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How competitive is Sweden in the photovoltaic industry?

A comparison between Sweden and Germany

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Abstract

The renewable energy sector and its industry is becoming an important issue for meeting the electricity demand in the near future. Photovoltaic (solar energy) is one of the fastest growing markets within this renewable energy sector.

This thesis investigates Sweden's competitiveness in the photovoltaic industry.

Sweden's photovoltaic industry will be compared to the German PV industry, because Germany is one of the leading countries in this sector.

In this case study, Germany should be seen as a benchmark for Sweden. In order to analyse the competitiveness of Sweden and Germany in the photovoltaic industry, I will use the diamond model from Porter. This model includes factors, which are important to create competitive advantage in a particular industry.

This thesis should provide useful information for the government and companies within this sector about strengths and weaknesses in the photovoltaic industry in Sweden.

Key words: Competitive Advantage, Sweden, Germany, Photovoltaic, Industry

1 Introduction

1.1 Background Information

The transition from fossil fuels to renewable energy has become an important issue of the last years. On the one hand, energy demand was constantly rising over the last decades and therefore the world is in need of more energy production.

On the other hand, we should try to reduce CO₂ emissions to prevent global warming and therefore we need a transition to renewable energy sources instead of burning fossil fuels.

The global financial crisis had an enormous impact on the energy markets and lead also to a decrease in energy consumption. But as soon as the economy recovers, the energy demand will rise again. Many countries make use of the financial crisis by promoting clean energy with their stimulus packages.

The Scenario of the World Energy Outlook predict an energy demand increase by 1.5 % per year between 2007 and 2030 and fossil fuels will be the main energy source. The report predicts that fossil fuels will account for more than three-quarters of the overall energy in the next 20 years.

On the other hand, the report also pointed out that the use of modern renewable energy technologies (wind, solar, geothermal, tide and wave energy, and bio-energy) excluding hydro power will have the fastest increase of all energy sources.¹

The European Union set also the target to consume 20% of its energy from renewable energy by 2020 and the forecast shows that the member states are on track to meet this target.²

The RES report showed that macroeconomic effects of renewable energy development would have a positive impact on employment. There are already economic benefits from the renewable energy sector and goal-oriented and efficient renewable energy policies could increase this sector in the future.³

¹ Cf. http://www.worldenergyoutlook.org/docs/weo2009/WE02009_es_english.pdf

² Cf. Ragwitz et al., 2009, p. 1

³ Cf. Ragwitz et al., 2009, p. 195

As the renewable energy sector could be one of the economic driving forces in the near future, the competition in this market would increase. Therefore companies have to generate competitive advantages to assert themselves on the market. Good economic conditions and infrastructure of a country could support the companies to achieve market-leading positions on a global scale. Therefore the competitiveness of a nation would play an important role in this fast growing sector of industry.

1.2 Research problem

The European Union supports the sector of renewable energy sources (wind power, thermal power, photovoltaic, hydro-electric power, tidal power, geothermal energy and biomass) in order to become more independent from fossil fuels. The growth of the renewable energy sector should be the new economic driving force, which stimulates employment in Europe, creates new technologies, and improve the trade balance.

The European Union set ambitious targets for all Member States, which include that the EU will reach a 20% share of energy from renewable sources by 2020 and a 10% share of renewable energy specifically in the transport sector. Therefore national action plans are required in order to establish pathways for the development of renewable energy sources.⁴

Photovoltaic has a big potential within the renewable energy sector. The photovoltaic sector has the highest annual growth rate between 1997 and 2006 across the renewable energy sector. This sector grew on average by 56% over this nine-year period, from 0.04 TWh in 1997 to 2.2 TWh in 2006.⁵

Sweden wants also to make its contribution to achieve the Union's ambitious targets. This is why Sweden, like the other Member States, tries to reduce emissions, increase the efficiency of energy use and increase the proportion of renewable energy.

The Swedish Green Electricity certificate system is a market-based system, which supports expansion of production of electricity from renewable energy sources.

Electricity produced from the following sources is qualified for certificates: solar energy, geothermal energy, wind power, certain biofuels and certain hydro power.⁶

⁴ http://ec.europa.eu/energy/renewables/index_en.htm

⁵ Cf. Ragwitz, 2009, p. 30

⁶ Cf. Högberg, 2008, p. 36

According to the Swedish Energy Agency, the solar energy production is in the early stages of development, even compared to the other renewable energy sources.

However, there is a willingness to promote this sector in the near future.

Sweden should invest in the solar energy industry due to the fact that Sweden has a technology-based economy and the growth rate of this industry is very high compared to other renewable energy sectors.

These conditions can be seen as incentives for Sweden to improve and increase this sector of industry.

Germany's photovoltaic industry, for example, is leading at the international level and could be seen as best practise model.

1.3 Aim and scope

As mentioned before, Sweden would have the possibility to tap into the solar energy market.

For that reason, this master thesis will investigate Sweden's competitiveness in terms of the solar energy sector.

In order to analyse the competitiveness, I will use Porter's diamond model as theory to investigate Sweden's position. The diamond model will be also applied to Germany.

Which means that this thesis will include a comparison between Sweden and Germany regarding the competitiveness in the photovoltaic sector.

The photovoltaic industry includes manufacturers of solar cells and modules.

The theory about the competitive advantage of nations includes different factors that are influencing the competitiveness of nations in terms of particular industries. These factors are: firm strategy, structure, and rivalry, factor conditions, demand conditions, related and supporting industries, government, and chance.

This thesis will investigate in each of these factors (excluding chance) in order to get a detailed analysis. With such an analysis one can see the strengths and weaknesses of Sweden in different and important economic conditions in relation to Germany.

Sweden's competitiveness in the photovoltaic industry will be compared with Germany, because Germany is one of the leading countries in this industry. In the Renewables Global Status Report of 2009, Germany is one of the top five countries in terms of new

capacity investments and power capacity in the in renewable energy. Some years ago, they were even leading in wind power and solar PV sector.⁷

As Germany is a leading country in terms of R&D and production in the photovoltaic sector, it must be assumed that Sweden would have weaknesses in most of the factors regarding Porter's diamond model. On the other hand Sweden could also have strengths related to Germany. If Sweden is aware of their strengths, they could use it to compete with other nations on a global scale.

The thesis will investigate in the photovoltaic sector, because the full range of renewable energy sources (hydro, wind, solar, geothermal, tide and wave energy, and bio-energy) would exceed the limit of this master thesis and solar energy is one of the fastest growing renewable energy sources.

The analysis should show how big the differences are of each determinant of the diamond model between these two countries. As already mentioned before, Germany should be seen as a benchmark. The conclusion part will include a brief summary of each factor and focus especially on the biggest differences of these countries. Based on these differences, Sweden should maybe think to invest in these factors to improve their competitiveness.

1.4 Outline of the thesis

The first part of the thesis will include the theoretical framework. As mentioned before, Porter's diamond model will be the theoretical fundament. This part will include the determinants of national advantage (diamond model), which are factor conditions, demand conditions, related and supporting industries, firm strategy, structure, and rivalry, government, and chance. Before I will describe the diamond model, Porter's models to analyse the competitiveness on a firm level will be included. Besides, critiques about Porter's model will be also described in the theoretical part.

In part two, the diamond model will be applied to competitiveness between Sweden and Germany in terms of the photovoltaic sector. Strengths and weaknesses of each country can be illustrated based on this comparison.

Germany has been selected, because this country is one of the leading nations in terms of solar energy. As mentioned before, Germany is used as a benchmark in this thesis.

⁷ Cf. Burrett et al., 2009, p. 11

The last part of the master thesis will include the conclusion and recommendation for further investigations. This part will summarize the biggest differences between these countries and try to give a complete overview about the competitiveness of Sweden in the solar energy sector.

2 Theory

Porter explained in his book “The competitive advantage of nations” how to measure competitiveness of countries regarding to particular industry sectors.

In order to define how nations can support firms to act on a global-scale, one has to look how companies can create their competitive advantage.

Firms compete in international markets against each other and therefore the competitiveness of a nation as such cannot guarantee the companies success.⁸

Porter developed also models to analyse the competitiveness on a firm level. The competitive forces are one of his instruments to determine industry competition. These five forces are: 1) the threat of new entrants, 2) the threat of substitute products or services, 3 the bargaining power of suppliers 4) the bargaining power of buyers, and 5) the rivalry among the existing competitors.

He also stressed the importance of generic strategies, which supports the companies to achieve a stable position within the industry in terms of their core competence.

The structure of the industry plays a crucial role in international competition, because structural change opens new possibilities for competitors to switch to new industries. Based on the competitive five forces, companies can take these opportunities into account. The environment of a nation can support and path the way for companies if such structural changes occur.⁹

The competitive strategies that are mentioned before can be applied to every company. It does not matter whether the company is competing domestically or internationally. According to the competitive advantages of nations, Porter focus on companies that are acting on an international level. Therefore the companies have to develop an

⁸ Cf. Porter, 1990, p. 33

⁹ Cf. Porter, 1990, p. 35-39

international strategy and the competitiveness of a nation could reinforce their advantages.¹⁰

Different industries are in need of different strategies in order to gain competitive advantages on an international level, because the industry structure is different. Referring to the competitiveness of a country, the country will succeed if their national circumstances provide an innovation friendly environment. Which means that companies are pushed to find better ways of competing and improving their firm's products and processes.¹¹

The penetration of a market differs widely between industries and even industry segments. That's why companies should create competitive advantages that are adapted to their industry. To analyse the competitive advantage of an industry, one should not only focus on cost differences, such as economies of scale, because the key to success is different between the sectors of industry.

The home base of a firm play an important part in international success, because the strategy is defined, core product is developed and process development takes place. Even if some parts of the value chain are performed outside their home country.¹²

Therefore the home base is the starting point for a global strategy in the industry. In this process the nation can create a supporting environment for companies to compete internationally.

The diamond model includes factors, which are important for a supporting environment in order to measure the competitiveness of an industry.¹³

According to the photovoltaic industry, related and supporting industries as well as advanced factor conditions such as education are most important to create competitive advantage.

¹⁰ Cf. Porter, 1990, p. 53

¹¹ Cf. Porter, 1990, p. 67-68

¹² Cf. Porter, 1990, p. 69

¹³ Cf. Porter, 1990, p. 70-71

The photovoltaic industry consists of PV module manufacturers and solar cell producers. These two types of manufacturers are related to high-tech industry and are dependent on a widely spread supplying industry.

The supplying industry is also related to the medium and high-tech sector and therefore has to be innovative to compete against their rivals.

An efficient network and joint development between these two sectors is an important way to create competitive advantage.

Such a type of industry is also in need of highly skilled personnel to create product and process innovations.

These factors are included in Porter's diamond model and will be described in more detail in the following chapters.

Industry or industry segments of a nation have an advantage to achieve success, if the national diamond is stronger than in another country.

The determinants in Porter's diamond model are affecting each other. That's why this model has to be seen as a system.

Nation's can reach competitive advantages in a sector, even if they have not achieved advantage in every determinant, because the interplay of advantage in other determinants can reinforce the competitiveness of the whole "diamond".¹⁴

In Germany, for example, the photovoltaic industry is supported by the interplay of supplying industries and excellent education in the field of engineering and government subsidies.

