Competitive advantage of German renewable energy firms in Russia - An empirical study based on Porter's diamond*

*Corinna Dögl, Dirk Holtbrügge***

This article analyzes the competitive advantage of German renewable energy firms in Russia. Based on Porter's diamond model of competitiveness, we examine the demand for renewable energy in Russia and German firms' ability to meet this demand. While the overall demand for renewable energy in Russia is still low, the study reveals formidable opportunities in the fields of biomass, solar and wind energy. Our findings are meant to address managers in the renewable energy industry and to aid policy makers in environmental support and action.

Dieser Artikel analysiert die Wettbewerbsvorteile deutscher Unternehmen im Bereich erneuerbarer Energien in Russland. Basierend auf Porter's Diamantansatz untersuchen wir die Nachfrage nach erneuerbaren Energien in Russland und die Fähigkeit deutscher Unternehmungen, diese zu bedienen. Während die Nachfrage nach erneuerbaren Energien in Russland insgesamt noch auf einem niedrigen Niveau ist, zeigt die Studie im Bereich Biomasse, Solar- und Windenergie beträchtliche Marktchancen auf. Die Ergebnisse der Studie haben zahlreiche Implikationen für Manager von Unternehmungen im Bereich erneuerbarer Energien und für politische Entscheidungsträger im Energie- und Umweltsektor.

Key words: Renewable energy, Russia, Porter's diamond

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Introduction

Russia's demand for renewable energy

In terms of power generation, Russia ranks fourth behind the US, China, and India, and has some of the largest reserves in natural gas and coal worldwide (European Bank of Reconstruction and Development (EBRD) 2005). Today, the energy mix in Russia is dominated by gas, which accounts for 54 percent of the total primary energy supply (TPES) and 43 percent of electricity generation (Merle-Béral 2006). Contrary to most other countries, Russia may be a country that actually benefits from global warming during the next years. Lower winter heating costs, a longer and more northerly agricultural growing season and increased tourism could have positive effects on local energy demand, while the global demand for oil will not fall significantly in the future (Stern 2008).

In contrast to many developed countries and emerging markets, Russia does not make large efforts to complement fossil funds by renewables. Currently, the use of renewable energy accounts for one only percent of the TPES. Oil and gas are comparably cheap and perceived as specific industries with special provisions by the Russian government. As a consequence, investments in renewable energies are much lower in Russia as compared to investments in other countries. On the other hand, Russia has very favorable conditions for wind power, solar energy, and biomass. Due to its size and variety of geographic features, Russia is said to be a renewable energy sleeping giant and does not have any lower renewable energy potential than China or the European Union (Grigor'ev/Chuprov 2008).

In almost all parts of Russia, there is at least one of three types of renewable energy sources that could be economically used now. These are wind power, solar energy, and biomass. Russia's forests cover more than 40 percent of the entire landmass and represent nearly one quarter of the forests worldwide. This means ample biomass energy resources are available, which have only been minimally exploited up until now (EU-Russia Technology Centre 2004). With its vast size, Russia receives a lot of solar radiation. The highest potential for solar energy can be found in the southwest of the country, e.g., in North Caucasus. Until now, however, the building of a solar power plant has been postponed (World Energy Council [WEC] 2007). In large parts of Russia, wind energy has great potential, which is realized only to a minimal degree. In 2007, the share of wind energy accounts for a mere 0.1 percent of renewable energies and only 0.001 percent of the total energy production in Russia. Up to 10 percent of the total electricity generation could be allocated through wind energy (Grigor'ev/Chuprov 2008).

Russia also has the opportunity to increase its use of renewable energies, which can be important in the Russian energy mix in the future (Merle-Béral 2006). Russians are slowly realizing the risks that environmental issues pose to

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economic growth and are becoming more ecologically conscious (O'Neill/Lawson 2007). Large parts of the country are contaminated by leaky pipelines or polluted by outdated power plants. Moreover, Russia ratified the Kyoto protocol in 2004 and thus, committed itself to reducing CO2 emissions. Thus, it is worthwhile to analyze the potential of biomass, solar, and wind energy in the country, and how it could be realized in the future. In particular, we will analyze which role German renewable energy firms could play in this context.

The renewable energy sector in Germany

In terms of a global transition from fossil fuels to renewable energy, German firms play a leading role as, Germany is one of the world's leading research hubs for environmental technologies. Moreover, German firms occupy excellent market positions in all fields of renewable energies, particularly in solar, wind, and biomass energies (Ernst/Young 2008). The strong market position provides German firms with the unique chance to supply the world market with its own green technologies and to create long-term competitive advantages (Petermann 2008) while ensuring climatic compatible growth in emerging markets.

In the past decade, the share of renewable electricity has more than doubled, and no other country has been able to grow renewable energy capacity as quickly as Germany (Wüstenhagen/Bilharz 2006). During this time, many German firms have advanced to be nationally and internationally competitive, providing key components in biomass, solar and wind facilities (Kohler 2008). A survey of 1,500 firms in the environmental industry confirmed that the renewable energy business is booming (Federal Ministry of Environment, Protection of Nature and Nuclear Safety 2007). This fast development has enabled Germany to obtain a leading market position in environmental technology. Lead markets link critical future challenges to technological innovations and are highly competitive (Mansfield 1968; Porter 1990). German firms in the renewable energy sector are characterized by high R&D expenditures and a large number of patents, which is the basis of their technological leadership (Umweltbundesamt [UBA] 2007). German firms develop high-quality technical solutions that gain worldwide acceptance (Kaiser 2007). Even now, German renewable energy technologies are being exported, and have achieved leading market positions in many other countries as well (Kohler 2008). It is expected that this leading role will also help them benefit from the growing demand in the emerging markets in Eastern Europe and Asia (Federal Ministry of Environment, Protection of Nature and Nuclear Safety 2007).

