political risk in general. Even where strict environmental policies are in place, legislative institutions may fail. For example, Schuman and Lin (2012) state that in China, despite its RE laws and large RE sector, firms are hardly penalized for not obeying these laws. Thus, we assume is a negative relationship between environmental policy stability and the beta of RE firms.

H4.1: The higher (lower) the political risk in a country the higher (lower) the beta of RE firms

H4.2: The higher (lower) the environmental policy stringency in a country the lower (higher) the beta of RE firms

H4.3: The higher (lower) the overall environmental policy stability in a country the lower (higher) the beta of RE firms

Figure 1 graphically displays the derived hypotheses from the literature review. Oil returns negatively influence the systematic risk of renewable firms. Net-imports negatively affect the systematic risk of RE firms. Technological innovation lowers the beta and political risk positively influences it. Both environmental policy stringency and stability lower the beta.

2.5 Research Framework

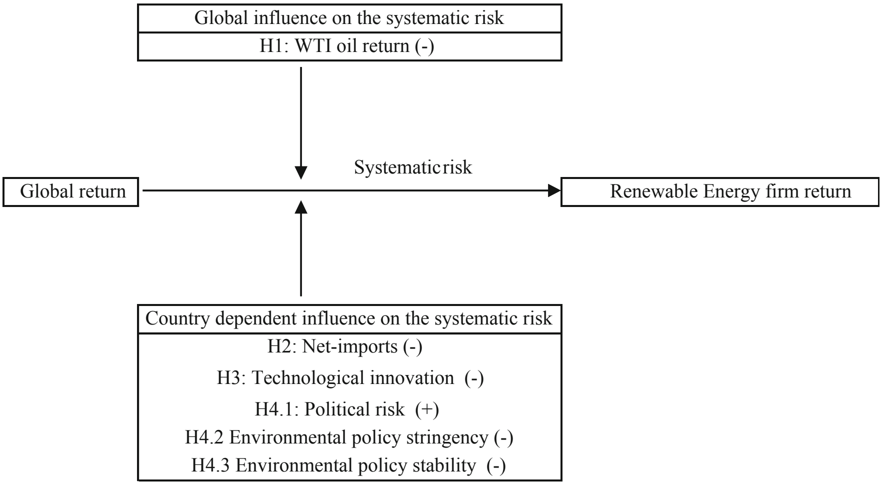

Fig. 1 Research framework

3 Methodology and Data

This chapter uses a dynamic beta model, in line with Sadorsky (2012), as will be elaborated on. Also, this section describes the firms included in the sample, as well as the macroeconomic data on global- and country-specific variables. The time period covered is 2005–2016.

3.1 Methodology

A dynamic beta model (Abell and Krueger 1989) can describe the systematic risk of RE firms. "Papers published in the 1980s used the term variable beta. Today, the terms variable beta, time varying and dynamic beta are used interchangeably" (Sadorsky 2012, p. 42) to describe the type of model. The model is an extension of the capital asset pricing model (CAPM), which is often referred to as Sharpe's single index model (SIMM) (Sharpe 1964).

Abell and Krueger (1989) use the method to determine the apparently similar macroeconomic effects on beta across US industries. Whereas their study focuses on macroeconomic influences on beta, it has similarities with Glova (2014), who described Central, Eastern, and Southeastern Europe (CESEE) country betas based on global risk factors and local risk factors. Therefore, this chapter uses the methodology described by Abell and Krueger (1989), with one variable that is irrespective of a firm's country and five variables that are country specific: oil return, and net-imports, technology, political risk, environmental policy stringency, and environmental stability. We aim to explain the effect of these variables on the systematic risk of RE firms.

The structural model in this chapter extends the SIMM with a set of other factors, $\delta' Z_{it}$, explaining stock return R_{it} of RE firm i at time t. In this multifactor model (1),

$$R_{it} = \alpha_i + \beta_i R_{mt} + \delta' Z_{it} + \varepsilon_{it} \tag{1}$$

R_{it} represents the RE firm's monthly stock return, calculated as $ln(p_t/p_{t-1})$ and adjusted for dividend payments and corporate actions. R_{mt} are the monthly returns of the MSCI All Country World Index (ACWI), referred to as global return. The corresponding β_i measures the sensitivity to the global return (systematic risk) of RE firm i. The α_i is the component of a security's return that is independent of the global return, and the ε_{it} is the error term.

