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The Development of Green Industries in China and Its Implications for Developing Countries

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This thesis aims to investigate the different mechanisms that Chinese companies in green industries used to acquire technological capabilities and how they changed over time. The thesis also aims to examine how the geographical pattern in outbound Chinese greenfield foreign direct investment has changed over time. By examining the inbound and outbound greenfield foreign direct investment pattern in China and by performing case studies of several Chinese solar and wind power companies, several interesting conclusions were made. While the role of foreign direct investment as a mechanism to acquire capabilities remains inconclusive, the findings suggest that Chinese solar and wind companies used a dual focus of acquiring capabilities through both internal and external sources of knowledge and technology. Furthermore, as the companies became more technologically advanced, the mechanisms that were used to acquire capabilities from external sources evolved to require increasingly more effort and interaction with external actors. Moreover, the geographical pattern in outbound Chinese greenfield foreign direct investment in green industries shifted from flowing to high-income countries to middle-income countries, and particularly middle-income countries in Asia, around 2014. Based on the development in the solar and wind industries in China, several policies are suggested to the middle-income countries that received Chinese investment in solar and wind power.

Key words: green industries, developing countries, the Global South, technological capabilities, learning, economic catch-up, China

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1 Introduction

With climate change catching up to humanity, we are finally starting to see major attempts to reduce the impact that humanity has on our planet. The most prominent act, with 193 countries having adopted it, came from the United Nations which in 2015 proposed the 2030 Agenda for Sustainable Development which aims to achieve economic, social, and environmental development for all (United Nations, 2019a). Initiatives such as this are needed considering countries that completed an economic catch-up, such as South Korea and Singapore, and countries in the process of catching up, such as China and India, have dramatically increased their Carbon Dioxide emissions (The World Bank, 2019). If humanity's impact on our climate is to be contained, developing countries cannot follow the path to economic development that developed countries have. Therefore, the process of catching up through leapfrogging or skipping technologies that rely on fossil fuels will be crucial for developing countries.

Rather than following in the same footsteps as developed countries did, access to modern technologies to catch up may allow companies in developing countries to leapfrog some steps along the way. Considering that developing countries' technological capacity tends to be low and therefore may have to rely on accessing other countries' knowledge instead, the topic of knowledge and technology diffusion is key to understanding economic and environmental catch-up (Chaminade, Lundvall & Haneef, 2018). More specifically, emerging countries such as China and India have managed to catch up to developed countries in specific green industries by acquiring knowledge and technology from abroad while simultaneously upgrading internal technological capabilities (Fu & Zhang, 2011). However, there is relatively little research on the importance of different learning mechanisms at different levels of development, and there is even less research on how knowledge and technology can spread between developing countries.

By examining the greenfield foreign direct investment (FDI) flowing in and out of China in green industries and the development of key companies in the Chinese solar and wind industries, the thesis attempts two main objectives. First, to understand how the solar and wind industries developed in China, and what mechanisms were used to acquire knowledge and technology. Second, to examine how the geographical pattern of Chinese greenfield FDI in green industries has developed over time, and what lessons can be learned from the Chinese experience in terms of knowledge and technology acquirement for developing countries.

In sum, inbound FDI may have played a vital role in the development of Chinese green industries, but the results remain inconclusive. The case studies of the Chinese companies found that Chinese wind and solar companies used a dual focus on both internal and external learning to acquire capabilities. While internal learning was focused on in-house research and development (R&D), external learning evolved over time through different mechanisms that

required increasing levels of interaction with external actors. Finally, it was evident that Chinese greenfield FDI in green industries shifted focus around 2014 from flowing to high-income countries to middle-income countries, thus shedding light into the little researched area of how FDI flows between developing countries. Finally, based on the development of Chinese solar and wind power, policy advice are given to other developing countries.

1.1 Aim and Research Questions

The study has two main objectives. First, to examine the role that greenfield FDI and other mechanisms of acquiring capabilities have played in the development of Chinese green industries. Second, to investigate the evolution of the geographical pattern of outbound Chinese greenfield FDI in green industries. The research questions that the thesis attempts to answer are:

To what extent have Chinese companies used greenfield FDI and other mechanisms to learn and acquire technological capabilities in green industries?
and
How has the geographical pattern of outbound Chinese greenfield FDI in green industries developed over time?

The remainder of the thesis is structured as follows. Section two consists of a literature review of previous research on general aspects of learning, the role that FDI can play as a learning mechanism, how the role of emerging multinational companies has evolved over time, the literature that exists on knowledge diffusion between developing countries, and a description of how the Chinese solar and wind power industries developed. Section three and four describes the data and methods used in the thesis. Section five consists of an analysis of greenfield FDI data as well as case studies of Chinese solar and wind companies. Finally, section six consists of conclusions, policy advice, and potential avenues for future research.

2 Literature review and background

An overwhelming majority of the research on knowledge diffusion has been done by looking at knowledge flows between developed countries or between developed countries and developing countries. However, there is an evident lack of research on how knowledge flows between developing countries. Furthermore, while there has been much research on how technological capabilities are built in developing countries, there is a lack of information on the role that different mechanisms of learning play at different levels of technological capabilities (Bell and Figueiredo, 2012).

There are several different mechanisms of learning, which can lead to knowledge and technology diffusion. For example, technology and knowledge can be transferred by trading or licensing with other nations, and while it does require a certain level of technological capacity to be able to use different technologies, these mechanisms can also lead to learning by using reverse engineering or simply using the new technology (Chaminade, Lundvall & Haneef, 2018; Keller, 2004.; MacGarvie, 2006).

Another example of how knowledge can spread is through individuals such as students or professionals who go abroad or move to different companies. Furthermore, the concept of 'brain-drain' is often discussed as one of the major challenges for developing countries. However, Saxenian (2006) argues that it is possible to turn brain drain into brain circulation as emigrants from developing countries return to their origin countries if the right opportunities exist.

Fu, Pietrobelli and Soete (2011) found that companies take part in global value chains with the intent of acquiring and upgrading their capabilities by learning from customers. The authors also note that this approach can be particularly valuable for companies from developing countries since they have a hard time innovating themselves. However, FDI can also be used to acquire knowledge and technology. FDI as an approach to acquire capabilities is studied by either investigating investments flowing out of a country or into a country. For example, investments flowing out of the host country with the intent of acquiring capabilities is made by opening subsidiaries in other countries to gain access to their knowledge and technology (Almeida & Phene, 2004; Kafouros, Buckley & Clegg, 2012; Tallman & Phene, 2007).

Investments flowing into the host country may lead to spillovers of knowledge and technology via different interactions between a domestic company and foreign actors, such as formal and informal relationships between companies or employees (Barnard, Cowan, Arroyabe Arranz & Müller, 2015; Bertschek, 1995; Contractor, 2013). However, it should be noted that Fu, Pietrobelli, and Soete (2011) found that such spillovers are dependent on how well the institutional framework functions as well as whether the host country maintains its efforts to innovate themselves rather than relying on foreign innovative capacity.

The purpose of this literature review is to gain a greater understanding of the different dynamics involved with learning, particularly learning through FDI and more specifically in the context of developing countries (South-South linkages). To achieve this, the literature review will utilize the innovation studies literature to learn more about absorptive capacity, capability building, and how learning is done. Furthermore, the literature review will also focus on the international business literature on the internationalization of companies and FDI spillover effects. Finally, since there is such a significant gap in the literature on the topic of knowledge diffusion between developing countries, the literature review will extend the review to multiple groups of literature (international business, innovation studies, and development studies) to find information.

2.1 Interactive learning

The taxonomy of learning

The literature makes several distinctions between different kinds of knowledge and learning. There is a difference between codified and tacit knowledge where the former tends to be easier to transfer across space since it can easily be written down – such as information in a manual. Tacit knowledge, such as how to play an instrument, is sometimes referred to as "sticky" knowledge since it is harder to transfer across space because it is hard to write down or put into words (Lundvall & Johnson, 1994; Chaminade, Lundvall & Haneef, 2018).

Complementary to this distinction, there is a distinction to be made between experience-based learning and science-based learning. Science-based learning is based on "codified scientific and technical knowledge" with a focus on formal R&D while experience-based learning is based on "doing, using and interacting" (DUI) and is mainly attained by attempting to solve new problems and face-to-face interaction (Asheim & Gertler, 2006; Jensen, Johnson, Lorenz & Lundvall, p. 680, 2007).

The distinction between experience-based learning and science-based learning is especially useful when adopting a sectoral perspective (Malerba, 2002; Pavitt, 1984). Malerba (2005) describes the notion of a sectoral innovation system in which the processes of learning and innovation differs between different sectors depending on, for example, the technology, non-company organizations, knowledge base, and institutions that are relevant for a sector. For instance, he explains that the chemicals sector relies on large multinational companies' R&D efforts that utilize their economies of scale and complement their internal R&D with external knowledge. In contrast to this, he explains that the machine tools sector instead largely relies on more experience-based learning through apprenticeships and depend much less on science-based efforts to learn. This difference highlights the importance that different learning mechanisms play in various sectors.

It should also be mentioned that Jensen et al. (2007) found that companies that combine science-based and experience-based learning are more innovative and that the different forms

of learning are used with varying intensities in different companies. Furthermore, the authors note that both scholars and policymakers favor a focus on science-based learning.

This view is mirrored in Chaminade, Lundvall, and Haneef (2018) who argue that the bias towards science-based learning is especially problematic when investigating developing countries since they have less formal R&D activities in the business sector. It is argued that the problem may be born out of how hard it is to quantify experience-based learning, compared to science-based learning where there are a number of indicators such as spending on R&D, number of patents, education levels, etc. (Chaminade, Lundvall & Haneef, 2018; Jensen et al., 2007).

It is also essential to make the distinction between market-seeking investments and knowledge-seeking investments. Chaminade and Gómez (2016) categorize knowledge-seeking investments as investments in R&D or design, development, and testing (DDT). Moreover, as the name implies knowledge-seeking investments are made with the intent of learning, but market-seeking investments can also lead to learning via, for example, learning by doing, the mobility of labor, or interacting with other actors in a supply chain, (Bell & Figueiredo, 2012; Chaminade, Lundvall & Haneef, 2018; Fu, Pietrobelli & Soete, 2011; Hansen & Lema, 2019).

The final relatively common distinction that can be seen in the literature is between internal and external learning. Internal learning happens inside the companies, such as learning by doing on the job or communication within the company (Bell & Figueiredo, 2012). External (interactive) learning consists of learning from external sources and can take place in the local, national, or international setting, for example, by working with other companies or customers (Svetina & Prodan, 2008). Examples of different external learning mechanisms can be seen in table 1.

Table 1: Examples of internal and external learning mechanisms to acquire technological capabilities Source: Adapted from Hansen and Lema (2019)

Mechanisms of internal learning	**Mechanisms of external learning**
Apprenticeships	Collaboration and cooperation with actors outside the company (e.g. R&D collaborations with universities)
In-house R&D units	External training in other companies
In-house training programs	Informal imitation of competitors
Learning by doing/using (DUI)	Joint ventures
Learning through codified systems (e.g. manuals)	Licensing technology
Problem solving	Mergers and acquisitions
Specialised task forces and engineering teams	Recruitment of skilled individuals
Systematic data collection and feedback from users	Reverse engineering of imported products
Trial and error experimentation	Trade of capital goods and services
	User-producer interaction

Mechanisms of learning and its relationship with technological capabilities

It should be noted that while innovation is key to competing on the forefront of the global economy, the process for a company to achieve and improve their innovative capacity is a gradual and complex process of acquiring technological capabilities (Dutrénit, 2004; Dutrénit, Lee, Nelson, Soete & Vera-Cruz, 2013; Katz, 1987).

Acquiring technological capabilities is not automatic and actors that acquire new technology or knowledge has to be able to "identify, assimilate, and exploit" (Cohen & Levinthal, p. 569, 1989) that knowledge if it is to be used efficiently (Borensztein, Gregorio & Lee, 1998; Fu, Pietrobelli & Soete, 2011; Jennifer P. Poole, 2013). The ability of a company or country to make use of new knowledge and technology is often called absorptive capacity, which is a term that goes back to Cohen & Levinthal (1989). The absorptive capacity of a country or company is decided by several factors such as the level of human capital (Xu, 2000) and the institutional environment (Coe, Helpman & Hoffmaister, 2009).