For determining whether German firms in the renewable energy sector have a competitive advantage in Russia in biomass, solar, and wind energy, Porter's Diamond (1990) will be elaborated upon as theoretical concept. This concept is argued to be an appropriate framework because it suggests that the national

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home market (Germany) plays an important role in shaping the extent to which it is likely to achieve advantages in other countries (Russia).

In the next section, Porter's model is described and adapted to the renewable energy industries. Afterwards, propositions for determining the competitive advantage of German firms in Russia will be derived. Then, the measures to empirically test the approach for the renewable energy industry will be explained. In the following section, the findings will be presented and discussed. Finally, we will summarize the main contributions of this study, discuss its limitations, and provide recommendations for further research.

Theoretical framework and research propositions

Competitive advantage and Porter's diamond model

During recent years, many researchers have discussed competitive advantages of nations, industries, and firms from various perspectives. In general, there are two conflicting perspectives on the determinants of competitive advantage. While researchers, such as Barney (1991) and Grant (1991) focus on resource-based explanations for competitive advantage, industrial economists such as Porter (1980) propose industry-based explanations. In this study, we focus on the competitive advantage of a specific industry and therefore, follow Porter's approach. According to Porter, competitive advantage in a given industry is a combination of the ability to innovate, to improve processes and products as well as to compete (Porter 1990:69). For determining national competitive advantage in different industries, Porter (1990) developed a conceptual framework which he labeled diamond that consists of four interrelated determinants:

Factor conditions represent a country's factor endowment and can be distinguished in basic factors and advanced factors. Natural resources, physical resources, unskilled labor as well as capital resources belong to the basic factors, whereas modern digital data communication infrastructure and highly educated personnel represent the advanced factors.

Demand conditions describe the nature of domestic demand for products or services in a certain industry. Three broad attributes are significant: the composition, the size and pattern of growth as well as the internationalization of domestic demand.

Related and supporting industries are industries, in which firms can share activities intersectorally in the value chain, e.g., technology development, suppliers, distribution, and marketing.

Firm strategy, structure and rivalry describe the conditions of a country that determine how firms are organized and run. In addition, goals (i.e. firm

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objectives, goals of individuals), domestic rivalry, and new business formation determine this factor.

Two exogenous factors – chance and government – may also impact competitive advantage. Chance includes events that cannot be influenced by firms, e.g., acts of pure inventions, major technological discontinuities, and surges of world or regional demand. Finally, the government can influence each of the four determinants in a positive or negative way.

Our adaption of Porter's framework to the renewable energy industry in Russia is based on suggestions and modifications from several previous studies (Cartwright 1993; Davies/Ellis 2000; Dunning 1993; Narula 1993; Rugman/D'Cruz 1993; Sledge 2005). First, we applied Cartwright's (1993:61) "simplified quantitative model based on interval scales with the aim of faithfully interpreting Porter's intentions." While Porter (1990) describes the diamond conditions in a narrative and qualitative way, this approach also allows for a quantitative analysis. Thus, influencing several subsequent empirical studies (Moon/Rugman/Verbeke 1998; Sledge 2005; Stone/Ranchhod 2006; Clarkson/Fink/Kraus 2007). Secondly, we excluded chance because this exogenous factor can barely be predicted (Porter 1990; Cartwright 1993) and replaced it with culture (O ´Shauhnessy 1996; Steger/Schindel/Krapf 2002). This is in line with Van den Bosch and Van Proijeen (1992), who criticize that the impact of national culture is given too little attention in Porter's model and suggest combining Porter's framework of competitive advantage with Hofstede's dimensions of national culture. They argue, for example, that uncertainty avoidance has a negative influence on the diffusion of new technologies. Based on these considerations our research model consists of four determining factors and two exogenous factors which have been intensively discussed in previous studies (Figure 1).

To analyze related and supporting industries as well as rivalry in the home market, we also included foreign multinational corporations as they have a decisive influence on the country's competitiveness. The exclusive focus on domesitc country characteristics would neglect the influence of multinational corporations on foreign markets (Dunning 1993). In particular, we do not only look at the Russian diamond of competitive advantage, but combine this with the German one. This construction of double diamonds (Cartwright 1993; Rugman/D'Cruz 1993) allows us to analyze the competitive position of German renewable energy firms in Russia.

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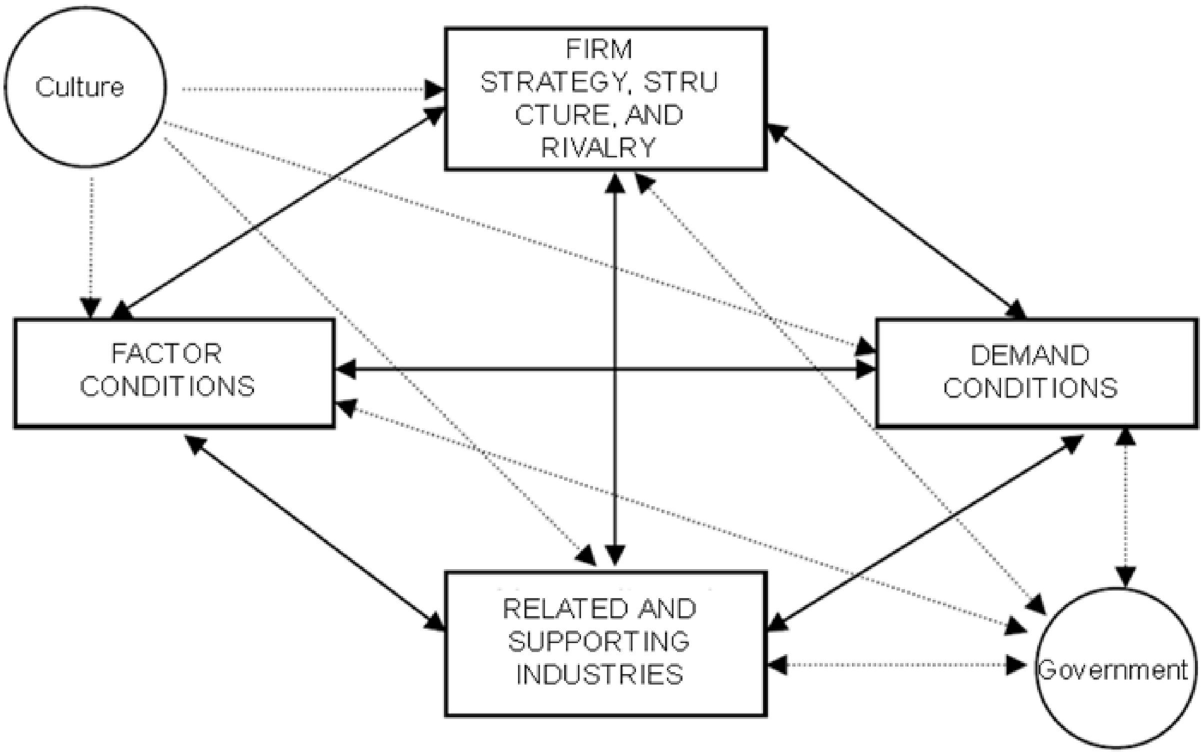
Figure 1. Porter's Diamond model