The CAPM can be adapted to a dynamic beta model if beta varies with a set of fundamental factors (Rosenberg and Marathe 1976). Such a model provides investors with valuable information on the sensitivity of beta to certain factors (Abell and Krueger 1989). We expect that the beta depends on the set of variables from Fig. 1. Our model describes beta in terms of a constant influenced by a global variable and five country-specific variables. This leads to,

$$\beta_{it} = \theta_i + \gamma' X_{it} + v_{it} \tag{2}$$

with θ_i as the constant and X_{it} as a vector of variables affecting the beta of a RE firm i, at time t, hence β_{it}. So, β_{it}varies linearly with a set of descriptors X_{it}. Also, γ are coefficients of the proportion by which the beta is adjusted in response to movements in these descriptors (Abell and Krueger 1989). The v_{it} are random error terms. In most of our regressions we use pooled OLS, meaning that $\theta_i = \theta$. This θ_i can also depend on country or industry. Importantly, using country-dependent variables as descriptors of beta yield a beta that is expected to be the same for all firms from that country at time t. This is a strong assumption. However, the aim is to estimate the effects on beta rather than individual firm betas. Also, it is not possible to directly estimate the effects on beta as beta is unknown in Eq. (2). Thus, we estimate the effects on beta jointly in a reduced form by substituting Eq. (2) with Eq. (1). This yields:

$$R_{it} = \alpha + (\theta_i + \gamma' X_{it}) R_{mt} + \delta' Z_{it} + \vartheta_{it} \tag{3}$$

In this case α_i becomes α. This means that α is no longer firm dependent. Furthermore, $\vartheta_{it} = \varepsilon_{it} + v_{it} R_{mt}$ is assumed to be normally distributed with zero mean.

Now, we can indirectly determine values for parameters γ in Eq. (2) by the estimation of Eq. (3). In this model, $\theta_i R_{mt}$ (the constant) is the separate influence of the world index (global return) on firm return after incorporating the hypothesized effects on systematic risk. The information of the effect of these variables on beta comes from the γ coefficients in Eq. (3). Hence, a negative coefficient γ indicates that the beta of Eq. (3) is reduced because of an increase in X_{it}. Vice versa, a positive coefficient indicates that the beta increases because of an increase in X_{it}. Hypothetically, if $\theta_i R_{mt} = 1.2$, and $\gamma_i = -0.1$, the global return has a diminishing effect on a RE firm's return at a higher X_{it}. For each unit that X_{it} increases, the market index effect on firm return decreases by $-0.1*1$, ceteris paribus.

Firms and their country-specific factors are matched based on ISO Code. One drawback of this is that firms have operations in multiple countries. However, ISO codes mostly reflect the country in which most revenue is gathered, management is settled, and laws are obeyed. The unbalanced panel is examined over a period of 12 years and per month, which results in a maximum of 144 monthly observations per firm. Furthermore, this panel data set is estimated using OLS and corrected for panel standard errors (PCSE), which makes the model robust to heteroscedasticity and contemporaneous correlation (Beck and Katz 1995).

3.2 Data

This research uses a large sample of stocks listed RE firms based on Bloomberg Industry Classification Standards (BICS). Previous studies mainly focused on either RE indices (Henriques and Sadorsky 2008; Inchauspe et al. 2015), or small samples of firms from these indices (Sadorsky 2012; Bohl et al. 2013), or a sample of emerging market RE firms (Donovan and Nuñez 2012). These samples included less than 70 firms. We start with 644 firms from 53 different countries (based on ISO code) that are listed on stock exchanges around the world.

The BICS classifies firms on primary business by measuring the source of revenue, operating income, assets, and market perception (Bloomberg Index Methodology 2015). We included all listed firms with BICS codes 1311 and 19101112, which respectively reflect all firms majorly engaged in "RE and Renewable Electricity." These firms range from wind generation firms, to producers of their equipment and from fuel cell producing firms to RE construction firms.

Furthermore, firms need enough stock return observations to result in a beta that accurately reflects the systematic risk of the firm. Here, we follow Damodaran (1999b). Whereas annual and quarterly data may result in too less observations, beta estimations based on daily data may suffer from a nontrading bias. It is best to use at least 36 monthly return observations. We retrieved monthly return data, conditionally on at least 24 months of observations. We are interested in the aggregate beta of multiple firms in a country rather than individual firm betas. Consequently, the sample consists of 578 firms from 52 countries (see Table 2).

