National champions or global partners? Explaining firm responses to industrial policy in China's nuclear and wind sectors

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Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of the author's knowledge, it contains no material previously published or written by another person, except where due reference is made in the text.

Rongfang PAN
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Abstract

State-industry coordination has been regarded as fundamental to effective policy intervention, but the fact is that the state sometimes meets resistance from certain industrial sectors in the efforts of building national industries. So why are firms in some industrial sectors cooperative with the state but those in other sectors unresponsive to state directions? While studies have shown that the pursuit of economic competitiveness and national security accounts for the techno-nationalist orientation of a state, few explain the distinct firm responses to state directions across sectors. In order to understand the sectoral variation in firm behavior, this thesis develops a theoretical framework based on industry characteristics and examines manufacturing industries in two categories, complex product systems (CoPS) and mass-production. It proposes that the distinct natures of the sectors are associated with different domestic-foreign business relationships, which tend to lead to distinct firm responses to state policy in these sectors. Looking into China's nuclear and wind power sectors, respectively representing CoPS and mass-manufacturing, the research finds different outcomes despite Beijing's commitment to a nationalist agenda in both sectors. Indigenous Chinese firms in nuclear power established long-standing strategic business relationships with international vendors and were unresponsive to the national policy of reducing foreign technology dependence, whereas those in wind power were supportive of Beijing's nationalist policies because of the rivalry with leading global producers. Through theoretical and empirical studies, this thesis generates conclusions that are relevant to other political economies and can be applied to other industry sectors.

Abbreviations

863 Program	National High-Tech R&D Program
973 Program	National Basic Research Program
AECL	Atomic Energy of Canada Limited
AMSC	American Superconductor
ASE	Atomstroyexport
BIPV	Building-integrated PV projects
CASC	China Aerospace Science and Technology Corporation
CASS	Chinese Academy of Social Sciences
CAST	China Association for Science and Technology
CASTED	Chinese Academy of Science and Technology for Development
CCP	Chinese Communist Party
CDB	China Development Bank
CGN	Refer to "CGNPC"
CGNPC	China Guangdong Nuclear Power Corporation
CNNC	China National Nuclear Corporation
CNPE	China Nuclear Power Engineering Co., Ltd
CNPRI	China Nuclear Power Technology Research Institute
CNTIC	China National Technical Imp & Exp Corp.
CoPS	Complex Product Systems
COSTIND	Commission for Science, Technology and Industry for National Defense
CPIC	China Power Investment Corporation
CRESP	China Renewable Energy Scale-up Programme
CSIC	China Shipbuilding Industry Corporation
CWEA	Chinese Wind Energy Association
DEC	Dongfang Electric Corporation
DHI	Dalian Heavy Industry
DRC	Development Research Center
ERI	Energy Research Institute
First MMI	First Ministry of Machine Industry
FYP	Five-Year-Plan
GE	General Electric

Gen-II	Second generation
Gen-II+	Second generation plus
Gen-III	Third generation
Gen-III+	Third generation plus
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IPRs	Intellectual property rights
IRENA	International Renewable Energy Agency
JCCT	Sino-US Joint Commission on Commerce and Trade
JVs	Joint ventures
KIBS	Knowledge-intensive business services
LSPV	Large-scale PV projects
MNI	Ministry of Nuclear Industry
MOE	Ministry of Energy
MOF	Ministry of Finance
MOST	Ministry of Science and Technology
MWREP	Ministry of Water Resources and Electric Power
NBSC	National Bureau of Statistics of China
NDRC	National Development and Reform Commission
NEA	National Energy Administration
NEC	National Energy Commission
NHIC	North Heavy Industry Corporation
NIEs	Newly Industrialized Economies
NIIP	National Indigenous Innovation Product
NNSA	National Nuclear Safety Administration
NPIC	Nuclear Power Institute of China
NPPs	Nuclear power plants
NSSS	Nuclear Steam Supply System
OECD	Organisation for Economic Co-operation and Development
PE	Private Equity
R&D	Research and development
REL	Renewable Energy Law
REN21	Renewable Energy Policy Network for the 21st Century
S&T	Science and technology
SASAC	State-owned Assets Supervision and Administration Commission
SDPC	State Development Planning Commission

Second MMB	Second Ministry of Machine Building
SEIs	Strategic Emerging Industries
SETC	State Economic and Trade Commission
SNERDI	Shanghai Nuclear Engineering Research and Design Institute
SNPTC	State Nuclear Power Technology Corporation
Solar PV	Solar photovoltaic
SPC	State Planning Commission
SPCC	State Power Corporation of China
SSTC	State Science and Technology Commission
TEDA	Tianjin Economic-Technological Development Area
UNFCCC	Nations Framework Convention on Climate Change
USCBC	US-China Business Council
USW	United Steelworkers Union
WFOEs	Wholly foreign-owned enterprises
WNA	World Nuclear Association
WTG	wind turbine generators
XWEC	Xinjiang Wind Energy Company

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Chapter 1
Techno-nationalism and the study of firm behavior

1. Introduction

This thesis is about firm behavior: why firms across sectors respond differently to state policies in pursuit of techno-nationalist goals. Firm behavior here is not understood as the pursuit of interests in policy formulation but rather firms' response to the state commitment of building a national industry. In the industrialization process, firms in some sectors are dedicated to fending off foreign competition and making use of government support to become privileged "national champions", whereas firms in other sectors make themselves into the "global partners" of technologically advanced companies and are decidedly lukewarm towards nationalist initiatives. This thesis explores sectoral variation in firm behavior through studies of new energy industries in China, and provides a theoretical framework that explains why firms in different sectors are more or less responsive to state policy. This is done through an examination of two industry sectors, wind and nuclear power.

This chapter introduces the present research through the following moves. It first summarizes the literature on techno-nationalism, including the limits on state capacity in this regard. It then discusses the theoretical and empirical significance of understanding firm behavior by demonstrating that it is an important factor that affects effective policy intervention. This discussion is followed by a detailed statement of the research question and an outlining of the research design to address the question. This chapter then briefly reviews principal findings from the research and closes by indicating the structure of the thesis.

2. Current perspectives

Techno-nationalism is seen in many countries, where governments tend to link technological capability with national interests. Countries with such a tendency regard technology as "a crucial national asset in a highly competitive world" (Kennedy 2013: 913). In particular, states in some industrializing countries stress the essential role of independent manufacturing and technological capabilities in maintaining national security and promoting domestic economic growth (Keller and Samuels 2003; Samuels 1994: 307).[1] For these countries, national interests

[1] For in-depth discussion, please see Chapter 2.

lie in building a national industry comprised of not only domestically owned firms but also domestically owned technologies. In order to achieve the goal, states in these countries are generally committed to enhancing the competitiveness of domestic firms and turning them into "national champions" in the international market. The post-war rise of Japan and consequently South Korea and Taiwan was a well-researched area to delineate the process. Despite being a late-comer compared to its East Asian neighbors, China has long been described as a country with the same tradition (Feigenbaum 2003). Notwithstanding the externally-oriented and market-friendly policies in these countries, most of the countries attached great emphasis on national ownership and technological autonomy in industrial upgrading.

A neo-mercantilist rationale was seen dominating in techno-nationalist countries, where states intervene actively in economic activities. Scholars of development research found that states in the East Asian newly industrialized economies (NIEs) placed top priority on economic development because of a sense of insecurity and the vulnerabilities related to resource constraints and external threats (Doner, Ritchie and Slater 2005; Johnson 1982: 307; Matthews and Ravenhill 1994: 76). Therefore, a developmental orientation is associated with an ideology of striving for economic and technological independence from other states. A number of studies examined the experience of the East Asian NIEs and attributed their economic success to the developmental states at work (Amsden 1989; Haggard 1990; Johnson 1982; Wade 1990; White 1988). In these countries, the nationalist goals were facilitated by states, which developed a set of policy instruments to enhance domestic productive and innovative competencies. These policies nurtured indigenous firms through government subsidies, tax incentives, better access to low-interest credit loans, preferences in public procurement, and other regulatory privileges. In many cases, governments in these countries imposed technology transfer requirements on foreign partners for the development of local industrial capabilities. This line of research pointed to an East Asian model that differed from the neo-liberal approach in the Anglo-Saxon countries, one that stressed the bureaucratic role in targeting and promoting strategic industries through the use of industrial policies.

The capacity of states to formulate and implement policy is essential to fulfill the tasks of fostering national industrial and technological development. In the developmental state literature, states in the East Asian NIEs were seen as strong, cohesive, and autonomous in the policy process (Amsden 1989; Johnson 1982; White 1988). As bureaucratic agencies did not simply represent the preferences of particular political groups and individual firms, they had the autonomy to develop strategies and policies for industrial upgrading. Such state autonomy enjoyed support from a strong and rational bureaucracy staffed by professional and competent bureaucrats based on meritocratic recruitment. The capacity was also strengthened by powerful "pilot agencies" within the bureaucracy, which provided strategic guidance for the purpose of economic transformation and helped industrial sectors overcome obstacles of late development. The interventionist state committed to industrial promotion had access to a variety of policy instruments to wield influence over private sector behavior. As Zysman (1983) demonstrated, the government's control of the financial system contributed to the state's capacity to intervene in the economy. These policy tools included but were not limited to the organization of cartels, tax rebates, and the promotion of state companies (Johnson *et al.* 1989).

In reality, state capacity is often constrained by two institutional factors: bureaucratic coordination and government-business interactions. First, with a focus on the complex and dynamic internal workings of the state, studies criticized the simplistic assumption of the state as an internally cohesive, rational, and unitary actor (Moon and Prasad 1998). Variations in the executive-bureaucratic nexus, intra-bureaucratic dynamics, and bureaucratic constituents led to differing policy choices and outcomes (Cho 1992). The rationality of states was challenged by the fact that industrial policies were highly politicized (Haggard and Moon 1990; Moon and Prasad 1998). On top of the influence of political parties, decision-making within the states was often decentralized (Murakami 1987; Noble 1987). In *Divided Sun*, Callon (1995) showed that contrary to the widely accepted coherence argument, the industrial policy process in Japan was fraught with bureaucratic sectionalism and inter-agency rivalries. Similarly in China, the authority below the peak of Chinese politics was fragmented, segmented and stratified among ministries and provinces (Lieberthal and Lampton 1992; Lieberthal and Oksenberg 1988). Conflicting interests were seen among functionally specific clusters of bureaucracies (Shirk 1994: 93) as well as among multi-level governments (White 1993). In particular, diverging interests between the central and local governments undermined state capacity for channeling capital and resources to competitive firms (Thun 2004).

Another limit to state power is the ineffective coordination with society and specifically with industrial capital in policy-making and implementation. In addition to the need for internal coherence, the embeddedness of state in deep links with the private sector is essential to successful state action, which can be achieved through "the continual negotiation and renegotiation of goals and policies" (Evans 1995: 59). Within the collaborative relationship that took place, there were two-way flows of information occurring between state agencies and firms. That is, firms were "disciplined" by the state, and government support was contingent on firms meeting agreed criteria. Even so, firms still have some degree of agency in policy implementation, either in a positive or a negative way. As discussed by Chibber (2003: 7), the quality of state intervention also lies in whether a state was able to "extract performance" from industrial actors in exchange for the supports that were given to them. In this sense, the degree of firms' willingness to cooperate with the government would affect the state's ability to achieve nationalist goals in the country. Depending on whether business interests are consistent with national ones, firms may be more or less responsive to state policy and as a result facilitate or impede the state-initiated industrialization.

The restraining effect of institutional factors to state capacity is also applicable to the sub-national economy and industrial sectors. Research has already been conducted on analyzing the effectiveness of state intervention based on "the fit between local institutions and firms within a particular sector" (Segal and Thun 2001: 557). Later scholars in this group furthered the research to include variation at the local level: the impact of local bureaucratic structures and government-business relations on the effectiveness of industrial policy in different localities. Looking into China's information technology and auto industries respectively, Segal (2003) and Thun (2006) compared a few municipalities and found that different combinations of local institutional arrangements led to different economic outcomes. Similarly, another stream of studies on "networked polity" also showed that the same logic applied to local and sectoral politics, which shaped the networks of state agencies and industry actors in a country, and between these actors and those in the international production markets (Breznitz 2007; Ó Riain 2004). In the *Politics of High-tech Growth*, Ó Riain (2004) argued that an alliance between the state and domestic technical communities helped promote the information economy in Ireland, Taiwan and Israel.

3. Problem statement

One problem in the existing studies is that sector-specific institutional variation, especially in terms of government-business collaboration, remains largely overlooked and unexplored. In the investigation of local variation, Segal (2003) and Thun (2006) focused on a single industry in a single country. Similarly in the state-level analysis, Ó Riain (2004) only observed one industry in different countries because the comparison can only be achieved by holding constant the industry sector. This constraint determines that their focus is not on sectoral variation, which is an essential part to the understanding of varying practices in industrializing economies. The importance of sectoral politics has been established by researchers stressing the multiple forms of state-industry relationships in the specific sector level, because of which state can both fail and succeed in their industrialization efforts in different sectors (Breznitz 2007: 206). Some emphasized the sectoral analysis of institutional structures because the pattern of whether a state was able to advance industrialization goals was coherent within certain types of sectors (Evans 1995: 81-82; Samuels 2003: 8). While there are many studies focusing on sectoral analysis, most were not designed to explain variations across sectors within a country.

This thesis aims to fill this gap by exploring the various state-industry relationships and firm behavior in different sectors in the same country. By holding constant bureaucratic structures and economic transformation at the national level in a single country, this study of sectoral variation pays greater attention to the state's relations with or its capacity to "extract performance" from firms. In this sense, state-industry coordination in the shared effort of industrial upgrading plays a pivotal role in facilitating national industrial and technological development, but a lack of the coordination may result in a weakening of state capacity in different sectors. As Norris (2010: 3) argued, one important factor for the successful "economic statecraft" is "alignment of goals between the state and the commercial actors", and it would be a challenge for the state to manipulate commercial actors when business interests diverge from those of the state. In a country where the state plays an activist role in industrialization, not all industrial actors follow state directions and are whole-heartedly supportive of government policies. While a cooperative industry is necessary for effective state intervention, one that is apathetic about state-led development erodes a public-private synergy that is supposed to contribute to effective state intervention. In other words, whether business interests are aligned with those of the state or whether firms actively cooperate with the state in nationalist initiatives determines economic outcomes.