Source: modified from Porter (1990)

Propositions

Factor conditions, which are divided into basic factors and advanced factors, represent a country's factor endowment. Although competitive advantage can be generated by both, basic factors have a lower potential (Dunning 1993). For the renewable energy industry, natural resources such as biomass, wind, or solar irradiation can be considered to be basic factors (Vestergaard/Branstrup/Goddard 2004), while infrastructure as well as scientific and engineering institutions represent advanced factors. The stronger the advanced factors in an industry, the more competitive the firms in this industry are (Porter 1990). Without appropriate advanced factor conditions, firms would have to expend their own resources to provide such structures for commerce. For example, the quality of employees is crucial for the renewable energy industry because of its high-tech nature (especially solar resources and products vital for wind energy). The larger the pool of qualified employees in a country's manufacturing industry, the more qualified employees available for foreign firms as well. Foreign firms also hire local employees and benefit from their qualifications and skills. Thus, we assume that differences in factor conditions are a main source of competitive advantage, and propose:

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Proposition 1a: The larger the differences in factor conditions with regard to renewable energies between Germany and Russia, the higher the competitiveness of German firms in Russia.

Demand conditions describe the nature of domestic demand for products or services in an industry. The quality of domestic demand is more important than its quantity. Porter argues that demanding customers expect innovations and pressure firms to develop more sophisticated products or services. Therefore, domestic demand can be considered to be a primary source of competitiveness. This would mean that a high level of national demand for renewable energies drives firms in this industry to become innovative and internationally competitive. Based on those considerations, we assume that firms in the renewable energy sector that are highly innovative are also able to customize their products better to the conditions in other countries. Therefore, we propose:

Proposition 1b: The larger the differences in demand conditions with regard to renewable energies between Germany and Russia, the higher the competitiveness of German firms in Russia.

Related and supporting industries include firms that directly or indirectly affect a given industry. Porter (1990) argues that focal industry national success is likely if the country has a competitive advantage in related and supporting industries. The existence of successful related and supporting industries in the domestic market provides opportunities for communication and technical exchange. Additionally, focal industry international success can also generate demand for complementary products. For renewable energies, it can be argued that particularly high-tech industries are relevant. Spillover effects of these industries may enhance the innovativeness of technologies in the biomass, wind and solar industry and thus, the competitive advantage of firms operating in these sectors. Therefore, the following proposition can be deduced:

Proposition 1c: The larger the differences in related and supporting industries with regard to renewable energies between Germany and Russia, the higher the competitiveness of German firms in Russia.

The factor firm structure, strategy, and rivalry includes country conditions that influence domestic rivalry as well as how firms are organized and run (Porter 1990). The more firms that exist in a sector, the fiercer the competition and the stronger the pressure for innovative firm strategies and structures. Declining industries, on the other hand, are often characterized by a low degree of rivalry as well as less innovative firm strategies and structures. The same applies to industries that are dominated by monopolistic firms. We assume that this applies to the renewable energy industries as well, where innovativeness and the adaptation of new technologies are key sources of competitive advantage. On the basis of this argument, we can derive the following proposition:

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Proposition 1d: The larger the differences in firm strategy, structure, and rivalry with regard to renewable energies between Germany and Russia, the higher the competitiveness of German firms in Russia.

Porter (1990) argues that a large diamond represents high competitiveness and a small diamond represents low competitiveness. As the four determining factors influence each other, their relationship is better characterized by a multiplicative combination than by an additive combination. A country in which all four determining factors show a medium value is more competitive than a country where two values are high and two are low. Thus, we propose:

Proposition 2: The larger the diamond surface area of the German diamond compared to the respective Russian diamond, the higher the competitive advantage of German firms in Russia.

Methodology

Data collection

Previous research in the area of national competitiveness has often been survey-based (Papanastassou/Pearce 1999). While surveys have particular advantages, they are also often characterized by small sample sizes, subjectivity, and self-reporting bias. In attempt to avoid these disadvantages, this study is based on secondary data.

An extensive set of official and semi-official international sources (Worldbank, EU, Organization for Economic Co-operation and Development [OECD], International Energy Agency [IEA], United Environment Programme [UNEP] and Sustainable Energy Finance Initiative [SEFI], World Economic Forum) as well as publications of non-governmental organizations (such as the World Wind Energy Association [WWEA] and chambers of industry and commerce) have been screened. Moreover, we analyzed company reports and other internet resources. Because these sources provided all data that is needed for our study, the collection of primary data was not necessary.