Furthermore, Criscuolo and Narula (2008) argue that absorptive capacity is essential not only for countries that are in the process of catching up but also to developed countries. However, the authors continue noting that absorptive capacity will play a smaller role the closer the technological frontier a country is. They argue this since countries will increasingly have to rely on their ability to innovate due to the cumulative nature of learning and the increasing complexity copying more advanced external knowledge.

Similarly, a recent article by Hansen and Lema (2019) concluded that multinational companies make use of different learning mechanisms at different levels of technological capabilities, but the authors stress that different companies will have varying results with the same learning mechanism even if they are at the same level of technological capabilities. This is in line with Ramamurti's (2012) idea that other factors, such as country of origin, the global environment for internationalization, and what industry the company is active in all play a role in a company's internationalization strategy. Moreover, a study by Lema and Lema (2012) examined three green industries in China and India found that more traditional mechanisms of external learning such as trading capital goods, inbound FDI, and licensing technology were vital for the formation and take-off of the industries. However, the authors explain that traditional mechanisms became obsolete as companies' technological capabilities were upgraded and were instead replaced by more unconventional methods such as joint R&D and international R&D collaborations.

2.2 Interactive learning via internationalization

One of the ways that companies can learn from foreign companies is by making outbound investments to foreign countries, often referred to as internationalization. Internationalization is sometimes done with the specific intent of acquiring new or upgraded capabilities (Contractor, 2013). For example, a company from an emerging economy can internationalize

by making an acquisition of a foreign company from a developed economy to acquire and learn about their technology or other capabilities.

The literature in international business previously had a more or less set pattern in which a company internationalizes, often referred to as the Uppsala internationalization model or the stages model of internationalization (Johanson & Vahlne, 1977). The model predicts that companies first internationalize to countries that are similar to the home country and then gradually to countries that are less similar to the home country. Rather than following in the footsteps of multinational companies from developed countries which had mainly followed the Uppsala model, many multinational companies from emerging economies instead did the opposite: internationalizing to distant and very different countries and only after doing so did they go to countries that were more similar to themselves (Ramamurti, 2012).

There are different proposed explanations to why companies from developing countries are not following the Uppsala model. For example, it might be the case that multinational companies are used to poor institutional environments and are therefore more pragmatic, enabling them to internationalize further away (Contractor, 2013; Cuervo-Cazurra & Genc, 2008; Ghemawat & Khanna, 1998; Khanna & Palepu, 2006). Another example comes from Mathews (2006), who argues that companies that internationalized earlier had to rely on the company's own ability to create connections whereas newcomers during recent decades can internationalize much easier since they can tap into global value chains and networks that were put in place by the earlier multinational companies.

There are also different explanations of why companies from developing countries internationalize. Many authors argue that they internationalize with a knowledge-seeking intent to acquire capabilities that they lack rather than going there with a market-seeking intent (Awate, Larsen & Mudambi, 2015; Cui, Meyer & Hu, 2014; Deng, 2009; Madhok & Keyhani, 2012; Mathews, 2006). In contrast to this, Ramamurti (2012) argues that while these companies might go abroad with a knowledge-seeking intent, it is unlikely that they do so without having other advantages that allow them to compete internationally. Furthermore, he argues that the internationalization of these companies might be knowledge-seeking but that their ultimate goal is to commercialize their new capabilities in their home countries rather than in other countries. However, if a company manages to internationalize and bring back better technology to utilize in their home countries, they could at a later stage go abroad again with upgraded capabilities only this time with a market-seeking intent (Ramamurti, 2012).

Also somewhat at odds with the popular explanation that companies from emerging countries internationalize to acquire missing capabilities, Minin and Zhang (2010) found that while Chinese multinational companies internationalized to Europe with a knowledge-seeking intent, they also found evidence that companies set up R&D facilities to adapt technologies to the European market rather than solely focusing on learning.

Additionally, there is a discussion on how companies determine where to internationalize. Bas and Sierra (2002) found that the strengths of both the host and the home country were important in companies' decisions on where to internationalize for R&D purposes. Similarly, the study by Demirbag and Glaister (2010) found that, at the regional level, the home and host country's conditions played a significant role in determining where companies

internationalized. On the company level, the authors found that experience with R&D projects outside of the home country and experience in the host country were crucial variables in determining where to internationalize.

2.3 Interactive learning via FDI spillovers

The story so far has been one where companies from emerging economies acquire capabilities by internationalizing into developed economies. However, FDI flowing into a country can also have a role in knowledge diffusion. While some authors argue that inbound FDI does not facilitate technology diffusion and may even harm domestic companies (Aitken & Harrison, 1999; Chang, Chen & McAleer, 2013; Fu & Zhang, 2011; Lichtenberg & de la Potterie, 1996), many authors argue that FDI can lead to positive spillovers to domestic companies (Xu, 2000; He & Mu, 2012; Jennifer P. Poole, 2013; Meyer, 2004).

Negative spillovers from FDI can, for example, come in the form of investing companies taking market shares from domestic companies and thereby reducing the productivity of domestic companies (Aitken & Harrison, 1999). According to Meyer (2004), the literature has found that inbound FDI mainly leads to knowledge diffusion in two ways. First, the demonstration effect, which can occur if a company in the recipient country sees a new product or form of organization being adapted to the local context and then imitates what they see. Second, knowledge can be diffused through the movement of employees, for example, by the investing company training local employees, or skilled individuals moving to other companies and thereby bringing the employee's tacit knowledge to the new company. Finally, Meyer (2004) emphasizes that the level of absorptive capacity in companies plays a crucial role in knowledge and technology diffusion.

Similarly, Xu (2000) found that for knowledge and technology spillovers from FDI to benefit a country, the country needs to be at a level of human capital that allows for workers to utilize the knowledge or technology. Similarly, He and Mu (2012) found that Chinese companies in the telecommunication equipment industry and the automobile industry will benefit from increasing their efforts in absorbing and integrating foreign acquired technology. Furthermore, when examining the Chinese telecommunication equipment industry, Fan (2006) found that companies needed to focus on developing their ability to innovate from the beginning if they wished to compete on the domestic market in China.

This is in contrast with Kim's (1980) approach, which argues that the development of technological capabilities for emerging economies follows three stages. First, the acquisition of foreign technology, followed by assimilation of that technology, and finally, the improvement of that technology. However, Jin and von Zedtwitz (2008) found that Kim's (1980) model did not always hold for Chinese companies and instead expanded the model by noting that the different stages can occur simultaneously and they also added a fourth stage in which the technology becomes outdated.

It should not be forgotten that investments do not occur in a vacuum but are affected by the environment where the investment is made. Contractor (2013) argues that state support has

played a vital role for multinational companies from some countries such as Russia and China, while it has not been important for other emerging economies, such as India. Several authors have found that state intervention was vital in attracting technology, knowledge, and investment from other countries and therefore a key component in the success of several Chinese industries (Contractor, 2013; He & Mu, 2012; Mu & Lee, 2005) and particularly in green industries (Fu & Zhang, 2011; Lema & Ruby, 2007; Lewis, 2011; Tan, 2010).

2.4 The role of emerging multinationals

The role of multinational companies from emerging economies has changed drastically during recent decades. Contractor (2013) explains that during the early 1990s, most multinational companies from emerging economies barely had any competitive advantages except for the protection offered to them by their respective governments. However, the story today is very different.

Today, many companies from emerging economies can compete against multinational enterprises even from developed economies despite lacking the institutional, technological, and economic capabilities that companies from developed economies often have (Khanna and Palepu, 2006; Cuervo-Cazurra and Genc, 2008; Ramamurti, 2012). Furthermore, the competition that multinational companies from emerging economies are subject to also force them to learn and become more efficient or be outmatched by their competitors (He & Mu, 2012; Xu, 2000). An example of their prominence can be seen in the fact that, in the period from 2003 to 2013, China and India attracted the highest amount of greenfield investments in R&D and DDT out of any country in the world (Castellani & Castelli, 2013).

Several explanations have been proposed in attempts to understand the success of multinational enterprises from developing countries. However, according to Ramamurti (2012), there is no consensus on why these companies can compete with world leaders.

One example of an argument to why these companies are successful is that they become successful by exploiting the comparative advantages of their home country, such as low wages or their access to natural resources (Aulakh, Kotabe & Teegen, 2000). Contractor (2013) argues that while lower wages definitely is a competitive advantage for emerging economies – and increasingly so in some cases, as educated workers in emerging economies are rivaling their counterparts from developed economies. However, he continues explaining that this argument does not always hold considering, for example, that greater worker efficiency due to technology can enable companies to compete without relying on cheap labor.

Another proposed explanation for the success of multinational companies from emerging economies is that companies from emerging countries do have competitive advantages, only that they are different from the advantages that companies from developed countries have. For example, rather than having superior technology or a globally recognized brand, companies

might have more knowledge about customers in emerging economies, have access to cheap capital, or be more pragmatic and work well under different institutional circumstances because of their experience in poor business environments (Contractor, 2013; Cuervo-Cazurra & Genc, 2008; Ghemawat & Khanna, 1998; Khanna & Palepu, 2006).

This resonates with Mathews' (2006) findings which explains that rather than following the traditional view of globalization in which a few large global companies control large parts of the global economy, global incumbent companies are having trouble maintaining their dominant position against the more nimble and pragmatic newcomers in the rapidly changing global economy.

2.5 FDI between developing countries (South-South)

As mentioned previously, there is an apparent lack of research on knowledge diffusion between developing countries. One possible explanation for this is that developing countries utilize science-based learning less and instead favor experience-based learning, which is hard to quantify (Chaminade, Lundvall & Haneef, 2018).[1] However, there are a few studies that have tried to fill this gap in the literature.

Amighini & Sanfilippo (2014) found that the smaller technological gap and similar production capabilities between developing countries in Africa – compared to the gap between developed and developing countries – promoted greater diversification in important low-technology industries and also led to improved quality on export goods.

Similarly, Harirchi and Chaminade (2014) found that user-producer interactions across borders led to greater novelty in innovations, and this was especially true for user-producer interactions between developing countries compared to interactions between developed and developing countries. This is in line with Chaminade and Gómez's (2016) suggestion that innovations from developing countries may be better suited for other developing countries compared to innovations from developed countries.

Using the fDi Markets database on greenfield investments with data from 2003 to 2014, Chaminade and Gómez (2016) found several interesting observations. First, they found that technology-driven investment (investments in R&D, DDT, technology support centers, ICT, and infrastructure) between developing countries were rare but increased over the period. Second, this increase was mainly due to investments in ICT flowing within the same world region. Third, the investments were mainly made by a few actors who are active in developing countries. Fourth, India and China attracted the most technology-driven FDI, and they were also the most important investors to other developing countries. Finally, the

[1] A possible but unconfirmed explanation is that authors from developing countries with more real-life experience are writing on this topic but that their research is not being recognized.

outbound investments from China and India were mainly in DDT, which suggests that they were done with the intent of adapting technologies to markets in developing countries.

The remaining section in the literature review will give background information on the development of the solar and wind power industries in China. Particular attention will be given to these industries in the empirical analysis, and they were chosen for two reasons. First, the solar and wind industries attracted the highest amount of outbound Chinese greenfield FDI out of all green industries. Second, solar and wind power are two of the most developed green industries in China. Using data from well-developed industries will allow for a clearer picture of the impact that different mechanisms of acquiring capabilities have had since more developed industries are likely to have used different mechanisms of acquiring technological capabilities (Lema & Lema, 2012).

2.6 Chinese FDI in green technologies

2.6.1 Solar power

Solar power technology is usually divided into solar photovoltaics (solar PV) and solar water heaters. Although the solar water heater technology is widely used in some areas of the world, and in particular China, the solar PV technology is becoming increasingly cheaper and is also the target for most investments and interest. Furthermore, a large majority of the investments in the fDiMarkets database was from companies whose websites indicated that they only sold solar PV panels while few companies sold solar water heaters as well. Therefore, this section will focus on the solar PV industry.

