

## Mobilizing Scarce Resource through Social Networks: Exploring Mechanism that Accelerated the Growth of the Chinese PV Industry

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**Abstract**--This paper explores how the Chinese photovoltaic (PV) industry had grown extremely fast from the middle of 2000s, and successfully dominated the world PV product market, by conducting a detailed field study on the industry cluster of Wuxi area in Jiangsu Province, which involves interviews to more than 42 persons and the questionnaire survey. Whereas prior research has tended to emphasize roles of the central government and entrepreneurial activities of major PV firms, we rather focus on processes that enabled PV firms, including small and medium ones, to get access to the resources such as technology, management know-how, and skilled labors, which were critical for their growth but rare in China. Our study particularly indicates that social networks based on informal and personal relations had taken very important roles for Chinese PV firms to overcome problems derived from scarcity of such critical resources. But it also implies that this process has induced homogeneity of firms and driven intense price competition in the market. The study sheds a light on both positive and negative roles of socially-embedded relations on the industrial growth in developing countries.

### I. RESEARCH BACKGROUND

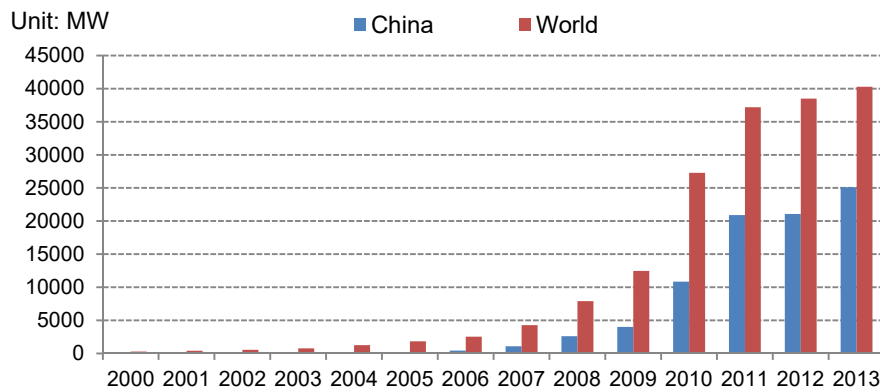
Following adoption of the Kyoto Protocol at the third Conference of the Parties (COP3) at the Framework Convention on Climate Change in December 1997, expectations for renewable energy rose in countries around the world. Because it is a distributed source of power, photovoltaic generation (PV) in particular offers advantages in terms of low risk and easy maintenance, and national governments have undertaken policy assistance centered on Feed-in Tariff systems (FIT) with the aim of facilitating its use.

The global PV market began its rapid growth, especially

in Europe, from about 2005. Renewable energy diffusion policies such as FIT were behind this development. For example, based on amendment of its Renewable Energy Act in August 2004, Germany sharply raised the purchase price for PV, and abolished the upper limit on capacity of power generation facilities eligible for purchases. Given such fixed prices, businesses whose electric power sales were guaranteed for a certain time period poured into the PV market. The firms that initially enjoyed these benefits were in Europe, and especially in Germany. Although Japanese companies controlled the global PV market until 2006, the German company Q Cells sat in the top seat when the European market expanded following amendment of the FIT act. Financial conditions at Q Cells remained robust until 2008; afterwards, however, operating conditions deteriorated and the company filed for bankruptcy in 2012. Instead it was a Chinese firm that took its place and have dominated the global PV market.

As shown in Figure 1, PV cells from Chinese firms, which barely had a presence in the market before 2006, exceeded 50% of global production in 2011 and by 2013 had attained a market share of more than 60%.

In the industry where Chinese firms had been overwhelmingly late-comers, they captured the global market in the blink of an eye as they substantively established the market. The speed of China's growth in the PV industry is significant in comparison with Japan in the semiconductor industry, which took 32 years to attain a market share comparable to that of the United States [3], or to Korea in the DRAM industry, which required 13 years to surpass Japan and the U.S. [11].



Source: Zhu, J., Wu, Y.Y. and Han, C. H. (2013)

Figure 1: Change in PV cell production

Why were Chinese firms able to dominate the PV industry so thoroughly so quickly? While certainly due to the fact Chinese firms have improved the price performance of their PV products and increased their product competitiveness in the market, what enabled them to achieve such competitiveness in so short a time span? These are questions behind this research.

## II. EXPLANATIONS GIVEN IN THE EXISTING STUDIES AND FOCUS OF THIS RESEARCH

If newly developing countries are to catch up with advanced countries, they must overcome various liabilities of newness [16]. They often face shortages of resources critical for business development such as technology, production know-how, and management capabilities as well as highly skilled workers who possess these resources. They also lack enough credits and reputations to gather financial and human resources, and to acquire customers. Within the process by which China's PV industry grew at a speed unparalleled in the past, thus, there must be a unique mechanism to overcome such liabilities of newness.

In this regard, existing studies have discussed at least the following three aspects to explain the extremely rapid growth in the Chinese PV industry: (1) strong governmental supports, (2) dependence on turnkey solution, and (3) role of entrepreneurial activity.

### A. Strong Governmental Support

The rapid growth of Chinese firms is frequently explained as the result of generous protective policies by Chinese government [10][15]. The PV industry as well is no exception [5]<sup>1</sup>.