Method

To determine German firms' competitive advantage in Russia, we calculated two separate diamonds and compared them in form of a double diamond as proposed by Dunning (1993) and Rugman and D'Cruz (1993). The four dimensions of the diamond were specified for the renewable energy industry and calculated with a simplified quantitative model based on interval scales (Cartwright 1993). Thereby, each variable was determined by a composite score of two causal variables, which were itemized by different proxy variables for the renewable energy industry. Table 1 lists all causal and proxy variables that we used to determine the competitive advantage of Germany and Russia.

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Table 1. Operationalization of Porter's diamond for the renewable energy industry

Determinants	Interval scale	Causal Variable	Proxy Variable
Factor Conditions	**(max. 20)**		
Basic	(1-10)	Natural Resources	Available potential of renewable energy resources
Advanced	(1-10)	Scientists, Infrastructure and Innovation	- Quality of math and science education - Renewable energy infrastructure - Patent applications filed under the PCT for renewable technologies
Demand Conditions	**(max. 20)**		
Market Volume	(1-10)	Market Size and Growth	- Currently installed capacity in MW - Market growth (% p.a.)
Sophistication	(1-10)	R&D Investments and Sophistication	- New investment by region (VC/PE) 2007 in million USD - Education index
Related and Supporting Industries	**(max. 20)**		
Related Companies	(1-10)	Related and Supporting Firms	Share of medium and high-tech value added in total manufacturing
Support	(1-10)	R&D Investments	Gross domestic expenditure on R&D
Firm Strategy, Structure and Rivalry	**(max. 20)**		
Rivalry	(1-10)	Competition in Domestic Product Market	Competition intensity
Structure/Strategy	(1-10)	M&A Innovative Drive	- Corporate M&A by country - Capacity of innovation
Government and Culture	**(max. 4)**		
Government	(-2-2)	Government Support	Financial support systems and environmental regulations
Culture	(-2-2)	Impact of National Culture	Hofstede: values for "masculinity" and "uncertainty avoidance"

For the purpose of constructing and interpreting the double diamonds with regard to the size of the axes and the surface area, we added the two causal variables market volume and structure/strategy from Porter's original study (1990), which were not included in the quantitative approach by Cartwright (1993). For the measurement of the proxy variables, we computed an interval scale with a minimum of zero and a maximum of ten. If a causal variable was

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determined by more than one proxy variable, the arithmetical average was calculated. This resulted in one score with values between zero and ten.

For government and culture, we adopted a three-point scale from Cartwright (1993). For example, an interventionist policy with a negative impact on the diamond was evaluated with -2, a policy that has no influence on the diamond with 0 and a government that facilitates the diamond process with +2. We summed up the scores of both factors and obtained scores between -4 and +4. Thereby, every score point represents 10 percent. Hence, a score of +4 extends the axes of the diamond to 140 percent of its initial value and a score of -4 reduces the axes to 60 percent.

Measures

Factor conditions. To determinate basic and advanced factors, we adopted measures used in several previous studies. Basic factors were measured by the amount of natural resources (Clarkson/Fink/Kraus 2007; Vestergaard et al. 2004) and advanced factors by the number of scientific and engineering institutions (Nair et al. 2007), infrastructure (Sledge 2005), and patent applications (Clarkson et al. 2007; Sledge 2005).

Natural resources are crucial for the renewable energy industry because without biomass, sun-light, or wind, renewable energy could not be generated. The natural resources could also be regarded as an influencing factor on the national level as they could be utilized by nearly all industries. In this case, the natural resources are input factors for generating renewable energy and, therefore, regarded as an industry level factor. To analyze natural renewable energy resources, their potential in Germany and Russia was examined and approximated in terms of megawatts with reference to the most recent predictions.

Scientific and engineering institutions are considered to be knowledge resources that increase the advanced factor endowments in knowledge-intensive industries, such as the renewable energy industry (Porter 1990). In our study we measured the scientific and engineering institutions with the index “Quality of Math and Science Education” taken from the Global Competitiveness Report 2007/2008 (Porter/Sala-i-Martin/Schwab 2007).

We measured infrastructure by using the Renewables Infrastructure Index, which is one element of the Ernst & Young Renewable Energy Country Attractiveness Index and offers specialized and current information for this industry (Ernst/Young 2008). Since only data for Germany are available, we used qualitative data for the Russian renewable energy infrastructure (Unep/Sefi 2008; Wookey 2008) and interpreted them in an analogous manner.

Beise and Cleff (2004:479) argue that “country-specific attributes that increase the international competitiveness of a locally adopted innovation are more

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important for the international success of a firm's innovation than other advantages a country can have as the first to market." The renewable energy industry is highly innovative and innovations are generally generated through R and D. Patents are an indicator for innovation and provide information about specific technological areas (Johnstone/Hascic/Popp 2008). In our study, we used the actual number of patents in each renewable energy technology as a measure for innovative strength. Therefore, initially, the relevant IPC codes for renewable energy technologies were established (OECD 2008a), and the latest available data (2005) of all relevant patents in biomass, solar, and wind energy were extracted from the OECD patent database (OECD 2008b). Before the linear transformation of the data into scores between zero and ten, we log-transformed the original quantitative data due to large gaps between the country values.

Demand conditions. We measured this factor by combining consumer sophistication as well as size and growth of domestic market demand (Sledge 2005; Moon/Rugman/Verbeke 1998; Brouthers/Brouthers 1997). The market volume of the home market is determined by the current market size and the future market growth for a technology.

However, market size has been used in recent studies with different methods of measurement. Nachum (1998), who investigates the Swedish engineering consulting industry, measures the size of domestic demand in terms of total annual investment in engineering consulting within a country, and Sledge (2005) uses the automotive competitor revenues within the home country as a percentage of the total global automotive industry. In this study, we used the total capacity in megawatts installed by the end of 2007 to determine market size. We also log-transformed this data before the linear transformation.