The Chinese solar power industry has undergone rapid progress in recent times, going from focusing on relatively simple solar consumer goods like garden lamps during the 1990s to now having several companies among the global top 10 solar power companies in the world (Fu & Zhang, 2011). Chinese companies managed to enter the solar industry by making use of their relatively low costs of production and when the two companies Suntech Power and Yingli Solar started their production of solar PV during the 2000s, the Chinese production grew at a much faster pace compared to global levels (Fu & Zhang, 2011; Marigo, 2007). The Chinese market share in the global solar industry continued to grow, accounting for 32,7% in 2008 and 38% in 2009, making China the country with the largest annual production of solar PV cells (EurObserv'ER, 2010). However, the vast majority of the production went to exports and in 2008 China's global share of installed solar power was very modest but has since drastically improved, which can be seen by the fact that China installed 53.3% of the world's solar capacity in 2017 (Fu & Zhang, 2011; SolarPower Europe, 2018).

According to Fu and Zhang (2011), the explosive growth in installations was produced by two reasons. First, it became increasingly apparent to the Chinese government that a high reliance on foreign markets would become increasingly problematic with time. Second, the Chinese government raised its goals to reduce the impact of climate change after the 2009 United

Nation's climate conference in Copenhagen, and for the goals to be achieved, Solar power would have to be a big part of China's energy supply.

Lema and Lema (2012) explain that all of the large companies in the Chinese solar power industry are R&D intensive but that licensing technologies from foreign countries was initially very important and continues to play a role. Adding to this, Fu and Zhang (2011) conclude that while licensing played an important role, the large solar power companies also put substantial efforts into assimilating and adapting foreign technologies to fit their technological capabilities. This indicates that developing countries may not only need to acquire technology and knowledge from abroad, but they might also have to be able to tweak and adapt any acquired technologies.

Furthermore, inbound FDI was initially not important for the solar industry but had increasing importance during the catch-up process while unconventional technology transfer mechanisms (e.g., foreign acquisitions, joint R&D, and overseas R&D) also played a larger role as the industry developed (Lema & Lema, 2012). Moreover, Fu and Zhang (2011) explain that the links between the solar power industry and universities and research institutions have also been key in the industry's success. Furthermore, they note that as the Chinese industry has developed, collaborations both on the national and international level has become increasingly important.

2.6.2 Wind power

Similar to the solar power industry in China, the wind power industry has also experienced rapid growth. This is especially impressive considering that the wind turbine industry is much more technology intensive than the solar PV industry. The Chinese wind power sector began in 1986 with three imported wind turbines capable of producing 55 kW each (Zhengming, Qingyi & Xing, 1999). The focus was on improving basic conditions for the sector, and the overall growth of the Chinese wind power industry was low during the initial period due to inefficient and conflicting policies (Lema and Ruby, 2007).

Lema and Ruby (2007) note that from 1994 to 1999, the growing recognition of the negative effects the burning of fossil fuels has on both the environment and human health led to increased efforts by the Chinese state to upgrade their renewable energy system. The Chinese government successfully attracted funds from organizations such as the World Bank and the United Nations while countries such as Denmark, Japan, and the US were crucial in the transfer of important technology, knowledge, and funds (Goldwind, 2019a; Lema & Ruby, 2007). While the Chinese domestic wind power capacity increased substantially during the period, there was still a lack of state capacity and coordination between state actors which made it hard for the manufacturing industry to develop and imports continued to be important in the Chinese wind industry (Lema & Ruby, 2007; Lew, 2000).

While the Chinese wind industry had relied on foreign technology, it started domestic production of wind turbines in 1997 which was made possible by research efforts by companies which had invested in R&D and adapted wind turbines to the Chinese environment and technological capabilities (Goldwind, 2019a). Furthermore, Lema and Ruby (2007)

explain that from 2000 to 2006, changes were made in the organizational structure of the Chinese bureaucracy in the power sector which allowed for the creation of an incentive structure and regulations which led to a reduction in the price of wind power generated electricity. To complement this, the leading Chinese wind power companies acquired European technology through licensing technology, allowing them to further improve their capabilities (Lema, Berger & Song, 2011). Furthermore, the large market in China improved Chinese companies' bargaining power in attempts to trade technology for market access when negotiating collaborations with foreign companies (Hansen & Lema, 2019).

The organizational changes also attracted more FDI (with conditions on a gradually rising local content requirement) which was vital in building up the Chinese wind manufacturing industry – reducing the need to pay for expensive transport prices of imports – and the wind power sector in general (Lema & Ruby, 2007; Lema & Lema, 2012).

As the technological capabilities of the Chinese companies developed, the licensing relationships continued, but they also developed into a relationship in which both parties were involved in the development of new products (Lema, Berger & Song, 2011). That said, it should be noted that most of the Chinese companies in the industry have not reached the frontier when it comes to technological capabilities (Zhou, Li, Lema & Urban, 2016).

Hansen and Lema (2019) explain that as more time passed, the high levels of growth allowed for large investments in in-house R&D for some of the largest companies which eventually allowed them to reduce their reliance on the licenses from abroad and instead develop their own designs. They continue explaining that the R&D efforts were then complemented through mostly unconventional methods of acquiring technology, such as foreign acquisitions and internationalizing R&D to developed countries.

The largest Chinese wind companies have played a key role in diffusing and re-innovating the wind power technology in China (Tan, 2010). Furthermore, since Chinese companies do not themselves produce most of the components they use and instead rely on other companies to do so which means that the value chain in the wind power industry plays a more significant role in the Chinese wind industry compared to the European (Lema, Berger & Song, 2011).

During more recent years, government policies have continued to be key in the development of the wind and other renewable energy sectors, devoting increasing attention to international projects under the One Belt, One Road initiative (Goldwind, 2017).

Overall, this thesis will attempt to fill the literature gap about the importance of different mechanisms of learning and how they develop over time as well as how knowledge diffuses between developing countries. To fill this gap, the two previously mentioned research questions will be used as guidelines for the thesis. The research questions are:

To what extent have Chinese companies used greenfield FDI and other mechanisms to learn and acquire technological capabilities in green industries?

and

How has the geographical pattern of outbound Chinese greenfield FDI in green industries developed over time?

3 Data

The thesis will use three data sources: fDiMarkets, annual reports, and online information in the form of company websites and articles.

3.1 fDiMarkets

The thesis will be using the fDi Markets dataset.[2] It is a database which tracks greenfield FDI and is created by the Financial Times.[3] It is used by different governments, multinationals, academic organizations, and global organizations such the United Nations which used it in the development of their annual World Investment Report (fDi Markets, 2019; United Nations, 2019b)

Examples of the variables that fDiMarkets track are: project date, name of investing company and parent company, destination and origin country, cluster, what industry and sub-sector the investment is going into, and size of the investment. The key variables for this thesis are project date, investing company, parent company, source country, destination country, sub-sector, size of the investment, and industry activity.

The database started in 2003 and is still ongoing. Their data comes from the Financial Times newswires and internal sources, thousands of media sources, data from industry organizations and agencies dealing with investments, and data from companies working in publication and market research (fDi Markets, 2019). Since the dataset is based on these kinds of sources rather than on data from national government agencies, there may be investments that are missed in the process of collecting the data (United Nations, 2019b).

The database collects data based on the announcements of investments rather than when the investment is made which means the dataset may contain some investments that are simply intentions of data rather than actual investments (United Nations, 2019b). Finally, some companies do not give information on the size of their investment, and fDiMarkets instead uses an econometric model to make estimations on the size of the investment (fDi Markets, 2019).

Similar databases, such as the ones from UNCTAD and the OECD account for all cross-border investments that are recorded. However, the fDi Markets database gives more detailed

[2] The fDi Markets database website can be found here: https://www.fdimarkets.com/

[3] Greenfield investments are investments that build new facilities and stands in contrast to brownfield investments which are investments in an already existing facility.

information about the investments compared to other datasets and is therefore the better choice for this thesis (United Nations, 2019b).

3.2 Annual reports and company websites

Annual reports are reports on the activities that a company has been involved in throughout a year. Examining annual reports of companies will allow for insight into the development of the companies. Furthermore, while the annual reports are audited by independent actors, companies still have an incentive to look as good as possible in the annual reports to attract more investment and keep current investors interested.

Company websites usually provide information on the history and activities of a company. However, companies also have an incentive to make themselves look as good as possible on these websites. Because of this, information that is found from company websites will be confirmed using different articles.

4 Methods

The approach in this thesis is split into three stages. First, a quantitative overview of Chinese greenfield FDI in green industries from 2003 to 2018. Green industries will be identified as investments in the cluster of environmental technologies in fDiMarkets. Second, using the same data as in stage one, stage two will examine more closely the greenfield FDI pattern in the Chinese solar and wind power industries. The third section will consist of case studies of Chinese solar and wind companies to examine whether the results from stage two can be confirmed and what mechanisms were used to acquire capabilities and how they changed over time. The data used in the third section will be annual reports and the websites of the companies.

A case study is a qualitative approach which involves a more in-depth exploration of a topic over time (Creswell, 2014). As the case study will use several different annual reports for each company, it should enable the thesis to gain insight into the different mechanisms of capability acquisition that the companies have used and how they changed over time.

4.1 The three stages of the method

4.1.1 An overview of Chinese greenfield FDI in green industries

The first stage will utilize the fDiMarkets database on greenfield FDI from 2003 to 2018 to examine whether there are patterns in the data that suggest that FDI has been important in the development of Chinese green industries. The analysis will be looking at the overall inbound and outbound FDI pattern, but also at the pattern of knowledge-seeking FDI. Following the work of Chaminade and Gómez (2016), investments in the industry activity of R&D or DDT will be considered knowledge-seeking investments. However, investments in industry activities that are clearly knowledge-seeking (e.g., education and training) will also be regarded as knowledge-seeking.

The outbound Chinese greenfield investments in green industries consist of 515 investments, adding up to a total of 79820 million USD. There were 426 recorded inbound Chinese greenfield investments in green industries which added up to 30267 million USD.

It is worth noting that the dataset shows no outbound FDI from China in green industries until 2006 despite covering the period from 2003 to 2018. It is possible that the dataset is missing outbound investments in green industries before 2006. It is also possible that Chinese

companies relied on exports rather than investments before 2006, however, it is expected that there would be at least some outbound greenfield FDI between 2003 and 2005.

4.1.2 The Chinese solar and wind power industries

The second stage will also use data on greenfield FDI from 2003 to 2018 from the fDiMarkets database. This stage will attempt to more closely examine the solar and wind industries to investigate whether there is a greenfield FDI pattern that suggests that greenfield FDI has been important in the development of the technologies at the sectoral level. It will first examine the outbound and inbound greenfield FDI pattern across time and income groups. The countries will be split into the income groups of high-income, upper-middle-income, lower-middle-income, and low-income countries according to the World Bank's lending group categorization from 2019 which is based on the gross national income of the countries.[4] The analysis will also examine whether there is a concentration in the outbound knowledge-seeking FDI across time. A concentration of outbound knowledge-seeking FDI around a specific period suggests that it was an important mechanism of acquiring knowledge during that period.

About 79% of the outbound Chinese greenfield investments in all other electrical equipment and components were done by companies that manufacture components used in solar power, such as wafers and crystalline silicone. The percentage for inbound investments was 88%. The investments in all other electrical equipment and components that are directly related to solar power will be included in the analysis of the solar power industry.

Whether the investment is directly related to solar is determined by examining the investing company's website to see if they produce components to solar panels. If the company also sells components that are not related to solar cells, the company website and online articles will be examined to see if information on the specific investment can be found to determine whether the investment was related to solar or not. If no such information is found, the investment will not be included in the analysis in the second stage. The same process was done for investments in engines and turbines since almost every investment in engines and turbines was directly related to wind power.

There were 86 outbound investments in solar power which added up to 23686 million USD while there were 209 investments in all other electrical equipment and components related to solar which added up to 6902 million USD. There were 25 inbound greenfield investments in solar power which amounted to 2766 million USD and 57 investments which added up to 3347 million USD in all other electrical equipment and components related to solar power.

There were 22 inbound investments in wind power in the recorded period, and they added up to 2782 million USD. There were 42 inbound investments in engines and turbines that were related to wind power, and they added up to 3011 million USD. There were 27 outbound

[4] The lending groups can be found here: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

investments in wind power and they added up to 9499 million USD while there were 28 outbound investments in engines and turbines which added up to 903 million USD.