The possible variance in the state-industry relationship lies in whether short-term business interests are consistent with long-term national ones. When seen in the embedded autonomy approach, the processes of policy-making and implementation are reflected in the interactions between states and firms, with firms sometimes being the initiators of particular policies and an identification of specific collaborative mechanisms through which policies were implemented (Evans 1995; Noble 1998). However, when the government takes the initiative to formulate policy in consideration of long-term national interests, firms may be in a position to choose how to respond to state policy. In terms of achieving techno-nationalist goals, state policy may not always agree with short-term business interests, and business responses to state directions determine the effectiveness of policy implementation. In this sense, this thesis is not dealing with the question of how policy is formulated but rather, once a country commits itself to specific policies in pursuit of techno-nationalist goals, what the response of firms is to that policy.

So in a country guided by a nationalist ideology, why do firms in some sectors cooperate with the state but those in other sectors are less supportive of state policy? Previous studies emphasized the fact that a mix of conditions such as the threat of wars and colonial legacies gave rise to interlocking government-business ties that remained in place even when circumstances changed and the imperative factors diminished over time (Stubbs 2009). With the changing global security environment and rapid economic growth, there was a reorientation of the relationship in which state capacity was weakened and industrial capital was strengthened. However, due to entrenched ideas and sticky institutions the state-industry alliance was still at work generally as a whole in countries with a techno-nationalist tradition. Therefore, the holistic approach to techno-nationalism does not give reasons for sectoral variation in firm behavior, or firms' responses to policy intervention. The fact is that different practices prevail at the firm level in different types of production and processes. In many cases states face greater challenges or need more time than expected to have the desired outcomes due to business resistance in some industries. Since a national threat is identified as the cause of state-industry coordination that is durable over time, what is responsible for the variant firm behavior in different sectors?

4. Research design and case studies

The thesis is motivated by this puzzle and seeks to explain the variant business responses to state-initiated industrialization across sectors. Studies of local variation have identified the origins of local government institutions based on region-specific characteristics, mainly the institutional context of central-local relations as well as the local culture and shared beliefs among government officials and industrial actors (Segal 2003: 42-46; 156-161). Similarly, the study of sectoral variation should be based on sector-specific characteristics. Traditional studies of firm behavior normally explored the organizational efforts of industrial actors in the policy process rather than the prevailing preferences of firms as individuals in a specific sector (Moe 1980; Olson 1965). Sector-specific economic characteristics such as ownership type, company size, and industry structures have been found to have an effect on firm behavior and types of government-business interactions (Kennedy 2006; Noble 1998). However, most research concentrated on the collective action of firms in driving state policy without explaining whether individual firms are willing to follow the state-led promotion of indigenous capabilities in different sectors. In order to explain the contrasting firm behavior, this thesis begins with searching for the industry characteristics that affect firms' willingness to cooperate with the state in national industrial development.

Considering the role of technology acquisition in industrial development, the nature of production and particularly technology complexity may be related to the dependent variable. In the literature on late-industrialization, firms from some industrializing economies generally relied on those from technologically advanced countries and tended to cooperate with the state to reduce the foreign control and grow in manufacturing and technological capabilities (Amsden 1989). In the process, it is almost always easier for governments to limit foreign ownership control than to wean domestic firms off foreign technology dependence. When firms are not able to assume independent production or develop proprietary technologies, they may find that the effort of working toward technology autonomy puts their profit-making potential at risks. Due to the expected loss from breaking away from foreign dependence, domestic firms may resist the state by preventing this happening. In this scenario, they may choose to maintain their relationships with foreign firms at the cost of the institutional supports they can receive from the state. Therefore, whether firms from industrializing countries want to follow the state in pushing through a nationalist agenda depends on the transferability of skills, which is determined by the nature of production and especially the complexity of technology systems.[2]

This thesis attempts to address the central question by exploring the links between industry characteristics and firm behavior. In doing so, it enquires into the following sub-questions. First, what are the industry attributes and their impact on the accessibility of technologies and capabilities in a particular sector, and how do firms in the sector acquire technologies from the international market? Second, in what ways does the mode of technology acquisition influence business interests, and how would the form of business collaborations affect the relationships between technology recipients and international providers? Third, how would the incentive systems shape institutional arrangements between state and industry, and determine firms' response to the state-directed industrial upgrading? It is expected that these investigations would help understand different firm behavior in a techno-nationalist country, and the fact that firms in some sectors follow state directions and behave in a nationalist way but firms in other sectors are half-hearted in implementing nationalist policies and unresponsive to the government's guidance.

The investigation is carried out in the context of China considering its rising significance in the world economy, historically rooted techno-nationalist ideology, and sectoral variations. As China is rapidly rising as one of the largest economies as well as exporters in the world, it currently enjoys an escalating global influence derived from its internal developments. Over the three decades of economic transformation and spectacular growth, China together with other emerging economies came to the forefront of development studies. In spite of controversies, political economists see China as generally fitting into a developmental state model driven by a nationalist goal. As inter-agency rivalries and local interest divergences are not uniquely Chinese, these factors will not set China apart as a unique case out of East Asian countries. And as seen in its Asian neighbors, industrial policies and selection of promising sectors are common practices, and differing business responses to nationalist initiatives are similarly prevalent in China. Unlike some scholarly work highlighting the "uniqueness" of the Chinese way of development as a "China Model" or "Beijing Consensus" (Ramo 2004), this project places the

[2] For a detailed discussion, see Chapter 2.

Chinese experience within a broader comparative context and is meant to generate conclusions relevant to other political economies and that can be tested in other cases.

Setting the story in China helps hold the general context constant so that comparisons can be made against the same background. Since a nationalist ideology has dominated China's economic transformation most of the time, it experienced a revival in the early 21st century. The liberal market reform gave way to some extent to a new round of state activism after China's WTO accession in the end of 2001. Factors such as a fading socialist ideology, Asian Financial Crisis, challenges originated in WTO rules, and risks of civil unrest were identified as sources of systemic vulnerability that led to the change in China at that time (Naughton 2011; Naughton and Segal 2003: 160-61). In addition, the country's dependence on foreign technologies was seen as a threat to national security, which justified the goal of achieving technological autonomy by nurturing national firms with indigenous capabilities (Segal 2003). At that time, nationalist voices in Chinese academia took hold and validated the need for government intervention and industrial policies in the promotion of national industries. Since then, Beijing placed greater emphasis on advancing indigenous innovation capability than before and was committed to achieve industrial upgrading in the whole economy, in particular the targeted sectors that were expected to give the country's economy not only a boost but also a sustainable future.

In order to understand why the nationalist goal was pushed through successfully in some sectors but not in others, this project examines the nuclear energy industry and the wind power sector focusing on the period from 2003 onwards. The two cases were selected for the following reasons. First and foremost, the authority overseeing the two sectors is the same after the 2003 institutional restructuring. This fact makes possible the comparison of firm behavior across sectors by holding the state structure constant. Second, the two sectors experienced the same nation-wide economic transformation over time. Both the nuclear and wind power sectors started at the time of China's opening-up policy in the 1980s and went through the same changes of policy environment in the past three decades. Neither was given strategic significance in national industrial development and energy use until 2003. As it did to the automobile industry in the 1990s, Beijing designated the two sectors along with many others as new frontiers of industrial development in the early 2000s. Aside from such consideration as energy supply and environmental conversation, the Chinese government also regarded the two sectors as new growth points and new frontiers for industrial upgrading. Third, the sectors under examination pose a perfect contrast to the central question of the thesis: firms in the wind energy sector followed Beijing's guidance for the most part of its catching-up process whereas those in the nuclear energy industry were largely unresponsive to national policy initiatives. The two sectors are perfect testing grounds for why firms played out so differently when the central government was trying to implement a nationalist strategy across the economy. Fourth, the two sectors are selected as comparable but least similar cases that differ significantly on the independent variables specified in the sub-questions of the research, mainly industry attributes and domestic-foreign business relationships.

This research makes use of both primary and secondary sources of information to inquire into the cases discussed above. It draws heavily on sources in Chinese, especially Chinese media, such as Outlook Weekly (*Liaowang*), Caijing Magazine (*Caijing*), New Century Weekly (*XinShiji Zhoukan*), Business Watch Magazine (*Shangwu Zhoukan*), China Economic Weekly (*Zhongguo Jingji Zhoukan*), and China Business Journal (*Zhongguo Jingying Bao*). The heavy reliance on Chinese sources is balanced by an extensive use of Western media reports in Factiva, including Reuters News, Bloomberg, *New York Times*, and the *Wall Street Journal*. Other than that, data collection also relied on written material from various sources, including academic research, official policy releases, and reports of industry associations, research institutions, and government departments. These were supplemented by semi-structured interviews conducted in China between 2012 and 2013, and participants in the research include government officials at various levels, business executives and scholars. The fieldwork included meetings with current and previous employees in the selected industry sectors; it covered visits to bureaucratic agencies overseeing industrial planning, science and technology, and energy administration; it also included scholarly visits to universities and public research institutes, where many scholars actually took part in the panel discussions for national policy-making (see Appendix: The list of interviews, 2012-2013).

Through the lens of comparative case studies, this thesis seeks to build on and add to the literature on techno-nationalism and the political economy of industrial upgrading. More specifically, the research is meant to take the development research further by exploring the origins of business interests, which are seen to have an impact on state capacity and policy effectiveness. Existing studies identified external threat and resource constraints as the reasons for a cooperative state-industry relationship; this project goes beyond this existing literature to shed light on sectoral variations in the relationship and firms' responses to state directions within a country guided by a nationalist ideology. A further significance of the study is that it takes into consideration cross-border business collaborations while most existing studies largely leave foreign firms out of the understanding of business interests and their impact on state policy. Some include discussions of multinational corporations and global production networks but fail to incorporate them in the examination of firms' interactions with states. At the same time, this thesis also provides an institutional analysis following the tradition of earlier studies of China's industrial policy-making and implementation. With the growing academic attention on a stronger political role of industry in China (Deng and Kennedy 2010; Guo 2003b: 194; Kennedy 2005: 3), this project contributes to the inquiry by answering why firms in certain sectors choose to resist Beijing's guidance but not in others, which remains under-investigated.

5. Argument in brief

This thesis investigates whether the nature of technology and production in a particular sector determines the mode of technology acquisition and transnational business cooperation in that sector, which affects domestic firms' reactions towards the state policy of promoting national industries. As discussed in the theory chapter (Chapter 2), industry attributes are accountable for firms' preferences in regard to whether they want to incorporate foreign business interests into part of their own. While generally Chinese firms are cooperative in implementing a nationalist agenda, some in certain sectors have to bundle their business fortune with overseas technology suppliers and push for open policies. Subject to the nature of technology and production, industry actors in some sectors have to enter into strategic business relationships with global lead firms but in others are able to quickly seize technological capabilities and compete with international firms at the frontier. Therefore, for firms from late-industrializing economies, how they react to state directions depends on the relationships with global lead firms. In the sectors where transnational business coalitions are necessary for technology transfer, firms are likely to pursue open policies and challenge the central authority; whereas in other sectors where technologies are readily available, firms do not have to form business coalitions with foreign suppliers, but instead make good use of national support for advantages over foreign manufacturers.

The differing natures of industries and domestic-foreign business relationships are fully reflected in two distinct types of sectors, respectively Complex Product Systems (CoPS) and mass-manufacturing industries.[3] In sectors with CoPS, technology recipients have to establish long-standing strategic business relationships with international vendors due to the difficulty of technology duplication and the need for protracted interactions in customized and engineering-based processes. They derive their intimate relationships with foreign partners from the very complex component interfaces, the need for system integration and project management skills, and the conversion from conceptual to detailed designs. All these normally take a very long time to develop and tend to reinforce the collaboration as a result of a long life cycle, high entry barriers and industry concentration. At the same time, international vendors also need to cooperate with firms from emerging economies not only for business expansion but also for

[3] For more details, see Chapter 2.

brushing up skills and maintaining competitiveness through more installations and follow-on services. For the same reason that technologies and capabilities are "sticky" and "locked in", well-established firms do not have to worry about losing competitiveness even through close interactions with recipients. Therefore, domestic and foreign firms in CoPS need to team up to win contracts: sometimes domestic firms act on behalf of their foreign partners and thus become a challenge to the nationalist initiatives of the state.

In mass-manufacturing sectors, however, transnational coalitions are neither necessary for late-comers nor appealing to global lead firms because of technology transferability and the relative ease of rapid overtaking through codified and standardized production processes. Late-comers could rapidly ramp up production without binding themselves to foreign pioneering manufacturers because of the relatively simple component interfaces, the replicable production line and cost minimization, and most importantly the possibility of reverse engineering with or without help. Production capacity could be achieved with the help of small design firms in a very short period of time due to short product cycle, low entry barriers and large number of competitors. With respect to global lead manufacturers, they have no incentives to get involved in the production process of late-comers considering the relative ease of technology transfer and being overtaken. Bearing such considerations in mind, world-leading firms tend to make every effort to stay away from potential competitors to avoid technology spill-over, even after they decide to enter the target market for greater opportunity. As a result of the competing interests, firms from emerging economies are in a position to compete with global leaders for orders and thus are generally proactive in response to central government support.