Market growth is as important as the absolute size of the market and indicates a future trend. A fast growing domestic market encourages firms in a country to adopt new technologies and leads them away from the belief that "such technologies would make existing investments redundant" (Porter 1990:94). We derived the data for this item from the alternative policy scenario of the World Energy Outlook 2006 for biomass and wind energy (2004–2015). In this report, values for Germany are not available, so we used the data published in a report by the German Federal Ministry of Environment, Protection of Nature and Nuclear Safety (2009) instead. For solar energy, values from the European Photovoltaic Industry Association (2008) "Global Market Outlook for Photovoltaics until 2012" were used. The market growth for solar energy was only determined from 2007 to 2012. For the solar energy market growth in Russia, quantitative data are not available, so qualitative data were used in its place (Gati 2008; Worldbank 2007).

To determinate sophistication of domestic demand, most recent studies use R&D investments (Boyle et al. 2008; Vestergaard et al. 2004) as well as sophisticated

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and demanding buyers (Moon et al. 1998; Sledge 2005) as proxy variables. We measured R&D investments in the renewable energy industry by using the venture capital and private equity (VC/PE) investments in 2007 for each technology. VC/PE investments describe "all money invested by venture capital and private equity funds as equity in the firms developing renewable energy technology" (Boyle et al. 2008). The relevant data was obtained by combining the VC/PE new investments in technology in 2007 and the VC/PE transactions by country in 2007 (Unep/Sefi 2008). For Russia, quantitative data for VC/PE investments were not found, instead we used qualitative data sources to describe renewable energy investments in Russia (Worldbank 2007).

Firms can also gain competitive advantage if domestic buyers are sophisticated and demanding with regard to products or services (Porter 1990). Moon et al. (1998) and Sledge (2005) propose that demand sophistication will increase with the level of education. Therefore, we used the education index of the United Nations Development Programme to measure this item (United Nations Development Programme 2008). This measurement is similar to Moon et al. (1998), who determine the consumer's sophistication for the automotive industry by using the percentage of the population with higher education degrees in the domestic market.

Related and supporting industries. Although the related and supporting industries can differ for each renewable energy technology, they all belong to the medium and high-tech industry. Examples for these are the high-tech companies Conergy and M+W Zander FE GmbH, which are suppliers for firms in the biomass, solar, and wind energy sectors as well (Conergy 2008; M+W Zander 2008). Based on these considerations, we measured the strength of related industries by the share of medium and high-tech value added in the country's total manufacturing (United Nation Industrial Development Organization [UNIDO] 2008).

The renewable energy industries and their related and supporting industries are considered to be very innovative. Therefore, we used gross domestic expenditure on R&D as a measure for the level of development of the supporting industry (Nachum 1998; Maxoulis/Charalampous/Kalogirou 2007). The data was extracted of the OECD Factbook 2008, which provides a global overview of the major economic, social, and environment indicators (OECD 2008c).

Firm structure, strategy and rivalry. This determinant is separated into two causal variables: rivalry as well as structure and strategy. We measured rivalry by the competition in the domestic product market. Structure and strategy were determined by corporate mergers and acquisitions (M&A) in a country and the capacity of innovation. To measure the competition in the domestic product market, we used a qualitative description similar to the method applied by Nair et al. (2007). Therefore, we examined the total turnover in a country, amount of firms, firm size, and the number of employees.

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We measured structure and strategy with the amount of M&A activities (Sledge 2005) and the innovation drive (Clarkson et al. 2007). Continuing M&A activities in the renewable energy industry represent a consolidation that tends to create tighter market conditions (Boyle et al. 2008). Additionally, backward vertical integration up to the level of component making can be expected across all renewable energy technologies (Haag/Hauff/Dringenberg 2007). We used corporate M&A volume by country, which is considered to be an appropriate proxy variable to represent firm strategy and structure (Sledge 2005). To determine M&A activity in the renewable energy industry, corporate M&A in 2007 by country was utilized. We obtained the data from the "Global Trends in Sustainable Energy Investment 2008" report of UNEP & SEFI (Boyle et al. 2008). For Russia, neither quantitative nor qualitative M&A data could be found. Therefore we assumed that considerable M&A activities did not take place in Russia. Another element of firm strategy and structure is the firm's innovative drive, which is extremely important for the renewable energy industry. We measured innovative drive with the capacity of innovation that describes how firms obtain technology (Clarkson et al. 2007). The data was derived from the Global Competitiveness Report 2007/2008 (Porter et al. 2007).

Government and culture. We measured government with governmental support for renewable energy technologies (Vestergaard et al. 2004). Government is a decisive factor for the renewable energy sector, because without governmental support, there would be no market for renewable energy technologies (Beise/Rennings 2005). The main governmental influence on the international competitiveness of renewable energy technologies lies in the financial support in the form of feed-in tariffs (Wüstenhagen/Bilharz 2006). By 2007, 37 countries had already adopted feed-in policies and more than half of these countries passed these policies in recent years (Renewable Energy Policy Network for the 21st Century [REN21] 2007). In addition to feed-in tariffs, many other important promotion policies exist. Further financial support instruments are direct investment support, soft loans and tax allowances (Grotz 2005). Another important factor is the stringency of environmental regulations, which represents a critical factor for comparative advantage (Porter/Van der Linde 1995; Costantini/Crespi 2008). In the short run, firms can also benefit from well-crafted environmental regulations that are stricter or are introduced earlier than those faced by their competitors in other countries. As a result, stringent environmental regulations stimulate innovation and enhance competitiveness (Porter/Van der Linde 1995). In this study, we examined all information about financial support systems for renewable energy technologies as well as environmental regulations with a qualitative measure used by Vestergaard et al. (2004), and calculated a score between -2 and +2.