4.1.3 Case studies of Chinese solar and wind companies

The third stage will be using annual reports to perform case studies of two to three companies in the Chinese solar and wind industries. The focus of the case studies will be to examine whether the results from the second stage can be seen in the companies as well. The case studies will also investigate what other mechanisms the companies used to acquire knowledge and technology and how they developed over time. Additionally, the case studies will give a summary of the history of the companies that were chosen. The data from fDiMarkets on the specific companies will then be used to see whether additional information can be added to the case study.

Performing a case study such as this should allow the thesis to identify specific investments, projects, or events that have led to the companies acquiring new technology or knowledge and should therefore be a good method to answer the question of when and how FDI and other mechanisms were used to acquire technological capabilities.

The companies will be chosen based on how many investments and the sum of these investments that are available in fDiMarkets. If any of the selected companies do not have their annual reports available online, its website and other articles will be used to gather information on its history. In this case, academic and news articles will be used to confirm the information on the website to give the most accurate representation possible of the company. If there is still a lack of information on the company, another company will be picked for the case study.

Examining the Chinese greenfield FDI pattern in the first two stages should enable the thesis to find a suggestion of what role greenfield FDI has played in upgrading the technological capabilities of Chinese companies in green industries. However, since FDI does not automatically lead to spillovers, examining the greenfield FDI pattern can only lead to a suggestion of the role that it has played in the development of green industries in China. Therefore, stage one and two will be complemented with the case studies in stage three to see whether they reach similar conclusions.

4.2 Limitations

While the thesis uses both quantitative and qualitative approaches, the thesis is descriptive and cannot infer causality. It instead tries to triangulate different data (fDiMarkets and annual reports/websites) to find a conclusion. Furthermore, the thesis uses secondary data. Had

primary data on FDI spillovers been collected from different Chinese companies in green industries, the thesis may have been able to infer causality through the use of correlation analysis.

Internal validity is problematic in this thesis, considering that inbound FDI does not automatically lead to learning. However, as mentioned previously, the case studies will be used to complement the analysis of the fDiMarkets data to counteract these problems.

The results from stage two can likely not be generalized to other technologies as different technologies operate under different circumstances and environments. However, it is possible that the results of stage three can be partly generalized to the wind and solar industries in other developing countries. The results should still be contextualized to any environment in which they are used. For example, the Indian wind industry does not operate under the same circumstances as the Chinese wind industry does.

Since the companies for the case studies will be chosen based on how many and how large investments they have made, it will likely be the larger and most successful companies that are examined in the case studies as they tend to have more access to capital and therefore make more investments. However, more mature companies are more likely to have used different mechanisms of acquiring knowledge and technology and are therefore more likely to give insight into the development of when the different mechanisms are used (Lema & Lema, 2012). Finally, since larger and more developed companies tend to use more unconventional mechanisms of knowledge and technology transfer which use more interaction between the company and other actors (Lema & Lema, 2012), it may be that the focus on larger companies gives more importance to unconventional mechanisms than what the majority of companies do.

4.3 The categorization of countries

Throughout recent history, many terms have been used to categorize countries according to their economic and political development. Some of the most common categorizations are first, second, and third-world countries; developing and developed countries; donor and recipient countries; and the Global North and Global South. It used to be the case that there was more or less a consensus on using developing and developed countries in the literature, but with time the differences between countries grew to create a wide range of countries with different characteristics. This sparked a debate which highlighted the drawbacks of different categorizations and has, in turn, led to an increasing number of categorizations being used in the literature (Harris, Moore & Schmitz, 2009). The debate has led to categorizations of countries ranging from the share of the population that has digital access to determining a country's purchasing-power parity using the price of a Big Mac.

This thesis will use the terms developing and developed countries, where developed countries are classified as high-income countries and developing countries are classified as upper-

middle, lower-middle, and low-income countries according to the World Bank's lending groups from 2019. However, the empirical analysis will use the World Bank's lending groups to provide some nuance between different developing countries.

5 Empirical Analysis

5.1 Results

5.1.1 An overview of Chinese greenfield FDI in green industries

Figure 1 shows the size of investments flowing into China from January 2003 to October 2018, and Figure 2 shows the same for outbound investments. Furthermore, the dataset shows no recorded outbound investment in these technologies before 2006, while the data on inbound investments start in 2003.

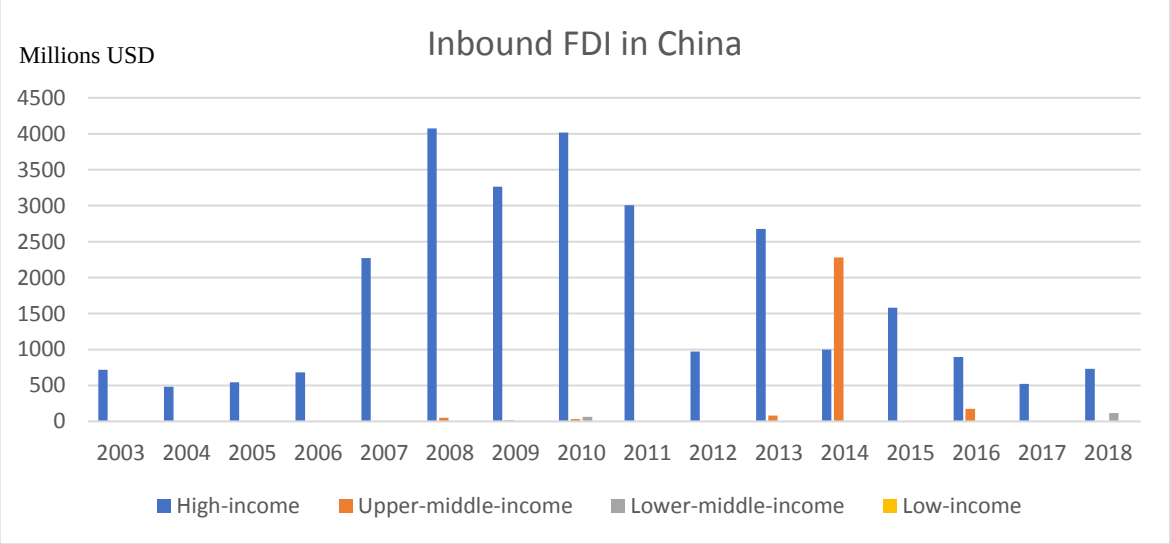

Figure 1: Inbound Chinese greenfield FDI by income group 2003-2018
Source: Own elaboration based on fDiMarkets (2019b)

About 91% of the total sum of the inbound investments came from high-income countries, and the remaining 9% came from mainly Malaysia and a small fraction from India. About 55% of the total sum of the outbound investments went to developing countries in Asia, and 63% went to Asia if you add the investments in high-income Asian countries including Oceania. There was a particularly large flow of investment into Indonesia, India, Pakistan, Kazakhstan, Laos, and Malaysia among the developing countries that received Chinese investments. 18% went to Europe, 7% to North America, 6% to North Africa, 4% to South America and the Caribbean, and 2% to Sub-Saharan Africa.

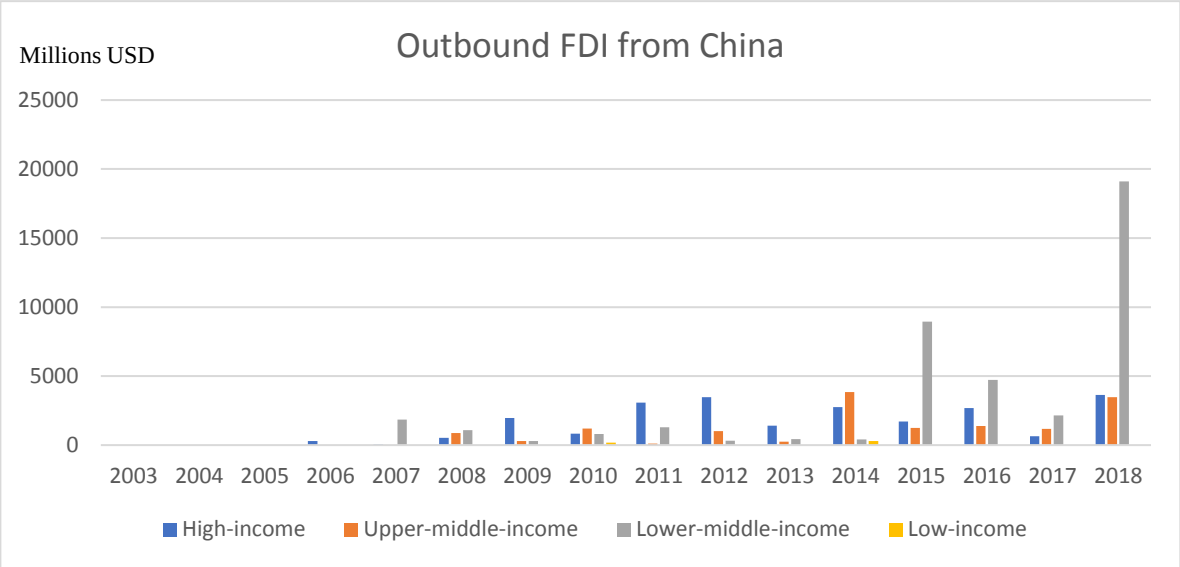

Figure 2: Outbound Chinese greenfield FDI by income group 2003-2018
Source: Own elaboration based on fDiMarkets (2019b)

Although the scale is different in the two graphs, there is a pattern of inbound investments increasing from around 2006 and then slowing down after 2014. In contrast to this, Figure 2 shows that outbound investments, while initially low, increased starting in 2006 and a sharp increase can be seen beginning in 2013. The dramatic increase in 2018 is due to a single investment of 17800 million USD investment in hydropower in Indonesia. The pattern suggests that FDI spillovers may have benefited the Chinese industries from 2006 to 2014 and that the capabilities that Chinese companies acquired through FDI spillovers were then utilized from 2013 to 2018.

As mentioned previously, knowledge-seeking investments are usually split into R&D and DDT. R&D is normally referred to as basic research or research with the intent of expanding the existing knowledge-base to come up with new products. DDT, on the other hand, is typically considered as applied research, meaning it is performed to solve specific problems. It should also be noted that while knowledge-seeking investments are considered to be more likely to lead to learning, there is no guarantee that they will be successful.

Furthermore, if knowledge diffusion is to occur between foreign companies and Chinese companies, some connection or relationship between the two has to exist (Contractor, 2013). For example, a foreign company that sets up an R&D location in China may employ Chinese employees who acquire knowledge in this employment and a Chinese company may at some point poach this employee, successfully acquiring the knowledge that the employee had (Contractor, 2013).

Out of the 515 recorded outbound investments, only 28 were knowledge-seeking. The outbound knowledge-seeking investments added up to 691 million USD or 0.9% of all outbound investment. They all went to high-income countries, except for one who went into South Africa. There were 426 recorded inbound greenfield investments and 30 of these were knowledge-seeking and they added up to 1147 million USD.

The inbound knowledge-seeking investments were evenly split between R&D and DDT, but there were also two investments in education and training. Furthermore, six of the investments were co-locations. A co-location entails that the investments were partnerships between two companies and likely led to knowledge spillovers between the co-locating companies. The inbound knowledge-seeking investments all came from high-income countries. The flow of knowledge-seeking investments can be seen in figure 3.