In fact various policy assistance for China's PV firms was in place [19]. There is, for example, a government secured lending interest rate. In contrast to the normal interest rate of 7.10% at financial institutions, for PV firms in Jiangsu Province, an interest rate of 5.62% is applied<sup>2</sup>. In addition to such preferential interest rates, direct subsidies exist as well. Furthermore, there is preferential treatment that serves to significantly mitigate substantive land charges such as rent through the repayment of land use fees and the agent construction of plants by the government.

Nevertheless, the subsidy period is two years and the interest subsidized is limited to 3.0 million yuan. A maximum of 2.0 million yuan per company has also been set for the subsidy. Eligibility to receive these preferential measures has been limited chiefly to major companies. As discussed later, the rapid price decline of PV cell and modules around 2010 and 2011 has resulted from the cost reduction efforts by small and medium-scale firms and competition among them. The large firms have procured low-cost modules from designated plants of small and medium-size module manufacturers<sup>3</sup> that

did not receive direct governmental supports. While financial assistance from the government has undeniably contributed to the development of China's PV firms, there are limits to how well one can explain the competitiveness of China's PV industry using just sovereign support, which is biased toward large enterprises<sup>4</sup>.

### B. Dependence on Turnkey Solution

Second, firms in developing countries may be able to achieve a fast growth by acquiring critical technology from foreign manufacturers that provide a set of equipment with services and supports. In high-tech industries such as a semiconductor industry, equipment manufactures have come to provide a full-range of solution containing an entire product line with all the required production equipment and operating knowhow as a single package, which is called turnkey solution (TKS). The PV industry is not an exception. In the latter half of the 2000s, the TKS business expanded in the global PV industry. Backed by ample funding through government support, purchasing TKS could be a means of Chinese firms to quickly catch up. Some existing studies discussed that emergence of the European and the US TKS providers may be the primary cause for the fast growth of the Chinese PV industry [12][18].

However, our preliminary study in Wuxi in Jiangsu Province, which is described below, was unable to uncover sufficient factual corroboration for this, finding that only production lines operated by China Guodian Corporation, a state-run entity, had been purchased as a TKS. As one management executive at a medium-sized module firm remarked, "We don't purchase TKS because when you do that, it drives up the amount of your investment in the line by three times"<sup>5</sup>.

Such a remark can be verified from equipment firm side in Europe as well. Figure 2 shows the revenue structure of centrotherm photovoltaics AG (Centrotherm) in Germany, which was a leading PV equipment manufacturer. Figure 2 indicates that most of this company's revenue growth was from single production equipment sales, not TKS. In fact, managers at Centrotherm have that they supplied only a limited number of TKS to Chinese firms<sup>6</sup>. Managers at another main production equipment firm in Germany, similarly described that Chinese firms tend not to purchase TKS<sup>7</sup>.

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July 30, 2013.

<sup>4</sup> Low labor costs are also often pointed to as the fount of Chinese firms' competitiveness. The proportion of PV product cost accounted for by labor costs has never been high. According to a trial calculation completed in 2006 by the Institute of Energy Economics, Japan, the proportion of PV module unit price (yen/W) accounted for by labor costs did not exceed 11% when it envisaged a case of 1 GW annual output [8]. The contribution of low labor costs to competitiveness is thought to be limited.

<sup>5</sup> Taken from an interview by the authors with the president of GSPV, Mr. Wang Daowu. Conducted on August 6, 2012.

<sup>6</sup> Taken from an interview by the authors with managers of centrotherm photovoltaics AG. Conducted at centrotherm photovoltaics AG, on July 26, 2014.

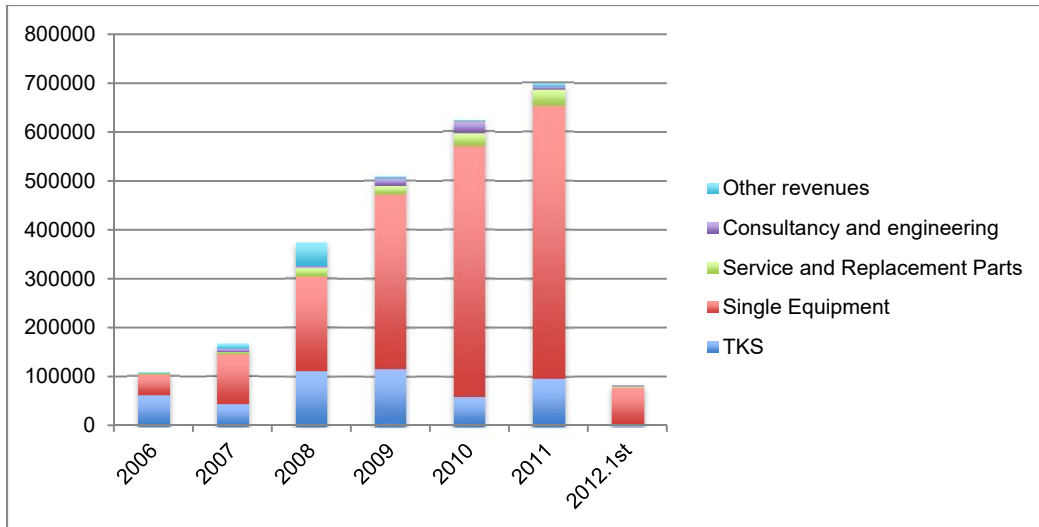
<sup>7</sup> Taken from an interview by the authors with managers of Schmid Technology GmbH. Conducted at Schmid Technology GmbH, on July 30, 2014.