To measure the impact of culture on the renewable energy industry, two of Hofstede's cultural dimensions – uncertainty avoidance and masculinity – were

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used. Concerning the latter, Kedia and Bhagat (1988) argue that masculine countries are generally more effective in new technologies than feminine countries and support this argument with the successful technological diffusion in the highly masculine countries Japan, Singapore, Hong Kong and Taiwan. Uncertainty avoidance has an important impact on the internationalization of domestic demand. The more uncertainty is avoided in a culture, the less it is open to foreign influences. Also, the openness to new ideas is strongly negatively correlated with uncertainty avoidance (Hofstede 2001; Van den Bosch/Van Prooijen 1992). Hofstede (2001) measured uncertainty avoidance on a scale between zero and 100, with zero representing low uncertainty avoidance and 100 representing high uncertainty avoidance. Masculinity was measured in a similar way. We calculated the arithmetical average of both items and linearly transformed it into a score between -2 and 2.

Findings and discussion

In the following, we report the main findings by comparing the diamonds of Germany and Russia for the renewable energy industry. We distinguish between biomass, wind and solar energy, and report the findings related to the individual dimensions of the diamond first. Afterwards, we analyze the diamond surface areas for the three technologies.

Diamond axes

Government and culture influence all other determinants in size and are therefore presented first.

Table 2 shows that both determinants have a positive impact on the renewable energy industry in Germany, especially for the solar and biomass industries. The influence on the wind industry is also positive, but the score is slightly lower. This can be explained by the fact that wind energy is already a relatively mature technology and the governmental support has been reduced during the last few years. In Russia, government and culture have a strongly negative impact on the renewable energy industry. First, there are no laws supporting renewable energies (Grigor'ev/Chuprov 2008) and only limited promotion policies have been put in place. Second, little attention has been paid to regenerative energy sources in terms of Russia's massive fossil fuel reserves (IEA 2007; WEC 2007). Similarly, culture has a more positive influence in Germany than it has in Russia. According to Hofstede's cultural dimensions, German culture is much more masculine, which means that the likelihood of adapting and implementing innovative renewable energy technologies is much higher than in Russia. For example, innovative technologies for energy saving and renewable energies are very common in Germany, but have yet to find large acceptance in Russia. Thus, it can be assumed that German renewable energy firms have considerable

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competitive advantage in Russia with regard to governmental support and culture.

Table 2. Descriptive results and differences

			biomass	solar	wind
Government and Culture	**Germany**	Government	2.0	2.0	2.0
		Culture	0.0	0.0	0.0
		Sum	2.0	2.0	2.0
	Russia	Government	-2.0	-2.0	-2.0
		Culture	-1.0	-1.0	-1.0
		Sum	-3.0	-3.0	-3.0
	Difference		**5.0**	**5.0**	**5.0**
Factor Conditions	**Germany**	Basic	3.6	3.6	7.2
		Advanced	9.2	9.2	9.2
		Sum	12.8	12.8	16.4
	Russia	Basic	3.5	3.5	7.0
		Advanced	3.3	3.3	3.0
		Sum	6.8	6.8	10.0
	Difference		**6.0**	**6.0**	**6.4**
Demand Conditions	**Germany**	Market Volume	10.8	8.4	7.2
		Sophistication	12.0	12.0	12.0
		Sum	22.8	20.4	19.2
	Russia	Market Volume	4.9	0.7	4.6
		Sophistication	3.9	3.9	3.9
		Sum	8.8	4.6	8.4
	Difference		**14.0**	**15.9**	**10.8**
Related and Supporting Industries	**Germany**	Related Companies	9.6	10.8	10.8
		Support	8.4	8.4	8.4
		Sum	18.0	19.2	19.2
	Russia	Related Companies	2.8	2.1	2.1
		Support	2.1	2.1	2.1
		Sum	4.9	4.2	4.2
	Difference		**13.1**	**15.0**	**15.0**
Firm Strategy, Structure and Rivalry	**Germany**	Strategy, Structure	11.4	11.4	11.4
		Rivalrly	10.8	12.0	10.8
		Sum	22.2	23.4	22.2
	Russia	Strategy, Structure	1.4	1.4	1.4
		Rivalrly	3.5	0.7	3.5
		Sum	4.9	2.1	4.9
	Difference		**17.3**	**21.3**	**17.3**

There are also significant differences between the two countries in terms of factor conditions. This is mainly a result of the excellent advanced factor

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conditions in Germany. The quality of math and science education as well as the renewable energy infrastructure is much more advanced than in Russia. Moreover, Russia is trails in terms of patent applications in this field. On the contrary, little differences exist in terms of basic factor conditions. While the conditions for biomass and solar energy are less favorable in both countries because of the relative small numbers of sun hours and the limited natural biomass resources that can be used for energy generation, the wind conditions are favorable. Thus, in accordance with proposition 1a, a high competitive advantage of German firms in Russia in this area can be assumed.

In terms of demand conditions, Germany stands apart in its level of R&D spending for renewable energy technologies (Unep/Sefi 2008). Demanding customers as well as high research and development expenditures are reasons as to why Germany reached a leading market position in the renewable energy industry worldwide. Demanding customer pressure firms to continuously innovate and improve their products. Compared to Germany, the scores for Russia are much lower. The differences are particularly large in terms of sophistication. Moreover, Russia has a very low solar energy score, which can be explained by both the lack of currently installed solar energy capacity as well as the absence of R&D expenditures for solar technology (Worldbank 2007; WEC 2007). In both countries, the market for renewable energy is growing rapidly. This trend is expected to continue in the coming years. The absolute level of demand, however, is much lower in Russia. In terms of proposition 1b, a comparative advantage of German firms with regard to this dimension can be assumed.

The related and supporting industries reveal large differences between Germany and Russia as well. Table 2 indicates that the values for Germany are significantly higher than those for Russia, thus supporting proposition 1c. The largest differences can be observed in the solar and wind energy sectors. The competitive advantage that may result from this favorable position of German firms is, however, reduced by high customs and local content requirements in Russia. Thus, German firms in the renewable energy sector can exploit their advantage only if companies in related and supporting industries also invest in Russia. If German firms had to rely on local suppliers, their competitive advantage in Russia would be considerably reduced.