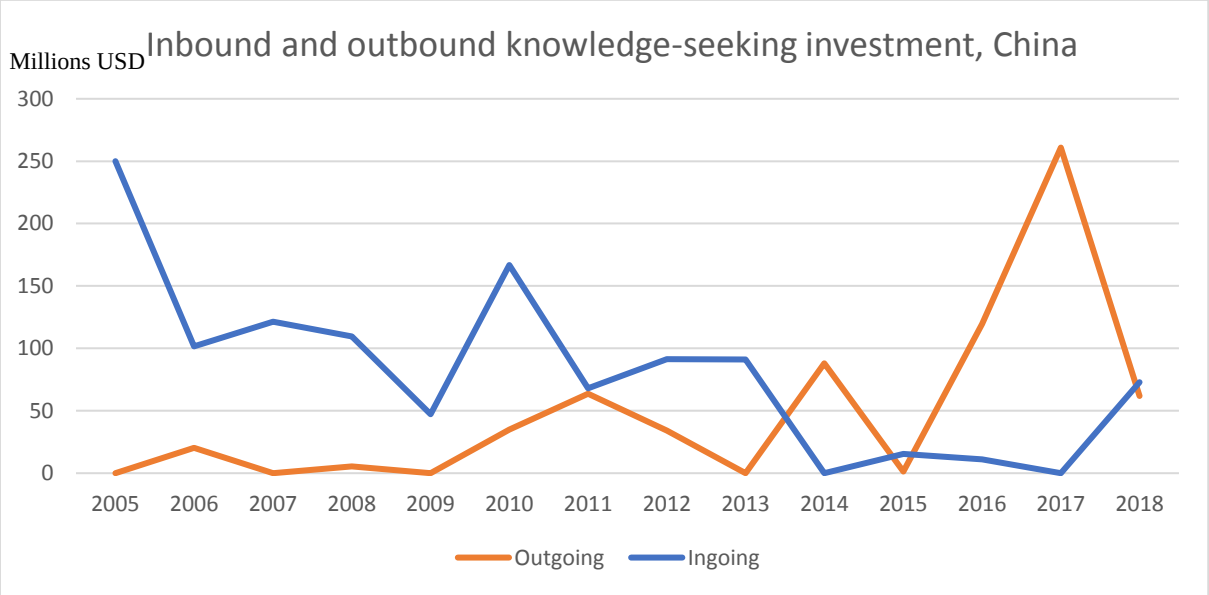

Figure 3: Inbound and outbound Chinese knowledge-seeking greenfield FDI 2003-2018
Source: Own elaboration based on fDiMarkets (2019b)

87% of the sum of outbound knowledge-seeking investments were in DDT, 12% in R&D, and the remaining 1% in education and training. All of the outbound knowledge-seeking investments were in high-income countries except for one investment in education and training, which went to South Africa. The focus on DDT or applied research suggests that Chinese companies made knowledge-seeking investments mainly to adopt or change existing products to new conditions rather than to come up with new technologies. Overall, the knowledge-seeking investments seem to follow a pattern similar to that in figure 1 and 2.

5.1.2 The Chinese solar power industry

As previously mentioned, a majority of FDI in all other electrical equipment and components (EEC) were directly related to solar power and these investments have been included in this sector. Figure 4 shows the inbound FDI in EEC, and figure 5 shows inbound FDI in solar power. All of the investments came from high-income countries.

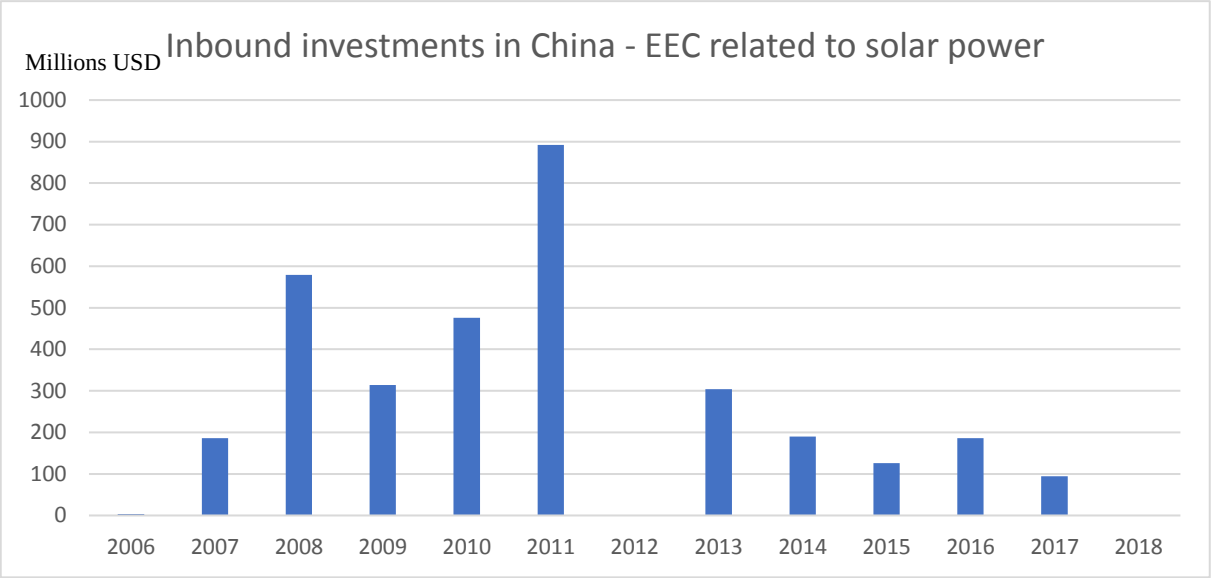

Figure 4: Inbound Chinese greenfield FDI in all other electrical equipment and components 2003-2018
Source: Own elaboration based on fDiMarkets (2019b)

The pattern in figure 4 shows that the majority of FDI in EEC was made from 2007 to 2011. After 2011, the flow slowed down considerably. Figure 5 instead indicates a stream of FDI that is mainly located in the years after 2011. This pattern suggests that FDI spillovers may have been important in building capabilities in the Chinese solar industry from 2007 and throughout the rest of the period. This is in line with Lema and Lema (2012) who found that inbound FDI was beginning to gain importance in the late 2010s.

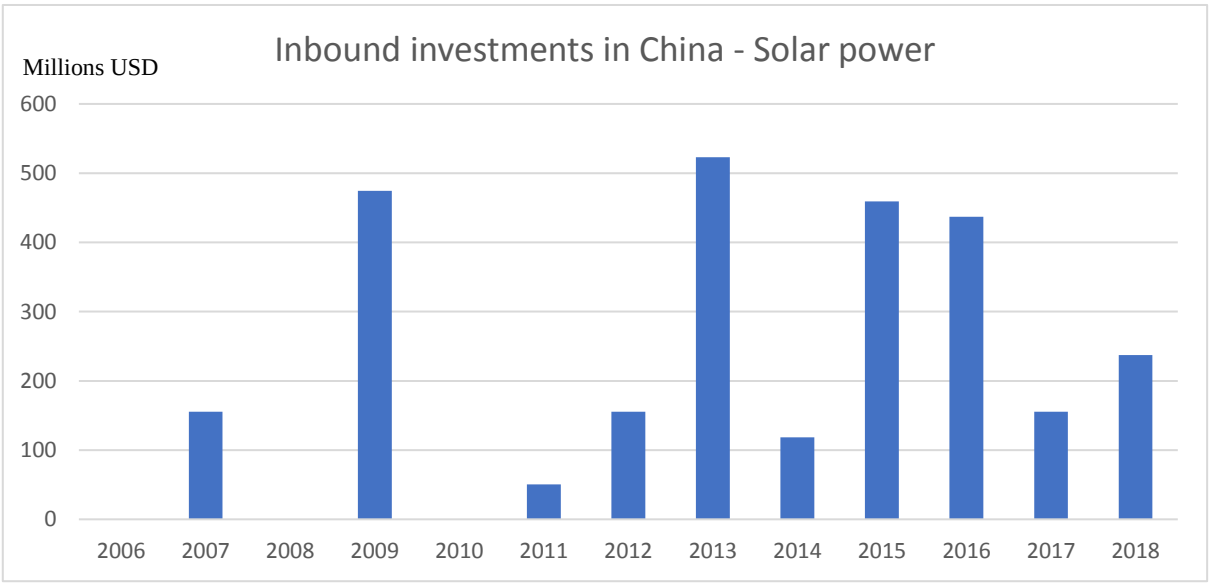

Figure 5: Inbound Chinese greenfield FDI in solar power 2003-2018
Source: Own elaboration based on fDiMarkets (2019b)

Figure 6 shows the outbound FDI pattern in solar power. The first years show little to no investments, but it quickly takes off starting 2011. The flow of investment is initially focused on high-income countries but swaps focus to middle-income countries, and especially lower-middle income countries, in 2014.

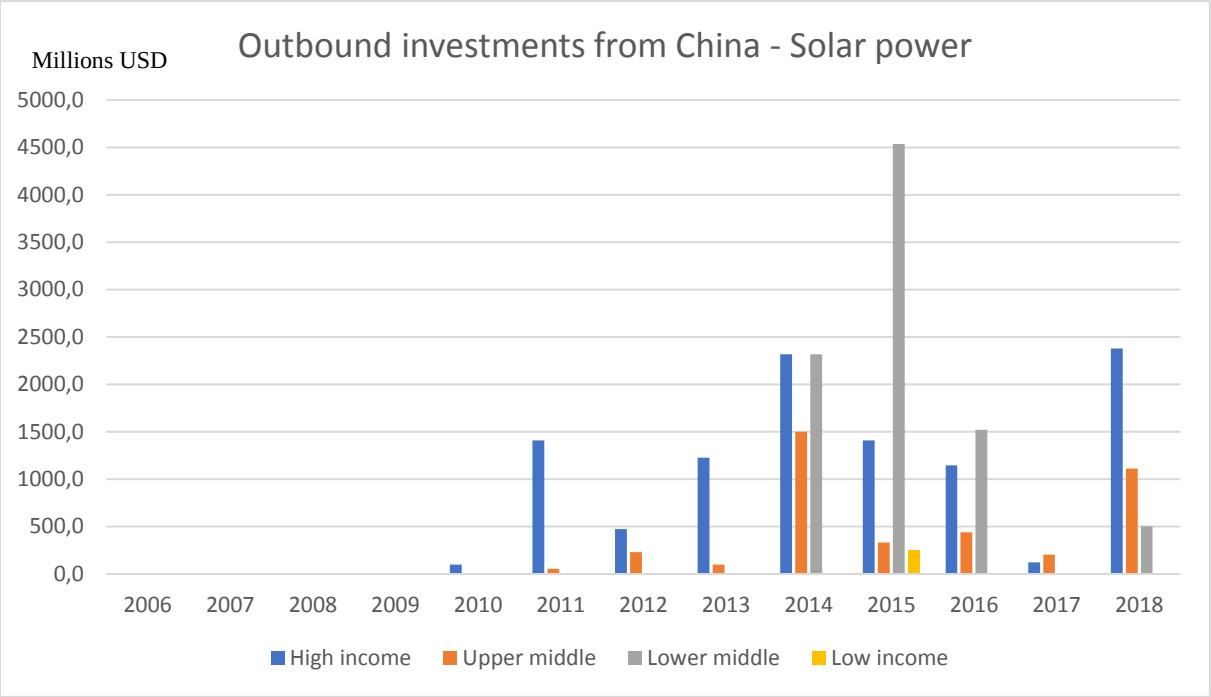

Figure 6: Outbound Chinese greenfield FDI in solar power by income group 2003-2018
Source: Own elaboration based on fDiMarkets (2019b)

Figure 7 shows the outbound FDI pattern in EEC related to solar power. It shows that FDI in EEC took off a few years earlier compared to the outbound FDI in solar power. Similar to the solar power category, there is an initial focus on high-income countries which is then redirected to middle-income countries in 2013. A large majority of the investments into middle-income countries went into Asian countries, particularly into India and Pakistan.