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<sup>1</sup> On the basis of such an interpretation, the US government decided in October 2012 to slap anti-dumping and anti-subsidy measures on PV modules made in China.

<sup>2</sup> A similar advantageous interest rate exists throughout China as a whole.

<sup>3</sup> Taken from the interview by the authors with a manager of Hereon Solar in Wuxi on



Source: centrotherm photovoltaics AG annual reports

Figure 2: Breakdown of revenue at centrotherm photovoltaics AG (In TEUR)

### C. Role of Entrepreneurship in Major PV Firms

Early development of Chinese PV industries heavily depended on particular entrepreneurs who commenced PV business in China. Zhang and White [22] examined entrepreneurial strategies of ten large PV companies: four early movers entering in the industry before 2004 and six later comers. Based on detailed case analyses, they identified three ideal types of entrepreneurial strategies taken for overcoming liabilities of newness under the different institutional environments.

Similar to their study, much of the existing qualitative research tend to focus on major global firms such as Wuxi Suntech, Trina solar, and Yingli Solar, and shed light on entrepreneurial activities of their founders [13][20]. Certainly it was these major firms that had acquired a share in the global PV cell and module market, and importance of founders' entrepreneurship in these large firms is undeniable.

However, rapid sales expansion of Chinese PV products after 2010 and associated significant price drops cannot be solely attributed to capabilities of these large manufactures. Our field survey indicated that the cost of small and medium-sized module firms' products is lower than the cost of Wuxi Suntech's PV modules<sup>8</sup>. Major companies such as Suntech had been outsourcing module production to such highly cost competitive small and medium-size enterprises.

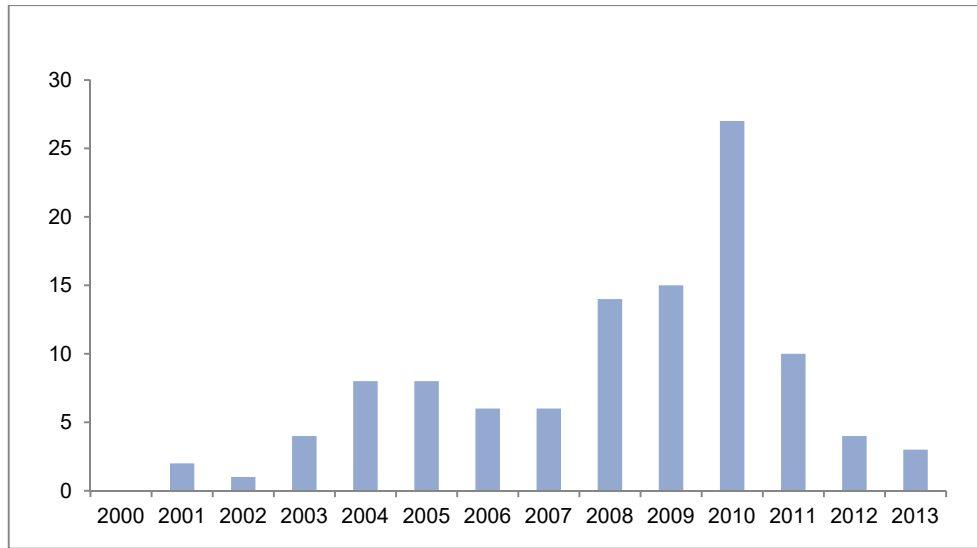
As seen in Figure 1, a sales growth rate of the Chinese PV industry is most significant in 2010 and 2011. In 2010 many small and medium-sized firms rushed into the PV businesses as shown in Figure 3 indicating the number of firms resisted in each year in Wuxi area of Jiangsu province, where a PV industry cluster is located. Profitability of large global PV manufactures has, since then, sharply declined despite

expansion of the global market. Figure 4 shows that almost all large Chinese PV manufactures fell into the red in 2011 and 2012; and many of them are still suffering a loss. Being confronted with keen price competition from small and medium-sized firms, the major firms were in a situation that compelled them to continuously strive to lower costs and hold down selling prices to the point of putting pressure on earnings, which, in turn, facilitated the expansion of global PV market. If so, the high level of cost competitiveness at small and medium-size firms may be related – at least indirectly – to the growth of China's PV industry in this period.

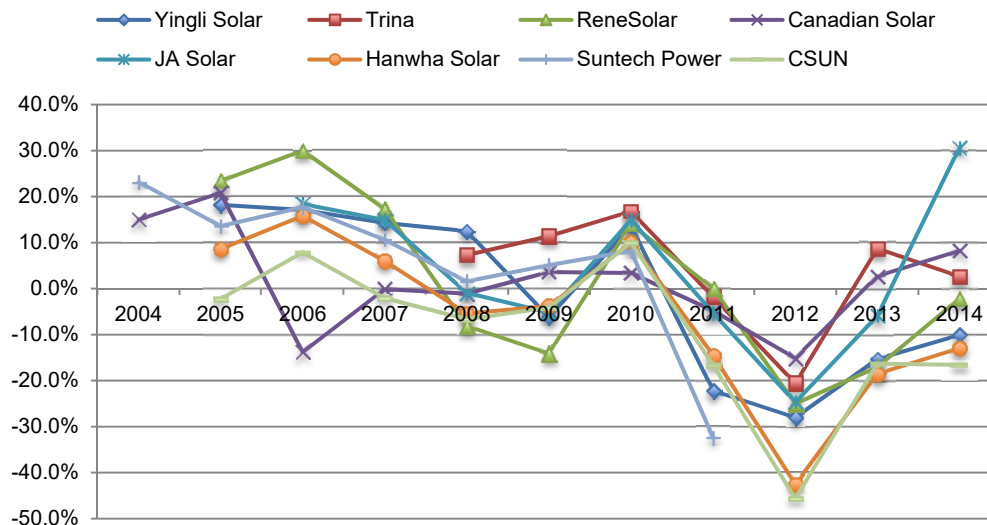
Why could small and medium sized firms easily enter in this market and obtain high cost competitiveness so quickly? To fully understand the rapid growth of Chinese PV industry by supplementing existing research, it seems indispensable to answer to this question. This is the main objective in the following analyses.