Table 2 Number of sampled renewable energy firms per country, 2005–2016

Country	ISO Code	Number of firms	Country	ISO Code	Number of firms	Country	ISO Code	Number of firms
UAE	AE	1	Hungary	HU	5	Peru	PE	2
Austria	AT	1	Indonesia	ID	1	Philippines	PH	2
Australia	AU	26	Ireland	IE	1	Pakistan	PK	1
Bosnia and Herzegovina	BA	4	Israel	IL	6	Poland	PL	12
Bangladesh	BD	2	India	IN	33	Romania	RO	1
Bulgaria	BG	2	Italy	IT	15	Serbia	RS	2
Brazil	BR	4	Jordan	JO	1	Russia	RU	3
Canada	CA	43	Japan	JP	4	Sweden	SE	8
Switzerland	CH	5	Kenya	KE	1	Singapore	SG	2
China	CN	104	South Korea	KR	19	Thailand	TH	10
Czech Republic	CZ	2	Kuwait	KW	1	Tunisia	TN	1
Germany	DE	35	Sri Lanka	LK	5	Turkey	TR	4
Denmark	DK	2	Malaysia	MY	7	Ukraine	UA	4
Spain	ES	6	Netherlands	NL	1	United States	US	108
France	FR	13	Norway	NO	4	Vietnam	VN	14
Great Britain	GB	21	New Zealand	NZ	4	South Africa	ZA	2
Greece	GR	1	Oman	OM	1	Total		578
Hong Kong	HK	20	Panama	PA	1			

Firm count is based on the ISO code belonging to the firm according to Bloomberg. Great Britain also includes firms from Jersey and Isle of Man. China's count also includes Taiwanese firms. Source: Bloomberg

Table 3 Global- and country-level influences on the systematic risk of renewable energy firms

Variable	Description
Global influence on systematic risk	
	Monthly
WTI oil return	Log return on the WTI crude oil generic 1st
Country influences on systematic risk	
	Yearly
Imports	Energy imports relative to energy use
Technology	(Patent applications/population) times thousand
PRS	Score on the Political Risk Index
EPS	Score on the Environmental Policy Stringency Index
(PRS+EPS)	Equally weighted score of PRS and EPS

Sources: Bloomberg, World Bank, WIPO, OECD, PRS group

3.3 A Global Factor

Oil price returns are measured as the monthly log return using the last day's closing price on the West Texas Instruments (WTI) Crude oil Generic 1st. These are the oil prices based on the nearest future contract and are the most widely traded physical commodity in the world (Henriques and Sadorsky 2008). Oil prices are retrieved from Bloomberg. See also Table 3.

3.4 Country Factors

3.4.1 Energy Imports, Net (% of Energy Use)

Data on net-imports is retrieved from the World Bank Databank and available until 2014 for most countries. Net-import is one of the most commonly used measures of security of energy supply (Kruyt et al. 2009). They are estimated relative to energy use in oil equivalents. A positive percentage indicates that a country imports more energy than it produces. A negative percentage indicates the opposite. Whereas a country can import a maximum of 100% of its total use, export quantities can exceed 100%. For example, UAE and Norway exported respectively 190.1% and 543.7% of their energy use in 2013. Energy use refers to the use of primary energy before transformation to other end-use fuels (Botta and Kozluk 2014).

3.4.2 Technology

This chapter measures technological innovation by focusing on the total patent applications in a country, as is widely done in the RE research (Verdolini and Galeotti 2011). This may not grasp the full benefit for RE firms. Patent applications on industry level are also available, but less extensive. We checked if environmentally related patent and total patent applications differ strongly, but they are 0.91 correlated. Data on patent applications is available until 2015 and retrieved from the WIPO Patent Database. Applications include both applications by residents and nonresidents counted by a filling office within a country. To be able to compare different countries regarding their patent applications, we calculated patents per thousand inhabitants.

3.4.3 Political Risk

Data about a country's political risk is based on the December reports of the International Country Risk Guide (ICRG) provided by the Political Risk Services group. The data is available until 2015 and retrieved from the World Bank. This political risk index (PRS) measures the political riskiness of a country and is a frequently used measure of political risk (Erb et al. 1996; Bekaert et al. 2014). A country's score depends on six dimensions. The yearly country score is the average of these components scores. The maximum score is 1 and the minimum score is 0. The higher the score on the political risk index, the lower the political risk. The highest score is 0.99 in our sample and the lowest score is 0.38 (Table 4).