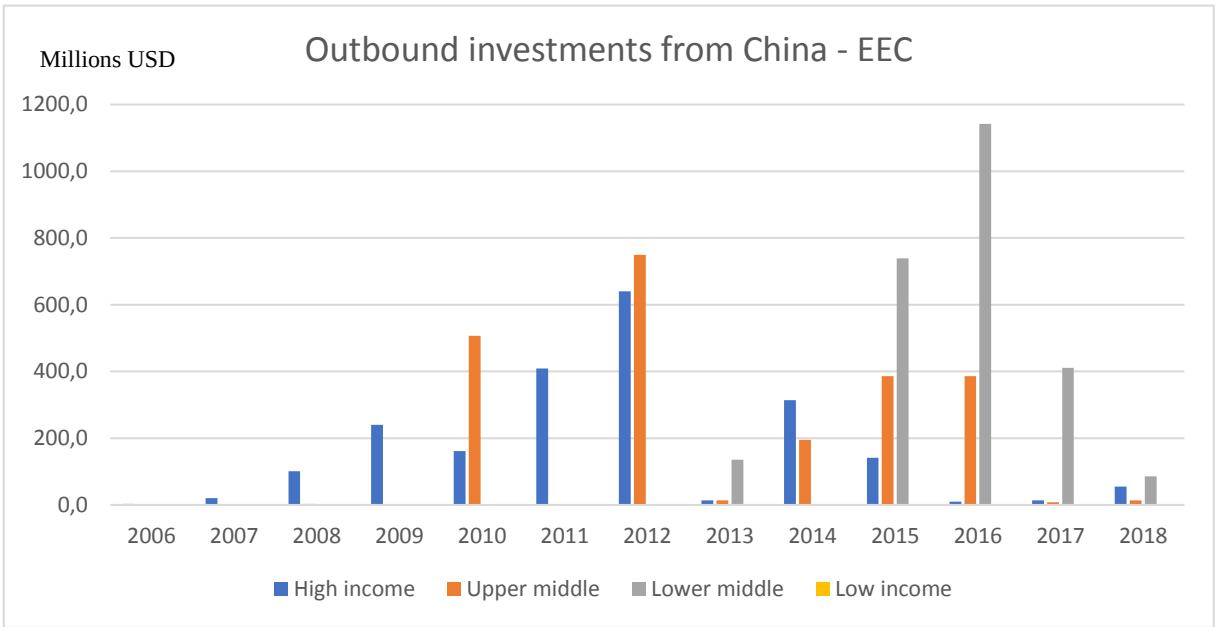

Figure 7: Outbound Chinese greenfield FDI in all other electrical equipment and components related to solar power by income group 2003-2018
Source: Own elaboration based on fDiMarkets (2019b)

The fact that the flow of investments into high-income countries started earlier in EEC compared to solar power suggests that Chinese companies may have entered these countries in an attempt to enter the value chain by becoming suppliers of components to domestic

companies in the solar industry. However, the majority of these investments were in headquarters and sales, marketing, and support and if the companies were trying to enter the value chain in these countries, they would likely have invested in manufacturing industries or other activities that would have allowed them to access the value chain instead.

There were four inbound knowledge-seeking investments in the solar industry, two in 2009 and two in 2013. They were all from high-income countries and three of them in R&D and one in DDT. One of the investments in 2009 was a co-location which, if the investing company had knowledge that the other co-locating company did not, is likely to have led to new knowledge in the Chinese industry. However, they are relatively few and spread out over time, which suggests that inbound knowledge-seeking FDI did not play a key role in building capabilities in the Chinese solar industry.

There were also seven outbound knowledge-seeking investments in EEC, all of which went to high-income countries. They can be seen in table 1. Five of them were from 2010 to 2011 and the remaining two in 2014 and 2015. All of them were in DDT, which suggests that they were made to adapt products to different conditions. Furthermore, most of the outbound investments in DDT occurred around the same time as the outbound investments in solar power started increasing in 2011. There is also some overlap in the destination of the DDT and solar power investments, strengthening the suggestion that the investments were made to adapt products to new locations. Furthermore, all of the knowledge-seeking investments were made by large companies, suggesting that smaller companies rely on other mechanisms to acquire knowledge.

Table 2: Outbound knowledge-seeking greenfield FDI from China in the solar industry
Source: fDiMarkets (2019b)

Year	Destination country	Investment (in millions USD)	Industry activity	Sub-sector	Parent Company
2010	Germany	0,84	Design, Development & Testing	All other electrical equipment & components	China Guodian Corporation
2010	Australia	34,9	Design, Development & Testing	All other electrical equipment & components	Suntech Power Holdings
2011	Singapore	34,9	Design, Development & Testing	All other electrical equipment & components	Yingli Green Energy
2011	United States	14	Design, Development & Testing	All other electrical equipment & components	Yingli Green Energy
2011	Spain	12,1	Design, Development & Testing	All other electrical equipment & components	Yingli Green Energy
2014	United States	14	Design, Development & Testing	All other electrical equipment & components	Hanergy Holdings Group

2015	Germany	1,35	Design, Development & Testing	All other electrical equipment & components	China National Building Material

5.1.3 The Chinese wind power industry

Most of the investments in engines and turbines have been included in this section of the thesis since almost all of the FDI in engines and turbines were directly related to wind power. Figure 8 displays the distribution of the inbound investments of both wind power and engines and turbines over time. The two sub-sectors are shown in the same graph because they showed a very similar investment flow over the period. All of the inbound FDI came from high-income countries except for one investment of 80 million USD from Malaysia in wind power in 2013 and one 65 million USD investment from India in engines and turbines in 2010. Figure 9 displays the outbound investment pattern in wind power and engines and turbines.

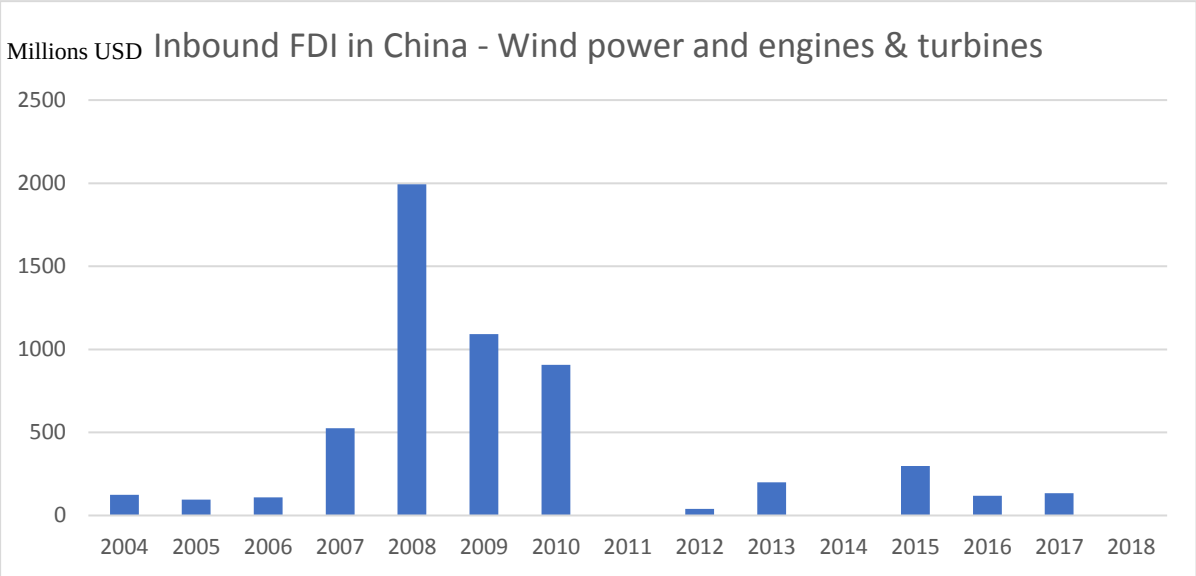

Figure 8: Inbound Chinese greenfield FDI in wind power and engines & turbines 2003-2018
Source: Own elaboration based on fDiMarkets (2019b)

Figure 9 shows a concentration of outbound FDI from 2007 to 2010, after which it stopped almost entirely. The outbound pattern shows an FDI flow with a small concentration of investments that starts around 2009 until 2012 and a second, larger, concentration beginning in 2015. Most of the investments in the first concentration flowed to high-income countries, whereas middle-income countries were the main target during the second concentration. The investments into middle-income countries mainly flowed into India and Pakistan, but Kazakhstan also received a considerable amount of investment. The outbound pattern suggests that inbound FDI, and perhaps internationalization to high-income countries, played a role in building the Chinese wind sector's capabilities during the first half of the period and prepared them for their internationalization during later years.

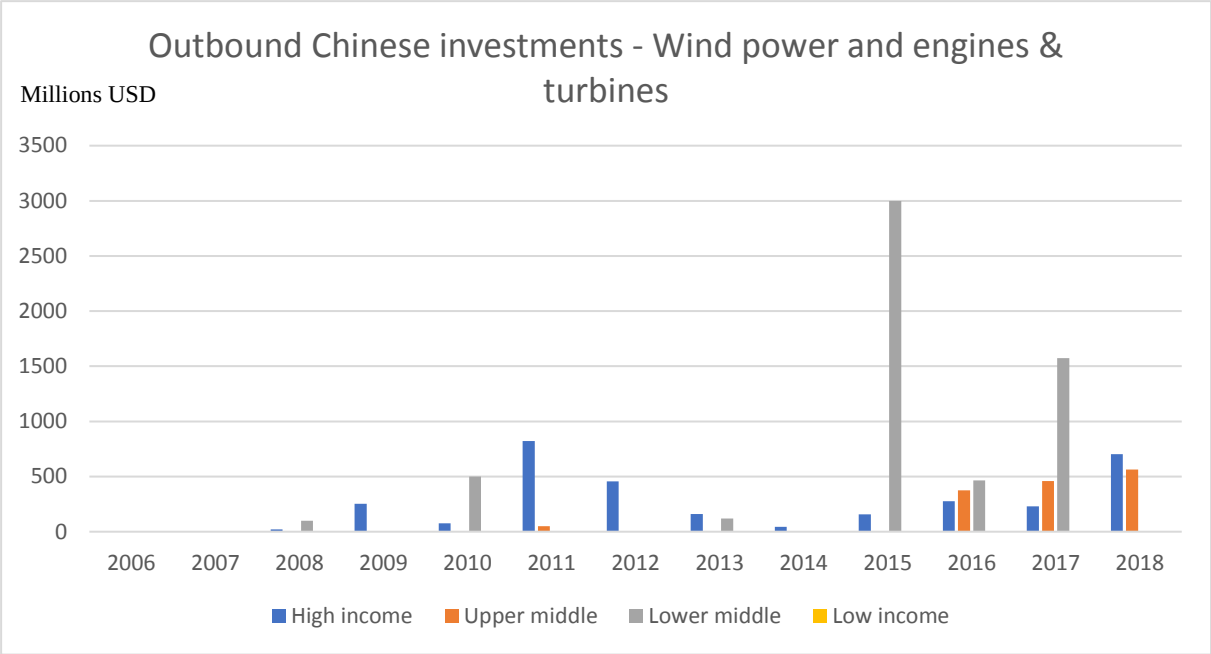

Figure 9: Outbound Chinese greenfield FDI in wind power and engines & turbines by income group 2003-2018
Source: Own elaboration based on fDiMarkets (2019b)

There were four inbound knowledge-seeking investments related to the wind industry which were spread out across the period. There was however one investment in 2012 from France in DDT and one in 2015 from the US in education and training, both of which were co-locations which suggests at least some degree of knowledge-spillover between the co-locators. Given the lack of concentration in time, inbound knowledge-seeking FDI most likely did not play a key role throughout the period but may have still been important for the co-locaters.

There were more outbound knowledge-seeking investments, and they also showed a higher concentration in time. The outbound knowledge-seeking FDI can be seen in table 2. They were all in high-income countries and the engines and turbines sub-sector. Four of them were in the US, three of which were performed by Envision Energy which is one of the largest Chinese wind power companies. Since seven out of the eight outbound knowledge-seeking investments were concentrated around 2016, it is likely that Chinese companies saw promise in outbound knowledge-seeking FDI as a tool to acquire technology and knowledge as the Chinese industry matured.

Table 3: Outbound knowledge-seeking greenfield FDI from China in the wind industry
Source: fDiMarkets (2019b)

Year	Destination country	Investment (in millions USD)	Industry activity	Sub-sector	Parent Company
2008	Denmark	5,4	Research & Development	Engines & Turbines	Envision Energy
2012	United States	27,1	Research & Development	Engines & Turbines	China Ming Yang Wind Power Group
2014	United States	39,9	Design, Development & Testing	Engines & Turbines	Envision Energy

2016	United States	39,9	Design, Development & Testing	Engines & Turbines	Envision Energy
2016	Denmark	39,9	Design, Development & Testing	Engines & Turbines	Xinjiang Goldwind
2016	United States	39,9	Design, Development & Testing	Engines & Turbines	Envision Energy
2018	Spain	2,7	Design, Development & Testing	Engines & Turbines	Sany
2018	Denmark	12,7	Design, Development & Testing	Engines & Turbines	Xinjiang Goldwind

The following section will study several Chinese companies in the wind and solar industries more closely to examine the development of different companies across time. It will focus on their development and on the different mechanisms that they used to acquire new capabilities and how these mechanisms changed over time.