To achieve industrial development, developing countries must overcome the bottleneck of scarce resources such as technological capabilities, funding capacity and management skills, which they lack simply because they are late-comers. Government assistance might have partially functioned to dissolve bottlenecks from a capital aspect. The problems of insufficient technological capabilities and management skills, however, are not surmountable with government support alone, especially for small and medium-sized firms. The goal of this study is thus to uncover processes and mechanisms that resolve the problems attributable to the scarcity of those resources in the Chinese PV industry.

<sup>8</sup> Taken from the interview by the authors conducted on July 29, 2013, at EQ Solar.



Source: Authors summarized based on public lists  
**Figure 3: The number of newly resisted PV related firms**



Source: Annual reports  
**Figure 4: Net profit ratios for major Chinese PV manufactures**

### III. RESEARCH METHOD

To achieve our research goal, we conducted a series of interviews and a questionnaire survey by narrowing the focus to the city of Wuxi in Jiangsu Province, China.

We selected Wuxi not only because it is the founding place of Wuxi Suntech Power Co., Ltd., which had lead China's PV industry, but also because it has involved an industry cluster where many of leading companies and small and medium-scale firms are concentrated. Chinese produces nearly two-thirds of the world's PV cells. Of this, some two-thirds has been produced in Jiangsu Province<sup>9</sup>. Moreover,

one-third of the PV firms in Jiangsu Province are located in Wuxi area. Given these facts, we judged Wuxi to be a main production base globally for the PV industry.

The interview survey was conducted from March 2012 to November 2015. We conducted interviews over 80 hours with a total of 42 individuals working at PV-related businesses, public research laboratories, and university laboratories. The firms selected for the interviews included major global producers as well as small and medium-sized firms.

We took two steps to select companies First, with an introduction from the local government, we contacted major

<sup>9</sup> Taken from the interview by the authors with Mr. Su Jian. Conducted on August 27,

2014, at the Wuxi Branch of the China Council for The Promotion of International Trade.

solar cell producers in Wuxi area: Wuxi Suntech Power, Hareon Solar, and China Guodian Corporation. Our direct acquaintances, friends working for local government or private companies as well as a faculty member of Jiangnan University, also introduced us some interviewees in these companies.

Selection of small and medium-sized companies (SMC) was rather complex since even local government had not grasped the entire population of SMCs in this sector. Local government introduced us some companies. For others we leveraged a personal social network of our friend who had been running his own PV company. We also directly contacted several SMCs that exhibited in PV EXPOs held in Wuxi and Tokyo as well as those found in a telephone directory.

We implemented the questionnaire survey in two parts, one in August of 2014 and another in November, and obtained responses from a total of 16 companies. Because we adopted the method of not mailing the survey and having all the companies complete the questionnaire as we explained the contents face to face, the response rate was 100%. Due to the nature of selection processes described above, our sample may not be representative. To compensate for this shortcoming as well as small a sample size, we carefully conducted interviews with questionnaires by asking respondents not only about their own situations but also about situations of other respondents to check possible biases.

#### IV. EARLY DEVELOPMENT OF WUXI'S PV INDUSTRY

There are broadly defined two phases in the growth of the Wuxi PV cluster. The first phase is the period for the licensing-in of technology from foreign countries and its adaptation to domestic production, which existing studies mostly focused on. The second phase is the period when the technology and management know-how are rapidly and broadly propagated and shared across company boundaries within the region. It is this second phase that we mainly examine in this paper to understand the boost of Chinese PV firms since around 2010, which significantly contributed to proliferation of solar power stations in the world. It is also this phase where the unique mechanism that stimulated Wuxi's PV industry development can be seen. Before describing the second phase, we briefly describe the first phase of development because it provides the foundation for the second phase.

Wuxi's photovoltaic industry got its start with the establishment of Wuxi Suntech Power Co., Ltd. in 2001 by graduates from New South Wales University (UNSW) in Australia. For the establishment of Suntech Power, Dr. Shi Zhengrong, the primary founder, donated technology equivalent to 1.6 million dollars and 400,000 dollars in cash, while seven state-run enterprises in Wuxi invested a total of 6.0 million dollars. The first production line, which copied

the production line at UNSW and was comprised entirely of equipment manufactured in other countries, commenced operation in September 2002 with an annual production capacity of 10MW [20]. Later, the company constructed four production lines during the period between August 2004 and December 2005, and through these processes had improved its own production and technical capabilities. The company successfully listed its shares on the New York Stock Exchange on December 15, 2005, raising 400 million dollars in capital. Supported by ample funding capabilities, the company expanded production, and in 2011 took its position as Number One in the world.