3.4.4 Environmental Policy Stringency

Data on the environmental policy in a country is provided by the Organization for Economic Co-operation and Development (OECD) and available until either 2012 or 2015 for the majority of the countries. Environmental Policy Stringency (EPS) is defined as "the policy-induced cost of polluting by firms across different industries and policy instruments" (OECD 2016). The score is based on a composite-index approach (Botta and Kozluk 2014), focusing on fifteen instruments, subdivided over market- and nonmarket-based policies. The maximum achievable score is six (most stringent) and the minimum is zero (least stringent). In this sample, the Netherlands scores the highest in 2010 with a score of 4.13. Contrary, Brazil scores the lowest in 2011 with a score of 0.375 (Table 4).

3.4.5 Environmental Policy Stability

This chapter equally weights the score of the PRS and EPS. The PRS score ranges from 0 to 1 and the EPS score from 0 to 6. So, we multiply the PRS score by six and add the score to the EPS score to estimate the environmental policy stability of a country. This results in a minimum score of 3.3 for Indonesia in 2005 and the highest, 9.7 for the Netherlands in 2011 (Table 4).

Table 4 Summary statistics for listed renewable energy firms worldwide and country characteristics, 2005–2016

	Monthly firm return (%)	Monthly global return (%)	Monthly WTI oil return (%)	Yearly net-imports (%)	Yearly patent applications	Yearly PRS score	Yearly EPS score	Yearly (PRS + EPS score)
Mean	−2.0	0.3	0.2	20.9	0.4	0.75	2.5	6.9
Median	−0.9	0.7	1.0	27.0	0.2	0.79	2.5	7.5
Maximum	75.1	10.0	22.5	99.6	2.6	0.99	4.1	9.7
Minimum	−87.2	−13.6	−23.3	−764.3	0.0	0.38	0.38	3.3
Std. Dev.	22.9	4.4	9.0	71.0	0.4	0.14	0.93	1.6
Skewness	−0.2	−0.6	−0.4	−5.9	2.1	−0.53	−0.33	−0.5
Kurtosis	6.3	4.0	3.1	53.4	9.4	1.9	1.97	1.9
Observations (× 1000)	59.3	92.7	92.7	77.6	87.4	91.7	70.7	70.7

The sample contains 578 renewable energy firms from 52 countries. Monthly firm returns, Global returns, and WTI oil returns are winsorized on the 1st and 99th percentile. Net-imports are the total imports relative to a country's energy use (negative if net-exporter of energy). Patent applications are measured per thousand inhabitants. PRS is the score on the Political Risk Index and EPS is the score on the Environmental Policy Stringency. (PRS + EPS) is the equally weighted score and only used if both scores are available. Sources: Bloomberg, World Bank, WIPO, OECD, and PRS group

4 Results

In Table 5, this chapter shows pooled OLS estimates. Every column shows a new model. The first one has a single index model (SIMM). For completeness, we include the other variables of interest and estimate their effect on the monthly return of RE firms (Column 2). Third, we include the interaction effects between the global return and the WTI oil return, Net-imports, technology, PRS, and EPS one by one (Column 3–7). Fourth, we estimate the whole model (Column 8). The interaction effects are the main coefficients of interest for verifications of the hypotheses and represent the effect on systematic risk. The combination of the coefficient of global return and the coefficients of the interaction effects constitute the dynamic beta.

In the single index model (SIMM), Table 5 Column (1), the coefficient with global return is 1.18. This indicates that a 1% increase of the global market return leads to an expected aggregate increase in RE firm return of 1.18% and vice versa. So, RE firms are on average riskier than the market. This estimate does not deviate strongly from Damodaran's (2017) industry beta estimate of 1.14. Also, this estimate falls well with earlier research (see Table 1).

In Column (2), we see that the return of RE firms increases with WTI oil returns, indicating a substitution effect into RE stocks if oil prices rise. This finding contradicts the Henriques and Sadorsky (2012) argument that oil price movements are less important to RE firms. Hence, oil returns do matter. Furthermore, we see a negative effect of PRS on the return of RE firms. A higher score indicates a lower political risk and thus leads to a lower return. This confirms a positive relationship between political instability and stock market returns (Chen et al. 2016).