These findings are supported by the case studies in China's nuclear and wind power sectors, of which the former is a typical case of CoPS and the latter one of traditional manufacturing. As expected, the Chinese nuclear industry has strategic domestic-foreign business coalitions that are in pursuit of open policies whereas wind equipment production sees competing domestic and foreign interests that motivate local firms to respond positively to the central goal of building up a national industry. In the case of the nuclear industry, politically powerful coalitions played into bilateral government relations, in which Chinese firms lobbied Beijing to choose the foreign models they preferred and their foreign partners mobilized support from home governments for bidding. Chinese nuclear firms acted as their foreign partners' representatives to Beijing because of the need for foreign help with detailed design, construction and management. The CoPS attributes explain the incentives of domestic firms to accommodate foreign business interests and as a result are relatively indifferent to national industry policies.

As regards the wind equipment sector, equally matched producers competed in the Chinese market: local firms engaged in licensed production independently from foreign manufacturers while foreign manufacturers preferred complete control over local operations for the sake of protecting intellectual property. The fact that most Sino-foreign joint ventures did not work out well is perfect proof of the diverging interests between Chinese and foreign producers in the sector. Unlike in the nuclear power industry, the nature of mass-production determined that there was not a base for domestic-foreign coalitions and this was why Chinese indigenous firms became committed followers to Beijing's rules in the wind sector. As a result, Beijing remained largely assertive in building a national industry in the wind energy sector but had to make repeated compromises to the transnational coalitions and departed from its intended course in the nuclear power industry.

Aside from the systematic variations across sectors, each sector shows consistency in firm behavior regardless of timing and changing policy environment. Within the nuclear power sector, domestic-foreign coalitions went into being when China opened up to the outside world and persisted to the new century. Owing to the CoPS nature of nuclear power generation and the stickiness of nuclear technologies and capabilities, Chinese firms established strategic business relationships with foreign firms that strengthened over time and have been largely indifferent to Beijing's nationalist initiatives. The trend did not reverse even when the Chinese state called for technology independence across the nation in the 2000s. In the wind sector, in contrast, Chinese firms have regarded top global wind turbine makers as competitors and been cooperative with Beijing in building a national wind industry from the beginning. This is so because technologies are easily transferable among firms in the sector, where Chinese firms devoted themselves to the formation of indigenous technology and production capabilities while world leading producers avoided local partnerships for the fear of losing competitiveness. The rivalry between Chinese and foreign wind turbine makers was evident even in the 1990s when the Chinese government strongly encouraged domestic-foreign cooperation in the sector. Due to the nature of industries, we can see consistent firm behavior respectively in the Chinese nuclear and wind power sectors, and these patterns of firm behavior in each sector endure over time, both in times of relative openness (1980s-1990s) and in more nationalistic periods (post-2000).

6. Structure of the thesis

The thesis consists of six chapters. Chapter 2 defines a problem continuing the previous line of inquiry and develops a theoretical framework to address the question. It first reflects on existing studies on the institutional mechanisms that maintain a nationalist rationale in late-industrializing economies, and points out that few efforts have been made to explain the alternatives to a cooperative industry in different sectors. It then stresses the importance of focusing on sectoral variations and understanding why industrial actors slow down a nationalist agenda in some sectors but assist with state initiatives in others. Acknowledging the influence of bureaucratic and industrial forces on state capacity, the chapter advances an explanatory model for the varying industry behavior across sectors. It investigates the central question by answering the following three questions: What are the natures of technology and production in different sectors? How do these industry attributes affect domestic-foreign business relationships? and, How do the incentive systems define industries' responses to national policies and affect policy implementation?

Chapter 3 is devoted to describing the background of the study: the evolution of techno-nationalism in China's industrial development and Beijing's nationalist agenda in new energy industries. The chapter is divided into two parts. The first delineates how a techno-nationalist ideology evolved since China's independence and how it came to the fore again in the early twenty-first century. Focusing on a phase-wise examination, it stresses the role of changing internal and external factors in the vicissitudes of techno-nationalism in China, and shows that the risks related to liberal reforms were responsible for the renewed interest in techno-nationalism. The second part demonstrates Beijing's commitment to a nationalist agenda across the whole economy and the targeting of new energy industries, including nuclear power and wind power. It shows that the Chinese state made new energy a prominent part of the broader techno-nationalist initiative and took a heavy-handed approach in promoting local production and technological upgrading in these sectors. Both the nuclear and wind energy sectors received massive national support because of their great potential to become future "pillar" industries.

Chapter 4 and Chapter 5 look into the central question and test the hypotheses developed in Chapter 2 through the study of empirical cases. Chapter 4 scrutinizes the Chinese nuclear energy industry by going through the three inquiries outlined in Chapter 2. It begins by highlighting the distinct features of nuclear energy as a CoPS industry and stressing the fact that technology capabilities could not be easily transferred in the industry. The chapter then underscores the strategic business collaborations between Chinese nuclear firms and international vendors as a result of the stickiness of technologies in the sector. It then focuses on the impact of cross-border business coalitions on Chinese firms' relationship with state and responses to state policies. In particular, the chapter explores the third sub-question generally in chronological order, beginning with a brief overview of the industry between the early 1980s and 2000s and then dwelling on a detailed account of what happened in the most recent decade. At the end, the chapter briefly assesses to what extent business interests interferes with state control and policy implementation in the Chinese nuclear energy industry.

Chapter 5 examines the Chinese wind energy sector in a structure parallel to that of Chapter 4 but reveals a completely opposite case with contrasting natures and dynamics. It explores the sources of a cooperative industry capital in the wind energy sector through the three steps identified in Chapter 2. First, the chapter documents the nature of technology and production capability by setting wind energy in one of the mass-manufacturing sectors and underlines the fact that technology transfer is relatively easier than in the CoPS industries. Second, it examines the competing domestic-foreign business relationship owing to the quick catch-up process of Chinese wind firms and the fear of foreigners in losing their technology edges in the Chinese market. Third, an attempt is made to link the competing interests between Chinese and foreign-owned local firms to their support of Beijing's effort of building up production capacity in the sector. Similar to the nuclear energy chapter, this chapter begins its examination early from the 1980s but mainly focuses its attention on the period after 2003. Finally, it also evaluates how much impact a cooperative private sector has on policy effectiveness in China's wind power sector.

The concluding chapter (Chapter 6) summarizes the findings from the comparative case studies by considering them in the context of the broader research of international political economy. It begins by reviewing the case studies on the Chinese nuclear and wind energy industries, which provide support to the causal relationships among industry characteristics, cross-border business relationships, and firm behavior. The chapter then underscores how this thesis contributes to the literature on techno-nationalism and late-industrialization by establishing a link between industry characteristics and state capacity. It then recommends directions for future research, mainly the need for more case studies and further research in the context of other industrializing economies. The discussion closes by considering the implications this study has for the understanding of sector-specific state capacity, the non-monolithic nature of techno-nationalism, and the economic cooperation between industrializing and industrialized countries.

Chapter 2

A theory of firm responses to state policy

1. Introduction

Research on industrial policy and its implementation has a particular interest in state capacity, which mainly rests on policy apparatus and institutional arrangements between state and industry. Accordingly in explaining variations in developmental outcomes, scholars often look into the complex and dynamic internal workings of a state or whether the state can "get institutions right" in relation to the industry. As the principle works at the national level, it is expected to shed light on the understanding of policy performance in different sectors. When industry sectors in a country share the same state structure, they may have different types of institutional combinations between government and business. Based on the link between institutional arrangements and economic outcomes, this thesis assumes that policy effectiveness depends on the ways that industrial actors respond to state directions. In particular, the focus is on why firms in a sector are predisposed to engage in a more or less collaborative relationship with the state relating to national policies, especially those discriminating against foreign firms. The chapter develops a theoretical framework based on the characteristics of production and technologies in two distinct types of industries, complex product systems (CoPS) and mass-manufacturing. It proposes that the contrasting natures of the sectors are related to different cross-border business relationships, which tend to bring about distinct business incentives and firm responses to national policies in these sectors.

The rest of the chapter undertakes the above-mentioned task. Section two briefly reviews the literature on techno-nationalism and clarifies that in this research the term is synonymous with neo-mercantilism and industrial policies in emerging economies. Acknowledging a security threat as the origin of a nationalist rationale in a country, the discussion points out the need to explain why nationalist initiatives meet enthusiasm in some industry sectors but receive a tepid response from others. The third section builds on previous work on firm behavior and considers the potential explanatory power of industry characteristics, particularly in terms of product complexity and technology transferability. The fourth section explores how these characteristics shape business incentives and responses to state-directed industrial transformation, and brings forward specific hypotheses as a result of the causal inferences. In the process, it identifies two distinct types of industry sectors that are expected to see contrasting firm behavior and state-industry relationships. The fifth section outlines how the theory will be tested in empirical studies, where nuclear and wind represent the two different types of industry sectors identified in section four. The chapter concludes by reviewing what has been discussed and leads to the context analysis.

2. Techno-nationalism and industrial policy

Technologies have long been considered essential for nation-states to gain global economic competitiveness and national security, and advances in scientific and technological capabilities have been seen as key to industrialization all around the world. The post-war rise of Japan and consequently South Korea and Taiwan in the second half of the 20th century is a well-researched area to delineate the process. Their experiences represent a distinct way of industrial upgrading and achieving technological pre-eminence. The approach is based on the belief that foreign-invested firms and their technologies would pose serious challenges to nascent domestic ones and that overdependence on foreign technologies would lead to national security risks. It is therefore necessary for the states of late-industrializers to intervene actively into the workings of the economy, normally through the use of industrial policies, to enhance domestic technological capabilities and indigenous firms' competitiveness in the global economy (Amsden 1989; Gerschenkron 1962). Despite an open stance and unique Chinese characteristics, China has been described as a country with a similar tradition, one of being committed to reduce foreign dependence in the pursuit of technological prowess. The self-reliance complex in late-industrializers is generally known as techno-nationalism, which triggers natural self-defense when they face external threat or other vulnerable situations. Noting the ideology at the national level, the section ends by directing attention to the variant types of public-private efforts in achieving the nationalist goals at the sector level.

2.1 Techno-nationalism

With the link between technological prowess and national interests at its core, techno-nationalism bears different meanings when used in different contexts. It initially referred to the technology policy in the United States and other major industrial powers to prevent the foreign exploitation of their technologies in the 1980s (Ostry and Nelson 1995; Reich 1987). First appearing in the *Atlantic Monthly* in May 1987, the term was used to describe the emerging political concern in the United States about Japanese access to its technologies, and some national-oriented initiatives meant to give preference to American firms and protect American technological breakthroughs (Reich 1987). In relation to the fear of declining power compared to other states, the literature on techno-nationalism has latterly been largely focused on the catch-up of emerging economies by their moving up technological ladders. Most of the scholarly efforts have pointed to the fundamental role of reducing the dependence on foreign technologies in national security and economic prosperity (Feigenbaum 2003; Keller and Samuels 2003; Samuels 1994). While in developed countries techno-nationalism is chiefly concerned with maintaining power and prosperity by protecting technological edge (Kennedy 2013), in late-industrializers it is more relevant to gaining power and wealth through enhancing technological capability.

Most existing studies on techno-nationalism focus on industrializing economies and their aspirations for technological autonomy. In *Rich Nation, Strong Army*, Samuels (1994: x) demonstrated that Japan built up its techno-economic power guided by such a strong ideology, in which “technology is a fundamental element in national security, that it must be indigenized, diffused, and nurtured in order to make a nation rich and strong”. Looking at China in the second half of the twentieth century, Feigenbaum (2003) provided a similar rendition highlighting the central role of technology, the strategic underpinnings of industry policy, and the indigenization of technologies. Rather than simply referring to a specific set of industrial policies, these studies covered almost every aspect of building up national technological competencies and achieving independence from other states. They ran the gamut from historically rooted motivations for self-sufficiency to national systems of innovation, and from science and technology policy to measures promoting all-round penetration of knowledge among national actors. In general, these studies featured a holistic approach, a connection between defense and commercial production, and a well-orchestrated, self-reinforcing system of cooperation between public and private sectors.

Aside from the all-encompassing approach to techno-nationalism, some studies focus on the developmental aspect of techno-nationalism with a special interest in the neo-mercantilist rationale of industrial policy. Techno-nationalism is relevant to the technology decisions of the late-industrializers that prefer “making” their own proprietary technologies and building up national firms, which Amsden (2001) referred to as “independents”. Through the examination of a wide range of underdeveloped countries in Asia, Latin America and the Middle East, Amsden (2001) also discovered that another group of countries, namely “integrationists”, were generally content with “buying” skills and relying on foreign investment. The distinct patterns of technology choice represent the difference between techno-nationalism and techno-globalism, of which the latter underscores an open approach to techno-industry development. With regard to developing countries, international collaboration in innovation often means greater reliance on foreign advanced technologies than the other way round. Therefore, for the “independents” it is necessary to use industrial policy to reduce the insecurity related to foreign dependence, but the "integrationists" do not have such concerns and tend to follow market mechanisms. In this sense, techno-nationalism is associated with but not limited to policy interventions that the state uses to mend market imperfections in the area of techno-industrial development.

Featuring an independent complex in industrial policy, the ideal type of techno-nationalism at one extreme of a continuum is often manifested as an intermediate regime in practice. As Kennedy (2013: 912) put it, "techno-nationalism has pragmatic variants" and "states may adopt a mix of nationalistic and liberal policies in pursuit of national technological goals". At the core of "pragmatic techno-nationalism" is the promotion of indigenous technological capabilities by taking advantage of the opportunities provided by world economic integration, especially foreign technology transfer. The mixed regime echoes the concept of "neo-technonationalism" that stresses four elements as expanding state commitments, public-partnerships, openness toward foreigners, and international cooperation (Yamada 2000). In other words, strategic technology and industrial policies that are motivated by nationalism often go hand in hand with "leveraging the opportunities presented by globalization" (Suttmeier and Yao 2004: 3). Similarly, Keller and Samuels (2003: 12) referred to the regime as "techno-hybrids", in which countries like China "self-consciously invite high-technology foreign direct investment as a means of technical learning" and at the same time "position domestic firms to capture some portion of added value in the production process". With deepening globalization, therefore, the efforts of nurturing domestic innovation capacity and achieving technological autonomy in many countries often involve active engagement with the world economy.