5.1.4 Case studies of Chinese solar and wind companies

The thesis will now move on to the section of the analysis that uses annual reports and company websites as sources.

Yingli Green Energy

Yingli Green Energy or Yingli Solar is a solar power company that was created in 1997 and have competed with other companies based on its low production costs and its vertical integration.[5]

Even from the start, the company relied on exports to Europe due to the small market in China (Yingli Solar, 2008). However, the share of Yingli's products that went into China increased considerably as the Chinese market grew with the years (Yingli Solar, 2018). As Yingli developed its production capabilities and company brand, their exports increasingly went into European countries and then spread throughout the world into the Middle East, Asia, Africa, and the Americas (Yingli Solar, 2013; 2018). Despite their international focus, most of their operations – with the exception of sales and marketing – were located in China throughout the period (Yingli Solar, 2018).

Subsidized internal R&D were vital to improving their competitive advantage of low production costs throughout the period (Yingli Solar, 2018). However, in 2009 they collaborated with an energy research center and a private company in the Netherlands, under the name "PANDA" to create high-efficiency solar modules by using monocrystalline solar cells (Yingli Solar, 2013). PANDA was a success and are still being sold. Furthermore, in

[5] Vertical integration is a term used to describe a company that incorporates the production of components used in the production of the final product into their own facilities rather than relying on subcontracts.

2012 the company expanded its services to sell and invest in solar projects rather than relying on only selling solar panels and components (Yingli Solar, 2013).

The fDiMarkets (2019b) database shows that Yingli Solar performed 17 greenfield investments with a value of 847 million USD during the period. Most of these were considerable investments in headquarters and two in manufacturing. fDiMarkets (2019) data shows three knowledge-seeking DDT investments in the US, Spain, and Singapore. However, the annual reports do not mention any benefit from inbound FDI, suggesting that it was their internal R&D efforts, international DDT investments, and collaboration in the Netherlands which enabled them to upgrade their capabilities.

Trina Solar

Trina Solar was founded in 1997 but did not start production until 2003. The company utilized its low production costs and a vertically integrated business model to stay competitive, which means they followed the same business model as Yingli Solar (Trina Solar, 2007). By 2007, Trina Solar had integrated the manufacturing of silicon ingots, wafers, and solar cells for their solar module production. However, while low production costs were necessary for its competitiveness, the company has also made efforts to stay ahead of its competitors through upgrading their technological capabilities.

In 2006, they sold their products to different distributors, wholesalers, and system integrators, most of which were located in Germany, Italy, and Spain (Trina Solar, 2007). In 2010, the company had expanded into several expanding markets, such as Australia, China, France, Israel, India, Japan, and the US but most of their solar modules were sold to customers in Europe (Trina Solar, 2011). In 2015, the company had further expanded into Asia, Africa, the Middle East, Latin America, and the Caribbean Islands but more than half of the sales went to China or the US in 2015 (Trina Solar, 2016).

The focus of Trina Solar's R&D has been, similar to Yingli Solar, to improve the conversion efficiency of their solar cells and the effectiveness of their manufacturing processes (Trina Solar, 2016). According to Trina Solar's (2016) annual report for 2015, most of their R&D and manufacturing occurs in China but their R&D team works with several different actors, such as an academic committee, the company's manufacturing team, and different customers and suppliers. Furthermore, the report also notes that their R&D results have significantly improved since they finished a government-financed R&D laboratory next to their headquarters in China. The 2015 report also mentions that Trina Solar's R&D lab has worked with and will continue working with foreign R&D institutes such as their R&D lab in the US. Furthermore, Trina Solar has set up partnerships with research institutes, such as the Solar Energy Research Institute of Singapore and the Shanghai Institute of Microsystem and Information Technology (Trina Solar, 2016).

Trina Solar's (2016) annual report on 2015 mentions that the solar PV industry is labor intensive and requires relatively little technology which is further strengthened by the fact that only about 1% of Trina Solar's revenue went into R&D in 2013, 2014, and 2015 (Trina Solar, 2016).

The fDiMarkets (2019b) database had data on 21 greenfield investments from Trina Solar, adding up to 2136 million USD. There were no knowledge-seeking investments among these. There were only four investments in electricity generation and three in manufacturing, but they were all relatively large investments and accounted for 54% and 36% of the total sum of investments respectively. Overall, there are no indications in the annual reports or in the data that greenfield FDI played a major role in acquiring knowledge or technology for Trina Solar. It seems their acquirement of knowledge was instead based on their internal R&D and R&D partnerships with both domestic and international universities, research institutions, and suppliers.

Suntech Power

Suntech Power was created in 2001 and had become one of the leading solar energy companies in the world in terms of production by 2005. The company went bankrupt in 2012 but was bought by another company and continued production.

Similar to the other two companies Suntech Power relied on exporting to European countries, however, a significant portion of the company's sales were made in China and as the company developed, it expanded into other markets in the Americas, Europe, Asia, and Africa (Suntech Power, 2006; Suntech Power, 2012). In late 2018, the company was present in over 80 countries but despite their international presence, Suntech Power's establishments were mainly located in China (Suntech Power, 2019).

According to Suntech Power's (2006) annual report from 2005, the company was not vertically integrated during the 2000s and instead based their competitiveness on four main aspects. First, its low manufacturing costs, which is common in Chinese based companies, and semi-automatization. Second, its relationships with customers and suppliers. Third, its large-scale manufacturing in high-quality solar cells which was enabled by its manufacturing technology. Finally, its superior technological capabilities.

As time passed the company saw the benefits of vertical integration, and in 2010 Suntech Power became fully vertically integrated after acquiring a German silicon wafer and ingot manufacturing company (Suntech Power, 2012). Furthermore, Suntech Power utilized acquisitions of both Chinese and foreign companies to upgrade their production capacity (Suntech Power, 2006).

Just as the other two solar companies, Suntech Power relied heavily on their in-house R&D establishments in China (Suntech Power, 2006; 2012). Their R&D efforts were led by some of their senior managers in the company who had long experience in the solar PV industry (Suntech Power, 2012). In 2005, the company not only focused on developing and implementing more advanced technologies to reduce their costs, but they also researched the next generation of solar cells (Suntech Power, 2006).

At this point, the company utilized both monocrystalline and multicrystalline solar cells in their production to add more flexibility to the manufacturing process and in answering customer demands (Suntech Power, 2012). This gave Suntech Power an advantage as the other two companies focused on only one until much later.

One of the critical differences between Suntech Power and the other two companies (Yingli Green Energy and Trina Solar) is that Suntech Power already from 2005 had established cooperation relationships with five universities and research institutions, which had increased to seven in 2011(Suntech Power, 2012). Among these seven were, for example, the University of Technology in Australia, Zhongshan University in China, and Shanghai Jiatong University in China. Besides the cooperation in R&D, these partnerships allowed Suntech Power access to advanced testing facilities and equipment and also let the company follow industry trends easier (Suntech Power, 2006).

Since 2011, Suntech has entered several different partnerships both in and out of China. For example, in 2017 Suntech Solar signed a partnership with Jolywood Solar Technology to produce a new solar module (Suntech Power, 2018). In 2018, Suntech entered into a partnership with a Dutch solar company named DSM Advanced Solar to developed customized solar modules (Suntech Power, 2017).

fDiMarkets (2019b) had data on 25 greenfield investments ranging from 2007 to 2016. However, most of these were smaller investments in sales, marketing, and support which in total it added up to 393 million USD. The company only made one greenfield knowledge-seeking investment, which was a DDT investment of 34,9 million USD to Australia. Overall, it seems to be the case that Suntech Power relied on its in-house R&D which was initially spearheaded by Chinese but later also foreign experts in the industry. As the company developed its technological capabilities it initiated several R&D partnerships with universities and research facilities.

Xinjiang Goldwind

Created in 1998, Xinjiang Goldwind or Goldwind, was one of the first companies to start manufacturing in the wind industry in China and also the first Chinese company to internationalize. Goldwind focuses on their strong R&D and manufacturing capabilities to stay ahead of both domestic and international competitors and has achieved and maintained the status as one of the global leaders in the wind industry for several years (Goldwind, 2017).

While Goldwind started in China, it made its first international sale to Cuba in 2008, and in 2010 they increased their efforts to further penetrate international markets (Goldwind, 2019a; Goldwind, 2010). For example, they have since expanded their operations in developed markets in Europe and North America, but have also entered emerging wind markets such as Uzbekistan, Turkey, Kazakhstan, Ethiopia, and Brazil (Goldwind, 2017).

To get a grasp of the growth of the company’s expansion in the wind market during the last few years, one can compare the 60 subsidiaries and seven joint ventures it had in 2010 to the 266 subsidiaries and 17 joint ventures it had in 2017(Goldwind, 2010; 2017). The primary intent behind the acquisition and creation of their subsidiaries varied but several of the acquisitions have been made to improve their R&D efforts (Goldwind, 2017).

According to Goldwind's (2019b) website, key components of their success during their first decade was their R&D efforts, government promotion of their products, and buying licenses of technology from German companies to enter the market. The website also notes that the

licensing of the technologies eventually led to joint product design, which was an essential step to achieving independent innovation.

In 2007, the company was listed in a Chinese stock exchange to raise funds which enabled mass production (Goldwind, 2019a). The company continued to grow and develop its manufacturing and technology through R&D and an acquisition of a German company (Goldwind, 2010; 2019a). After 2010, Goldwind increased its efforts to go international both in sales, projects, and efforts to improve their technological capabilities (Goldwind, 2019a).

Examples of this are their R&D centers in Australia, Denmark, Germany, and the US as well as other partnerships with private companies and suppliers (Goldwind, 2017). Furthermore, the company established the Goldwind University in 2011 and has several partnerships with Chinese universities to improve their internal learning infrastructure (Goldwind, 2019b). In 2017, the company had invested in several other technologies, such as big data and cloud computing to improve the development of its wind power products (Goldwind, 2017).

fDiMarkets (2019b) data shows 13 greenfield investments made by Goldwind with the first one occurring in 2008 and the last one in 2018. However, only two of these were knowledge-seeking and they occurred rather late in 2016 and 2018, at which point Goldwind had already developed some world-class capabilities. This suggests that outbound knowledge-seeking greenfield FDI did not play a key role in catching up with other global competitors.

Envision Energy

Envision is a latecomer company that was founded in 2007 but has quickly caught up with the industry and risen to the global top 10 companies in the wind industry. Even from the start, Envision's strategy focused on technology rather than following most other Chinese companies that focused on low labor costs (Ready, Hill & Thomas, 2014).

To reach the top, Envision's founder Lei Zhang employed highly talented individuals from all over the world and from different industries, such as Danish engineers, American software architects, and Japanese managers (Ready, Hill & Thomas, 2014). The world-class capabilities that came with these individuals were crucial in Envision's success, first in China and then internationally. However, the company's diversity was also present in its R&D and other ventures. According to Envision's (2019a) website, the company has R&D centers in China, Singapore, Denmark, Germany, and the US as well as regional offices in Asia, Europe, and the Americas. The website also mentions that Envision has invested in several other technologies such as big data to develop its wind turbines further.

Moreover, Envision has established partnerships with several universities and research facilities such as the National University of Singapore, Stanford University, University of Sussex, and the national renewable energy laboratory in the US. Envision has also partnered with other privately owned companies, such as Keppel Urban Solutions to research smart cities, and PTT to develop batteries and renewable energy technologies (Envision, 2019b).

fDi Markets (2019b) had data on ten greenfield investments from Envision, one in 2008 and the remaining nine were distributed from 2014 to 2017. Five of these were knowledge-seeking, one in R&D and four in DDT. All of them were in high-income countries. Two of

the DDT investments were made in 2016 on the same location but one of them is an expansion of the other, suggesting that the first investment was successful enough to warrant an expansion only months after the first one was done.