The solar electricity potential is lower in Germany compared to many other countries in Southern Europe such as Spain and Italy.¹⁵

However, this interplay of factors in Germany led to a fast growing home demand and Germany had the most installed PV capacity in the world in 2006.¹⁶

¹⁴ Cf. Porter, 1990, p. 73

¹⁵ <http://re.jrc.ec.europa.eu/pvgis/apps3/pvest.php#>

¹⁶ Cf. Hoehner, 2007, p. 12

Porter's diamond model consists of following four determinants:

- Factor conditions
- Demand conditions
- Related and supporting industries
- Firm strategy, structure, and rivalry

In this theory part I will describe each determinant in order to get a better understanding of Porter's diamond model. Porter extended his theory with two other factors, which are influencing the four determinants. These two factors are:

- The role of government
- The role of chance

After explaining the four determinants mentioned before, I will also take a look at these two factors. Especially the role of government is an important factor for the competitive advantages of a nation.

2.1 Factor conditions

In Economic History many scholars used the expression "factors of production" which includes factors such as labour, arable land, capital, natural resources, and infrastructure. Some of these famous scholars are Robert M. Solow and Paul M. Romer. Solow (1956) developed the neo-classical growth model, which is using labour, capital, and technological change as variables to explain economic growth. Romer (1986; 1990) developed alternatives to Solow's model in which research and development are factors of technological change.

Porter adopts parts of these theories to explain the determinant "factor condition" in his diamond model.

According to arable land and natural resources, these factors are of less importance in advanced industries in Porter's view, because these factors can be created within a nation and are not a feature of the landscape. The actual availability and amount of

resources are less important than the development of these factors, respectively the upgrading and specializing to a particular industry.

However, given factors such as natural resources and geography is taken into account as one can see in the following description.¹⁷

As mentioned before “factors of production” are explained in too broad terms, Porter grouped these factors into:

- Human resources
- Physical resources
- Knowledge resources
- Capital resources
- Infrastructure

Human resources can be divided into skills, and cost of employees and quantity.

Physical resources involve quality, accessibility, and cost of the nation’s land, water, and other physical traits. Besides, climatic conditions, location geographic size can be seen as part of physical resources.

The nation’s pool of scientific, technical, and market knowledge have effects on goods and services and can be summarized as knowledge resources. The availability of knowledge is depended on universities, government research institutes, government statistical agencies, and private research facilities.

Capital resources describe the amount of funds that are available to finance industry, such as bonds, debts, equity, and venture capital.

Cost and quality of transportation system and communication system are parts of the infrastructure. Furthermore, health care, cultural institutions and housing stock can be

¹⁷ Cf. Porter, 1990, p. 74

included to the infrastructure, because they have effect on the quality of life. Therefore they are responsible for the attractiveness of a country as a place to live and work.¹⁸

Nations should use these factors in an efficient and effective way in order to achieve competitive advantage. Today, many developed countries are comparable in terms of factor conditions, because they have similar infrastructure and education systems. Therefore the availability of skilled workers from universities and other education institutes are identical.

However, an increase in labour mobility could have negative effects on this factor availability of a nation regardless of whether in the unskilled, semiskilled or high-skilled sector.¹⁹

As Porter saw differences within the factor conditions, he implemented a hierarchy among these factors.

Climate, location, unskilled and semiskilled labour and natural resources can be seen as basic factors.

Whereas, highly educated employees such as graduate engineers and computer scientists, and university research institutes and modern data communication infrastructure are parts of the advanced factors.

Sustained investments in physical and human capital are important to develop advanced factors in order to achieve significant competitive advantage.

A nation needs sophisticated human resources and technology to create truly advanced factors.

Many companies face the difficulty to provide themselves with advanced factors or to attain them from abroad via subsidiaries.²⁰

Yetton (1992) pointed out that Porter described advanced factors (engineers, research centres, digital data equipment) as most important to competitive advantage. On the other side, basic factors (climate, natural resources, location) are neglected by their limited necessity or widening availability or ready access on international markets.

¹⁸ Cf. Porter, 1990, p. 74-75

¹⁹ Cf. Porter, 1990, p. 76

²⁰ Cf. Porter, 1990, p. 77

Porter assumes in his conclusion that resource-based industries are in the same category as low technology or low skill industries, because both are depended on basic factors. Porter also pointed out that the rate of return on basic factors is relatively low, irrespective of their location. Furthermore he argued that competitive advantage in such industries is also unsustainable, because global competitors can easily gain some of the basic factors from somewhere else.

However, the classification of resource-based industries with those characterised by low technology and skills show scant evidence in some cases. In Australia, for example, mineral prospecting and extractive techniques are often highly specialised and therefore are in need of advanced technologies.

Furthermore, returns on these natural resources are not uniformly low. Porter also ignored the fact that returns to shareholders in terms of exports lead to wealth creation. Resource-based industries have been successful over long time periods in Australia. Products of companies, which can be classified as commodities may show minimal rate of return. However, industries with differentiated source products in terms of quality or suitability for specific applications have usually success and gain high returns. For example, firing technologies become more sophisticated over time and require specific and reliable performance. Coal is no longer a commodity, but it is a differentiated product, for which all grades don't have ready substitutes.²¹

Moon (1998) argued that Porter's view on multinational activities led to an underestimation of the potential of Singapore's economy in terms of basic factor conditions. Porter pointed out that most of the foreign multinationals are attracted by Singapore's relatively low-cost, and well-educated work force. Furthermore, multinational companies are located in Singapore, because of the efficient infrastructure including roads, airports, ports, and telecommunications.

Porter argued that Singapore's primary advantage are basic factors such as unskilled and semi-skilled labour and location, which are not very important regarding national competitive advantage.

However, Singapore has been the most successful economy within the newly industrialized countries. This success is mainly due to the fact that lot of investments have taken place, both inbound foreign direct investments by foreign multinational

²¹ Cf. Yetton et al., 1992, p. 113

companies in Singapore and outbound foreign direct investments by Singapore firms in foreign countries.

Investments from foreign companies bring capital and technology, whereas outbound investments support Singapore to achieve access to cheap labour and natural resources. The sustainable competitive advantage of many Singapore industries was enabled by the combination of domestic and international diamond determinants.²²

Moon (1998) also pointed out that Porter draw incorrect conclusions of the Korean economy, because Porter asserted that Korea's competitive advantage has primarily been based on basic factor conditions, but its future will depend on demand conditions, related and supporting industries, and domestic rivalry. He pointed out the importance of three determinants of his diamond model, but neglected the factor conditions. However, Moon's analysis about Korea's competitiveness showed that the future of Korean economy depends more on factor conditions than any other determinant.²³

Porter (1990) also distinguished between generalized and specialized factors. Generalized factors are described as stock of well-motivated employees with college education.

These factors can be used in a wide range of industry.

On the other hand, specialized factors include skilled employees, who have knowledge in particular fields and infrastructure with specific characteristics.

These factors are mostly limited to certain industry sectors.

In order to create competitive advantages, nations should rather focus on specialized factors than on generalized factors. Because of the fact that generalized factors are available in most countries.²⁴

The firms are in need of specialized factors when it comes to complex activities within the company and they should be available to generate competitive advantage.

Specialized factors have also a strong connection to innovation, which creates new products and processes that can be more competitive on the market.

²² Moon et al., 1998, p. 139

²³ Cf. Moon et al., 1998, p. 147

²⁴ Cf. Porter, 1990, p. 78

Specialized factors can be use more effectively in domestic market, because of the proximity to the resources. Foreign companies could face problems if they want to access specialized factors.

Besides, these factors are constantly increasing, which means that today's specialized factors could become generalized factors in the near future.²⁵

Nations can use mechanism to create specialized factors, which implicate apprenticeship programs, public and private educational institutions, and government and private research institutes.²⁶

In the photovoltaic industry, advanced and specialized factors are important to create competitive advantage, because this industry is related to the high-tech sector.

2.2 Demand conditions

This determinate is related to the need and behaviour of the consumers within a nation. Industry segments can achieve competitive advantage, if companies within this sector get a faster and more precise picture of customer needs than foreign companies in their market.

Costumers should push firms to innovate faster, because then home-based firms can create competitive advantages against their competitors from abroad.

The ability for companies to identify costumer's needs is heavily depended on the home market. Firms have a better understanding of their home market to innovative and improve products and services, because proximity and cultural aspects lead to a clearer communication.²⁷

Industry segments differ in terms of the market size, because some sectors act more global than others.

A nation's firm can reach competitive advantages more easily on a global scale, if the sector grab high market shares in the home market, whereas the market share in other nations is comparatively small.

²⁵ Cf. Porter, 1990, p. 79

²⁶ Cf. Porter, 1990, p. 80

²⁷ Cf. Porter, 1990, p. 86

The size of the segment could be important to gain national advantage by the use of economics of scale or learning curve effects. If a sector of industry has the biggest market share compared to the other sectors, it could take the most advantage of economies of scale in order to be competitive on a global-scale.

On the other hand, firms that compete globally are usually not in the need of a high home market share, because they can reach a big market on the global-scale even if their home market is still small.

For example, Swiss companies took a leading position in equipment and services for tunnelling, even if their home market is relatively small compared to other nations.

According to the photovoltaic sector, the size of the home market should be seen as quite important, because it facilitates new companies, supporting industries, and government to invest in this sector.

The leading export countries in the photovoltaic sector such as Germany, USA, and Japan have also a large home market.

Small sectors of industry could also be seen as less attractive for a nation to invest in, because they are not profitable compared to others. New or developing sectors usually face this problem. These sectors are also engaged in research to develop their products so that they can spend less time on manufacturing, product design, and marketing resources.²⁸

The photovoltaic industry is still in the early stages of development compared to other energy technologies, but it is also one of the world's fastest growing energy technologies.²⁹

Branches of industry could benefit from a broad range of related segments to gain competitive advantage. Especially, highly engineered products and services can gain experience from related sectors in order to facilitate entering foreign markets.

The U.S. air-conditioning equipment industry has many segments, because of differences in climate, building, and end-user behaviour. Based on the broad range of segments within this industry, U.S. companies create competitive advantage in foreign markets,

²⁸ Cf. Porter, 1990, p. 87

²⁹ Cf. Ragwitz, 2009, p. 30

because they had already experience with different climate and buildings somewhere in the United States.³⁰

2.2.1 Sophisticated and demanding buyers

Companies within a nation achieve competitive advantage if their domestic costumers are leading in terms of demand and sophistication compared to all other nations. Firms can use the cultural and physical proximity to identify their costumer's needs.

Firms are able to integrate their sophisticated costumers in the development process in order to support product and process innovations.

If companies are in the business-to-business market, they have the advantage to create joint development work compared to the foreign companies.³¹

High standards of product quality, features, and service will be demanded from the sophisticated costumers, which lead to competitive advantages in products and processes.

Climate, geography, taxation, social norms, and natural resource availability can lead to unusual needs of the buyers in a country and therefore are different to the costumers' requirements of other nations.³²

Also factor conditions can influence the demand of an industry in terms of timing. Climate conditions, dependence on imported energy and support from the government pushed Denmark to invest in renewable energy sources. Because of the demand for renewable energy, Denmark was one of the pioneer nations in wind power. For that reason Danish companies are leading in producing and exporting windmills on a global-scale.³³

According to demand conditions, Yetton (1992) pointed out that Porter had some weaknesses in his methodology, because many categorisations are subjective and descriptive. Strong domestic demand, for example, does not imply demand in other nations. Besides, Porter do not provide clear or articulated measures for strength of

³⁰ Cf. Porter, 1990, p. 88

³¹ Cf. Porter, 1990, p. 89

³² Cf. Porter, 1990, p. 90

³³ Cf. Porter, 1990, p. 92

factors of a diamond, which make it harder for somebody to estimate if demand conditions are strong, medium or weak.