Through this growth process, Suntech Power both improved its technological capabilities and cultivated top-class human resources, and provided an incubation function to produce spinout firms. Those spinout companies basically copied Suntech's production line. Company A is one example of such spinout firms, established in February 2004 by three founders in Zhangjiagang, Jiangsu Province. From line design to equipment used, the first production line was a complete copy of Suntech Power's entire production line. Company A took advantage of the technology and know-how learned at Suntech Power to expand its scale of production and achieved sales of 800 million yuan in 2008.

At the early stage, Suntech Power sought to prevent the outflow of technology by spin-offs by measures such as claims for damages. However, Suntech expected the cost of equipment and materials to fall as a result of the newly-established companies using the same equipment and materials as Suntech, and eventually allowed spinouts to be created freely<sup>10</sup>.

The initial development of Wuxi's photovoltaic industry have been achieved as a result of such spin-offs, which disseminated design technology, production know-how and operating and management know-how from Suntech Power.

#### V. PROCESS OF SHARING SCARCE RESOURCES AMONG FIRMS

The distinctive characteristics of the mechanism that supported rapid development of Wuxi's PV industry can be seen most conspicuously in the second phase.

The second phase was the period during which technology and operating know-how accumulated at Suntech Power as a starting point were broadly shared across company boundaries and industrial clusters were formed. During this phase the frequent movement of human resources among firms, and technology transfers and information sharing through social networks based on personal friendships, both played a vital role.

<sup>10</sup> Taken from the interview by the authors with (then) CEO of Suntech Power. Conducted on August 19, 2014, at Suntech Power.

*A. Acquisition of human resources from other companies*

Many of Wuxi's PV firms are newly-established companies that lack experience in the PV industry. Among the 16 firms responding to the questionnaire, 13 of the founders were companies with absolutely no experience in PV-related businesses. Consequently these firms had to acquire the design technology, production technology, purchasing information and other essential elements needed to develop their PV businesses from other companies.

In fact, 13 of the 16 companies gave "Acquisition of human resources from another company" as the way of technology acquisition at the time of their establishment. So it appears that recruiting human resources who are knowledgeable about production technology and copying equipment and line configurations in order to begin production is a typical approach.

A breakdown of the employment of engineers working at these 16 firms shows that employment of new graduates accounts for 44.6% of hires, while mid-career hiring from other PV-related companies accounts for the majority at 51.2%. The situation for purchasing managers is similar, with 44.9% being hired as new graduates, compared with 53.0% who are mid-career hires from the other PV-related companies.

Two presidents of middle-sized PV firms commented as follows regarding the hiring of other companies' human resources.

...if you can engage 2 or 3 people or so who are knowledgeable about the production technology, you can commence production almost immediately. ...we didn't have too many details about PV technology when we launched our business. So... the options we considered were, do we study at Suntech Power, or hire Suntech Power's people? ...the latter is advantageous... because it's immediately useful<sup>11</sup>.

...among small and medium-size firms like ours, there are also many that had only money when they were started. Therefore, whether it was the technology or management – honestly speaking, few people understood it from the beginning. Having someone who is already knowledgeable do it for you is efficient, so most firms... try to hire human resource from other companies<sup>12</sup>.

The quickest way to begin production is to recruit a production process general manager who understands the entire production line, or people with a corresponding level of know-how, to lead each team. Therefore such human resources have an especially high degree of mobility, and in

some instances a team that was recruited from another company will be recruited away by yet another firm<sup>13</sup>.

*B. Sharing of technology, human resources and information through networks of friends*

What is distinctive in the development process of Wuxi's PV industry is the key role fulfilled by information sharing through informal and personal networks. The presidents of PV firms, for example, privately hold social get-togethers and traded various information on topics ranging from production technology and operating know-how to information on technology and management personnel. The president of the module firm offered the following observations on this point:

...we PV firm presidents often go out for a drink. Such drinking parties are held with a frequency of about once a week, and we mutually exchange information about our companies. So we exchange most of the information concerning our companies, such as what technologies we're using for production, what kind of engineers we've hired, how we are developing our businesses, and so on<sup>14</sup>...

While many of these presidents initially become acquainted through business transactions, they also maintain their relationships not only as mere business acquaintances but as personal friends as well. Within the circle of PV industry presidents, the distinction between business discussions and conversations as friends is not always clear, and when viewed from the objective of "maximization of their own company's profits" they also engage in information exchanges that at first glance seem illogical as well. For example, even when there is a potentially competitive relationship they will introduce peers to markets and vendors, share operating know-how, and help resolve production problems.

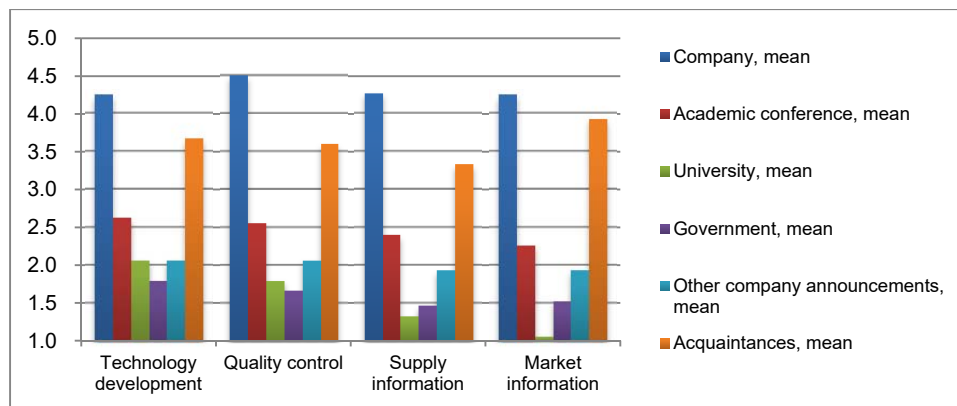
Figure 5 shows the results (mean values) of an evaluation of how information on technological development, quality control, supply sources and markets is obtained, rated from 5 points to 1 point in order of importance. From this figure as well we can see that PV firms in Wuxi are supported by networks of friends. According to the figure, "Acquaintances" are the second most important source of information after "Company's own information-gathering efforts".