There was also an unusually large DDT investment of 238 million USD done in Software and IT service in IT in 2017 (fDi Markets, 2019b). The investment was used to build a new global digital hub to perform "leading edge technological explorations into big data, artificial intelligence, smart cities and grids in the home" and is being used to work with some of the leading companies and high-end research institutions in Singapore to come up with a model for smart cities that can be replicated and scaled up elsewhere (Envision, 2019b).

While it has only briefly been mentioned in this section, government policies were crucial to the development of both the wind and solar industries. Subsidized R&D was crucial in developing the absorptive capacity of the Chinese companies, which enabled them to understand and adapt foreign technology and also innovate new products in the solar industry and to effectively utilize and later use this knowledge to come up with their own designs in the wind industry (Goldwind, 2017; Trina Solar, 2016; Yingli Solar, 2013).

The solar companies that were examined quickly started exporting to Europe and had Europe as their primary market for several years before the Chinese market for solar panels drastically expanded during the late 2000s (Suntech Power, 2012; Trina Solar, 2011; Yingli Solar, 2013). Europe used several economic incentives to attract investment in both solar and wind power, such as feed-in tariffs[6], reduced cost of capital goods, tax incentives, and net metering[7] (Goldwind, 2010; Suntech Power, 2012; Yingli Solar, 2018).

5.2 Discussion

This thesis aimed to answer the research questions of whether green industries in China have been absorbing technology and knowledge from high-income countries and if so, what different mechanisms have been used. Furthermore, the thesis has also examined the development of the geographical pattern of Chinese greenfield FDI over time.

The overview of the greenfield FDI pattern showed that there was a concentration of inbound investments during the late 2000s and early 2010s, which was followed by a concentration of outbound investments during more recent years. The knowledge-seeking investments followed a similar pattern. However, closer inspection of the solar power sector showed that there was a continuous flow of inbound investments starting in 2007, which suggests that inbound FDI was key to the development of the Chinese solar power industry. These results are similar to Lema and Lema's (2012) findings, which suggest that inbound FDI started to occur in the late 2000s in the Chinese solar industry. There was a concentration of outbound

[6] Feed-in tariffs are (often long-term) policies that ensure fixed electricity prices to producers of electricity

[7] Net metering are policies that enable consumers to sell sustainably generated electricity back to the grid

knowledge-seeking investments in 2010 and 2011 which is also in line with Lema and Lema's (2012) results, but it should be noted that there were few knowledge-seeking after 2011.

The wind industry experienced a concentration of inbound investment from 2007 to 2010 which was followed by little inbound investments in the rest of the period. This stands in contrast to Lema and Lema's (2012) conclusion that inbound FDI was important in the period when the wind industry was formed in China but has been of little importance since. Furthermore, there was a concentration of outbound knowledge-seeking investments around 2016 which again stands in contrast to Lema and Lema's (2012) results which suggested that outbound R&D investments were important to the Chinese wind industry around 2012. Moreover, the case studies of both wind and solar power companies in China did not find strong evidence of inbound FDI playing an important role in the development of the industries. That said, measuring FDI spillovers is problematic and this could explain the lack of mentions about the effect of inbound FDI in the annual reports (Meyer, 2004).

The case studies of the Chinese companies suggests that Chinese wind and solar companies displayed a dual focus of internal (in-house R&D) and external efforts (e.g., knowledge-seeking FDI and research collaborations) to build capabilities. This suggests two things. First, companies seem to rely on a combination of mechanisms of acquiring knowledge rather than focusing on one mechanism. Second, the companies display a co-evolution between internal efforts to build capabilities (in-house R&D) and attempts to obtain knowledge from external sources (e.g., knowledge-seeking FDI and research collaborations). Such a process would explain the strong presence of in-house R&D efforts throughout the period and the increasing interaction with external actors over time.

This is in line with Lema and Lema (2012) who found that Chinese companies in green industries first used conventional mechanisms of acquiring capabilities that generally requires less effort and interaction with other actors, such as licensing. As the Chinese companies' technological capabilities improved, licensing played a smaller role and unconventional mechanisms of acquiring capabilities that require more effort and interaction with other actors, such as collaborative R&D and overseas R&D gained importance. Moreover, the case studies showed that although the overall strategy of the different companies was similar, there were some differences which strengthen the conclusion of Hansen and Lema (2019) which suggested that different learning mechanisms may have different levels of success within different companies.

Furthermore, the case studies found that both Goldwind and Envision recently entered into and created ventures related to big data, cloud computing, and other advanced ICT technologies to further the development of their wind turbines. This hints at a new chapter for the technological frontier in China, or perhaps the global wind industry, in which companies use relatively new or unutilized advanced ICT technologies to enhance their productivity.

The quantitative analysis also looked at the distribution of the investments over income groups and found that almost all inbound investments came from high-income countries. Both the overview of the general outbound Chinese FDI pattern (figure 2) and the outbound FDI pattern in the Chinese solar (figure 6 and 7) and wind technologies (figure 9) showed a shift from high-income countries to middle-income countries from around 2014 and onwards. Two

interesting conclusions can be made from this. First, considering China's lacking institutional environment (Khanna & Palepu, 2006), this is in line with Ramamurti's (2012) conclusion that many multinational companies from emerging economies first internationalize to countries that are very different from themselves, and then go to countries more similar to them. Second, the shift to middle-income countries from around 2014 and onwards suggests a cascade effect in which technological capabilities acquired in the previous period might further be transferred towards less technologically advanced countries.

Since both different companies and different countries function under different circumstances, they are unlikely to follow identical paths to development. However, an increased understanding of how the mechanisms of acquiring knowledge developed over time in Chinese companies could reveal important information to policymakers and governments in developing countries. Whether recipient countries can utilize the Chinese investments to learn depends on several factors, such as how advanced the recipient country's solar and wind power industries are, the absorptive capacity of the recipient country and different companies in the recipient country, and the institutional environment in the recipient country.

However, the shift in the Chinese investment pattern to middle-income countries may prove to be a valuable opportunity to acquire Chinese knowledge and technology, particularly in India, Pakistan, and Kazakhstan which received substantial investments in wind and solar power. Furthermore, Fu and Zhang (2011) found that companies from developing countries often have to tweak and adapt acquired technologies to use them efficiently and (Chaminade & Gómez, 2016) found that innovations from developing countries may be better adapted to other developing countries. In other words, it might be more efficient for companies that receive Chinese FDI in green technologies to learn from Chinese companies rather than from high-income countries. However, if knowledge and technology diffusion is to occur from Chinese companies to local companies in recipient economies, the government in the recipient economies will likely play a key role. This conclusion is in line with several other authors who have argued that government intervention will be crucial for the diffusion of green technologies in developing countries (Fu & Zhang, 2011; Lema & Ruby, 2007; Lewis, 2011; Tan, 2010).

The results from the analysis indicate that both governments and solar and wind companies in developing countries should focus on improving their absorptive capacity through in-house R&D and training of employees while simultaneously attempting to acquire knowledge from external sources. Improving the domestic companies' internal abilities to generate knowledge will not only enhance its technological capabilities and make it easier to adapt and learn from foreign knowledge and technology, but it will also make the domestic companies more attractive as research partners. Furthermore, absorptive capacity is more important the further away a company is from the technological frontier (Criscuolo & Narula, 2008). Acquirement of knowledge from external sources should first focus on conventional mechanisms since they are generally more straightforward, cheaper, and are easier to access and as the technological capabilities of a company develops it should move on to more unconventional methods of acquiring external knowledge and technology (Lema & Lema, 2012).

To promote future FDI and consumer demand in the recipient countries, feed-in tariffs, subsidized capital goods, tax incentives, and net metering could be used. Such incentives,

while costly, may be necessary for the recipient economies to reduce the risk that investing companies have to make. Furthermore, such means could be used to bargain for conditions that improve the chances of interaction between foreign companies and local companies. Examples of these kinds of conditions are local content requirements, joint ventures, training of local employees, and trading technology for market-access via collaborations. However, governments in recipient economies still have to exercise caution when implementing policies directed to increase interaction between Chinese (and other foreign) and domestic companies to make sure that the policies do not discourage further investment. This will be even more important in countries with smaller energy markets since countries with larger markets can use the size of their market to bargain with foreign companies (Hansen & Lema, 2019). Government and policymakers should also take care to contextualize any policies since what works in one country may have different effects in another country. Trial and error may therefore be necessary for effective implementation of different policies.

With this said, since companies are profit-maximizing, they will not give away knowledge or technology to potential competitors unless they gain something from it (Meyer, 2004). Furthermore, the transfer of knowledge and technology from external actors is not automatic but instead depends on how the technology is used within the recipient company (Lema & Lema, 2012). For example, a company will typically not learn something from foreign technology just because they obtain it. What is needed is an effort from the recipient company to learn, such as tweaking and making other efforts to understand the technology.

Finally, it should be mentioned that different technologies operate under different circumstances which may be a deciding factor in how national industries develop. For example, according to Lema, Berger, and Song (2011), wind power companies rarely acquire components for manufacturing across borders because of the high transportation costs that are associated with turbines and some components used in turbines. This is interesting since there was little overlap in the destination of outbound Chinese greenfield FDI in wind power and engines in turbines. This implies that the recipient countries of Chinese investments in wind power may have a good opportunity to become suppliers of components to these companies.

6 Conclusion

6.1 Research Aims

In the light of institutions at all levels giving more and more attention to climate change and different ways to combat it, there is also increasingly more academic research on the topic. The increasing attention given to environmental problems and the success of some emerging economies in catching up in green industries have opened up for much research. It will be crucial to examine these success stories to see whether there are lessons to be learned that will benefit other developing countries. More specifically, working to fully understand the success behind, for example, China's catch-up in the solar and wind industries may lead to valuable knowledge that can be used in other developing countries.

To find out more about green industries in China, this thesis has asked the questions of whether green industries in China has absorbed technology and knowledge from foreign countries and if so, through what mechanism. Furthermore, the thesis has also examined how the geographical pattern of outbound Chinese greenfield FDI in green industries has developed over time.

The results show that Chinese companies in green technologies have been and continue to absorb technology and knowledge from high-income countries through a variety of mechanisms. However, the role of FDI remains inconclusive. Additionally, the case studies of Chinese wind and solar companies found that a dual focus of both internal and external learning was present in the examined companies. The internal learning mainly consisted of in-house R&D throughout the companies' development while the mechanisms that were used to acquire external knowledge and technology evolved from conventional mechanisms that generally require less effort and interaction with other actors and investment from the Chinese company (e.g. licensing) to unconventional mechanisms which require more effort and interaction with other actors (e.g. R&D collaborations and knowledge-seeking R&D in foreign countries).

It was also found that the general outbound Chinese greenfield FDI pattern and the outbound FDI pattern in the Chinese solar and wind industries shifted focus from flowing into high-income countries to middle-income countries around 2014. This suggests an opportunity for the recipient middle-income countries to absorb technology and knowledge from Chinese companies. The case studies of Chinese wind and solar companies found several possible policies that may be of interest to policymakers and governments in developing countries.

6.2 Future Research

There are several potential avenues for future research related to this thesis. First, due to the lacking data sources of this thesis, only companies at the technological frontier were examined in the case studies. It could prove interesting to make similar analyses on small- and middle-sized companies that are active in green industries.

Second, investigating whether China or other developing countries have acted as catalysts for knowledge diffusion to other developing countries, or in other words, examining whether a developing country that acquired knowledge from foreign sources spread their knowledge to other developing countries could add valuable information to the discussion. What mechanisms were used to transfer the knowledge and what the differences between acquiring knowledge from a developed and developing country are of particular importance. This will require the use of primary data collected on-site.

Third, it would be beneficial to investigate under what circumstances and what activities FDI spillovers occur. For example, are FDI spillovers more likely to occur in manufacturing activities? DDT or R&D activities? Electricity generation? What about the role of headquarters in FDI spillover? These are likely to be highly dependent on the industry the investments are made in.

Finally, this thesis found that Chinese wind companies at the technological frontier have started utilizing advanced ICT technologies to improve the efficiency of their turbines. Other research could explore the effect these technologies have had and whether the use of such technologies is constricted to frontier companies or if these technologies are present in less technologically advanced wind companies as well. It could also be examined if the use of advanced ICT technologies is constricted to the wind industry or if they are present in other green industries as well.

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