There is also no sort of uniform indicators of “sophisticated demand” in order to explain why New Zealand farmers are more sophisticated than German. The rank of sophistication of farmers in other countries (Switzerland and Australia) is also never explained.³⁴

2.2.2 Demand size and pattern of growth

The size and pattern of growth of home demand can increase competitive advantage in an industry, if their buyers are sophisticated and acting on an international level. However, there are different opinions of the importance of the size of the home market. Many economists argue that there is causality between size and competitiveness, but the reasoning and direction of causality is quite different.

Some authors pointed out that economies of scale are very important for competitive advantage and therefore the home market should be large. Other economists hold the opinion that a small home market pressures the companies to export their goods and services and because of that they are in need of competitive advantage to have international success.³⁵

Economies of scale and education could push firms within a segment to invest more in the development of technology, and improvements of productivity. These investments would contribute to competitive advantages.

The size of the home market may be not important in every industry.

However, in certain segments of industries, such as industries with heavy share of R&D, general leaps of technology, and large-scale production should have a high size of home market. As mentioned before, the proximity of large home demand facilitates the decision-making process of investments and this lead to competitive advantages.

Particular industries may not create demand in other nations, which means that the competitive advantage of a nation in this industry is irrelevant.³⁶

³⁴ Cf. Yetton et al., 1992, p. 101

³⁵ Cf. Porter, 1990, p. 92

³⁶ Cf. Porter, 1990, p. 93

As mentioned already earlier, the photovoltaic industry is related to the high-tech sector and therefore is an industry with a heavy share of R&D and also large-scale production. That's why the size of the home market is one important factor in this sector of industry.

In order to create an innovation-friendly environment within an industry, the range of buyers should be broad. If only one or two customers share the home market, there would be less incentive for competition. Whereas a certain number of consumers have to compete against each other and therefore find new ways of developing their products and services. This would lead also to new market information, which supports the ideas about new product and service innovations.

Yetton (1992) pointed out that in Porter's view the size of the domestic market is not always important for competitive advantage. Porter argued that size has not been a problem for Switzerland to gain advantage on a global-scale in some industries. However, Yetton (1992) criticised that Switzerland borders on densely and largely populated nations of similar living standards. These circumstances do not lead to an appropriate comparison.

New Zealand has an extremely small, and isolated economy. In this case, Porter argued that this size is a constraint that can be overcome by international trade, because New Zealand could not only depend on the domestic base to increase its standard of living. A successful product would quickly saturate the small size of the local market and firms are in need to expand into international markets. He has also argued that using determinants of another nation's diamond, such as demand, cannot be a long-term strategy to create national competitive advantage. However, in Zealand's case he has no explanation why or how companies should bring their global headquarters back home, when the home country is such a small, and isolated market.³⁷

2.2.3 Rate of Growth of Home Demand

The rate of growth of home demand can also play an important role in terms of competitive advantage. Based on the rate of investment, one can see how rapidly the home market is growing relative to its size. Companies are willing to adopt new technologies earlier, if there is a rapid domestic growth within this industry, because

³⁷ Cf. Yetton et al., 1992, p. 105

firms feel confident about the rate of return on their investments. Therefore they invest in large and efficient facilities, because they know that they will make full use out of it.

During periods of technological change, the rate of growth of home demand is of primary importance. Companies need the support of the nation to invest in new products and facilities.³⁸

If people demanding earlier for particular products and services within a country, local firms would become sooner established in this industry than their foreign competitors. Profound knowledge and longer experience are reasons why local firms would take advantage.

Product variety plays also an important role in this context. Firms will focus on segments where the growth rate could be high, because of signals from the demand side. Therefore investments are directed to this sector, which lead to competitive advantage.³⁹

Another aspect of competitive advantage could be early saturation. While early demand supports companies to penetrate the market, early saturation would pressure the firms to more product and process innovations. Cost cutting, improved products and services, and new features are the consequences of a saturated home market, because costumers have more options to choose from.

A combination of saturated home market and rising demand in foreign markets would reinforce the nation's firm success.⁴⁰

2.2.4 The interplay of demand conditions

All home demand conditions influencing each other and each of them support nation's firms at various stages of industry levels.

Domestic demand should especially increase investments and innovations in the sectors of industry. Furthermore, it should support sophisticated industries with advanced technology.

³⁸ Cf. Porter, 1990, p. 94

³⁹ Cf. Porter, 1990, p. 95

⁴⁰ Cf. Porter, 1990, p. 96

This determinant also correlates with other determinants of the “diamond model”. For example, growth in domestic demand and large home market is in need of competition between the local firms, because otherwise there would be no incentive for innovation. These circumstances would prevent companies to take advantages on global markets.⁴¹

2.3 Related and supporting industries

The third determinant of national advantage contains the supplier industries and related industries, which should be competitive at an international level. In Japan, for example, the tool production industry is highly successful on a global-scale, because they have one of the best suppliers of motors, and other building components. Swedish companies have competitive advantage in the fabricated steel industry, such as cutting tools and ball bearings. One reason for this dominating position is the more sophisticated local supply industry in specialty steels.

Supplier industries that are competitive on a global-scale can transfer their advantage to many other industries. Which means that these sectors of industry have the possibility to compete internationally, because the suppliers can support them in terms of quality and other features.

Semiconductors are a good example for providing many other industries.⁴²

2.3.1 Supplier Industries

As mentioned before, supplier industries facilitate advantages in downstream industries, because they support them with access to high quality products and cost-saving inputs.⁴³

More significant than access to machinery or other inputs is the advantage that home-based suppliers provide in terms of ongoing coordination. I described in the previous chapter how linkages between the value chains of firms and their suppliers are important to competitive advantage.

⁴¹ Cf. Porter, 1990, p. 99

⁴² Cf. Porter, 1990, p. 100

⁴³ Cf. Porter, 1990, p. 101

However, the availability to inputs of the supplying industry such as machinery is not the most important advantage of having a world-class domestic supplier industry.

The access to machinery, components, and other inputs has becoming much easier on global markets through globalization.

Effective and efficient use of inputs of supplier industries is of prime importance to create competitive advantages.

The cooperation of suppliers with their business partner in terms of the value chain is more relevant than the access to machinery and components.⁴⁴

The value chain consists of primary activities, which are inbound logistics, operations (manufacturing), outbound logistics, marketing and sales, and after-sale services. On the other hand, there are also support activities that include firm infrastructure, human resource management, technology development, and procurement.

In order to reach competitive advantage, firms have to be more efficient in most parts of the value chain than their competitors.⁴⁵

The process of innovation and improvement is probably the most beneficial part to acquire from home-based suppliers. Firms, which have a good and close relationship with their domestic suppliers, have more and better opportunities to achieve competitive advantage. New ideas, insights to supplier innovations, useful information access are one of these opportunities.

Good relationships can also lead to joint development work and know-how about important issues. The output of these cooperation's are mostly customized solutions.

Another advantage of the exchange of R&D is reduction of development time.

The whole sector of an industry is usually benefiting from a world-class supplier, because these companies tend to share information with many business partners.⁴⁶

Porter (1990) mentioned that world-class suppliers have subsidiaries in many other countries, but they should have the R&D department and other important facilities in

⁴⁴ Cf. Porter, 1990, p. 103

⁴⁵ Cf. Porter, 1990, p. 40

⁴⁶ Cf. Porter, 1990, p. 103

their home country. Otherwise, the nation's firms miss the opportunity for joint development and the access to quick information.

Suppliers from abroad have usually less incentives to expend their core competencies in a foreign market. Therefore the industry could not take full advantage of the foreign suppliers.

However, a nation's industry can profit from suppliers, which are successful on a global-scale. These suppliers can provide the companies with important information and use the most advanced technologies.

All supplier industries of a particular sector of industry have to gain national advantage competitive in order to create competitive advantage in this industry.

Components, which have less impact on the product or process performance, can be purchased from abroad.⁴⁷

2.3.2 Related Industries

The presence of related industries usually attract competition, which leads to new competitive industries. Related industries can be described as companies that have the same activities in the value chain or produce substitute products or services.

Manufacturing, marketing, technology development, and distribution can be such sharing activities.⁴⁸

As mentioned in the supplier industry, related industry should be competitive internationally in order to provide information exchange about the market and technical issues.

Besides, the information flow is easier and quicker, because of geographical proximity and similarities in culture. Related industries also create opportunities of new entrants. These new competitors can emerge from bargaining power of suppliers and buyers, substitute products and services, and lateral entrants according to Porter's model of the five competitive forces.

⁴⁷ Cf. Porter, 1990, p. 104

⁴⁸ Cf. Porter, 1990, p. 105

Related industries are able to share activities along the value chain and can even form alliances.

Atlas Copco (mining machinery) and Sandvik (rock drills) are both located in Sweden and share a long relationship, which led to a formal marketing alliance.

An industry, which is leading on a global-scale, can also attract demand for complementary products or services. For example, the American computer industry possesses high market shares abroad. These circumstances lead to an enormous demand for American software, American computer peripherals, and American database service in many other nations.

Besides, complementary products or services facilitate firms to work together, which may create advantages in terms of cost efficiency and better product performance.⁴⁹

If many related industries have competitive advantage, it would be much easier to gain national success in this particular industry. Related industries that are innovative and share crucial activities can be seen as important for the success on a global-scale. Japanese facsimile industry profited from the Japan's leading position in photographic and telecommunication equipment, copiers, and other office machines, which are supporting technologies for the facsimile industry.

Related and supported industries are interacting with all the other determinants of the "diamond".

These industries, for example, are in need of advanced factors such as skilled workers and good institutes of higher education. Furthermore, strong home demand and active rivalry within the industry are essential for the emergence of competitive related and supported industries.⁵⁰

The supplying industry of the photovoltaic sector is very important to create competitive advantage, because it is directly involved in the production of solar components.

⁴⁹ Cf. Porter, 1990, p. 106

⁵⁰ Cf. Porter, 1990, p. 107

Many suppliers support the manufacturers of solar cells and modules to develop efficient solar cells, because they provide them innovative machinery or processes. This helps the solar cells and modules manufacturers to increase efficiency and reduce costs.

Suppliers, such as plant manufacturers, are facing new challenges for each new client, because have to adapt the individual requirements of their clients.

Therefore plant manufacturers have themselves become an important carrier of technology knowledge with regard to the manufacture of solar technology.

Some of the important solar cells manufacturing processes and production steps are mining and processing of raw materials (silicon, indium, etc.), sawing machines, wafer machines, process-cleaning methods, cell machines, and laser technology.⁵¹

Yetton (1992) criticized the neglect of history in terms of related and supporting industries.

Nations with resourced based industry and a strong diamond in related and supporting industries have mostly been active in that industry in the nineteenth century.

Therefore it would be to native to suggest that New Zealand's pulp and paper machinery industry could create a stronger diamond by developing a local equipment supply capacity. As a consequence, this country would have to compete with a well-established Swedish, Finnish or American equipment supplier industry.⁵²

2.4 Firm strategy, structure, and rivalry

The environment in which firms are created, organized, and managed is included in the fourth determinant of national competitive advantage in an industry.

Besides, it also describes the effects of domestic rivalry. There are various approaches to strategies, goals, and ways of organizing companies between different countries. If these different aspects of firm structure meet the requirements of the particular industry, this sector would create competitive advantage.⁵³

The countries environment have impact on the way firms are managed and decide to compete. A nation usually does not support all firms across the whole industry of a

⁵¹ Cf. Überzig, 2007, p. 6-8

⁵² Cf. Yetton et al. 1992, p. 113

⁵³ Cf. Porter, 1990, p. 107

country in the same. However, the national context shows tendencies to particular industries, which are clearly evident.