In this sense, techno-nationalism should be treated as an ideological motivation and in many cases involves the expedient use of mercantile and liberal policy instruments. Some studies have underscored the historical legacy and a policy orientation toward technological autonomy in many late developers. Even though Naughton and Segal (2003: 161) acknowledged that China became more open to foreign technology and investments than in the past, they insisted that "China remains strongly technonationalist" if techno-nationalism is conceptualized "as an ideological orientation toward self-sustained autonomy and independence from other states, rather than a specific set of policies". Similarly, Segal (2003: 167) also argued that "it is important to stress the strategic context of technonationalism rather than the policy tools". On top of the historical legacy and continuity of a nationalistic sentiment, some scholars paid attention to policy variation and changes that many countries have undergone as a result of changing global economic environment. In *the Rise of "the Rest"*, Amsden (2001) stressed that the "independents" need to buy large quantities of foreign technology. Even Japan, the paradigmatic example of techno-nationalism, used to rely on imported technology and its technological success was attributed to "the paradox of autonomy through dependence" (Samuels 1994: 271). These studies paved the ways for the understanding of mixed policy regimes. Be it "neo-technonationalism", "techno-hybrids", "open techno-nationalism" (Kang and Segal 2006), or "pragmatic techno-nationalism" (Kennedy 2013), a common aspiration of the late-industrializers is to seek a balance between achieving technological independence and maintaining links with the outside world.

The literature on techno-nationalism is rich and multifaceted, and an understanding of the term should not miss the following connotations. First, even though techno-nationalism can be protecting or gaining technological preeminence, it is often examined in the context of late-industrializing countries aiming for technological competencies and autonomy. Second, it is related to but should not be reduced to state intervention and policy tools meant to mitigate the risks of foreign technology dependence. Third, techno-nationalism is often not the antithesis of an open economy but may be pursued in a pragmatic manner that allows for exchange with the outside world (Kennedy 2013). In brief, pragmatic variants of techno-nationalism are common in the government effort towards achieving technological autonomy.

2.2 The root of techno-nationalism and state-industry cooperation

The techno-nationalist orientation of a nation-state originated from perceived weakness that was associated with national insecurity. The lack of technological capability might cause foreign dependence and pose a threat to a country's national defense and economic competitiveness. This is true for both technologically advanced countries and underdeveloped economies. As Reich (1987) noted, the rise of techno-nationalism in the United States was attributed to the fear of becoming "a technically inferior producer" and consequently "a less independent, less influential, and less secure nation". In late-industrializers, Samuels (1994) found that Japanese techno-nationalism was derived from a sense of insecurity and vulnerability throughout Japanese history. Similarly, policymakers in Korea and Taiwan underscored the connection between economic development and national security, and thus a balance between strategic concerns and firms' interests (Fields 1995). And according to Keller and Samuels (2003: 9), techno-nationalist ideology stemmed from an apprehension of "predatory foreign investors" that "would snuff out nascent domestic ones". This is so because the risks of dependence on foreign technologies are not only related to possible attacks but also sudden price rises or cut-offs of technology supplies when there is not a strong domestic industry.

Security concerns as the motivation for techno-nationalism was similarly conducive to a developmental ideology in late-industrializing economies. In a review of the East Asian experience, Stubbs (2009: 8-9) found a mix of the motivational factors for developmental states, including culture, resource constraints, national insecurity, and capital inflow. Among all the factors, the existence of concerns about security was the most reported facilitative condition for the countries to place top priority on industrialization through the enhancement of productivity. In the post-war period, Japan accelerated its pace in technological and industrial development due to the vulnerability related to such “situational imperatives” as a lack of natural resources, a large population and the need to trade (Johnson 1982: 307). Other countries such as South Korea also pursued a developmental path because state elites perceived their political fortunes being tied to national welfare and their responses to “adverse circumstances”, including poor resource endowments and internal and external threats (Matthews and Ravenhill 1994: 76). The point resonates and is fully developed in the “system vulnerability” argument (Doner, Ritchie and Slater 2005), that developmental states had arisen from the political leaders’ incentives to sustain broad coalitions when facing security threats and resource constraints.

Under such vulnerable conditions, the states pursuing technological autonomy played a directing role in economic activities. In order to overcome market failures and address non-economic issues such as national security, the state actively intervened in the market by directing capital into targeted industrial sectors and selected groups of companies (Amsden 1989). The interventionist state was committed to promoting the innovation capacity of domestic firms through the use of diverse policy instruments, both carrots and sticks. Looking into the experiences of successful East Asian countries, domestic firms in these sectors often enjoy government subsidies, access to low-interest credit loans, preferences in public procurement process, tax incentives or other regulatory privileges. With an aim to increase local productivity, the governments in Japan, Korea and Taiwan supported R&D activities and imposed a technological transfer requirement on foreign investment. Another strategy was the promotion of a nation’s own technical standards in particular industries to insulate domestic firms from foreign competition. Complementary to the incentive system, the governments also imposed performance criteria for the sake of efficient resource allocation among industry actors. Even though studies have challenged state capacity considering the structural complexity of the state and its rationality in decision-making (Haggard and Moon 1990; Moon and Prasad 1998; Murakami 1987; Noble 1987), it is hard to deny the vital role of the state in directing the course of techno-industrial development in the countries with a nationalist goal.

Similarly, security concerns also justified the strategic coordination between state and industry, an important aspect of the state-guided approach in attaining technological independence. Developmental-state theorists demonstrated it was the state-industry cooperation that helped promote technology and production capabilities of domestic firms so that their nations could compete in the international market place (Amsden 1989; Haggard 1990; Johnson

1982; Wade 1990). Within the relationship, state and industry could reach agreement through "reciprocal consent", in which the state provided support in return for the industry meeting certain performance requirements (Samuels 1987). Industry actors were willing to cooperate with the state because of the same reasons that a centralized state authority was needed to intervene in the market. Due to the Second World War, East Asia's social groups were generally fragmented and business organizations were severely weakened, which resulted in top-down decision-making directed by the state (Johnson *et al.* 1989). This is because the private sector in the region was "willing to cede authority to a centralized state in order to repel the external threat" (Stubbs 2009: 7). The interests of public and private sectors alike coincided in avoiding foreign control, and the coordination in limiting foreign competitors helped protect infant industries and provide space for domestically owned firms to survive and grow (Amsden 2001).

Like the techno-nationalist ideology deep-rooted in a country, developmental institutions tended to remain in place despite changing global security and economic environment. Since techno-nationalism and developmentalism are known to be related to particular situations in a particular period of time, a shifting environment might mean changes in the ideas and institutions. Conventional wisdom has it that as a result of interacting with global economy, state-coordinated institutions are giving way to that of a liberal market (Strange 1996). In the highly integrated world economy, governments become increasingly constrained in the use of protective policies due to the international regimes and intergovernmental agreements that require economic openness (Cox and Sinclair 1996). However, the understanding of a retreating state was challenged by scholars stressing institutional continuity. Notwithstanding a waning nationalist idea and an undermining state role after the Cold War, the neo-mercantilist ideas and institutions became deeply entrenched in the countries and continued to influence policy-making because they "produced widespread prosperity, social stability and security against external attack" (Stubbs 2009: 12). Weiss (2003: 25) also pointed to the tenacity of pre-existing arrangements and argued that "the challenges of openness do not negate the significance of domestic institutions" but "tend to make existing normative and organizational structures more important". An open economic environment may serve to strengthen public-private coordination because under international pressure economic actors may invite, rather than reject, state involvement (Weiss 2003: 267). Weiss (2003: 268) suggests that the change occurred in an 'adaptive' way so that institutional arrangements tend to endure, "even if in newly modified form".

2.3 Unexplained sectoral variation in firm behavior

Existing studies have revealed the emergence and endurance of techno-nationalist ideas and institutions in a particular country but few paid attention to the heterogeneity at the sectoral level. As discussed earlier, a sense of insecurity was accountable for the nationalist initiatives and public-private cooperation in countries with developmental goals. Since all the state and non-state actors within a national border face the same security and economic environment, it is expected that the strategic cooperation between government and business prevail in the whole country. However, the public-private interactions and business reactions to state control vary across industrial sectors. Therefore, strategic concerns fail to explain distinct institutional structures in different sectors within an economy guided by a nationalist ideology. Some scholars have made efforts in tracing the historical roots of local institutional differences (Segal 2003; Segal and Thun 2001; Thun 2006) but few investigated the causes of sectoral variation despite the significance it bore in the understanding of development.

On top of a nationalist idea permeating state and society, it is necessary to understand the varying incentive systems and institutional structures in different sectors. In this sense this research agrees with Breznitz (2007: 30; 206) on the importance of sectoral politics, that there are diverging forms of state-industry relationships and political processes in different industrial sectors, and that economic institutions in sectors should be incorporated for the understanding of the developmental state. Similarly, Evans (1995: 81-82) argued that the unit of analysis should be sectors because they tend to vary systematically in patterns of state involvement and modes of governance. Similarly, Keller and Samuels (2003: 8) also pointed to the importance of sectoral analysis of institutional structures because “here there is more coherence within types of production or processes than within types of states”. Even though sectoral analysis abounds in development research, most studies are not designed to explain systematic variations across sectors with an overarching nationalist rationale at the national level. *Rich Nation, Strong Army* (Samuels 1994) adopted a sectoral perspective but all the sectors under examination supported a consistent image of techno-nationalist Japan.

Just as developmental institutions account for overall economic success at the national level, those at the industry level also influence policy performance in different sectors. Within the strategic relationship between state and industry, an institutional balance was the key to increasing domestic technology input in industrial transformation. For the state, too much autonomy from business interests may result in disconnection from the market but too much intervention in economic activities may lead to corruption and rent-seeking. Both situations may mean less efficient resource allocation. As the public-private relationship provided “institutionalized channels for the continual negotiation and renegotiations of goals and policies", an ideal situation would be "embedded autonomy", where the state could get involved in business activities without being hijacked by powerful groups in the policy process (Evans 1995: 59). Policy success or failure mainly depends on whether the state can "get the institutions right" and find a balance between "full autonomy and full embeddedness" (Rodrik 2007: 111). Only in an institutional setting making the relationship right will one find interventionist policies that might stimulate industrial upgrading and promote high-quality growth. Therefore, the effectiveness of policy intervention mainly rests with the institutional linkages between the government and the private sector. And the same is true at the industrial level.

In addition to the long tradition of studying state capacity and internal cohesion, effective intervention also depends on whether an industry is cooperative with or indifferent to government initiatives. Governments made use of industrial policy to overcome market imperfections and achieve economies of scale. On the one hand, the rationality of states in decision-making as well as the consistency and efficiency of industrial policies were challenged by empirical studies. Due to the complex and dynamic internal workings of the state structure, the industrial policy process tends to be fraught with bureaucratic sectionalism and decentralization (Callon 1995; Haggard and Moon 1990; Moon and Prasad 1998; Murakami 1987; Noble 1987). On the other hand, business preferences and behavior sometimes deflect governments away from the interventionist goals. Studies on industrializing economies show that industry characteristics have shaped the incentives of business actors and the patterns of state-industry ties (Amsden 2001; Kennedy 2005; Noble 1998). While the constraints in state capacity were seen accountable for the ineffectiveness of industrial policy, the resistance of industrial actors or a problem of "collection action" among domestic firms was given special attention (Noble 1998). Therefore, apart from internal state structures, effective state intervention is contingent on government-business interactions and particularly cooperative business responses to industrial polices.

Bearing the two sides of the same coin in mind, this thesis attempts to explain the divergent practices of business actors and why the state-industry coordination works well in some sectors but not in others. In many cases a nationalist concept only remains at the central level but mobilizing industries around that goal is another thing in localities and sectors. Within a state-dominated economy, the way that firms interact with the government varies dramatically across sectors and not all are responsive to state directions. In order to understand policy outcomes, especially when focusing on a particular sector, it is indispensable to "look at individual firms and how their strategies resonate with state actions" (Evans 1995: 20). Heterogeneity is particularly prominent in an economy as large as China, in which the state has played an activist role in the industrialization process. Notwithstanding the fact that the central government has been trying to push through a nationalist agenda across much of the economy, observation shows that firms in some sectors play by the rules of Beijing but those in other sectors resist the national initiatives of promoting indigenous production capability. While a responsive industry seeking compromise with the state is regarded as necessary for effective policy intervention, an unresponsive one towards centralized authority undermines public-private cooperation. Since strategic coordination between state and industry is key to industrial accomplishments, it is necessary to systematically explain the variant business reactions to the state-dominated policy process in different industrial sectors.

This task becomes particularly important as non-state interests and arrangements become increasingly visible in China. As Kong (2009: 790) argued, "[M]marketization and integration into the world economy have led to pluralization of both the Chinese society and its decision-making process". Economic reform has created new socio-economic forces and changed the balance of power between state and economy in China. In particular, the increasing political activism of non-state actors such as privately owned firms and MNCs has complicated the policy process. Firms in China have increased their efforts in defending their interests and involvement in policymaking. The state-dominated policy process is now being replaced by a mixed one with both top-down and bottom-up interactions. In Guo Xiaoqin's words (Guo 2003b: 194), "an emerging powerful entrepreneurial class could gradually and ultimately become the main engine of China's reform economy and a constituency independent from state power that demands a strong voice in the political process." China's industrial policies can no longer be regarded as the clear intentions of a strong state or only the result of negotiations among bureaucratic agencies (Kennedy 2005: 3). Business lobbying is becoming an integral part of China's policy process at both the local and national levels (Deng and Kennedy 2010).