In Column (3), we see a negative effect of oil returns on systematic risk. Herewith, we accept *H1*: an oil price increase leads to a lower level of systematic risk for RE firms. This result is in sharp contrast with Sadorsky (2012), who finds a positive effect of oil returns on systematic risk. This chapter finds that a 1% increase in oil prices leads, ceteris paribus, to a 1.95% decrease of systematic risk. One standard deviation increase in oil returns reduces beta by 0.17 (Table 6). This means that the sensitivity of RE firm with respect to global market returns decreases in times of increasing oil prices, whereas it increases in times of decreasing oil prices.

Column (4) shows a positive influence of net-imports on systematic risk, which contradicts *H2* that being relative more dependent on energy imports decreases the systematic risk of RE firms. One standard deviation increase in a country's energy import relative to its use results in a deviation of 0.14 in beta and vice versa (Table 6). A difference between net-exporting 50.1% and net-importing 56.4% yields a difference in beta of 0.21. Global market returns have an increased effect on RE firm returns in cases of relatively high net imports. An explanation of this finding may be that an increased energy import from abroad outweighs the incentive to invest more in RE. This results in uncertainty in future cash flows and increased sensitivity to global returns. Also, countries with higher net-imports may still view importing energy as a more cost-effective solution to energy security, while neglecting the societal benefit of RE.

Table 5 Dynamic beta model of 578 renewable energy firms over the period 2005–2016

	SIMM (1)	Multifactor (2)	H1 (3)	H2 (4)	H3 (5)	H4.1 (6)	H4.2 (7)	H4.3 (8)
Constant	−0.024*** (−8.605)	0.032** (2.328)	0.035** (2.529)	0.032** (2.334)	0.032** (2.303)	0.031** (2.202)	0.031** (2.287)	0.033** (2.427)
Global return	1.184*** (18.470)	1.115*** (13.740)	1.075*** (13.500)	1.083*** (13.329)	1.152*** (12.872)	1.45*** (4.951)	1.396*** (9.039)	1.394*** (5.984)
WTI oil return		0.148*** (3.613)	0.141*** (3.538)	0.148*** (3.612)	0.148*** (3.615)	0.148*** (3.612)	0.148*** (3.645)	0.141*** (3.550)
Net-Imports		1.56E-05 (0.919)	1.50E-05 (1.005)	9.67E-06 (0.0596)	1.57E-05 (0.926)	1.57E-06 (0.926)	1.57E-05 (0.929)	1.13E-05 (0.699)
Patents		−0.004 (−1.170)	−0.005 (−1.368)	−0.004 (−1.153)	−0.004 (−1.126)	−0.005 (−1.150)	−0.004 (−1.194)	−0.005 (−1.338)
PRS		−0.072*** (−3.264)	−0.069*** (−3.184)	−0.072*** (−3.259)	−0.071*** (−3.247)	−0.069*** (−3.150)	−0.0725*** (−3.312)	−0.068*** (−3.120)
EPS		−0.002 (−0.515)	−0.002 (−0.614)	−0.002 (−0.529)	−0.003 (−0.519)	−0.002 (−0.548)	−0.001 (−0.344)	−0.002 (−0.581)
Dynamic beta								
Global return ∗ WTI oil return			−1.954*** (−3.110)					−1.943*** (3.099)
Global return ∗ Net-imports				0.002*** (4.411)				0.002*** (4.331)
Global return ∗ Patents					−0.090 (1.182)			−0.043 (−0.561)
Global return ∗ PRS						−0.429 (−1.260)		

Global return ∗ EPS							−0.121** (−2.343)	
Global return ∗ (PRS + EPS)								−0.047* (−1.591)
Cross-sections included	578	445	445	445	445	445	445	445
Total panel (unbalanced) observations	59305	39084	39084	39084	39084	39084	39084	39084
Adjusted R-squared	0.052	0.058	0.060	0.059	0.058	0.059	0.059	0.061