German companies, for example, have usually leader with technical backgrounds in the top management and the structure of the company implies a strong hierarchy. On the other hand, international successful companies in Italy are often small- or medium-sized firms, which have a private ownership and the company behaviour is like an extended family.

From this one can infer that companies are run in different ways across the nations. Sectors of industries within a nation that are benefited from the national environment in terms of patterns of organization and management practices can more easily gain competitive advantage.

The nature of the relationships with customers, the attitude toward international activities, group versus hierarchical style, the strength of individual initiative, the tools of decision making, the ability to coordinate across functions, training, background, orientation of leaders, and the relationship between labour and management are important differences in management practices across the nations.⁵⁴

There are so many different aspects in which firms are structured and managed, wherefore it is impossible to generalize all this influences. However, norms of interpersonal interaction, social norms of individualistic or group behaviour, attitudes toward authority, professional standards, and attitudes toward management are one of the most important aspects.

These aspects are influenced by cultural and social aspects such as educational system, family structure, social and religious history, and many other intangible values, which unique to national conditions.

The national environment also has an impact on the firms' willingness to operate globally and their international expertise. One of these aspects is the attitude towards travel.

⁵⁴ Cf. Porter, 1990, p. 108

Switzerland and Sweden, for example, have long experience in travelling and for them it is a way of life. In industries, which are in need of far-flung global strategies and sensitive relations with local governments and costumers, Swiss and Swedish companies are competing well.

Countries with good language skills and the ability and willingness to learn new languages are supporting factors for companies to compete internationally.⁵⁵

2.4.1 Company Goals

The motivation of owners and holders of debt, ownership structure, the nature of the corporate governance, and the incentive processes that affects the motivation of senior managers are influencing factors of company goals.

The characteristics of a countries' public capital market has an impact on the aims of publicly owned corporations.

Widely used standards for rate of return, local tax system, and identity of shareholders are aspects of the capital markets, which are quite different among between the nations.

Banks play crucial role in terms of investments, because they are important holders of equity shares. They have also effects on boards of directors and guiding corporate investments.

Mature industries with constantly investments in research and new facilities are supporting companies regarding competition.⁵⁶

A big impact on national advantage is due to capital, ownership structure, market conditions, and the nature of corporate governance. These factors are influencing a nation in two ways. On the one hand, industries have different intensity of using funds, different risk profiles, different investment time horizons, and different average sustained rates of return.

On the other hand, the capital market of a country set different objectives for different sectors of industry.

An established institutional structure can create competitive advantage in some industries, but also neglect others. Nations will gain competitive advantage in industries,

⁵⁵ Cf. Porter, 1990, p. 109

⁵⁶ Cf. Porter, 1990, p. 110

where the aims of owners and top management meet the needs of the particular industry.⁵⁷

Firm structure and strategy and company goals are quite difficult to measure and useful sources about this topic regarding the photovoltaic industry are not available.

That's why this part will be excluded in the analysis.

One can assume, that these factors are pretty similar, because most of the firms in the photovoltaic industry are multinational corporations.

2.4.2 Domestic rivalry

The level of motivation of people who manage and work in companies can have positive or negative effects on the success in a particular industry. Both, managers and workers should be motivated to develop their skills and increase working performance, if this is necessary for creating and sustaining competitive advantage.

The connection between dynamic rivalry and the development and persistence of competitive advantage in a particular industry was one of the strongest empirical findings in Porter's research. Many economists argued that domestic competition is not important for creating national advantage in an industry, because it leads to similar products and prevents companies from realizing if of scale.

Furthermore, some have the opinion that domestic rivalry is useless in terms of global competition.

Porter has doubts about this viewpoint, because his research about the most successful industries in ten nations showed other findings.

Strong local competition within an industry often leads to leading positions on al global-scale, even in small nations such as Sweden and Switzerland.⁵⁸

Domestic competition forces companies to improve and innovate. As a result, firms have to lower costs, improve quality and service and develop new products and processes.⁵⁹

⁵⁷ Cf. Porter, 1990, p. 111

⁵⁸ Cf. Porter, 1990, p. 117

⁵⁹ Cf. Porter, 1990, p. 118

The pressure that companies face in national competition facilitate not only innovations, it also pushes to innovate in ways that improve the competitive advantages of the nation's firms. If there is no domestic competition, companies will not have incentives to improve and innovate in their local markets.

The types of advantage that would exist being a local company, such as access to home market, a local supplier base, and factor costs would have are nullified through competition.⁶⁰

Domestic competition can also increase the stock of knowledge and skill in the national industry, because companies try to imitate each other and labour mobility within the sector of industry. For a particular company it is quiet impossible to keep all the knowledge and skills within the company. This is why the whole industry benefits from all these particular companies through faster innovation.

Ideas spread faster within a country than across countries, because for foreign companies it is difficult to be involved in such a process.

Firms are not able to keep innovations proprietary for a long time, which enables the other companies to adapt these innovations. This would lead again to more progress within the national industry compared to the foreign rivals and therefore competitive advantage can be created.

According to faster innovation, geographic concentration of competitors in a single city or region enables advantages, because of proximity to knowledge and information.⁶¹

Porter's diamond model has an emphasis on the home base, which also implies that competitively useful learning primary occurs domestically. However, Yetton (1992) pointed out that multi domestic companies have the ability to increase learning and know-how across different locations, and provide internal competition. He criticized Porter's argument that domestic rivalry is most important for competitive advantage, because in his view internal competition is as effective than external competition.

Inter-firm rivalry has limitations to gain competitive advantage in Porter's view, but multi-domestic companies have a lot of multiple operations for similar products using similar processes and therefore intra-firm rivalry can be highly effectively.

⁶⁰ Cf. Porter, 1990, p. 119

⁶¹ Cf. Porter, 1990, p. 120

Multi-domestic firms have the possibility to facilitate communication within the company, which will maximise learning and create innovations.

There is also an assumption that big, single domestic manufacturing plants are the basis for national competitive advantage such as Boeing.

Maybe Porter ignores this group of companies, because they seem to offer few benefits to the headquarters national economy, which would not increase competitive advantage within a nation.⁶²

Yetton (1992) argued that Porter did not examine multi-domestic firms seriously and therefore he did not recognise them as an effective form of global competition. In this case, he also neglected overseas operations and investments, which is one of the greatest weaknesses of his theory about the physical proximity for effective learning and innovation.

His empirical methodology is only based on exports, which could be to less information to draw conclusions.

In the case of Australia, which has a small, and isolated economy, market conditions can be problematically. This is why exporting companies with a large-scale home base will usually not evolve in, or be sustained primary by, such an environment.

However, Australia's multi-domestic firms are creating alternative firm structures and strategies, which is the foundation for international competitive advantage. These companies show how learning can occur effectively between multiple locations, and therefore they are not in need of their home base.

According to exchange of knowledge and learning within a multi-domestic company, the critical issue seems to be the capacity of the firm over time to capture the learning. On the other hand, the constancy of location in which learning first occurs, is not that important.⁶³

Yetton (1992) pointed out that multi-domestic companies tend to develop in industries where they are surrounded by medium-scale plants. Porter described the importance of large domestic plant where all the strategically important activities and learning is

⁶² Cf. Yetton et al., 1992, p. 116

⁶³ Cf. Yetton et al., 1992, p. 117

concentrated. However, in the case of multi-domestic firms, this view is not appropriate.

Two types of firms or industries (resources and multi-domestics) are mainly unexamined in Porter's cases, but these types are the most crucial factor for Australian economy to be successful.

These industries are also facing difficulties with proximity, which is one of the notions central to the diamond framework. One can assume that all the factors of the diamond model exist globally for the large, and particularly mineral, resource based industries. Multi-domestic companies, for example, have subsidies dispersed all around the world, which does not infer that they have less intense rivalry or consumers are less demanding.

The determinants of the diamond exist within the firm of multi-domestic companies and they have the ability to turn the appearing competitive disadvantages of geographic proximity into a source of advantage.⁶⁴

2.5 The role of chance

The determinants of the "diamond" influence the national environment in terms of competing in particular industries. In Porter's research about the most successful industries he come to the conclusion that chance events played an important role in some of these industries. These chance events are usually not affected by national circumstances and cannot be influenced by the firms or the national government. Following conditions are important regarding competitive advantage and can be included to the role of chance:

- Acts of pure innovation
- Major technological discontinuities (biotechnology, microelectronics etc.)
- Discontinuities in input costs such as the oil shocks
- Significant shifts in world financial markets or exchange rates
- Surges of world or regional demand
- Political decisions by foreign governments
- Wars

⁶⁴ Cf. Yetton et al., 1992, p. 117

Chance events can create drastic changes in the economy and therefore allow shifts in the industry, which could vary the conditions for competitive positions. They can create an environment where new nation's firms achieve competitive advantage, because the new and different conditions nullify the advantages of previously established competitors.⁶⁵

However, the national characteristics play a crucial role to what extent a nation can exploit these chance events, because chance events only allow shifts in competitive advantage in an industry.

Porter argued that the country with the most beneficial "diamond" would have the best position to transform chance events into competitive advantage. A national environment that is directed to new sources of advantage is most favourable for this transformation.⁶⁶

2.6 The role of government

The government can have big influences on the economy and particular industries. The success of Japan's and Korea's economy, for example, is often related to the governmental policy in these countries. It is quite difficult to understand the role of government in international competition.

According to Porter's point of view, the role of government should not be the fifth determinant, because it is just influencing the four other determinants.⁶⁷

Each of the four determinants is correlated with the government. They can influence as well as be influenced positively or negatively by the determinants of the diamond model.

Factor conditions, for example, are influenced by governmental policies in areas such as education and capital market. Government can also change local demand conditions, if the government bodies create local product standards or regulations that have an impact on consumers' needs.

The government is often an important buyer of many products in industries, such as defence goods, telecommunications equipment, and aircraft.

⁶⁵ Cf. Porter, 1990, p. 124

⁶⁶ Cf. Porter, 1990, p. 125

⁶⁷ Cf. Porter, 1990, p. 126

Government can also control advertising media or regulate supporting service within a country, which will change the conditions of related and supporting industries.⁶⁸

Besides, capital market regulation, antitrust laws, and tax policy established by the government have an impact on firm strategy, structure, and rivalry.

On the other side, the determinants can influence the governmental policy. For example, the number of local competitors influences investments in particular parts of the educational system.

Government safety standards are early applied in industries that have a strong home demand.⁶⁹

Yetton (1992) argued that Porter described the role of the government in a too general way. In the case of the Canadian industry, he had no well-defined position what government policy should do. He was just saying that the government has to create domestic rivalry where none exists.

So, he was relaxing the requirements of the diamond, because he tried to find rivals by international benchmarking, or searching for demand conditions elsewhere.⁷⁰

According to the case of Austria, Porter does not point out whether the government policies should reinforce the efforts of the existing diamond to have a higher percentage of firms move along the hypothesised trajectory, or to speed up that process.⁷¹

Ohmae (1995) pointed out that the industry is far more global in its orientation today than it was in previous decades. In the past, firms would support deals host governments in order to receive resources and skills in exchange for privileged access to local markets.

However, nowadays the situation has changed and state can no longer influence and shape the strategies of multinational corporations. These companies try to penetrate attractive markets wherever they are located and to tap promising pools of resources wherever they exist.