3. The significance of industry characteristics

This thesis attempts to address a central question regarding the incentives and responses of business actors toward state-dominated industrialization in different sectors. It differentiates itself from traditional studies that largely focused on the organizational efforts of economic actors. From *the Logic of Collective Action* (Olson 1965) to t*he Organization of Interests* (Moe 1980), collective action among industrial actors was the major theme in understanding business involvement in policy-making. And the discussions mainly revolved around how business interests were organized and how strong the interest groups were in influencing national-level politics in certain policy issue areas. Instead of looking at how collective interests materialize, this thesis stresses the prevailing preferences of firms as individuals in a targeted sector in terms of whether they are willing to cooperate with the state in promoting indigenous technology capabilities. In order to find out why domestic firms are responsive or unresponsive to state policy, the focus is on what factors would shape firms' values and their interactions with the state in that sector.

Economic characteristics have been identified as the factors affecting firm behavior and national industrial policies. Kennedy (2005) recognized the link between economic factors and patterns of government-business interactions, and identified ownership type, company size, industry concentration, technological sophistication, and so on, as influential factors in the policy process. In industries with greater foreign presence, transnational alliances are commonly seen, often putting Chinese and foreign firms on the same side of issues (Kennedy 2005: 170). This point was made clearer in the case of China's WAPI standard, where a broader policy coalition of MNCs and their local counterparts triumphed over a narrower one of local firms (Kennedy 2006). In Kennedy's opinion, size played a greater role than ownership or nationality in determining companies' influence on industrial policymaking. Noble (1998) also pointed out that industry structures are associated with collective action, and that a sector with a high level of industrial concentration is conducive to cooperation among firms. This line of research mainly evaluated firms' organized capacity to drive state policy but did not explain the intentions of firms in following or objecting state directions. This thesis thus goes further to see what industry characteristics would affect the willingness of business actors to come into strategic coordination with the state in building national industries.

What kind of industry attributes will determine whether firms are more or less supportive of state directions in the process of catching up with global lead firms? As discussed earlier, industry structure, especially the number and size of firms, is generally related to how firms in a sector organize and mobilize political and economic support and how efficiently group interests are articulated in interactions with the government. However, these factors say nothing about the preferences of individual firms. Ownership type might offer explanations for why domestic firms cooperate with governments but not why they choose not to. Related to historical experiences, the existing or perceived threat of foreign ownership control has been seen as the major determinant of public-private cooperation in attaining technological independence. Looking into the fate of foreign-owned companies in many late-industrializers in the post-war era, Amsden (1989: 20-21; 2001: 120-121) found that efforts were made "in both the public and private spheres" to avoid foreign control and that "the acquisition or marginalization of foreign manufacturing properties cleared the decks for the emergence of nationally owned businesses. It was a matter of history rather than theory that this happened most in countries with colonial backgrounds". Because of the memory of a miserable past and the fear of future foreign control, domestic firms need government support and protection for survival and growth. But the ownership control of foreign investors is at most an intervening variable because it does not explain why in some cases domestic firms lined up with foreign partners to challenge the national government and in fact hindered the formation of indigenous technological capability and the process of domestic industrialization.

Foreign technology control provides a useful perspective since most firms in industrializing countries relied heavily on foreign technologies in the early days. Due to weaknesses in independent R&D and production, domestic firms have to acquire technologies through import, joint ventures, licenses and joint design, and so on. In a country where domestic production is led by foreign firms, it is always easier for the government to limit foreign ownership control than to wean domestic firms off foreign technology dependence. For domestic firms, the restrictions on foreign ownership control are always appealing but those discouraging the use of foreign technologies are not necessarily so. These firms can be the government-selected "national champions" that received massive support and were obliged to invest heavily in independent R&D. Even though the development of indigenous technology capability is the common goal, divergences might appear between state and industry when the goal could not be achieved. Since state direction is meant to break away from foreign technology dependence, disciplinary or punishing measures might become a burden when firms could not assume independent production or obtain proprietary technical skills. Therefore, in the sectors in which technology acquisition is impossible in a short period of time, domestic firms might go against state directions due to foreign technology control.

Following the preceding discussion, the nature of production and in particular technology transferability might be the answer to the central question on firm behavior. Since technology acquisition is necessary for domestic firms to start and continue business, whether they want to follow the governments' instructions in developing independent capability depends on the ease of technology acquisition in a sector. In some sectors technologies and production skills are so readily transferable that firms in catch-up countries could take up independent production or even R&D. Even though some are weeded out in the process, those that are able to form independent skills are seen as standing up to the standards of government selection. On the contrary, in some other sectors technological capability cannot be easily transferred to another company even when suppliers agree to transfer technologies and all related documents. Due to the complexity of technologies, recipients have to rely on foreign technological assistance throughout implementation and as a result tend to resist the government initiatives of getting rid of foreign technology control. Therefore, the nature of technologies of a sector or more specifically the possibility of technology acquisition may shape business interests and firm behavior in that sector. The next section will explore these factors in more details and provide a theoretical framework that generates two hypotheses.

4. A sectoral variation approach based on the nature of industries

This section is devoted to understanding different firm behavior brought forward in the central question through the in-depth analysis of three sets of sub-questions. One important assumption for the questions is that firms in late-industrializing economies largely rely on foreign advanced technologies and need to acquire technology capabilities from global lead firms if they intend to enter the market. The first set of questions focuses on the nature of technology and production, and the relevant characteristics of an industry sector. These mainly include the complexity of products and systems, the barriers of market entry and product lifecycles, and how these factors affect the transferability of technological capabilities among industrial players. Following these questions, the second step is to examine how industry attributes would affect the interests of domestic firms and those at the international technology frontiers, and how the incentives system would shape domestic-foreign business relationships in the sector. The last set of questions further the analysis by exploring how the relationships would affect business reactions toward nationalist initiatives of reducing foreign technology dependence in late-industrializing economies. In answering the progressive questions, the section comes out with two corresponding hypotheses: *the first is that industry characteristics, in particular technology transferability or accessibility, are associated with different domestic-foreign business relationships in a particular sector; and the second is that transnational business relationships shape business interests and firm responses toward nationalist policies in that sector*.

4.1 Nature of industries

A typology of industry sectors based on the complexity of technology systems is the starting point of analyzing the nature of industry sectors. In a study of civilian nuclear power technology, Metzler and Steinfeld (2014) directed scholarly attention to a particular type of industry sectors typical of complex product systems (CoPS). Considering the dynamics of innovation and production, Hobday (1998: 689) set mass-produced commodity goods apart from CoPS that "are highly customized, engineering-intensive goods". CoPS are typical of a higher degree of "complexity" than commodity goods along a wide array of dimensions, and normally include high-value and high-technology products, control systems, and civil engineering constructs that are made in one-off projects and small batches over a long period of time. Examples include large-scale thermal or nuclear power plants, high-speed railway, offshore oil and gas drilling platforms (Metzler and Steinfeld 2014). Other than that, most industries fall into the category of mass-manufacturing, which involves making large-volume standardized products especially on assembly lines. It is typical of relatively simple component interfaces, a codified production process, and medium-low entry barriers in comparison to CoPS.[1] For analytical purposes, Hobday, Davies and Prencipe (2005: 1112-4) broke the dichotomy down into four categories from simple to complex technology systems, respectively assembly, subsystem, product system, and large technical systems or system of systems. There is a continuum of product complexity, but in order to simplify the examination this thesis concentrates on the two ideal types of CoPS and mass-production (assembly).

Unlike cost minimization in mass-manufacturing, competition in the sectors of complex technical systems is largely based on systems integration and engineering. In addition to the large number of components and subsystems involved, the ways they are integrated together, the difficulties of coordination, and the risk and uncertainty in management also distinguish CoPS from mass-produced goods. Accordingly, firms developing CoPS derive their core competitiveness not from economies of scale but from a broad range of capabilities centering on systems integration (Metzler and Steinfeld 2014). In terms of design, CoPS suppliers need to develop architectural concepts to link customized components together and decide how these concepts are implemented in practice; with respect to equipment sourcing, they have to organize and manage supply chains covering a diverse variety of components and subsystems; as for project management, they need to develop competencies in quality control and resources synchronization, which involve strategies for sophisticated coordination tasks. All these contribute to the competitive advantages of CoPS suppliers.

The multidisciplinary approach to CoPS makes learning and catching up by late-comers much more difficult than in mass-manufacturing. Considering the broad strategies required in CoPS production, incumbent suppliers tend to develop multidimensional strategies and skills involved in systems development that are difficult to duplicate. First of all, due to the extremely high demand for investment and cross-disciplinary expertise, only a few firms could develop the capability of providing bundled solutions of CoPS and the capability is entrenched in certain firms. Second, CoPS are highly customized and vary wildly from project to project. Technology recipients in developing countries or new entrants in the industries tend to find limited scope for routinized learning between product generations and even within products. Third, technology transfer is less possible in CoPS than in mass-manufacturing because CoPS suppliers mainly count on incremental product improvement rather than on radical innovation. Innovation in

[1] Though it can be the production of low value-added goods (such as clothes, toys, bolts and nuts), mass-manufacturing in the research mainly refers to the assembly of more complicated products (such as solar PV, wind power generators, automobiles, mobile phones, TV sets and video players) because of the particular interest in technology systems.

CoPS is a continuous process throughout all stages of design, development, and construction, and sometimes proceeds long after the delivery of CoPS. The process tends to extend over protracted periods and repeat from one generation of products to another. Hobday (1998: 696) stressed the difficulties of transferring knowledge in CoPS through the following discussion.

> From an engineering perspective, the one-off nature of many CoPS, means that it is difficult to systematically capture and recall previous design and development experiences. The larger the project and the more systemic and complex the product, the more important tacit knowledge is likely to be in CoPS project design and execution. In some cases (e.g., passenger airports), overall concept knowledge may reside in a small number of well-known individuals worldwide. In other cases, there may be only a handful of engineering teams capable of designing and building new versions of complex products.

4.2 Domestic-foreign business relationships

Due to the complexity and "stickiness" of production capability in CoPS, firms from emerging economies tend to rely on well-established suppliers throughout the whole process. From the beginning, models and designs do not materialize into projects without the help of CoPS suppliers. This is so even when both sides have already agreed on technology transfer. There is a large gap between the so-called conceptual and detailed designs: CoPS users[2] need suppliers to translate abstract concepts, diagrams and drawings into work packages identifying required equipment and inputs and providing sufficient instructions for construction at the plant site (Metzler and Steinfeld 2014). Aside from design, CoPS buyers also depend on international vendors for upstream supply networks in view of the wide range of components, technologies, skills and knowledge involved in the process. The reliance on CoPS suppliers is also reflected in project management capabilities for the sake of quality and reliability. Due to the one-off nature and extremely high cost of CoPS projects, quality control in production, delivery and operation is of high importance. In particular, users rely on their suppliers to provide related services and support for maintenance and operations. As the capabilities are not easily transferable among industrial players, it is difficult for firms from developing countries to become international vendors through cooperation with suppliers.

On the other side of the cooperation, international vendors also need to collaborate with technology recipients in CoPS production for a variety of reasons. Above all else, the nature of innovation in CoPS determines that suppliers need to renew their skills and competitive advantage through market access and project builds around the world. Capabilities cannot be

[2] For clarity, expressions such as CoPS users, buyers, technology recipients, new entrants, and late-comers will be used interchangeably in the chapter to represent firms from industrializing countries. These firms are normally owners and operators of the CoPS projects. Most of them rely on the technological capabilities of international suppliers from industrially advanced economies. Many bought designs or turn-key projects from international vendors and at the same time made great efforts to catch up with the global lead firms at the frontier of CoPS production.

turned into productivity and may deteriorate if there are not enough orders to work on. International bidding is necessary if the domestic market is limited. In order to win orders in a foreign market, international vendors have to team up with local project users because high-intensity user involvement is required to develop and deliver CoPS. This is because components and subsystems are tailored for specific customers and markets. In gathering user requirements, suppliers need to negotiate with local users on technical issues to decide on architectural designs and make adjustments. The collaboration continues even after the delivery of CoPS because suppliers are motivated to move downstream into service-intensive partnerships “to expand revenue streams and increase profitability” (Hobday, Davies and Prencipe 2005: 1109). Despite the in-depth interactions, international vendors do not worry about losing competitiveness and being challenged by local users in the international market considering the difficulty of technology transfer in CoPS sectors.

Because of the interdependence between them, CoPS suppliers and users are likely to develop strategic business partnerships and political coalitions that tend to persist and strengthen overtime. As CoPS projects are generally not relocatable and have to be implemented at the users’ site, suppliers and users are destined to work together; and if the users are from other countries, cross-border business cooperation is necessary throughout the production cycle, starting from design and development, production and delivery to maintenance and upgrading. As a project unfolds, the negotiations become an iterative and intricate process of consulting with users and adding new features in product systems. The coordination with users is complicated and deepened by “substantial feedback loops from later to earlier production stages which require alterations to overall system architectures or to the design of specific components” (Hobday 1998: 694). And the interdependence tends to last a long time, from project to project and from generation to generation. While the product lifecycle is long in itself, the need for technology upgrading makes the relationship even longer. There were cases that technology recipients eventually developed their own capabilities, but the process normally took a few decades, after which they might still rely on international vendors for core technologies.[3] In view of the long-term strategic cooperation and confluence of interests, international vendors and domestic users tend to enter into transnational business coalitions. Therefore, domestic-foreign coalitions are necessary to push for their common interests in the host government at critical points of time, especially at the biding stage.

In comparison with the sectors engaging in CoPS production, mass-manufacturing tells a completely different story in terms of technology transferability and transnational business relationships. Due to the standardized production process, relatively simpler component

[3] For a detailed discussion, see the case study on the Chinese nuclear energy industry (Chapter 4).

interfaces and the fewer skills required in traditional manufacturing sectors, late-comers have a better chance to acquire production capabilities than do those in CoPS sectors. And thanks to the relative ease of technology transfer, these firms have more options than in CoPS to start independent production, such as signing licensing agreements or buying automated production lines. Sometimes joint development or reverse engineering may help them develop independent know-how and free them from foreign control in business operations. Instead of skills in systems engineering and coordination, firms in high-volume production sectors mainly compete on economies of scale and cost minimization competencies. In this sense, firms from industrializing countries are sometimes in a better position to improve productivity than are foreign mature producers. In addition, relatively low entry barriers tend to deepen the competition for mass-production and further contribute to the cost advantage of late-industrializers.