The dependent variable in this model is monthly firm return. This table displays models based on an unbalanced panel OLS regression in the reduced form $R_{it} = \alpha + (\theta_i + \gamma' X_{it})R_{mt} + \delta' Z_{it} + \vartheta_{it}$, in which $\theta_i = \theta$ for all firms, reflecting a global beta influenced by factors X_{it}. $\delta' Z_{it}$ reflects a vector of variables explaining firm return. R_{mt} is the global market return. ϑ_{it}, constitutes the error term. Column (1) displays the baseline single index model. Column (2) shows a multifactor model describing the effects of individual variables on firm return. Column (3)–Column (8) adds the interaction between the hypothesized variables and systematic risk. The interaction coefficients explain the effect on systematic risk in response to movements in these variables. Net-imports are the total imports relative to a country's energy use (negative if net-exporter of energy). Patent applications are measured per thousand inhabitants. PRS is the score on the Political Risk Index and EPS is the score on the Environmental Policy Stringency. (PRS + EPS) is the equally weighted score and only used if both scores are available. The model is robust to heteroscedasticity and contemporaneous correlation (PCSE). ***, **, * refer to statistical significance at a 1%, 5%, and 10% level, respectively. T-statistics are reported between brackets. Sources: Bloomberg, World Bank, WIPO, OECD, and PRS group

Table 6 Impact of significant variables on the systematic risk of renewable energy firms, 2005–2016

	−2s	−s		$\bar{x}$		+s	+2s
WTI oil return	−0.178	−0.088	−0.043	0.002	0.047	0.092	0.182
Impact on beta	0.346	0.170	0.084	−0.004	−0.09	−0.178	−0.352
Net-Imports (%)	−121.1	−50.1	−14.6	20.9	56.4	91.9	∗
Impact on beta	−0.242	−0.100	−0.029	0.042	0.113	0.184	∗
(PRS+EPS)	3.588	5.227	6.047	6.866	7.686	8.505	10.144
Impact on beta	−0.169	−0.246	−0.284	−0.333	−0.361	−0.420	−0.477

This table displays the impacts of the significant effects on systematic risk based on Column (8) of Table 5. $\bar{x}$ indicates the sample mean. s is the sample standard deviation. Illustratively, a one standard deviation decrease in oil prices has an impact on beta of 0.17. Net-imports are the total imports relative to a country's energy use (negative if net-exporter of energy). PRS is the score on the Political Risk Index and EPS is the score on the Environmental Policy Stringency. (PRS + EPS) is the equally weighted score and only used if both scores are available. Sources: Bloomberg, World Bank, WIPO, OECD, and PRS group. ∗ the maximum net-imports are 100 (%), due to skewness two standard deviations fall outside the maximum range

In Column (5), we find no evidence in favor of *H3*. There is no significant effect of a country's technological innovation on the systematic risk of RE firms. Investors do not reward RE firms with a perception of lower risk, because of a higher technological innovation in their main country of business. This finding opposes Verdolini's and Galeotti's (2011) argument that there are barriers to wide-scale deployment technological innovation.

In Column (6), we find no significant effect of PRS on systematic risk and therewith this rejects *H4.1*. This is contradictory to a negative relationship between PRS and return. This could imply that a country's political risk is not systematic in nature. This is in line with Bekaert et al. (2016) who state that for the global investor political risk is only systematic in rare cases.

In Column (7), we find evidence in support of *H4.2*. Environmental stringent policies reduce the systematic risk of RE firms. The constant value of beta increases to 1.40 relative to Columns (1)–(5). However, EPS has a negative and significant effect of −0.121 on systematic risk. This means RE firm return is less sensitive with respect to global market returns in cases of a relatively high EPS scores. This confirms Sadorsky's (2012) proposal that governments can reduce systematic risk by indirectly stimulating consumers to purchase RE, by taxing fossil fuel usage and by imposing carbon taxes.

The main interest is the combined effect of PRS and EPS. The results confirm *H4.3*: overall, environmental policy stability reduces systematic risk. Column (8) shows that a combination of a stable government and stringent policies reduce beta with 0.047 if the score increases with 1%. The impact of a standard deviation increase in environmental policy stability (PRS + EPS) is a 0.09 decrease of systematic risk. The coefficient on the isolated effect of EPS in Column (7) indicates a predominant effect of EPS over PRS. Even though the Columns make up different models, we assume a higher EPS impact, given the range of possible values for both variables and the significance of this variable. The results confirm a negative effect of political instability on environmental policy (Fredriksson and Svensson 2003). The effectiveness of environmental policies is indeed partly dependent on political risk.

The results in Table 6 do not indicate if the effects of the hypothesized variables are the results of country differences or an evolvement of the variables over time. However, country differences in the variables deviate more than the development of the variables over time within a country. Thus, results are likely due to cross-country differences. We use country dummies to isolate the country effects in a country's individual beta. The remaining interaction effects are the result of the time effect. Table 7 displays the result of this isolation method.