⁶⁸ Cf. Porter, 1990, p. 127

⁶⁹ Cf. Porter, 1990, p. 128

⁷⁰ Cf. Yetton et al., 1992, p. 107

⁷¹ Cf. Yetton et al., 1992, p. 112

Government-funded subsidies or old-fashioned tax systems, which should encourage firms to invest in particular locations, are becoming more irrelevant as a decision criterion. Many western companies moving into new developed economies such as China and India. Firms are moving of good future perspectives, not because of governmental issues.⁷²

2.7 The dynamics of national advantage

All determinants of the diamond model are connected and therefore each of them can be influenced by the others. Domestic rivalry and geographic industry concentration are factors, which have the power to transform the “diamond” into a system. On the one hand, domestic rivalry facilitates the improvement of the entire national “diamond”. On the other hand, geographic concentration raises the interactions between the determinants of the “diamond”.

A consequence of the interaction between the factors is that a country’s competitive industries are primary connected together in terms of geographical proximity. Porter terms this kind of connection “clusters”, which are consisting of industries related by links of various kinds.

For example, 40 percent of total exports in Italy are related to clusters of industries all connected to food, fashion, or the home.

Industry clusters in transportation, forest products, and metals represent for over 50 percent of total exports in Sweden.⁷³

The relationships among the determinants are connected to the patterns of factor creation, because the determinants have an impact on the types of factors that are created in a country.

Effective mechanisms for creating and improving factors that are advanced and specialized are most important for competitive advantage, such as a world-class research institute in composite materials technology.⁷⁴

⁷² Cf. Ohmae, 1995, p. 3

⁷³ Cf. Porter, 1990, p. 131

⁷⁴ Cf. Porter, 1990, p. 132

Domestic rivalry is one of the most important mechanisms of factor creation, because many local competitors in dynamic competition will stimulate the development of skilled human resources, market-specific knowledge, related technologies, and specialized infrastructure.

Firms are also investing in factor creation themselves, because they are afraid to lose ground to their competitors.

Advanced and specialized factor creation is also depended on domestic rivals, which could initiate special programs in local school and universities, specialized apprenticeship programs, government-supported technical institutes and training centres, industry-specific trade journals, and other types of investment in factors by government and other institutions.

One big company can have a major economic influence on a town or region and therefore create useful and effective factor conditions. However, a group of domestic competitors have more potential to stimulate mechanisms for factor creation, because competition among local firms lead to court and develop relationships with educational and research institutions, and information providers.⁷⁵

These mechanisms of factor creation of a group of domestic competitors are not happen automatically. Domestic companies have to be in need of steadily upgrading the pool of factors, and try to facilitate investments in them. Therefore dynamic competition plays a crucial role in creating such conditions for improvement, as do pressure from buyers.

Related and supporting industries have also an impact of the pool of factors and the rate at which they are created. These industries have their own mechanism for creating and improving specialized factors and some of them are even transferable.

The Danish food and brewing industries, for example, entails educational programs, skilled employees, and research capabilities in biology, which have been a source of advantage in Denmark's insulin, food additives, and industrial enzyme industries.

Furthermore, mechanisms of factor creation are a due to the existence of a cluster of various industries, which are depended on common inputs, skills, and infrastructure.

⁷⁵ Cf. Porter, 1990, p. 134

These conditions stimulate educational institutions, firms, individuals, and government bodies to invest in important factor creation

Specialized infrastructure can have a big impact on industries, because spillover effects are improving factor quality and increase supply. In some cases, whole new industries emerge to supply specialized infrastructure to such clusters.

Demand conditions can also create particular types of factors. A certain level of demand for a product or sophisticated demand lead to transfer social and private investments into related factor creation. This local demand pressures advanced and specialized factors of production to grow up.⁷⁶

Dynamic domestic rivalry also raises home demand.

A group of aggressive domestic competitors increase the knowledge of their customers and therefore make them more sophisticated. This would lead to more demanding because the buyers come to expect a lot of attention.⁷⁷

The development of related and supporting industries can also be influenced by factor-creating mechanisms, because the industry can benefit from spillover effects in the form of knowledge, skills and technology.

The size and growth of home demand for a particular product can be connected to the level of specialization of supporting industries.⁷⁸

Home-based competitors that are also internationally successful, will pressure the supplier industry to develop. This would lead to more innovative suppliers, which have to improve their products and processes, because otherwise they would be replaced.

The geographical proximity of home bases intensify the interchange and cooperation on research and it is also a good basis for supplier industries to speed up their globalization and increase their competitive advantage.⁷⁹

⁷⁶ Cf. Porter, 1990, p. 135

⁷⁷ Cf. Porter, 1990, p. 137

⁷⁸ Cf. Porter, 1990, p. 138

⁷⁹ Cf. Porter, 1990, p. 139

2.8 General critique

In this chapter, I try to explain the view of Ohmae, who is a famous business and corporate strategist, about the competitiveness in global markets. He comments on Porter's diamond model, which will be also included in this chapter.

Furthermore, this part will describe the content of two other critical papers about Porter's diamond model. These critiques about the factors of the model are already mentioned in the previous chapters.

Ohmae (1995) argued that traditional national interest has become less important in a borderless world. Nevertheless, protection of the state by subsidies and other financial instruments will still play an important role for a nation.

Nations try to protect some of their domestic products by subsidising them, which means that other nations will have disadvantages to compete with them.

This could happen when economic activities and interest groups are bundled together in a single nation. However, it does not affect the value of co-locating such activities in the same geographical area. So, there has to be a distinction about it.⁸⁰

“Several contemporary scholars-Michael Porter, in *The Competitive Advantage of Nations*, being chief among them-have argued persuasively and, I think, correctly for the critical importance, especially in a global economy, of having clusters of related factor endowments located close together. Even in an information-driven age, skilled workers, extensive networks of supplier industries, and so on-the ingredients of what Porter calls the “diamond” of competitiveness-do, indeed, perform better when they exist in close geographical proximity.”⁸¹

Ohmae (1995) support the importance of the determinants of the diamond model in order to create competitive advantage, but he has a different view about the importance of these factors within a nation. He criticized that geographical groupings must not co-exist within the borders of a single nation state and have the same national interest to be effective.

⁸⁰ Cf. Ohmae, 1995, p. 64

⁸¹ Ohmae, 1995, p. 64

In his opinion, economic activities and groupings work sometimes even better when they are located across political borders and therefore national interest has no influence. Furthermore, he argued that the success of an industry or a region is not just the contribution of the state, but rather the combination of individuals, institutions, and culture, which is located in this particular industry or region.⁸²

Ohmae (1995) tried to describe in his book “The end of the nation state” that regional economies became more important over time and the traditional nation state has begun to dissolve in terms of economic activities.

He explained the transition from traditional national economic activities to regional economies through the changes in industry dynamics, available information (modern information technology), consumer preferences, and capital market.

Countries are burdened by open-ended subsidies and demands for the civil minimum. These and other conditions do not support the aspect that a nation is a meaningful unit of an up-to-date map of economic activity.

However, the nations are still major players on the world stage, but they have lost the ability to make effective decisions in terms of global economy.⁸³

Economic activity in today’s borderless world is not affected by the political boundary lines of traditional nation states or by the cultural boundary lines.

However, there is much evidence to support the notion that economic activities are in line with information-driven efforts in order to get a foothold in the global economy.

Furthermore, these efforts tend to follow a predictable trajectory and therefore economic areas are shifted through successive phases of development

The movement between the different stages of development is heavily dependent on the region’s ability to put the right policies, institutions, and infrastructure in place at the right time. Therefore, this development has nothing to do with cultural aspects.⁸⁴

In summary, it can be stated that Ohmae confirm the importance of Porter’s diamond model as a theoretical framework about the competitiveness of a nation, because the existence of geographical proximity leads to advantages in economic activities.

⁸² Cf. Ohmae, 1995, p. 64

⁸³ Cf. Ohmae, 1995, p. 79

⁸⁴ Cf. Ohmae, 1995, p. 21

However, in his view regional economies were reshaping the global markets and are more important in terms of economic success than the competitiveness of a nation.

The critiques about the Porter's diamond model, which are described in each of the determinants, originate from two scientific papers.

I will describe the content of these two papers very briefly in order to get a better understanding about them.

According to the Moon et al. (1998) paper, they try to explain the competitiveness of Korea and Singapore with a "double diamond" approach. In this paper, they tested the validity of the single diamond model from Porter and the generalized double diamond approach.

This generalized double diamond approach includes the domestic diamond and the "international" diamond relevant to its firms.

In the paper "Are Diamonds a Country's Best Friend" written by Yetton (1992), they tried to support their critical view about Porter's diamond model by applying his theory to the cases of Canada, New Zealand, and Australia.

3 Research design

The empirical part of the thesis could be seen as a multiple case study, because it is focusing on the competitiveness of Sweden and Germany in terms of the photovoltaic industry.

In a multiple case study, one can compare the different cases and investigate the differences.

According to the thesis, I want to apply Porter's diamond model, which is explained in the theory part, to the photovoltaic industry in Sweden and Germany. The aim will be to show how big the differences of competitiveness are in these two nations.

The larger the differences will be in each of the determinants of the diamond model (factor conditions, demand conditions, related and supporting industries, firm strategy, structure, and rivalry and role of the government) between Germany and Sweden in the photovoltaic industry, the higher the competitiveness of this nation, respectively their

companies. The role of chance will be excluded, because it is hard to predict what happens in the future.

Therefore the dimensions of the diamond are specified to the photovoltaic industry and the two separate diamonds are compared to determine the difference.

4 Data collection

This empirical study is based on secondary data. The secondary data can be divided in quantitative data and qualitative data. The quantitative data is primary collected by a set of official and semi-official international sources, such as World Economic Forum, Organization for Economic Co-operation and Development (OECD) and International Energy Agency (IEA) as well as publications from non-governmental organizations, such as Ernst & Young Renewable Energy Group.

5 Empirical analysis

In the next chapters, I will apply the diamond model to the photovoltaic industry in Germany and Sweden to investigate Sweden's competitiveness in this particular industry.

5.1 Factor conditions

Porter (1990) pointed out that advanced factors are more important than basic factors in terms of competitive advantage, which includes highly educated personnel, such as graduated engineers and university research institutes.

As a consequence, universities and other higher education play an important role in improving advanced factors.

In the case of the photovoltaic industry, highly educated employees are required to create competitive advantage, because the photovoltaic industry is related to the high-tech sector.

5.1.1 Knowledge resources

Scientific and engineering institutions are able to increase the advanced factor endowments in knowledge-intensive industries, such as the photovoltaic industry.

These scientific and engineering institutions are measured with the index “Quality of Math and Science Education” taken from the Global Competitiveness Report 2009/2010 (World Economic Forum).⁸⁵

The Global Competitiveness Report includes different pillars (factor-driven, efficiency-driven, innovation-driven), which contribute to the competitiveness of a country.

The index “Quality of Math and Science Education” is included in the section “Higher education and training”.

The measurement of each index is based on a survey. In this survey, participants were asked to evaluate questions, on a scale of 1 to 7, whereas 7 represent the best. The World Economic Forum established a close collaboration with its network of over 150 Partner Institutes, which administer the survey in their countries. The Partner Institutes are primary economic departments of national universities, independent research institutes, or business organizations.⁸⁶

Sweden scored 4.8 points out of 7 and ranked on place 36 worldwide, whereas Germany scored 4.5 points and ranked on place 45.