Due to the relative ease of technology duplication in mass-manufacturing sectors, firms are likely to see each other as rivals in a technology race as well as in market competition. Being concerned about losing competitiveness, long-established producers wish to prevent knowledge sharing with others, especially new entrants. When entering an emerging market, incumbent producers from industrialized countries try to prevent local firms from involvement in their production and avoid partnerships where technology transfer is required. And because of the ease of technology transfer, there exists a particular type of technology supplier providing knowledge-intensive business services (KIBS) in technologically advanced countries. These KIBS firms focus on product design and make a living by offering R&D services and selling licenses, and most importantly, they are not capable of or not interested in production (Miles *et al.* 1995; Muller 2001; Rodríguez and Nieto 2012; Strambach 2001). Due to the ready access to KIBS, late-comers could rapidly ramp up production through licensed production and become challenges to mature producers in a short period of time. Firms from industrializing countries do not have to seek partnership with top world producers but instead are inhospitable to foreign invested manufacturers who intend to grab a share of the local market. Unlike the strategic business cooperation in CoPS production, the relationships between firms from late-industrializers and global top producers in mass-manufacturing are mutually exclusive and competitive.

Drawing on the preceding discussion, we can expect different relationships between domestic and foreign firms in CoPS and mass-manufacturing sectors. *While in CoPS production firms from emerging economies and global lead firms have shared interests and need to enter into long-standing business coalitions, in high-volume production they are likely to see each other as rivals and threats to their own businesses.* The comparative analysis of CoPS and mass-production sectors shows that the more complex the product system of a sector is, the more difficulty new entrants have in gaining access to technical capabilities in that sector. For that reason, technology duplication is less likely in CoPS than in mass-manufacturing. A key difference between the two ideal types of sectors is that when accessing an emerging market, internationally established CoPS producers have to partner and closely interact with local firms but do not have to worry about losing competitiveness in a short period of time, whereas top producers of high-volume commodities do not necessarily need to cooperate with local firms and at the same time are constantly on the alert against their own technical know-hows being copied by others.

With respect to CoPS, late-comers tend to rely on international vendors for systems integration expertise, and because the projects are highly customized, negotiations and collaborations on all sorts of issues are indispensable between them throughout the stages of design, production, maintenance, and upgrade. They have to enter into strategic business partnerships to strive for their common interests, in which new entrants need global lead firms to start business whereas the latter need the former for market expansion, brushing up skills and strengthening competitiveness. And due to the long product lifecycle, the relationship tends to strengthen and stabilize over time. To the contrary in mass-manufacturing, newcomers are able to enter the market through a number of available choices in technology acquisition, and because of standardized and undifferentiated production they are engaged in cost-cutting competition with top world producers. Neither of the two sides is interested in partnering with each other: while newcomers do not necessarily need established producers for technologies and tend to be hostile towards them considering market share, the latter also do not need to cooperate with the former for market access (except for government restrictions) and tend to remain wary about technology transfer. As learning and catch-up could occur in a short period of time, the rivalry is always intense between new and incumbent producers, especially between local and foreign-invested manufacturers in an emerging economy.

4.3 Transnational business relationships and firm behavior

Knowing the link between industry attributes and domestic-foreign business relationships in a sector, it is necessary to see how these factors would affect domestic firms' responses toward government intervention in a developing country. In order to understand firm behavior, the next step is to examine what domestic firms intend to do in relation to foreign firms and in response to state directions. Firms may or may not react actively toward the nationalist policies of developmental states depending on whether the policies of reducing foreign technology dependence meet their interests. In many cases, firms from late-industrializing economies welcome policies discriminating against foreign firms because of domestic market competition. However, firms may resist nationalist initiatives if they share common interests and enter into business coalitions with global lead firms at the frontier of technologies and production. Under such circumstances, they may lobby for the inclusion of foreign players or the selection of foreign technologies in the national programs of industrial expansion. This is particularly true when firms are under foreign technology control and there is no way for them to sever the dependence on global lead firms in a short period of time. The intimate ties with foreign partners may distract them from focusing on independent R&D and developing their own IPRs. Proceeding to the explanation of firm behavior, the next part will investigate the two distinct types of industry sectors through the perspective discussed above.

In sectors focusing on activities related to CoPS, firms from industrializing economies are likely to neglect state policies because of long-term strategic business coalitions with global lead firms. In view of the need to work closely with and rely on international vendors in daily business operations, domestic CoPS firms regard their foreign partners as an integral part of their own interests and hence tend to find nationalist policies unappealing. In that sense, when a developmental state aims to build a national industry by limiting the use of foreign technologies, it is likely to meet resistance from domestic firms. As for the national promotion of indigenous capabilities, domestic-foreign cooperation in CoPS tends to interfere with the process because both tend to find nationalist policies a potential threat to their common interests. For that reason, local firms are likely to act as their foreign partners' representatives to the government and at the same time foreign firms might also lobby their home governments to exert influence on the host government. The transnational coalition is also reflected in international biddings and technology selections. As domestic CoPS users strive to win new orders through bundling together with international vendors, they tend to push the central government to choose the foreign models they preferred, which may impede the development of indigenous capabilities.

With a tendency to go against the state, local CoPS firms are powerful enough to drive state efforts to deviate from a nationalist track or at least slow down the process. Due to the strategic nature and economic significance of CoPS production, these sectors are normally highly politicized and regulated. Government and regulatory agencies are often involved in individual transactions and coordination tasks for a number of reasons, including "safety (as in large scale human transportation systems and nuclear power plants), the need for international standards (as in telecommunications systems), the need to prevent monopolistic abuse, and other strategic and military reasons" (Hobday 1998: 702). And in consideration of the extremely high complexity and cost, the government may directly create institutional systems to mobilize resources for the development of CoPS industries. Therefore, sometimes "governments own, control or closely oversee CoPS production and operation" in CoPS sectors (Hobday 1998: 702). On top of the close interactions with government and regulatory agencies, CoPS firms tend to derive political clout from a large company size: the sectors are normally concentrated amongst a few major industrial actors, mainly owners and operators of CoPS projects. Moreover, they can also borrow political influence from powerful coalitions with international vendors, which tend to make great efforts in persuading their home governments to put pressure on decision-makers in the host government. When the strategic transnational coalitions play into bilateral government relations, state policy is more likely to be driven by business interests.

In comparison to CoPS producers, firms in mass-manufacturing sectors are more likely to support nationalist policies. Considering the competing relationship with foreign producers and especially foreign-invested local plants, local firms tend to embrace nationalist policies discriminating against foreign competitors. Even though firms in developing countries have access to technical know-how and can start independent production in a short period of time, they tend to lag behind global top producers in aspects such as production skills, quality control, and after-sales services, especially in the early stages of development. Considering the arms-length competition in an emerging market, they need to cooperate with the national government in promoting independent capabilities and seizing market share. In terms of state-industry relationships, only some firms have direct access to the policy process and are able to influence national policies in mass-manufacturing sectors. Due to medium or low entry barriers, there are normally a large number of industrial players and the market tends to be highly contested. Except for the government-selected firms that can have their voices heard by the central government, most others are at the mercy of regular market mechanisms. As for domestic firms targeted for government support, their interests of becoming top producers are aligned with the government's intention of building "national teams".

Based on the above discussion we can expect that distinct domestic-foreign business relationships lead to contrasting firm behavior in CoPS and mass-manufacturing sectors. *Whereas CoPS firms are likely to be uncooperative with the state in order to defend the interests of their foreign partners, mass-manufacturers tend to respond actively to state directions due to fierce competition with global lead producers.* In view of the need for long-term strategic business coalitions with international vendors, CoPS firms prefer open policies and tend to resist the nationalist agenda of reducing foreign technology dependence; as CoPS sectors are not only highly politicized but also highly concentrated, domestic firms in coalitions with international vendors are so powerful that they may be able to interfere with the efforts of building up national industries and force state policy onto an integrationist path. Contrastingly, considering the rivalry with foreign competitors, producers in traditional mass-manufacturing sectors favor nationalist policies and are likely to follow state directions of promoting indigenous capabilities; as mass-production sectors are highly competitive, local firms do not have the incentive to resist government support in competing with foreign producers.

5. Empirical case studies

No matter how plausible a theory is, hypotheses and causal mechanisms need to be investigated carefully in empirical studies. In order to achieve the defined objective of the study and test the hypotheses developed in the preceding section, this thesis carries out in-depth analyses of two distinct industry sectors representing CoPS and mass-manufacturing, respectively nuclear power and wind energy in China. The two industries differ in almost every aspect of industry characteristics, such as product complexity, production type, entry barriers, and product lifecycle. Civilian nuclear energy is a paradigmatic CoPS industry, which is typical of extremely complex product systems and multi-disciplinary technologies, production tailored to specific customers, very high entry barriers, and long product lifecycle. System integration is the core capability of nuclear vendors and their positions in the international market tend to stabilize over decades due to the "stickiness" of production capabilities. By contrast, the wind energy sector belongs to the category of mass-manufacturing, where product and component interface is relatively simple, production is highly standardized, entry barriers are relatively low and product lifecycle is relatively short.

Each of the two industrial sectors will be analyzed in three steps developed in the theoretical framework. The first part of each case study focuses on the potential explanatory variable by identifying characteristics of the sectors in question and their implications for technology transferability. More specifically, the examination revolves around product complexity and production type, and their influence on core capabilities in nuclear and wind energy industries. Drawing on the hypothetical analyses from the theoretical framework, the first section explores the association between the types of production competencies, respectively systems integration and cost reduction in nuclear and wind, and the transferability of technological and productive capabilities. The second step of analysis in each case study then concentrates on what was the impact of industry attributes and technology transferability on cross-border industrial relations. In particular, studies of the two cases center on whether the distinct capabilities of firms in nuclear and wind energy industries led to different business interests and hence different types of business relationships between indigenous Chinese firms and long-established foreign firms.

Continuing with the causal inferences, the third part of each case study examines the role of transnational business relationships in shaping firms' responses to Beijing's nationalist initiatives. This part of the investigation accounts for the largest details of the research and tests the causal link between cross-border industrial relations and firm behavior in China's new and renewable energy industries. For the nuclear industry, the study looks into transnational business coalitions and their interactions with the Chinese government with a special focus on firm behavior in the selection of nuclear reactors, localized development, and project approvals. For wind equipment production, the analysis dwells on domestic-foreign competition and government-business interactions through such lenses as public-private cooperation in R&D, joint venture partnerships, and national bidding projects. In each case, the exploration starts from whether the interests of Chinese firms and their foreign counterparts were converging or diverging in the policy issue areas. It then proceeds to ask whether the incentives system of nuclear and wind firms individually shape their reactions to state policies in the two industrial sectors in China. With a brief review reaching back to the 1980s, the investigation focuses its attention on the post-WTO period, especially after the leadership change in 2003.

Throughout the two case studies, the research employs process tracing by looking into multiple data points in a sequence consistent with the theoretical framework. Between the independent variable and ultimate outcomes, the research links a few other factors, including industry characteristics such as technology transferability, motivations on the part of major industrial actors, and cross-border industrial relations. Before reaching the final point of firm behavior in each case, a wealth of data is taken into account to evaluate the decisional process involving all the intermediary dependent variables. By doing this, generalizations on each causal mechanism are made to develop hypotheses that can be linked together and contribute to the theory. The within-case analysis by providing more observations is expected to offset the deficiencies of a research with only two case studies. Before ending each case study, the research briefly assesses the impact of firm behavior on the Chinese state's ability to make and implement decisions in pursuit of national interests. In order to have a primary understanding of policy effectiveness, the last part also considers the progress of independent technological capabilities in the two industries and the adventures of indigenous Chinese firms in overseas market.

6. Conclusion

Highlighting the fundamental role of technological competence in national interests, techno-nationalism was first used to stand for the protective policies found in industrialized countries but has since been mainly associated with neo-mercantilism in late-industrializing economies. In this research, techno-nationalism follows the mainstream studies and focuses on the emerging economies that aim to achieve developmental goals through the pursuit of technological capabilities and autonomy. With a special interest in industrial policy, the research revolves around state directions and particularly state-industry cooperation in reducing the dependence on foreign technologies. The literature shows that concerns such as security concerns and economic “backwardness” have long been considered to be the major sources of techno-nationalist ideology and developmental institutions, which are expected to dominate a country facing vulnerable situations. However, in real life the relationship between government and business is not always cooperative, and industry does not always respond positively to the state’s nationalist agenda. State policy is sometimes driven by business interests and policy performance depends on whether an industry is cooperative or uncooperative with the state. Therefore, it is necessary to know why firms in some sectors are willing to cooperate with the state in the implementation of nationalist policies, but why those in other sectors are not willing to do so.

In order to explain business reactions toward state directions across sectors, the chapter developed a theoretical framework based on industry characteristics. It sought to add to the literature of techno-nationalism and especially industrial policy from a sectoral perspective. Compared with the studies centering on state capacity and bureaucratic rivalries within the state, this research mainly deals with state-industry relations with a special focus on business interests and their influence on national policy implementation. The theory unfolded based on three sets of sub-questions, with the first probing industry attributes and technology transferability, the second querying the associations between nature of industry and nature of domestic-foreign business relationships, and the third assessing the influence of transnational industrial relations on domestic business interests and behavior in relation to state policy. The inferential analysis produced two linked hypotheses: firms from CoPS sectors tend to develop strategic business coalitions with foreign firms whereas those undertaking mass-production are inherently hostile to each other; and because of the contrasting cross-border business relationships, CoPS producers are likely to be unresponsive to the nationalist efforts and interfere with the implementation of state policy, but mass-producers tend to cooperate with the state and follow state directions in carrying out industrial policy.