The effect of oil returns on systematic risk remains the same. In Column (1) (Table 7) the interaction coefficient is −1.84, and in Column (3) (Table 5) it is −1.95. This should not be surprising, because all country returns, irrespective of country, are dependent on the same oil returns. Interestingly, the coefficient of the interaction term Global return∗Net-imports becomes insignificant. If we capture the country-effect in the country dummy, there is no significant effect of net-imports on systematic risk anymore (Column 2). This means that there is no effect of changing net-imports over time and hence RE firms in countries with higher net imports have a higher systematic risk.

The interaction effect of technology and systematic risk remains insignificant (Column 3). Technological innovation does not reduce systematic risk and cross-country differences do not account for systematic risk differences. The interaction effect of PRS and systematic risk remains insignificant (4). This confirms Bekaert et al. (2016): for the global investor political risk is only systematic in rare cases. The interaction coefficient, Global return∗EPS becomes insignificant. Therefore, the evidence found in Table 6 is the result of cross-country EPS differences. This finding further supports *H4.2* and indicates that RE firms in countries with more stringent policies are less sensitive to global market returns and hence have a lower beta.

Lastly, Column 6 shows a negative, −0.267, coefficient on the interaction Global Return and (PRS + EPS). This coefficient tops the −0.047 found in Table 5, indicating that the sensitivity to global returns is lower in times of a high (PRS + EPS). Thus, the improvement of environmental policy stability over time reduces the systematic risk of RE firms. Also, the sensitivity to global returns is low in countries with a high (PRS + EPS) score. RE firms are inherently less risky in terms of beta in countries with high scores that further improve over time. This underlines that some country's policies are better facilitators for RE firms than others (Noothout et al. 2016).

Table 8 summarizes the results from Tables 5 and 7. It also shows the hypothesized direction and the actual direction of the effect of oil return and country level factors on systematic risk of RE firms. Hypothesis *H1*, *H2*, *H4.2*, and *H4.3* also hold when we remove countries with an overrepresentation or under representation in the sample (unshown results).

Table 7 Dynamic beta model of 578 renewable energy firms with country-dependent betas over the period 2005–2016

	H1 (1)	H2 (2)	H3 (3)	H4.1 (4)	H4.2 (5)	H4.3 (6)
Dynamic beta						
Global return ∗ WTI oil return	−1.842*** (−3.273)					−2.014*** (−3.015)
Global return ∗ Net-imports		0.002 (0.571)				0.005 (1.117)
Global return ∗ Patents			−0.221 (0.294)			−0.107 (−0.384)
Global return ∗ PRS				0.158 (0.192)		
Global return ∗ EPS					−0.193 (−1.463)	
Global return ∗ (PRS + EPS)						−0.267* (1.931)
Cross-sections included	578	542	545	571	448	445
Total panel (unbalanced) observations	59305	48118	55635	58057	44401	39084
Adjusted R-squared	0.058	0.057	0.055	0.057	0.054	0.059
Global return ∗ Country dummy	Yes	Yes	Yes	Yes	Yes	Yes

The dependent variable in this model is monthly firm return. This table displays models based on an unbalanced panel OLS regression in the reduced form $R_{it} = \alpha + (\theta_i + \gamma' X_{it})R_{mt} + \vartheta_{it}$, in which θ_i reflects a country-dependent beta that is influenced by factors X_{it}. R_{mt} is the global market return. ϑ_{it}, constitutes the error term. Column (1)-Column (6) show the interaction between the variables and systematic risk. Net-imports are the total imports relative to a country's energy use (negative if net-exporter of energy). Patent applications are measured per thousand inhabitants. PRS is the score on the Political Risk Index and EPS is the score on the Environmental Policy Stringency. (PRS + EPS) is the equally weighted score and only used if both scores are available. The model is robust to heteroscedasticity and contemporaneous correlation (PCSE). ***, **, * refer to statistical significance at a 1%, 5%, and 10% level, respectively. T-statistics are reported between brackets. Sources: Bloomberg, World Bank, WIPO, OECD, and PRS group

Table 8 A summary of the hypothesized influences on systematic risk and the main results in Tables 5 and 7