Sweden is in slight favour regarding the quality of math and science education due to this measurement.⁸⁷

This index can also be used for many other industries such as the mechanical and electrical engineering industry. However, the whole photovoltaic sector (including related and supporting industries) is dependent on a good quality of math and science education. Besides, it is just one part in this thesis how to measure factor conditions. The next chapters should demonstrate the importance of education in the field of renewable energy and the issues, which a country has to deal with.

Jennings (2008) pointed out that the rapid growth of renewable energy has increased the problem of shortage of skilled professionals, with experience in renewable energy.

⁸⁵ Cf. Dögl et al., 2010, p. 43

⁸⁶ Cf. Schwab et al., 2009, p. 50

⁸⁷ Cf. Schwab et al., 2009, p. 397

The demand of this type of skilled person includes designers, service and sales representatives, installers, policy analysts, scientists, engineers, teachers and researchers

All these types are contributing to the quality of the system.

Therefore education plays a crucial role in the development of a sustainable society, because it provides training for the employees and it trains researchers who will develop the next generation of system and devices.

Furthermore, it leads to confidence in the new products and shows the public to use them effectively.

The developments of new high technology industries, such as the photovoltaic industry, are heavily dependent on education as the examples of the computer industry and the aircraft industry clearly show.⁸⁸

Based on technological advances and market demands, the renewable energy industry will be need for more trained professionals. The success of the renewable energy industry is dependent on highest standards of performance and efficiency, because confidence of the customer should continue to grow in order to acquire a good reputation and therefore the demand will increase.

The development of the renewable energy industry is also in need of high quality engineering and market demand, but just these factors are not sufficient.

The system has to meet the customer needs to raise demand.

All levels of society, from consumers to managers, have to be supported by education and training to ensure that renewable energy systems meet the highest standards of efficiency.⁸⁹

5.1.2 R&D activities

As mentioned before, government and private research institutes as well as universities are knowledge resources, which can create competitive advantage.

The next paragraphs will highlight some of the R&D activities in the photovoltaic sector of Germany and Sweden, which are connected to such institutions.

⁸⁸ Cf. Jennings, 2008, p. 436

⁸⁹ Cf. Jennings, 2008, p. 438

The funding of these R&D activities will be not included in this section, but the will be taken into account in the chapter about related and supporting industries.

In Germany, the Programme on Energy Research and Energy Technology, financed by the Federal Ministry of Education and Research support R&D on different aspects of PV. In 2008, the government department supported 130 R&D projects on PV in total. The projects are focused on wafer based silicon technologies, thin-film technologies, development of system technology and alternative technologies, such as concentrating PV and crosscutting issues.

Since 2005, Q-Cells is working on high-efficiency silicon solar cells and boost their own R&D capacities to open a research centre in 2008. Q-Cells will launch two projects, which rely on the expertise of the Fraunhofer ISE, Freiburg and the ISFH, Hameln. ISE also published very a new world record of 41,1 % for a cell for concentrated photovoltaic.

The cooperation between University of Stuttgart and Zentrum für Sonnenenergie- und Wasserstoffforschung (ZSW) participates in a new task of the International Energy Agency.

In 2008, networks for the development of thin-film solar cells were initiated, which focus on topics such as material science including nanotechnology and the usage of synergies with other fields of research such as microelectronics or bionics.

The “Solarvalley Mitteldeutschland” cluster, which includes most of Germany’s PV industry, is growing into an internationally attractive centre.⁹⁰

In Sweden, the Uppsala University has focused on thin film CIGS solar cells since the 1990’s. This research has resulted in the spin-off company, Solibro AB, which produce these cells since 2008. The aim of the university is to achieve high performance and cost reduction, whilst using materials that minimise the impact on the environment.

Many of the several research projects are funded by the Swedish Research Council’s call for basic research. Polymer solar cells are one specific field, where research is conducted at several Universities in Sweden.

⁹⁰ Cf. Hünnekes in Watt et al., 2008, p. 59-60

Different research groups from Uppsala University, the Royal Institute of Technology and the public-private partnership company Swerea IVF AB are working together in the field of molecular solar cells, which achieved world class standard.

Lund University has the division of Energy and Building Design, which do also research on solar energy integration into buildings.

A division of Chalmers University of Technology in Gothenburg is studying innovation systems and policy issues and one research project has investigated the effects of support mechanisms for emerging energy technologies such as PV.

The SolEl programme is a national R&D programme with a focus on PV systems and their applications, which is funded by the Swedish Energy Agency, Swedish utilities, and manufacturing companies among others. The main objectives of this programme are to support technological development, analysis of performance and costs of PV systems, and demonstration of applications.⁹¹

The photovoltaic industry is and high-tech industry and should therefore be highly innovative.

Patens can be used as an innovation-indicator, because the patent-system is designed as an incentive-mechanism for the creation of new economically valuable knowledge.

Besides, this system provides detailed information about new technologies.

The weakness of using patents to measure innovation activity is that they are an indicator of invention rather than innovation.⁹²

There are also other indicators of innovation such as R&D data and bibliometric data (data on scientific publications and citation).

However, innovation is quite difficult to measure, because it is a multidimensional process, which is conceptualized in terms of ideas, learning, and the creation of knowledge.⁹³

⁹¹ Cf. Palmblad in Watt et al., 2008, p. 96-97

⁹² Cf. Fagerberg et al., 2005, p. 158

⁹³ Cf. Fagerberg et al., 2005, p. 151-152

The following numbers of patents, which will be used in this thesis as innovation-indicator, are based on the international patent classification H01L (semiconductors advices; electric solid state devices).⁹⁴

This classification includes all patents, which are related to the photovoltaic industry. The data of the following table is based on the OECD database.⁹⁵

Year	1999	2000	2001	2002	2003	2004	2005	2006
Germany	348.1	442.0	386.7	355.0	315.2	345.2	400.5	342.1
Sweden	35.1	19.0	18.8	8.3	11.5	21.1	9.9	21.7

Table 1: Number of patents

As one can see, Germany has more patents in this sector in this time period than Sweden. However Germany has about nine times higher population than Sweden. The next table will take this difference into consideration, because the numbers of patents of Germany are divided by nine.

Year	1999	2000	2001	2002	2003	2004	2005	2006
Germany	38.7	49.1	43.0	39.4	35.0	38.4	44.5	38.0
Sweden	35.1	19.0	18.8	8.3	11.5	21.1	9.9	21.7

Table 2: Number of patents related to population size

This table shows that Germany is dominating in number of patents compared to Sweden, which could be due to the fact that Germany is doing more research in the photovoltaic industry than Sweden in the last few years. Based on this database, there is no predictable trend in both countries.

5.1.3 Infrastructure

The quality of the infrastructure is also on aspect of the factor conditions of Porter's diamond model.

⁹⁴ <http://depatinet.dpma.de/ipc/ipc.do?s=H01&v=20100101&l=EN&dh=dh11&sn=n00&sci=i00#H01>

⁹⁵ <http://stats.oecd.org/index.aspx>

Porter (1990) pointed out that infrastructure includes many different aspects such as the type, quality, and user cost of infrastructure available that affects competition. In the analysis, the infrastructure will be focused on the renewable energy as well as the photovoltaic sector. Therefore it is a bit different to Porter's approach, because the index about infrastructure includes also other aspects.

The infrastructure will be measured by using the Renewables Infrastructure Index, which is one part of Ernst & Young Renewable Energy Country Attractiveness Index 2009/2010.

The Renewable Infrastructure Index is an assessment of the general regulatory infrastructure for renewable energy. The index is calculated on a weighted basis, which considers electricity market regulatory risk (29%), planning and grid connection issues (42%), and access to finance (29%).⁹⁶

In this index, Germany scored 64 points, whereas Sweden scored 52 points.⁹⁷

The Renewable Infrastructure Index is combined with each set of technology factors. These technology factors include every sector of renewable energy such as Solar PV index.

This index contains factors, such as power offtake attractiveness (19%), tax climate (11%), grant/soft loan availability (9%), market growth potential (18,5%), current installed base (8%), resource quality (19%), and project size (15,5%).⁹⁸

These factors can also be used to some extent to measure the attractiveness of infrastructure. Besides, the Solar PV index is most suitable for the photovoltaic industry compared to the Renewable Infrastructure Index.

In the Solar PV index, Germany scored 73 points, whereas Sweden scored 43.⁹⁹

As one can see, Germany is leading in both indexes and therefore has a more efficient infrastructure in the photovoltaic industry.

⁹⁶ Cf. Warren et al., 2010, p. 24

⁹⁷ Cf. Warren et al., 2010, p. 9

⁹⁸ Cf. Warren et al., 2010, p. 24

⁹⁹ Cf. Warren et al., 2010, p. 9

According to the factor conditions, Germany is more active and competitive than Sweden regarding this measurement. However, Germany has a longer experience in this particular industry and therefore can make use of it.

Sweden has a good quality in math and science education and the research programs cover a broad area within the photovoltaic solar energy, such as improvement of solar cells, policy issues, and PV systems and their applications.

5.2 Demand conditions

As Porter mentioned in his theory, market size and growth of domestic demand are important factors to create competitive advantage. These factors may be not important in every industry.

However he pointed out that in industries with a heavy share of R&D, such as the photovoltaic industry, these conditions should be taken into account.

5.2.1 Market size

In this thesis, the total capacity of megawatts installed by the end of 2008 will be used to determine market size. Furthermore, the capacity of photovoltaic energy will be related to the population size of each country in order to get another useful aspect of the domestic demand.

Germany had 5340 MW cumulative installed PV power by the end of 2008.¹⁰⁰

In Sweden, the total installed capacity reached 7.91 MW by the end of 2008.¹⁰¹

The installed PV power of Germany is about 675 times more than Sweden's PV power, which is an enormous difference.

The energy consumption is dependent on the market size, respectively the population size. That's why the different population sizes of Germany and Sweden will be taken into account in the following calculation.

¹⁰⁰ Cf. Wissing, 2009, p. 8

¹⁰¹ Cf. Hultqvist, 2009, p. 16

The table below will include the cumulative installed PV capacity by the end of 2007, the population size in 2007, and the ratio between these two figures.

	Cumulative installed PV capacity 2007 (MW)	Population size 2007 (million)	Cumulative installed PV capacity / population size (kW/capita)
Germany	5340	82.26 ¹⁰²	~0.649
Sweden	7.91	9.15 ¹⁰³	~0.000864

Table 3: Energy capacity PV

However, as shown in table 2, Germany is also leading in this calculation compared to Sweden. Which means that Sweden's economy should promote and facilitate the photovoltaic industry in order to increase home demand.

5.2.2 Growth rate

As already mentioned in the theory part, Porter (1990) pointed out that the growth rate of home demand is important in terms of competitive advantage, because firms will invest in sectors where the domestic growth rate is high.

The graphs below will include the cumulative installed PV capacity between 1993 and 2008 in Germany and Sweden. The output of the graphs should predict a trend of the demand on photovoltaic products. Germany's capacity is measured in megawatt, whereas Sweden's capacity is measured in kilowatt. The figures of Germany were published in the National Survey Report of PV Power Applications in Germany 2008¹⁰⁴ and the Swedish figures were published in the National Survey Report of PV Power Applications in Sweden 2008.¹⁰⁵

In the following graphs of Germany and Sweden, I will use the unit megawatt for Germany and kilowatt for Sweden, because I just want to analyse the trend of both countries.

The figures of Germany and Sweden differ widely, if one would use the same unit.