The high scores for Germany with regard to firm strategy, structure, and rivalry can be explained by the long history in the use of renewable energy in the domestic market, the high level of competition in all sectors and the increasing consolidation processes taking place there (Haag et al. 2007; UBA 2007; Unep/Sefi 2008). In Russia, significant differences exist within the individual industries, i.e., the rivalry in the biomass and wind energy sectors is stronger than in the solar industry. For example, in the wind industry several local companies produce turbines. Apart from this, equipment from foreign

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companies (Vestas, Sulzon, or Siemens) is imported. Moreover, the installed turbines are often outdaten or bought second hand (Boyko/Matevosyan 2007). Relating to our proposition 1d, this implies a significant competitive advantage of German firms in Russia, which is greater for this dimension than for any other diamond dimension.

Diamond surface areas

After reporting the main findings for each of the six dimensions of the diamonds separately, we will now analyze the diamond surface areas for the three technologies. Porter suggests that a large diamond represents high competitiveness and a small diamond represents low competitiveness. The diamond surface area is calculated by summing up the individual areas of each quadrant's triangle as shown in table 3.

Our results reveal that Germany has significantly larger diamond surface areas for all technologies as compared to Russia. According to proposition 2, this means a high competitive advantage of German firms in all three renewable energy industries in Russia. The largest difference can be observed in the solar energy industry and the smallest difference in the biomass industry. The wind industry ranks between these two.

The comparison of the surface areas also indicates formidable differences within the two countries. In Germany, the wind energy diamond is larger than the biomass diamond by far, and in Russia, the biomass diamond and wind energy diamonds are both twice as large as the solar energy diamond.

Contributions, limitations and implications for further research

This study was aimed to examine whether German firms in the renewable energy industry have a competitive advantage in Russia and on which determinants this advantage is based. We used a modified version of Porter's diamond model and adapted this to the renewable energy industry. We then tested the model empirically in Germany and Russia on the basis of secondary data.

The results demonstrate that German firms have a significant competitive advantage in all three technologies. Figure 2 illustrates the significant competitive advantage of German firms in Russia as well as several industry differences with regard to biomass, solar, and wind energy.

For example, the wind energy diamond in Russia is significantly larger than the biomass and solar diamonds, and in Germany, the wind industry diamond is more symmetric than the other two diamonds. The positive governmental and cultural influences have been decisive for the favorable development of the renewable energy demand in Germany over many years.

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Table 3. Calculation of diamond surface areas

Biomass industry	**Germany**	**Russia**
A_{SD} = Firm Strategy, Structure & Rivalry × ½ × Demand Conditions	246	21
A_{RD} = Related & Supporting Industries × ½ ×Demand Conditions	200	21
A_{FR} = Related & Supporting Industries × ½ × Factor Conditions	115	17
A_{SF} = Firm Strategy, Structure & Rivalry × ½ × Factor Conditions	142	17
Area surface	**703**	**76**
Difference (Germany - Russia)	**591**	
Solar industry	**Germany**	**Russia**
A_{SD} = Firm Strategy, Structure & Rivalry × ½ ×Demand Conditions	239	5
A_{RD} = Related & Supporting Industries × ½ × Demand Conditions	196	10
A_{FR} = Related & Supporting Industries × ½ × Factor Conditions	123	14
A_{SF} = Firm Strategy, Structure & Rivalry × ½ × Factor Conditions	150	7
Area surface	**708**	**36**
Difference (Germany - Russia)	**671**	
Wind industry	**Germany**	**Russia**
A_{SD} = Firm Strategy, Structure & Rivalry × ½ × Demand Conditions	213	21
A_{RD} = Related & Supporting Industries × ½ × Demand Conditions	184	18
A_{FR} = Related & Supporting Industries × ½ × Factor Conditions	157	21
A_{SF} = Firm Strategy, Structure & Rivalry × ½ × Factor Conditions	182	25
Area surface	**736**	**85**
Difference (Germany - Russia)	**665**	

Moreover, German firms face strong rivalry and the suppliers as well as the related and supporting industries in this sector are well developed. Disadvantages occur merely in natural factor conditions, mainly in the low number of hours of sunshine. In Russia, on the other hand, the renewable energy industry has not yet been developed. Particularly, lacking governmental support and unfavorable cultural conditions limit its development. Moreover, the renewable energy industry in Russia suffers from significant disadvantages in terms of related and supporting industries as well as with regard to firm strategy, structure, and rivalry. Thus, an important policy implication for the Russian