<sup>11</sup> Taken from the interview by the authors with president of Change PV. Conducted on August 26, 2014, at the company.

<sup>12</sup> Taken from the interview by the authors with president of Maoyao PV. Conducted on August 21, 2014, at the company.

<sup>13</sup> Taken from the interview by the authors with Mr. Wang Daowu, conducted at the Chinese Renewable Energy Conference & Exhibition on November 6, 2014.

<sup>14</sup> Taken from the interview by the authors with CEO of Company B. Conducted on July 29, 2013, at the company.



Source: Prepared by the authors based on questionnaire data  
**Figure 5: Importance as a means of acquiring information**

### C. Social networks beyond firm boundaries

Illustrating a specific example may help to understand how such a personal network works as a business entity going beyond firm boundary. The example here is a group that consists of 13 individuals who generally contact each other through Wechat (an Chinese SNS application). This Wechat group is named as the *Sodality of Lihu*, which forms a platform for sharing business information and facilitating cooperation among the small, medium, and even large-sized firms. The detail of this sodality is listed as Table 1.

Since members are business partners as well as personal friends each other, there are many business relationships within this sodality. For example A&M Solar started a steady outsourcing relationship with the GPPV. The A&M's annual PV module shipment is approximately 300MW in 2015, 250MW of which are provided by GPPV. Sveck Technology, originally founded in Dongguan, Guodong Province, has become the main supplier for Guofei PV since 2006, which was the parent company of GPPV. These PV module manufacturers also act as the main suppliers to EPC developers, like Wuxi Aineng Power Engineering, Hareon Solar, and CMEC.

The firms also cooperate on the marketing activities. For example, PGO that tried to expand its EPC business for PV power plant construction asked members of *Sodality of Lihu* to acquire direct access to the market information and could find its position. Until 2014 PGO has executed 705.13MW EPC construction projects in China.

There are financial supports between the sodality members as well. Yao Chengdong shown in Table 1 is a key person to other members since he can provide financial services and help firms digest acceptance bill at a better rate.

### D. Transfer of operating know-how through management outsourcing

Like technology, management know-how is a scarce, critical management resource for new entry into the PV industry. This enterprise management know-how is transferred among firms through a unique mechanism that can be called "management outsourcing". Entrepreneurs who have been successful in the PV industry sometimes become

presidents or members of management teams at other companies for a certain period of time through an arrangement to undertake only management operations. The example below of Mr. Sun Yong, the president of Sino-si Advanced Material illustrates this. Sino-si Advanced Material is a manufacturer of silicon products for PV that was established in 2006 by Sun Yong, a banker who, together with two friends, jointly invested three million yuan.

#### The example of Aido PV

In 2008, Sun Yong heard from an acquaintance who was the president of Aido PV, a silicon ingot and wafer fabrication firm, that operating conditions at Aido had deteriorated, and entered an agreement to lease and manage Aido's entire plant and pay the leasing fee in installments. Under the leasing agreement, Aido would collect a plant usage fee from Sino-si Advanced Material in return for all of Aido's operating income being paid to Sino-si Advanced Material. While title to the fixed assets would remain with Aido, the production line, manufacturing facilities, management and workers would all be under Sino-si Advanced Material's control. The *de facto* management rights can be regarded as having been transferred to Sino-si Advanced Material.

Based on this agreement, Sun Young replaced Aido's management team with Sino-si Advanced Material's management, and he himself assumed the role of Aido's president. After Sung Young had completely undertaken operations, Aido's operating results gradually improved, and in 2010 revenues reached 360 million yuan and net income was 30 million yuan, compared with revenue and net income in 2009 of 20 million yuan and five million yuan, respectively.

As a result of Sun Yong having taken the reins of Aido's operations, Aido's product quality and production efficiency were improved to the same level as Sino-si Advanced Material<sup>15</sup>. In this way, the operating know-how possessed by Sun Young was transferred to Aido.

<sup>15</sup> Taken from the interview by the authors with Mr. Sun Yong. Conducted on November 6, 2014, at the Chinese Renewable Energy Conference & Exhibition.