¹⁰² http://www.iea.org/stats/indicators.asp?COUNTRY_CODE=DE

¹⁰³ http://www.iea.org/stats/indicators.asp?COUNTRY_CODE=SE

¹⁰⁴ Cf. Wissing, 2009, p. 8

¹⁰⁵ Cf. Hultqvist, 2009, p. 16

The graph should also be seen as an indicator of acceptance and usage of this new technology and therefore is not in need of the same units.

The graphs below show the cumulative installed PV capacity in Germany and Sweden.

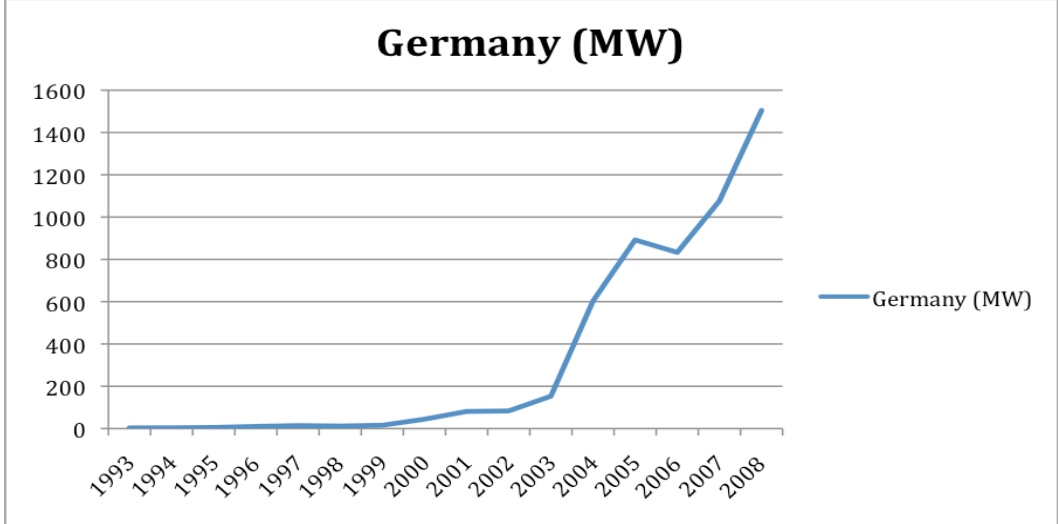


Figure 1: Cumulative installed PV capacity (Germany)

In figure 1, we see that the cumulative PV capacity in Germany increase dramatically in 2003 and afterwards continues to rise until 2008. One can see, that there is a positive trend in Germany’s PV market.

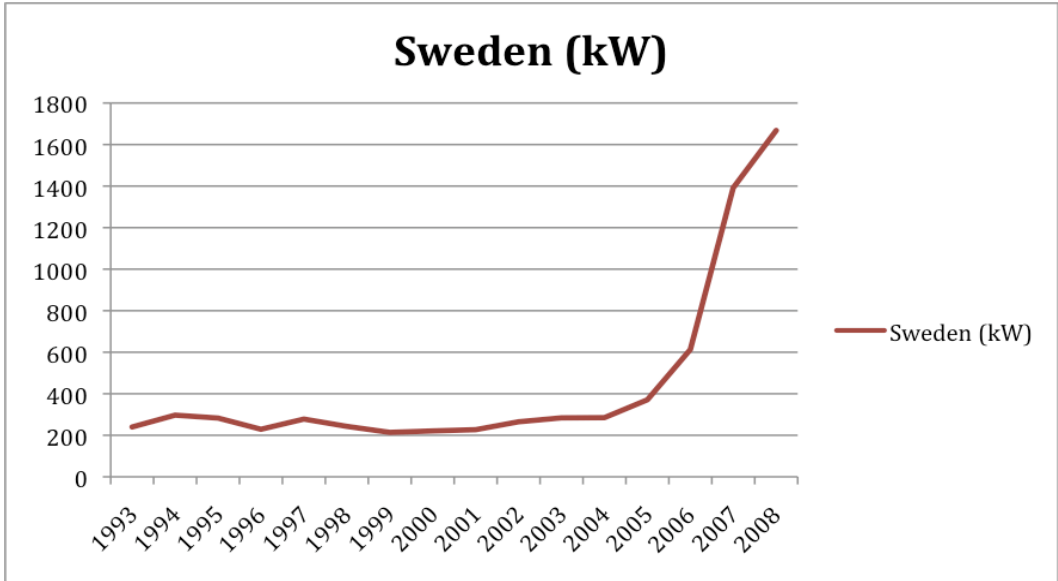


Figure 2: Cumulative installed PV capacity (Sweden)

Sweden's installed PV capacity was growing at the same level until 2005. Afterwards the PV capacity rose sharply until now. From this one can infer that there could be a significant upturn in the next few years.

According to table 5, Sandén et al. (2008) pointed out that the subsidies for PV installations in public buildings, which have been introduced in 2005, changed the PV market in Sweden drastically. The grid connected PV systems surpassed the benchmark of 1 Megawatt in 2007, which could be due to the fact that new companies entered between 2004 and 2007. During this time period, eight companies penetrated the market of PV system installations. Besides, many consultancy companies in the field of project management and inspection have emerged between 1997 and 2004. Some of them were even large engineering consultancy firms. The PV modules were supplied from Swedish as well as foreign companies and two multinational PV module retailers have established subsidiaries in Sweden since the introduction of the market formation programme. Sharp, is one of these companies, which is world leading in PV module production.¹⁰⁶

System buyers, who receive investment subsidies, are usually public organizations such as universities, churches, museums and health care centres. The most active buyer is the city of Malmö and therefore the city becomes a centre of excellence for solar energy. Sweden used Malmö's top position to create publicity and as flagship city for marketing campaigns.¹⁰⁷

In Sweden, the off-grid installed PV power is slightly leading compared to the grid-connected PV power.¹⁰⁸

By contrast, the German grid-connected PV power counts for nearly the whole installed PV capacity.¹⁰⁹

¹⁰⁶ Cf. Sandén et al., 2008, p. 12

¹⁰⁷ Cf. Sandén et al., 2008, p. 13

¹⁰⁸ Cf. Hultqvist, 2009, p. 16

¹⁰⁹ Cf. Wissing, 2009, p. 8

This could be one reason why there has no market for solar electricity emerged and why solar electricity is not sold in Sweden, neither from domestic installations, nor from installations abroad.

Sandén (2008) pointed out that nearly all electricity consumers have their own PV installations and these installations are not designed to supply a surplus to the grid. In 2007, only four solar electricity installations were covered by the certificate system, which could be due to the fact that low price of green electricity certificates and the high cost of metering have not stimulated this system.

Sweden's energy utilities have also a negative effect on the home demand.

Nearly every energy utility in Sweden, especially Vattenfall, has no expectation that the photovoltaic market will be a competitive alternative energy source for Sweden.

Besides, they have not shown any interest to facilitate the photovoltaic industry in the near future.

However, at least one small electric utility has shown interest in selling solar electricity. This firm offers PV systems and support their customers with arguments in communication with grid owners.

Besides, the Swedish people show willingness to adopt this technology, because a notable share of electricity consumers would pay a premium price for solar electricity. A survey of 11575 house owners showed that 29% would pay the double electricity price (about 0.2 Euro/kWh) or more for 100 kWh of solar electricity per year.

Furthermore, solar energy enjoys a good reputation in the Swedish society.

A yearly survey showed that solar energy has been the favoured energy source that most Swedish people want to invest more in. A favourable opinion on solar energy was the result of this study since the survey started in 1999 until 2006. Between 77% and 83% of the participants have argued that Sweden should invest more in solar energy. Another indicator of the awareness of solar cells is the media presence, which can be determined by the articles about solar cells in Swedish newspapers and magazines. A survey between 2000 and 2007 showed that the numbers of articles increased dramatically in 2007.¹¹⁰

¹¹⁰ Cf. Sandén et al., 2008, p. 14

According to demand conditions, Germany has a disproportionately larger home demand in PV systems than Sweden even if the figures are related to their population size.

However, the tendency of market development is very positive in both countries and the Swedish people show interest and acceptance about this technology. This could be a good starting point for an increasing home demand in the next few years.

5.3 Related and supporting industries

As mentioned in the theory part, competitive related and supplying industries will reinforce innovation and internationalization. Firms have a quick and easy access to domestic supplying industries in terms of know-how and other important information, because of the cultural and geographical proximity.

All related and supporting industries in the photovoltaic industry belong to the medium and high-tech industry.

The mechanical engineering and construction industry produce components for the photovoltaic industry and they are related to the medium-tech industry. On the other hand, the semiconductor industry, which is developing and producing solar cells, is located in the high-tech industry.¹¹¹

Based on these facts, the strength of related and supporting industries will be measured by the share of medium and high-tech value added in the country's total manufacturing. This index is included in the Industrial Development Report 2009 of the United Nations Industrial Development Organization (UNIDO).¹¹²

The share of medium/high-technology production in manufacturing value added was 61.1% in Germany in 2005. By comparison, the Swedish share of these technology industries accounts for 44.1 % in 2005.¹¹³

¹¹¹ Cf. Schwarzburger et al., 2009, p. 6

¹¹² Cf. Dögl et al., 2010, p. 45

¹¹³ Cf. Collier et al., 2009, p. 129-131

Dögl (2010) measured the level of development of supporting industries in the renewable energy sector with the gross domestic expenditure on R&D, because the related and supporting industries of this sector are considered to be very innovative. The data is used from the OECD Factbook 2009, which provides information about the expenditure on R&D as a percentage of GDP of all OECD countries.¹¹⁴

The expenditure of R&D in Germany was 2.53% of the GDP in 2007, whereas Sweden spent 3.63% of their GDP on R&D in the same year. Sweden is also leading in R&D investments compared to all other countries.¹¹⁵

As R&D spending statistics are available for the photovoltaic sector, I will focus on these figures, because they are more appropriate for this analysis.

Sweden has a national long-term energy research programme, which is managed by the Swedish Energy Agency. This programme includes also photovoltaic and its overall budget is about 100 MEUR.

The budget for PV is between 2 and 2.5 MEUR per year and provides funding for PV research, co-financed technological development, demonstration and business development.

Additional funding for R&D in the PV sector can also be received from other institutions such as the Swedish Research Council, the Nordic Energy Research programme, and the Agency for Innovation Systems and private foundations.¹¹⁶

In Germany, the BMU spent 39.3 MEUR for R&D projects regarding photovoltaic in 2008. 130 projects were financed in total by this budget, which include programs such as wafer based silicon technologies and thin-film technologies.

The BMBF funded 8 cooperative R&D projects in 2008, which amounted to a total of 19.5 MEUR. The "Sollarvalley Mitteldeutschland" cluster was also funded by the BMBF. Which means that the public budget for R&D in the photovoltaic sector is 58.8 MEUR in total.¹¹⁷

¹¹⁴ Cf. Dögl et al., 2010, p. 45

¹¹⁵ <http://titania.sourceoecd.org/pdf/factbook2009/302009011e-07-01-01.pdf>

¹¹⁶ Cf. Palmblad in Watt et al., 2008, p. 96

¹¹⁷ Cf. Wissing, 2009, p. 11-12

In Sweden the subsystems (related and supporting industry) of the photovoltaic industry are heavily dependent on external forces and the links between these subsystems are quite weak. The weakness of the subsystem is due to Sweden's small PV industry, because for a small market it is difficult to attract resources for expansion.¹¹⁸

The weakness of the production industry also creates problems for research and education, because PhDs cannot find qualified jobs in the Swedish photovoltaic industry. Therefore, it becomes more difficult to attract students towards these courses of studies. Sweden can only profit from graduated students, who gain experience in other countries and afterwards bring back important know-how to the Swedish PV system.