Chapter 3
Techno-nationalism in China's new energy industries

1. Introduction

A nationalist ideology has been deeply rooted in China's post-war history of technological and industrial development. Originated from the military techno-nationalism since the 1950s, a self-reliance complex ebbs and flows with the political and socio-economic situations but persevered to the present day in China's techno-economic strategies. Notwithstanding a general retreat in the 1980s, the ideology underwent a remarkable revival in China's civilian technology development in the 1990s, particularly after its WTO accession in the end of 2001. With technology-driven and sustainable development becoming the main theme of economic reforms, the Chinese state strengthened its commitment to national innovation capacity and placed a stronger emphasis on the role of "indigenous innovation (*Zizhu Chuangxin*)" in industrial upgrading. Under the circumstances, Beijing designated a wide range of industry sectors as the future areas for industrial upgrading and achieving technological prowess in the world. New energy sectors, mainly nuclear, wind, solar, hydro and biomass, were selected. They were selected not only for techno-nationalist goals but also for such considerations as energy shortages, climate changes and future growth. While the Chinese government was committed to building a national new energy industry, the efforts came out with different results in different sectors. The nuclear and wind energy sectors represent two distinct directions in response to Beijing's nationalist initiatives.

With a particular focus on changing state-industry relations, the chapter bridges Chapter 2 with Chapter 4 and Chapter 5. In the context of China's new energy industry, it introduces the central question that was brought forward in the theory chapter and will be examined in the following empirical chapters. The next section investigates the evolution of techno-nationalism at different stages, covering the early development of modern defense industries, civilian industrialization during the economic transformation, and the resurgence of a nationalist ideology in the new century. Section three concentrates on the situational imperatives that caused the Chinese government to target new energy sectors, and the heavy-handed approach it adopted to promote domestic production as well as indigenous innovation in the sectors. The section pays special attention to Beijing's nationalist agenda in the nuclear and wind energy sectors, and the strategic targeting of the two sectors in China's technological and industrial upgrading. The concluding section reviews the chapter and sets up the puzzle to be examined in the following empirical chapters.

2. The continuity and change of techno-nationalism in China

Techno-nationalism in contemporary China originated from the late 19th century and experienced important manifestations in the post-war era. Gaining technological capability has been the overarching theme in the country's struggles of constructing modern economic and defense systems. At the time of foreign aggression and consequent humiliations, a strong state was essential to the survival of the Chinese nation and the Chinese state's priority was given to building a military force relying on modern technologies (Zheng 1999: 23-5). Since the People's Republic was established, a techno-nationalist rationale has been embedded in the ideologies of China's political leadership and circulating within the Chinese state and industry. Stemming from a period of great external threat, techno-nationalism persists to the present time of peace and has played a significant role in the country's strivings for national security and economic development (Feigenbaum 2003). Even though the distinctive institutional arrangements developed in the 1950-60s became less relevant after China's liberal reforms at the end of the 1970s, the ideology has been deeply rooted in the economic and institutional development of the country. As a result of the changing conditions internally and externally, nationalist practices in China's industrial development underwent a general retreat in the 1990s and a remarkable renaissance in the 2000s. Since then, the Chinese state attached greater emphasis on technological upgrading and particularly on the promotion of indigenous technological capabilities of domestic firms.

The rise of techno-nationalism in China has been closely linked to the vulnerabilities of the state caused by internal and external factors at different stages. Throughout modern Chinese history, a "strong state complex" has been the main stream of Chinese nationalism, which arose whenever the state was challenged (Zheng 1999: 17). In the Maoist period, the presence of external threat and the need for national unity made a strong state necessary to catch up with Western powers in technological capability, and this led to the militarization of science and technology (S&T) and the mobilization of all domestic resources to develop nuclear weapons. Under the auspices of Deng Xiaoping, the pursuit of technological self-sufficiency gave way to the creation of economic wealth, and national economic policy transformed from central planning to market reform and opening to the outside world. As a result, the dominion of the state was compromised by marketization, decentralization, and globalization. At the beginning of the new century, reforms from the previous two decades had released many forces that went beyond the control of the state. In response to the declining capacity, the Chinese state made attempts to regain its control over industry, departmental and local interests, and international forces. It was against the backdrop that China entertained a renewed interest in technological self-sufficiency while accommodating the needs of integrating in to the world economy.

2.1 Military techno-nationalism (1950-1978)

An aspiration of national security propelled China onto a techno-nationalist path after its establishment in 1949. With a long history of civil war and foreign aggression, one of the most pressing tasks of the war-torn country at that time was to strive for peace and stability, and ward off the threat of nuclear weapons amid an international arms race. And the most pressing task for the Chinese state to prevent foreign aggression was to build a modernized military force. The Chinese leaders led by Mao Zedong decided on a strategy of "active defense" through the development of cutting-edge military technologies, especially nuclear weapons, missiles and nuclear-powered submarines. This took place within the political and economic institutions derived from the Soviet model, in which the party maintained a commanding height in political power and the central state a strong control over economic planning and management. The efforts finally led to the successful development of "Two Bombs and One Satellite", which were crystallized into the "spiritual monument" of self-reliance for the country (CAST 2009).[1] Under the conditions of external threats, weak industrial base and backward economy back in the 1960s, success in the strategic weapons programs represented a great achievement that was later acknowledged by Deng Xiaoping as a proof of China's capability and international position (CAST 2009).

China's nationalist strategy in techno-military industries gained prominence because of the weakness related to the technology dependence on other countries. Initially China received technical assistance from the Soviet Union to build a national nuclear program, but an ideological divergence between the two countries resulted in the Sino-Soviet Split and the discontinuation of the aid. According to the accords signed between 1955 and 1958, the Soviets were to help China construct an experimental nuclear reactor and a cyclotron, and to supply a prototype of the atomic bomb, missiles, and related technical data to the Chinese (Lewis and Xue 1988: Chapter 3; Liu and Liu 2009: 71-73). However, the joint defense projects did not go smoothly because of ideological conflict between the two countries: the radicalization of China's domestic politics and drastic left-turn of foreign policy conflicted with Soviet proposals for peaceful co-existence with the capitalist world led by the United States (Li 2012: 53). As a result of the deteriorating relations, in the mid-1960 the Soviet Union withdrew its experts

[1] "Two Bombs and One Satellite" refer to the successful development of atomic and hydrogen bombs in the 1960s as well as the "Dongfanghong No. 1" Satellite in 1970.

working in China and cut off the supply of key equipment and components, which left many civilian projects unfinished and stalled the defense programs. To break the "nuclear monopoly" of its adversaries, China continued the strategic weapons programs on its own and its technology community had to make overall adjustments to the original schedule. The termination of technical assistance reaffirmed the Chinese belief in not relying on others and the negative memory became an alarm bell ringing all the time. For Chinese leaders before economic transformation, foreign technology dependence went hand in hand with potential national security risks, and autonomy was a major theme in China's technological and industrial revitalization particularly in the post-independence era.

The strivings for technology independence created distinctive institutional arrangements that helped the implementation of the defense programs in China from the late 1950s to the 1970s. As the epitome of central planning, a radical mass-based system was believed to play a significant part in China's defense industrialization such as the development of "Two Bombs and One Satellite". It involved the intense mobilization of resources according to Mao's instruction of a "great synergy" (*Dali Xietong*), including major commitments of financial resources, and the organization of technical expertise and equipment supply across the whole country (Zhang 1999). A central committee within the party was established to lead the technocratic coalitions in carrying out the strategic programs. Despite dissenting voices in the leadership and disruptions to civilian industrialization, the programs continued even during the tumultuous years of class revolutions and natural disasters. China finished the first nuclear test in 1964 and became the fifth country that had nuclear weapons after US, Soviet Union, UK and France. Subsequently, the country launched the first Hydrogen bomb in 1967 and the first satellite named "Dongfanghong-1" in 1970. According to a People's Daily article in 1999, these achievements were attributed to a centralized authority as well as the "institutional advantages" that enable the socialist China to "mobilize resources to get great things done" (*Jizhong Liliang Ban Dashi*) (People's Daily Online 1999).

In spite of distinct discontinuities in China's scientific and technological development before 1978, nationalism as conception and practice were in full play in China's initial military modernization as well as civilian industrialization at this stage. Admittedly, the understanding of China's R&D experience is not limited to a consistent image considering the disorderly development and distinct discontinuities in the first three decades of its founding. At the stage of economic start-up, a developmental goal and ideological indoctrination were intertwined with periodic interruptions to the progress because of factional competitions and policy shifts between periods.[2] Suttmeier (1974) emphasized the varying strategies from one period to another, mainly represented by the "bureaucratic-professional model" and the "mobilization model". However, the disruptions and policy changes did not eclipse the need for national security and the subservience of scientific competence to the goal. Even though little progress occurred if the national economy was examined as a whole, China's scientific and technological plans nonetheless reflected the theme of self-reliance and catch-up throughout the stage, and the ideology was deeply rooted and carried along over the following decades.

2.2 Changes in techno-nationalism (1978-1999)

Along with the easing domestic and global environment, techno-nationalism in China gradually moved behind the curtain and liberal reforms came onto the scene in the late 1970s. When global environment became less hostile and the civil unrest came to an end in 1976, China under the Deng leadership shifted its priority from military modernization to economic construction. Through the demilitarization of its science and technology agenda, China sought to implement a developmental strategy for the modernization of civilian industries. With the new focus on economic prosperity, the Chinese state inaugurated a massive economic transformation that involved releasing control to market mechanisms and opening to the outside world. It deepened the market-oriented economic reform and global economic integration particularly after the Cold War. As a result of administrative decentralization and economic privatization, the balance between state and market was tilted toward the latter. And because of the open policies toward foreign trade and capital, the approaches to industrialization shifted from self-reliance to the encouragement of foreign technology transfer, which were known as "trading market for technology". As the liberal policies were adopted for the sake of "learning" foreign advanced technologies and establishing national industries, sometimes expedient measures with liberal elements were taken for long-term nationalist ends (Amsden 2001).

One direct result of the liberal reforms was a scaled-back state relative to the rise of industrial enterprises and the increasing role of business interests in policy process. The state-industry relationship in strategic defense industries did not change much but experienced dramatic changes in civilian industries as the market was maturing. In addition to bureaucratic contentions and local government interests, the emergence of business interests, state-owned or private, became another major force that could deflect the developmental goals at the center. Even though the state was far from disintegration and demise, its capacity was eroded by the pressures of market forces and transnational corporations (Naughton and Yang 2004; Zheng

[2] These mainly refer to the Maoist radical politics in the Anti-Rightist campaign (1957-1959) to purge "rightists" within the party, the Great Leap Forward (1958-1961) for rapid industrialization and prohibition of private farming, the ensuing great famine (1959-1961), and the Cultural Revolution (1966-1976) purging remnants of capitalist and feudalist elements in China.

2004). The commercial nature of the market and the profit-maximization preference of firms sometimes deviated from national long-term goals. More often than not, the deviation went beyond the country's security concerns as well as the ambitions of economic prosperity and better standards of living. In other words, the pursuit of public good by the Chinese state was sometimes subverted by industry's quest for economic competitiveness. Therefore, the "great synergy" in the 1950s and 1960s was no longer realistic especially in civilian industries after the economic transition in the 1970s. While the state-led coordination might be still possible in strategic defense industries supported by substantial investment, it met challenges from a stronger industry and the need to make profit in commercial production.

In addition to a stronger industry during the post-Mao era, the implementation of developmental policies was also compromised by bureaucratic fragmentation. The Chinese state has become less monolithic and more decentralized than in the earlier stage: institutional adaptation, proliferation and diversification created a complex system of state institutions (White 1991); and authority below the peak of Chinese politics is fragmented, segmented and stratified among ministries and regions (Lieberthal and Lampton 1992; Lieberthal and Oksenberg 1988; Shirk 1994). The decision-making fragmentation was reflected in and derived from conflicting interests among functionally specific clusters of bureaucracies, which hampered the state to translate national grand visions into policy outcomes. The ramification of goals and interests among agencies made the process not as neat and consistent as suggested by the late-industrialization literature. In particular, a misalignment emerged between the S&T policy structure and the industrial development system led by the NDRC. While on the one hand the S&T system represented by the State Science and Technology Commission (SSTC) was keen on technology advancement, the NDRC on the other hand put great emphasis on a balanced development as well as economic ties with other countries, and tend to give priority to efficiency and economy of scale over other considerations. This was referred to as "two separate pieces of skin" by Premier Wen, indicating a disjunction between S&T and economy, and the inconsistent support of moving up technological ladders and commercializing innovations (Wen 2011).

Due to the changes in political and economic institutions, techno-nationalism in China evolved into a complementary blend of a self-reliant legacy and the key elements of an open economy. The central government's efforts of building up domestic innovation and production capabilities were integrated into the global economy by opening up the economy to foreign investment and encouraging technology transfers through selective partnering with multinational corporations. The developmental goals of nurturing indigenous producers and achieving technology autonomy were pursued at the cost of giving control over domestic assets to foreign firms at the initial stage. On the one hand, foreign direct investment was welcomed and advanced foreign technologies and equipment are imported; and on the other hand, home-grown innovations and improvement were encouraged through the "introduction, digestion, absorption and re-innovation" of foreign technologies. In Chinese terms the practice was known as "walking on two legs", and in Japan's experiences was called "the paradox of autonomy through dependence" (Samuels 1994: 271). In the eyes of some political scientists, China could only be seen as a techno-hybrid embracing a limited form of techno-globalism: through global economic integration it managed to "position domestic firms to capture some portion of added value in the production process" (Keller and Samuels 2003: 12). This is echoed by the notice of "neo-technonationalism" in China where national interest "is pursued through leveraging the opportunities presented by globalization" (Suttmeier and Yao 2004: 3).