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TABLE 1: AN EXAMPLE OF SOCIAL NETWORK: SODALITY OF LIHU

Members' Name	Company Name	Position	Description of the Business Domain	Production Capacity	Location	Established Date
Zhang Jie	Wuxi A&M Solar Technology Co., Ltd.	CEO, Boardmember	Manufacture of PV Module	100MW	Wuxi	May 27, 2011
Zhou Yufei	Wuxi A&M Solar Technology Co., Ltd.	Vice President				
Cheng Zhongguang	Wuxi Sveck Technology Co., Ltd.	CEO, Owner	Manufacture of Tinned-Copper Ribbon, Metal Flat Wire and Photovoltaic Ribbon	-	Wuxi	October 18, 2007
Johnnie Wu	Jiangsu Green Power PV Co., Ltd(GPPV)	Executive Manager	Manufacture of PV Cell, PV Module	300~400MW	Changzhou	July 3, 2008
Ji Wenqiang	Wuxi Aineng Power Engineering Co., Ltd.	Executive Manager	Manufacture of PV Cell, PV Module. EPC Development	200MW	Wuxi	December 17, 2014
Han Li	Schrand (Wuxi) Electric Power Technology Co., Ltd.	CEO, Boardmember	Manufacture of PV Module. EPC Development	200MW	Wuxi	June 24, 2011
Pu Yonghua	Jiangsu Runda Photovoltaic Technology Co., Ltd.	CEO	Manufacture of PV Module	200MW	Wuxi	August 17, 2009
Zang Dongliang	Jiangsu Runda Photovoltaic Technology Co., Ltd.	Purchasing Manager				
Qiu Xin	Hareon Solar Technology Co., Ltd.	Vice President	Manufacture of PV Cell, PV Module. EPC Development	2.5GW	Wuxi	July 18, 1997
Feng Guoliang	Photovoltaic Green-Ecosystem Organization(GPO)	Secretary-general	Business platform for solar energy system development	-	-	August 22, 2013
Li Guangchun	China Machinery Engineering Corporation(CMEC)	Vice President	Contracting of International Engineering, Machinery Trading, EPC development	-	-	January 18, 2011
Sun Yong	Jiangin Dongsheng New Energy Co., Ltd.	CEO, Boardmember	Manufacture of Silicon Core	-	Wuxi	September 22, 2011
Yao Chengdong	-	-	PV Module sub-material supplier, Financial service supplier	-	Wuxi	-

### Example of Company C

This type of “management outsourcing” is not limited to Aido alone. At the request of entrepreneur friends in Wuxi, SunYong often engaged in management outsourcing. There was, for example, his management outsourcing of Company C, a subsidiary of China’s large silicon wafer firm, Company D. Between March and September 2013, Sun Young was responsible for the management outsourcing of Company C. Company C is a pure-play company in silicon ingot production, and as a subsidiary under the umbrella of Company D has transactions with Sino-si Advanced Material.

For three years running from 2010 to 2012, Company C operated in the red. Consequently a management executive at Company C asked Sun Young to provide management guidance. Sun Young accepted the request and signed a one-year agreement to “borrow” all of Company C, and in March 2013 brought in a management team of five individuals from Sino-si Advanced Material to replace the existing managers and began running the company.

As a result of this agreement, all of Company C’s plants were substantively controlled by Sino-si Advanced Material Wuxi Co., Ltd.. On the other hand, Sino-si Advanced Material had to pay an annual “leasing fee” of 30 million yuan per year. Because all of the company’s earnings net of the leasing fee would flow to Sino-si Advanced Material

Wuxi during the rental period, Sun Young worked diligently to pour all of the experience and know-how he had cultivated up to that point into running Company C. In fact, in just half a year the operating condition of Company C was improved, meaning the management outsourcing by Sun Young would terminate in September 2013 and the leasing fee for six months came to 15 million yuan. During this half year, Sun Young’s management know-how was transferred to Company C.

Situations where individuals other than Sun Young are assisting other firms’ operations as presidents and division managers even though they do not own the companies can also be found. All such examples are cases requested through friendships. In this way, successful entrepreneurs not only continuously establish companies as serial innovators, they sometimes act as presidents or management team members at other companies for a certain period of time.

## VI. SUMMARY AND DISCUSSION: PROS AND CONS OF RAPID DEVELOPMENT BASED ON RESOURCE SHARING

### A. Summary

By conducting a detailed field study on the industry cluster of Wuxi area in Jiangsu Province, this paper explored



how the Chinese photovoltaic (PV) industry had grown extremely fast from the middle of 2000s, and successfully dominated the world PV product market. The paper focused on processes that enabled PV firms to get access to the scarce resources such as technology, management know-how, and skilled labors, which were critical for their growth. Our study particularly indicates that social networks based on informal and personal relations had taken very important roles for Chinese PV firms to overcome problems derived from scarcity of such critical resources. But it also implies that this process has induced homogeneity of firms and driven intense price competition in the market. The study sheds a light on both positive and negative roles of socially-embedded relations on the industrial growth in developing countries.

*B. Discussion: a function of multi-layered relationships*

From the description provided so far, we can understand that among Wuxi's PV companies, relationships between firms mix business relationships with social relationships. Because friendships exist that are not simply divisible as a business, vital information concerning markets, technologies and suppliers is disclosed even to competitors. These friendships, however, are established through business, and moreover are relationships that are used to develop business. Industries cannot develop easily under conditions where resources such as technology, information and management skills are insufficient. We believe this resource scarcity has been overcome through networks of friends that have mixed business with social relationships. These scarce resources ride the networks of friends and are transferred and shared comparatively freely across the firm framework. As a result, learning efficiency as an industry have improved rapidly and accelerated the pace of growth.

Such social relationships in China, often referred as Guanxi, have been attracting much attention in existing studies as factors explaining strength of Chinese industries and corporations [1][2][4][6][9]. Guanxi works effectively under the unstable legal and regulatory frameworks, in particular, as an alternative for the formal governance mechanisms [21]. It also promotes managers to build trust beyond the firm boundary and facilitates exchanges of favors across organizations [9] as well as smoothing transactions and promoting exchanges of important business information [6]. Thanks to such effects, Guanxi has brought positive impacts on firm performance, as many studies have demonstrated to date [1][4][14].