The subsystem is dependent on resource supply from abroad and most suppliers of Sweden's PV industry are located in Germany. However, the growing interest for climate change and the growing world market for PV have raised expectations for PV in Sweden and this seems to affect resource mobilisation.¹¹⁹

German manufacturers of components, machines and production equipment for photovoltaic's generated a record turnover of 2.3 billion euro in 2008 and their export share was 81 percent.

The experience from related and supporting industries will enable the photovoltaic producers in terms of cost cutting. This machinery and equipment sector has become a key success factor in the photovoltaic industry.

The mechanical engineering industry is the biggest employer and one of the leading sectors in the German industry with about 975,000 employees and a sales turnover of 205 billion euro (2008).

Within this entire machinery industry, the photovoltaic equipment producers are doing comparatively well, even in 2009. Most of the companies are well prepared for the long-term growth and can easily compete on an international level.¹²⁰

According to related and supporting industries in the photovoltaic sector, Germany is leading on a global scale.

¹¹⁸ Cf. Sandén et al., 2008, p. 15

¹¹⁹ Cf. Sandén et al., 2008, p. 16

¹²⁰ Cf. Schwarzburger et al., 2009, p. 6

The budget for R&D projects in the photovoltaic sector in Germany is about 23 times bigger than in Sweden, whereas Sweden is leading in expenditure on R&D as a percentage of GDP. The small PV market and industry could be a reason that the related and supporting industries are still in the early stages of development.

5.4 Firm structure, strategy, and rivalry

According to Porter (1990), domestic rivalry facilitates competitive advantage, because firms have to be innovative in products and processes to compete against each other. It's quite hard to measure competition with the data available for both countries. Therefore my approach will be to highlight the most important companies regarding the photovoltaic industry in Germany and Sweden and their production capacity. Furthermore, I will describe the activities of the Swedish PV companies. In the photovoltaic industry, one has to distinguish between two different types of photovoltaic companies, which are module producers and cell producers.

Porter (1990) pointed out that strong local competition within an industry would lead to competitive advantage and therefore I will measure the number of companies within the photovoltaic industry in both countries.

One can assume that the more companies are related to the photovoltaic industry the stronger the competition will be.

Germany has solar cell producers as well as photovoltaic module producers. According to the photovoltaic firms, one has also to distinguish between silicon wafer based manufacturer and thin-film manufacturers.

Germany has 10 companies in the silicon wafer based solar cell production, which have a total production of 1221 MW in 2008.

The largest firms based on productive capacity are Q-Cells AG (585 MW), Deutsche Cell GmbH (170 MW), and Ersol Solar Energy AG (140 MW).

In the PV module sector, Germany has 16 companies, which have a total production of 1707 MW.

The most important firms in this sector are the same companies as in the solar cells

sector such as Q-Cells AG (760 MW), Ersol Solar Energy GmbH (220 MW), Deutsche Cell GmbH (190 MW), and Schott Solar GmbH (170 MW).¹²¹

All of the thin-film manufacturers produce solar cells and modules. This sector includes 17 companies with a total production of 289 MW in cells as well as in modules.

The largest producer in this field is First Solar GmbH with a production of 196 MW.¹²²

Sweden's overall production of PV modules was about 75-80 MW in 2007. Sweden has five important companies, which assemble imported solar cells into modules.¹²³

Gällivare Photovoltaic AB (GVP) was the first producer in Sweden and had the largest capacity until 2006 when REC Scanmodule expanded their production. The current capacity of GVP is 45 MWp./year, which is a rise of 15 MWp. /year from 2008. The firm plans to have their own cell production in the future, because it is now importing them from within Europe.

Arcitic Solar AB is another module producer company, which shares are held by NAPS (Finland) and Alfa Solar (Germany). They also buy cells from multiple cell producers within Europe.

REC ScanModule AB, which is a Norwegian company, produce every part of the product chain and are therefore a major player in the PV market. Their sub company of module fabrication is situated in Glava Sweden and the new fully automated module production line had been producing 132 MWp. during 2008. The maximum capacity of this production line is 154 MWp.

PV Enterprise Sweden AB is also a module producer firm, which faced some troubles to keep up their production in 2008, because they did not get enough cells. They fixed this problem, but they are now having difficulties because of the global crisis.

¹²¹ Cf. Wissing, 2009, p. 16

¹²² Cf. Wissing, 2009, p. 17

¹²³ Cf. Sandèn, 2008, p. 11

N67 solar is the youngest module producer company in Sweden and they are growing rapidly. Their capacity is constantly increasing and they export their PV modules to many countries within Europe such as Germany, Spain and Italy.

The firm has also a partnership agreement with Q-Cells, which provide them with solar cells.¹²⁴

Recently, the Swedish investment company Bore Wind, which is holding shares in Switchpower, bought 65 % of GVP. Switchpower is the Scandinavian market leader for turn-key building integrated and building applied solar photovoltaic power systems. These two companies are both located in Gällivare and help each other, if there is a lack of material or personnel. This is a positive example of local networks. However, the links between these companies and universities are weak.¹²⁵

Sweden has also no commercial solar cell production until 2008. However, Midsummer AB is producing solar cells on a research level and the company hopes to enter the market in the near future.¹²⁶

The photovoltaic industry in Germany consists of quiet more companies than in Sweden and the production capacity of leading companies in Germany is much bigger compared to the noticeable companies in Sweden. However, Sweden's PV industry in terms of solar cells and modules producer has grown rapidly in the last few years, which may increase investments in this sector in the near future.

5.5 The role of the government

In Porter's diamond model, the government has an interrelation to each of the determinants, which means that the government can have a great impact on the development of a particular industry. In this chapter, I will give a brief summary of the governmental strategies and goals in Germany and Sweden in the near future.

¹²⁴ Cf. Hultqvist, 2009, p. 23-24

¹²⁵ Cf. Sandèn, 2008, p. 12

¹²⁶ Cf. Hultqvist, 2009, p. 23

Dr. Norbert Röttgen, the Head of the Federal Environment Ministry, had emphasised that Germany will continue its investments in the photovoltaic sector, because solar energy is a market of the future. The aim is to expand the use of solar electricity so that photovoltaic will become a stronger energy source within the energy mix as today. Solar energy has the biggest potential for expansion compared to all other renewable energy sources and also a high potential of cost cutting.¹²⁷

That's why Germany is also focusing on the research about organic photovoltaic. The federal research ministry in Germany and some multinational companies introduced a programme to develop this new technology. The aim of this research programme is to develop lightweight and cost-efficient solar cells.¹²⁸

The government introduced a new renewable energy law that should on the one hand facilitate the expansion of solar energy and on the other hand reduce the subsidies.

The subsidies for photovoltaic have been pretty high in Germany and this lead to economic disincentives. Some goals of the new law are to increase the yearly expansion from 1.700 MW to 3.500 MW and to reduce the subsidies for photovoltaic roof systems by around 15 %.¹²⁹

The Swedish government has reduced extensive investments to existing technology and instead strengthen the development of new energy technology. The aims are to build large-scale renewable electricity production and the development of electricity networks. The wind power sector already produces on an industrial scale. The government will also support solar power among other renewable energy sources in order to reach this target.¹³⁰

¹²⁷ Cf. <http://www.erneuerbare-energien.de/inhalt/45706/4613/>

¹²⁸ Cf. http://www.bmbf.de/_search/searchresult.php?URL=http%3A%2F%2Fwww.bmbf.de%2Fpress%2F2084.php&QUERY=photovoltaik

¹²⁹ Cf. <http://www.erneuerbare-energien.de/inhalt/45707/4613/>

¹³⁰ Cf. <http://www.sweden.gov.se/sb/d/2031/a/120088>

Sandén (2008) pointed out that the support from the Swedish government to the photovoltaic sector was largely limited to research until 2005. Shortly afterwards, the government introduced a market deployment programme directed at PV systems on public buildings. This programme is supported by subsidies, which account for about EUR 16 million.¹³¹

The government, however, has not taken a clear position about official goals for solar cells. The Swedish government wants to focus on energy technologies that could have a large impact on the Swedish energy system to reach their target until 2020.¹³²

This statement is not a clear support for solar energy, respectively photovoltaic.

In July 2009, the Swedish government introduced a new financial support for the installation of solar cells and the interest of the people in making use of this state funding was greater than expected. The county administrative boards received more than 100 applications for a total amount of approximately SEK 100 million (~EUR 10 million) within the first week. This is twice as much as is allocated for 2009.

Birgitta Palmberger, Head of Department at the Swedish Energy Agency, said that the interest for solar cells can be seen as a big potential for solar energy in Sweden and it can help to create a market for grid-connected photovoltaic systems.

The financial support to solar cells was SEK 50 million (~EUR 5 million) in 2009 and for 2010 and 2011 between 50 and 60 million should be allocated to this sector.¹³³

One can see, that the governments of both countries are supporting solar energy in the future and create incentives for the photovoltaic industry and market.

However, Germany has a lot more experience in solar energy and it is one of the leading countries in the photovoltaic industry.

As Germany has an established market position in sector, the German government has more incentives to support this industry than the Swedish government.

¹³¹ Cf. Sandén, 2008, p. 2

¹³² Cf. Sandén, 2008, p. 14

¹³³ Cf. <http://www.energimyndigheten.se/en/Press/Press-releases/Great-interest-in-financial-support-to-solar-cells/>

6 Conclusion

In the conclusion part, I will summarize the differences between Germany and Sweden regarding each determinant of the diamond model. Besides, I will focus on the biggest differences of these two countries.

Germany has competitive advantage in terms of factor conditions compared to Sweden, because Germany invests more in R&D projects and more courses of studies in universities are related to photovoltaic or solar energy. However, Sweden has also an excellent level of technical education and some universities have already courses, which are related to photovoltaic.

According to demand conditions, Germany is also leading compared to Sweden, because the installed PV capacity is much higher. Sweden has also just a small grid connected PV system, because there are no incentives from the government to sell PV electricity to the grid.

However, Swedish people want to adopt this technology, because the interest of the people in making use of the subsidies for photovoltaic modules was greater than expected.

Germany has a big competitive advantage in terms of related and supporting industries and firm rivalry. Germany has already an established photovoltaic industry with many world-class companies. Furthermore, the supplying industry has also a leading position on a global-scale, whereas the Swedish supplying industry of photovoltaic cells and modules is in its early stage of development. Most of the suppliers are foreign companies and a lot of them are located in Germany.

According to the role of government, the government supports the photovoltaic sector in both countries. The German government has supported this industry far earlier than Sweden and therefore they have more experience with the incentive system of the photovoltaic industry.

One can see that Germany has competitive advantage in every determinant, but Sweden has established a good basis for developing the photovoltaic industry. The biggest difference, as I already mentioned before, is the supporting and related industry. As Germany has world-class companies in this sector of industry, Swedish companies should cooperate with these firms and Sweden can try to establish their own supplying industry.

The Swedish government should also try to get useful information (problems, pros & cons...) about the German incentive system introduced by the government. This information can be used to create incentives in order to stimulate the Swedish PV market and to support the PV industry.

To sum up, I can say that Sweden has the potential to become a competitive nation in the photovoltaic industry, because the country has good knowledge resources and education regarding this technology. Besides, the Swedish people show willingness to adopt this technology and the government try to support this industry.

Further research should be done to investigate Sweden's competitiveness in the photovoltaic industry to other important countries such as US, Japan, Spain, and, Italy.

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