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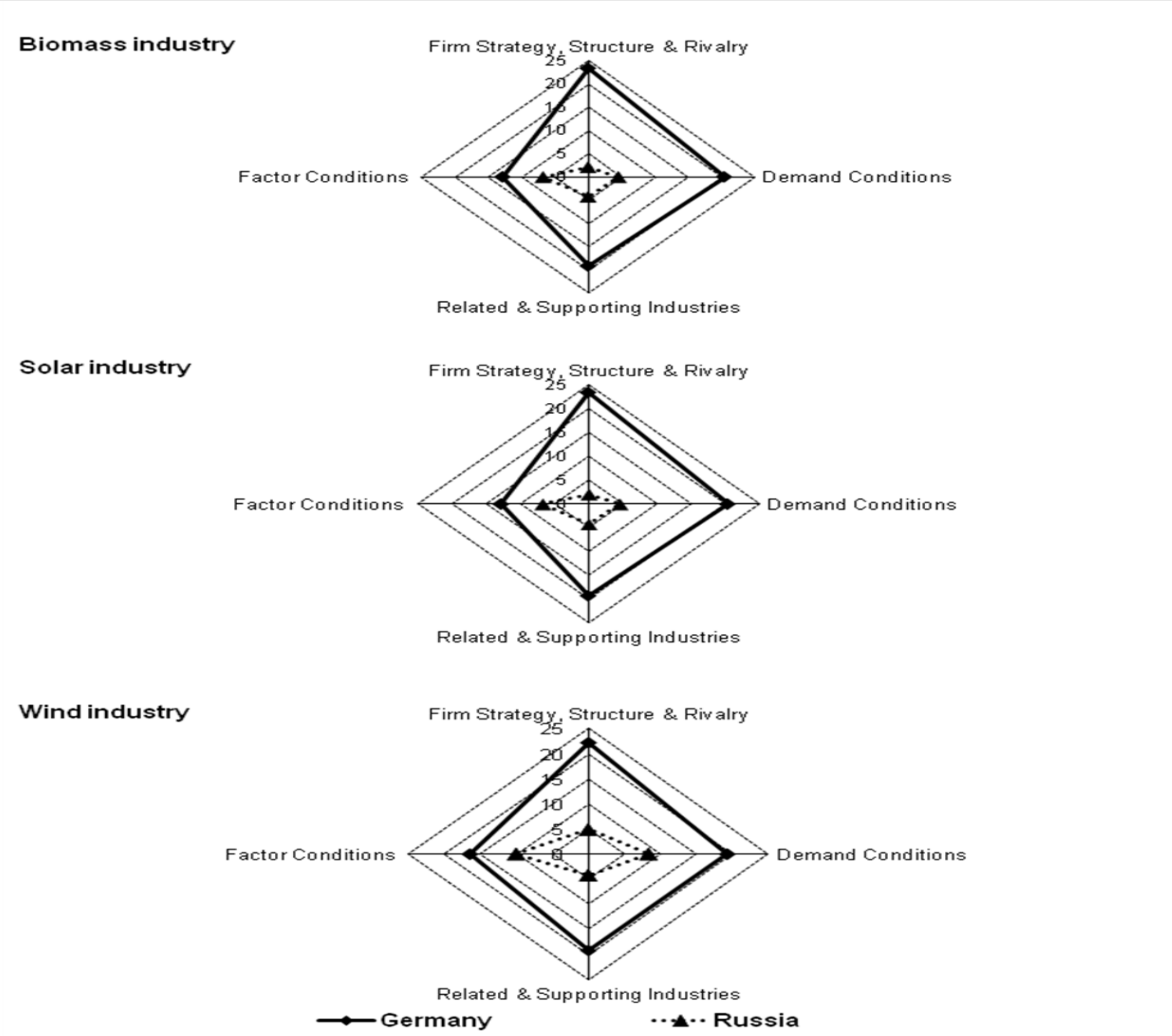
government would be to focus on this dimension of the diamond and to provide better conditions for Russian renewable energy firms. In particular, venture capital to strengthen their innovativeness and the promotion of cooperation with foreign partners may be appropriate. Moreover, governmental support would have a positive impact on the three other diamond dimensions as well.

Figure 2. Renewable energy diamonds for Germany and Russia



When interpreting these results, it has to be taken into account that this study only presents a snapshot of the current situation. Since the renewable energy industry is very dynamic, a replication of this study in some years might come to different results. For example, with the ratification of the Kyoto Protocol in 2004, Russia has committed itself to fulfill various energy targets. This might lead to considerable changes in Russia's renewable energy policy and thus, improve the competitiveness of this industry. Since the other five dimensions of the diamond are much less likely to change in the near future, however, the competitive advantage of German firms in Russia can be assumed to sustain for

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a long time. Thus, German firms are in a very favorable position when this renewable energy sleeping giant will awake.

As of now, the energy industry is part of the strategic sectors of the Russian economy and the Russian government does not allow 100 percent foreign ownership of power plants. Foreign firms in the energy sector are generally limited to ownership shares of less than 50 percent. For shares of 50 percent or more, foreign firms need the permission of the prime minister-led energy commission, as Russia is hesitant to give up control (Liuhto 2008). For the renewable energy industry, it might advantageous to lift this restriction, as Russian firms lack the knowledge and competence and express interest in Western, e.g. German, capital and knowledge in this industry. As German firms have a significant competitive advantage in this sector, Russian firms should cooperate with them in order to gain the relevant knowledge and to increase their competitiveness in the long run.

Some limitations result from the methodology of this study. Most of the secondary data was taken from official statistics, of which a few were not up to date. For the share of medium and high-tech value added in total manufacturing, for example, the most recent data available is from 2003. This applies particularly to variables that are not directly observable such as firm strategy or government policies. Although our measures may not be perfect reflections of these variables, we relied on those indicators, which have been used in previous studies most often. Moreover, we argue that our findings are robust to the use of alternative measures. For example, the results do not differ significantly when using the Ease of Doing Business Index (The World Bank Group 2009) instead of financial support systems an alternative measure of governmental policies. For several variables, no statistical data could be found, so that we had to rely on subjective perceptions.

As mentioned earlier, the diamond model of competitive advantage has not gone without criticism. For example, the role of government has been controversially debated. While according to Porter (1990:680), "government has an important role in influencing the 'diamond' but its role is ultimately a partial one. It only succeeds when working in tandem with the determinants," Stern (2008:412) argues that "government has an important role in directly funding skills and basic knowledge creation for science and technology," which is crucial for the renewable energy industry.

Therefore, further research should focus on the governmental influence on the development of renewable energy industries and analyze this factor in more detail. The cultural influence on the development of the renewable energy industry should also be analyzed further. Similarly, longitudinal studies reflecting the changes in the competitive position of German renewable energy firms in Russia over time would also be interesing. Finally, future studies should consider the impact of competitive advantage in quantitative terms such as FDI

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outflows, market shares, or profitability. Like most previous research, this study is based on the Porter's assumption that high scores for the six determinants of the diamond lead to competitive advantage without being able to statistically prove this relationship.

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