Our analysis on Wuxi's PV firms generally supports these findings provided by existing studies. Our contribution, in this sense, may merely reside in demonstration of how Guanxi works in a real business world in more detail with rich case description. Our study, however, may also have a unique contribution in its demonstrating effects of social relationships on dynamics of industry. Whereas existing studies tend to focus on impacts of Guanxi on firm-level or business-unit level performance, such effects are supposed to

interact each other to produce industry-wide effects if considering a reciprocal, often asymmetrical, nature of Guanxi [2]. If you obtain a favor through Guanxi, you are indebted to give a favor to another who, in turn, is obliged to give a favor some others, and so on. This chain of reciprocity is supposed to accelerate the diffusion and the sharing of scarce managerial resources within a region, which foster growth of productions. Somewhat ironically, this process may weaken a competitive advantage of each individual firm and squeeze a profit margin of its business. Such conjecture may give an alternative explanation on why, under certain conditions, Guanxi does not contribute to performance improvement, especially profit growth [4][14].

Our analysis shows that for Wuxi's small and medium-size enterprises, a firm's "framework" is extremely pliable or fragile. Normally, a "firm" is a discrete social entity in which administration, assets, employees, technologies and brand (company name) have been integrated. In the case of small and medium-size firms, ownership frequently will be consolidated there as well. Wuxi's small and medium-sized PV enterprises, however, cannot be viewed to be existing stably as single, unified firms. There is a strong image in which each of the management resources such as administration, assets, employees and technologies is independent and combined freely across the "firm" framework. Firm names and combinations of business activities are changed frequently as well.

In the example of Company C, Sun Young had the right to manage the company for a certain period of time even though the plant and the employees were not "his", and he brought in his own management team which applied its own operating know-how and technology. That is, the ownership, management, human resources, asset and technologies were combined flexibly across the framework of the firm.

Such flexible use of resources across the firm framework seems to be behind the growth of Wuxi's PV industry. In general, the intangible management resources such as technology, manufacturing know-how and operating know-how that cannot be obtained simply with money are one of the important factors that prevent the growth of firms in late-to-develop countries. The scarcity of such intangible assets becomes a bottleneck, so that even if capital can be prepared, for example, the speed of industrial development in a late-to-develop country will be limited. The PV industry in Wuxi uses these operating resources economically within the industry without confining them inside the framework of the firm. As a result, small and medium-size firms are able to maintain cost dominance, which in turn has promoted cost reductions at leading enterprises. In particular, because it is linked to homogeneity among firms, the recycling of critical management resources within the industry generates keen price competition as a result. This may further enhance the price competitiveness of Chinese firms.

On the other hand, however, the difference among firms becomes extremely small. Critical management information and resources being nimbly transferred and shared through

networks of friends also brings about the rapid homogenization of firms. If procurement information is shared, everyone is able to purchase under identical conditions, production lines are organized comparably including the equipment, and even management procedures are similar, it is natural that both product cost and quality will converge. In fact, this aspect where each firm is well acquainted with technologies, production lines and costs at other companies was revealed through our interviews. The president of one middle-sized module firm, for example, describes his own production line as follows.

Our production line is the same as at Mr. Wang's company. For the laminator and inspection equipment installed on the module production line, we've introduced the same manufacturer's products. In addition... we purchase nearly every item used for module production, including EVA, backsheets and glass, from the same supplier. So basically we're able to know the approximate cost at which Mr Wang's company is producing...<sup>16</sup>

Because they are mutually knowledgeable about purchasing terms and conditions and production lines, these presidents can to some extent surmise other companies' cost of manufacturing and quality level. Neither cost nor quality is necessarily a confidential matter. One CEO of the large PV firm remarked on this aspect as follows.

Small and medium-size firms think in a way that's destroying the order of industrial development. They're trying to survive by getting information from other firms and imitating other people' technology and management, not by charting their own course. With that approach, however, everyone ends up doing things the same way, which oppositely just intensifies the competition...<sup>17</sup>

Our finding is that although the rapid transfer and sharing of information and resources was an important factor producing rapid growth of the industry, it has simultaneously promoted bruising competition among firms and disrupted industry order, without leaving firms any profits. In fact, many of the firms we interviewed were acting by giving greater consideration to cost reductions with an eye on the assumed price six months in the future, rather than to competition with other companies. This is behavior close to that of a "price taker".

If surplus earnings do not remain with the firms, they cannot invest in next-generation technology R&D; their only recourse will be to maintain efforts to further reduce costs with existing technology. Should government capital assistance be discontinued, there's a possibility the industry's

development will come to a sharp halt at some future point. In fact, although China's PV firms have a high market share, their profit level is low. In other words, we might be able to say the very mechanism that promoted rapid industrial growth contains within itself the mechanisms that will hamper the industry's sound development.

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<sup>16</sup> Excerpt from the interview by the authors with CEO of Wuxi EQ Solar Technology Co., Ltd. Conducted on July 29, 2013, at Wuxi EQ Solar Technology Co., Ltd.'s module manufacturing plant.

<sup>17</sup> Taken the interview by the authors with CEO in the large PV Company E. Conducted on November 7, 2014, at Company E.

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