Variables	Hypothesis	Expected sign	Sign (pooled)	Significance (pooled)	Sign (country dummies)	Significance (country dummies)	Country effect
Global influence on systematic risk							
WTI oil return	H1	–	–	***	–	***	No
Local influence on systematic risk							
Imports	H2	–	+	***	+		Yes
Technology	H3	–	–		–		No
PRS	H4.1	–	–		+		No
EPS	H4.2	–	–	**	–		Yes
PRS+EPS	H4.3	–	–	*	–	*	Yes

Net-imports are the total imports relative to a country's energy use (negative if net-exporter of energy). Estimations are robust to heteroscedasticity and contemporaneous correlation (PCSE). ***, **, * refer to statistical significance at a 1%, 5%, and 10% level, respectively. Patent applications are measured per thousand inhabitants. PRS is the score on the Political Risk Index and EPS is the score on the Environmental Policy Stringency. (PRS + EPS) is the equally weighted score and only used if both scores are available. Sources: Bloomberg, World Bank, WIPO, OECD, and PRS group

5 Discussion and Conclusion

The hot topic of climate change in today's society boosts the demand for renewable energy (RE) in the coming years and ahead. However, the diversity within the sector, its innovative nature and the continuing developments ask for measures of systematic risk beyond current practices. This chapter puts forth a dynamic beta model that estimates this systematic risk with a combination of global- and country-specific macroeconomic factors. The main conclusion is that macroeconomic factors do influence systematic risk of the RE sector and should not be forgone in comparable firm analysis. From here, country-specific factors help to convert the risk of comparable RE firms abroad to the investment's country of interest.

First and in line with earlier research we can conclude that RE firm's beta deviate strongly from country to country, and from RE sub-industry to RE sub-industry. Second, this chapter finds that the global factor, oil-returns, is most dominant in explaining the systematic risk of RE firms. Increases in oil prices reduce the systematic risk of RE firms. Therefore, investors are willing to accept RE projects against a lower cost of capital if oil prices are expected to rise. Third, this chapter finds a small increasing effect of net-imports on systematic risk. In other words, countries that are net importers of energy increase the systematic risk of RE firms. Fourth, this chapter confirms the effectiveness of environmental stimulating policies. The combination of overall political stability and environmental policy stringency has a diminishing effect on beta. Especially, the latter is evident. So, governments can reward the RE sector with a lower risk assessment by creating market- and nonmarket-based environmental policies.

This chapter does not find an effect of a country's technological innovation on the systematic risk of RE firms. Therefore, we cannot shed further insights on technological innovation effects. In addition, this research cannot confirm the increasing effect of political risk on the beta of RE firms. Thus, the study joins the view that political risk is diversifiable.

The evidence opens up to several managerial implications. First, this research shows managers that RE projects do not have to be valued on an isolated basis. RE investments share common grounds of beta risk that can be quantified. Secondly, this research makes managers aware that betas from peer RE firms can differ as a result of country-dependent variables. Consequently, practitioners can decide to focus solely on peers from countries with the same energy trade balance and environmental policy stability.

However, there are limitations to this research that in turn open up to further research. The main limitation of this study relates to the short-lived nature of RE as an independent business. This study does not distinguish between firms that became a RE firm throughout the sample period and born RE firms. Furthermore, this chapter identifies RE firms based on BICS codes, which do not distinguish between firms with, e.g., 60% RE operations and, e.g., 100% RE operations. Herewith, this chapter cannot tell if its results are entirely attributable to the systematic risk of RE firms, or to a broader range of firms closely related with RE. From here, research could test the systematic risk of firms with varying RE activity. Furthermore, distinguishing between degrees of renewable activity potentially gives insights on the magnitude of, e.g., environmental policy on the systematic risk of firms with different degrees of RE activity. Donovan and Ñunez (2012) provide a method to find the "true" RE firm. They weight a RE firm by its intensity of activity in the RE sector (proxied by revenues from RE operations).

This study neglects the multinational natures of RE firms. We study the effect on the systematic risk from country to country. Firms are linked with country variables based on ISO codes that relate to the main country of business and do not represent the true exposure to country-specific variables in case of multinational operations. Others may want to study this.

Lastly, this chapter provides the first empirical evidence that environmental policy stability reduces the systematic risk of RE firms, so further research should focus on which policy instruments are a RE firm's best friend (Bürer and Wüstenhagen 2009). The environmental policy stringency index (EPS) gives an aggregate score, but it would be interesting to see whether investors discriminate between policy instruments when assessing a firm's risk.

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