At this stage, S&T was regarded as the "primary productive force" in revitalizing China's national economy (Xinhua News Agency 2009b). Research and development policies were made to address the institutional barriers to development. This involved a portfolio of policies promoting research capacity and financial, tax and fiscal instruments to implement the policies. In addition to rectify the regulatory environment that was antagonistic to innovation left from the earlier stage, the Chinese government started to reconstruct the R&D system in the mid-1980s (IDRC and SSTC 1997; Simon 1989; Suttmeier and Cao 1999; Xue 1997). At the center of the transformation were a number of national research programs, of which the most significant one was the 863 Program, a comprehensive program to develop critical technologies and close the technological gap with the rest of the world. To ensure economic and national security, these areas of technologies were selected for the localization, diffusion and nurturance of innovation capabilities, which incorporated the same elements as seen in Japanese techno-nationalism. Apart from cutting-edge technologies, a series of other programs, for example the 973 Program (the National Basic Research Program), were launched focusing on other areas, especially basic research, innovations and technologies to promote industrialization. By the end of the 1990s, Chinese S&T decision-makers started to emphasize the role of the state in building a national innovation system and promoting domestic innovative capacity (Shi and Liu 1999).

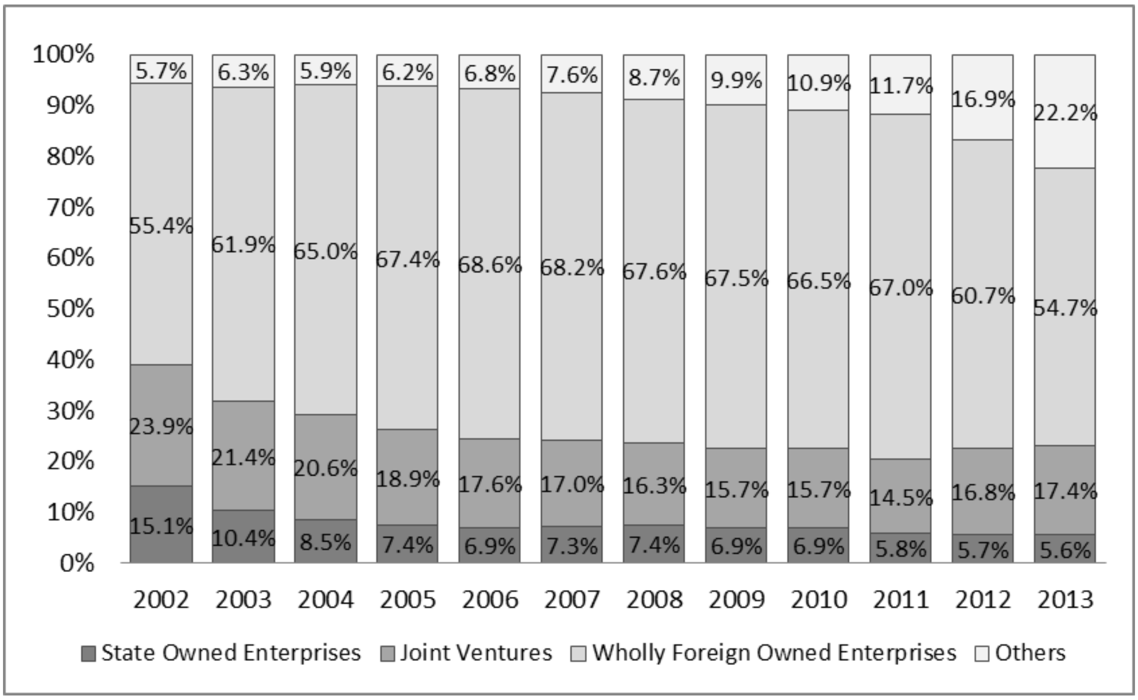
2.3 Revival of techno-nationalism in the new century (post-2000)

Entering the new Millennium, the risks associated with liberal reforms became increasingly prominent in China and brought techno-nationalism back to the fore again. While the traditional facilitating conditions for nationalist strategies in the post-war era were no longer relevant, a different set of concerns following the opening efforts imbued the ideological heritage new life and vitality in the country. As a consequence of the 1997-98 Asian Financial Crisis, the Chinese policy-makers became aware of the challenges that globalization and economic liberalization might bring to the country. They sensed the threat of international capital to national economic security and were concerned about the institutional problems that China shared with other East Asian economies (Wang 2000; Zheng 2004). They attributed the malaise of the crisis-stricken countries to deregulation and privatization under the pressure of the United States, which dominated the major international organizations including the WTO and the World Bank. In addition, the preparations China had made for WTO accession exposed its economy further to the associations with foreign investment. Along with the great opportunities that WTO entry was expected to bring about, anxieties abounded among Chinese about China's WTO commitments and its capability to respond to the new competitive challenges.

In addition to the exposure to an open market, the concern over foreign technology dependence also pushed China toward a knowledge-intensive developmental trajectory with renewing interest in nationalist policies. Despite its remarkable economic achievements, China entered the new century remaining at the low end of the industrial chain, and high technology has yet to become the major driver for industrial growth. By the end 1990s, China had seized opportunities in the global production networks where low labor costs mattered the most, and an input-driven type of growth dominated the entire economy. The structure of China's technology economy was "not so high-tech, nor so Chinese": for the most part the country was a low value-added assembler of imported high-tech components and most technology-intensive manufacturing is set up and managed by foreign investors (Rosen 2003). According to the statistics provided by the Ministry of Science and Technology (MOST), wholly foreign-owned enterprises (WFOEs) and joint ventures (JVs) accounted for the largest proportion of China's total exports of high-tech products (see Figure 3-1). As a result, most Chinese firms were stuck in low end commodity manufacturing, undifferentiated activities, and cost-cutting competition (Steinfeld 2004).

In stark contrast to the breakthroughs China made in spaceships and submarines, its record of innovation in commercial technologies had been weak. China can now stretch 'from the faraway heavens to the depths of the sea' with its successful launches of Shenjiu (space-crafts) and Jiaolong (manned deep-sea submarines) (Shen 2012), but this does not necessarily translate into a high-tech market share, because the approach to develop defense programs is not replicable in civilian industries where technological upgrading should be driven by industry actors. As Pye (2003) pointed out in a review, "The close linkage between technological development and security has meant that substantial resources have gone into a few key fields of science where China could claim world-class status, but the rest of its science lags far behind." Similarly in 'Low-tech bed, high-tech dreams', Rosen (2003: 27) suggested that commercial technology had little in common with these sensational projects, which were ‘the result of command-and-control policy with no budget constraints’, because ‘the object of commerce is not just to produce the most impressive product, but to do so profitably, and hence sustainably’. Most of the studies pointed to the same fact that in the beginning of the new century China was still left with limited capability in civilian industrial technology and the national innovation system in general.

Figure 3-1 Share of high-technology export by ownership types, 2002-2013



Source: Table 2-10 Exports of high-tech products by ownership, in China High-Tech Industry Data Book, available at http://www.sts.org.cn/sjkl/gjscy/data2014/data14.pdf, accessed on 15 May 2015

Seen as the country’s Achilles’ heel, S&T was elevated to the central place in national development strategy. China’s leadership recognized the “world factory” role that the country played in the global production network, where domestic producers depended on foreign innovation and had to pay royalty fees to technology suppliers. Considering the foreign control over China’s technological future and vulnerability related to the reliance, the Chinese state determined to play a dominant role in the promotion of national innovation capabilities and pursue technological strategies motivated by nationalism. The resumed strong-handed approach of the state tilted the balance away from market but did not fundamentally depart from the existing open trajectory and market reforms. As discussed later, the issuance of a national S&T plan in 2006 reflected the combination of top-down, state-directed initiatives and bottom-up, multifaceted efforts creating a business environment supportive of entrepreneurship (Segal 2011).

At the same time, some other factors within the country also led the Chinese state to engineer a more activist approach to economic management. The "new state activism" originated from a "reform fatigue" in the early 2000s when market-oriented economic reform in China gradually lost steam and was accompanied by problems associated with the heavy reliance on energy and resources, the risks of domestic instability due to high unemployment, and the concerns about social insecurity because of the inefficient public welfare system (Naughton 2011). Since the change to Hu-Wen administration in 2003, China experienced a "left tilt" (Naughton 2008) and witnessed a general reorientation that set the development path apart from one single-mindedly focusing on building market institutions in the 1980s and 1990s. Two major concepts came out to underscore the importance of a technology-driven and more inclusive type of growth, respectively "harmonious society (*Hexie Shehui*)" for building social institutions and "scientific development concept (*Kexue Fazhan Guan*)" for encouraging indigenous innovation and sustainable development. In order to achieve the goals, the Chinese state aimed to play a controlling role in addressing the identified problems such as foreign technology dependence, environmental deterioration, energy shortage and social issues. In place of a fading socialist ideology, economic nationalism became an alternative to justify the continuing role for the government and the Chinese Communist Party (CCP) in economic policy (Naughton and Segal 2003: 160-61).

This strategic shift was embedded in a spate of scholarly debates within China over what kind of strategy China should pursue to elevate the industrialization to a higher level. Leading the nation-wide discussion was the Lin-Guo debate published in the International Economic Review, a bimonthly by the Institute of World Economics and Politics, Chinese Academy of Social Sciences (CASS) (Guo 2003a; Lin and Sun 2003). Guo Kesha, former researcher in CASS and currently working in the State Council Research Office, argued that the comparative advantage of labor- and resource-intensive industries would put developing countries in an inferior position within the international trading system. He believed that government intervention and strategic trade policies would facilitate the development of technology-intensive industries and industrial upgrading. In response to Guo, Lin Yifu Justin, former professor at Peking University and currently Chief Economist and Senior Vice President of the World Bank, reiterated the significance of comparative advantage strategy in economic growth. He and his colleague contended that Comparative Advantage-Following (CAF) strategy would lead naturally to upgrading in industrial and technological structures but Comparative

Advantage-Defying (CAD) strategy would result in misallocation of resources to inefficient industries.

Alongside the big debate on economic growth were contending visions about achieving technological excellence. While some Chinese economists maintained that the most effective way would be to continue technology transfers from multinational corporations, some others, particularly those in the technical community, argued that technological spill-overs from multinationals were disappointing (Cao, Suttmeier and Simon 2009). Since China's WTO accession in 2001, the advocates of strategic industrial policies have published reports claiming that foreign dependence snuffed out the technological innovation capacity of the firms in Chinese "backbone" industries, such as automobiles, civil aircrafts and nuclear power (Gao 2001a; Gao 2001b; Gao 2011; Lu 2005; Lu 2006a; Lu 2006b; Lu and Feng 2004). Despite the focuses on diverse industries, one common point that the reports made was that the use of foreign investment and technologies did not assist but instead impeded the formation of domestic technological capabilities, and without intervention the situation was self-perpetuating and tended to reinforce the dependence on foreign technologies.

The nationalist voice finally took hold, and an ambitious plan was put into place to encourage and reward indigenous innovative technologies. In January 2006, the Medium and Long-Term Plan for Science and Technology Development (2006-2020) was issued by the State Council, and the "indigenous innovation" strategy was officially incorporated to guide technological and industrial development in China. The fifteen-year plan demonstrated the Chinese states' commitment to promote indigenous innovation, and to transform China into an "innovation-oriented" country by 2020 and a technological leader in the world by 2050 (Cao, Suttmeier and Simon 2006; Serger and Breidne 2007). One major target of the plan was to reduce China's foreign technology dependency to less than 30 percent by 2020, down from 50 percent in 2005.[3] Another objective of the plan was to increase the contribution of S&T in China's economic growth to 60 percent by the year 2020. Aside from the designation of national megaprojects, the Chinese government had adopted a set of techno-economic policies to enhance the competitiveness of indigenous firms. In addition, the State Council designated seven "Strategic Emerging Industries" (SEIs) in 2010 to intensify the support of indigenous firms engaging in high-technology innovation activities (The State Council 2010; Xinhua News Agency 2010). By fostering the future backbone industries, Beijing was meant to work toward sustainable national development backed by overall improvement in technological capability

[3] Foreign technology dependency in China is measured as the ratio of technology imports to the sum of technology imports and national R&D expenditures. Other goals of the MLP for S&T development include raising the contribution of science of technology to China's economy to 60% and moving into the world's top five countries in terms of invention patents granted to Chinese and international citations for Chinese scientific papers.

and industrial upgrading. In addition to the traditional policies, the government designed policy instruments to create a demand-pull effect on domestic innovation, including government procurement of innovative products and services, financial subsidies to end users, and establishment of technical standards (Duan and Pan 2014).

3. A nationalist agenda in new energy development

The Chinese state made alternative energy[4] a prominent part of the broader techno-nationalist initiative and a new frontier to achieve the developmental goals in the new era. Even though the exploration of non-fossil energy resources in China began early in the 1980s, production in the sectors was not commercialized and did not receive massive government support until the Tenth Five-Year-Plan (FYP, 2000-2005). This was because of the internal and external pressures China faced at that time, mainly energy supply shortage, dependence on energy import, environmental deterioration and risks related to foreign competition. As in the early 2000s the commercial use of new energies was new to China and most other countries, the Chinese government regarded it as an opportunity for the country to grab the "first-mover advantage" and take a leading position in the world. Starting from 2003, the Chinese government adopted a strong-handed approach to help domestic firms to thrive in the commercialization of new energy technologies, seeking to build them into important players in the international market, in terms of not only production and sales but also innovation and designs. It increased R&D support for the technological innovation of new energies through national science and technology programs. In addition to the traditional policy instruments focusing on incentives and input, market-creation methods have been employed to encourage local production by providing sales outlets for domestic firms. Since then, China's new energy sectors became a new growth engine for the country and commanded an increasingly large share of global new energy manufacturing.

3.1 Situational imperatives

New and renewable energies were put onto China's national agenda of technological upgrading in view of the vulnerabilities accompanying its economic success. Aside from the consideration of rich clean energy resources and huge market potential, new energy sectors ascended to a prominent position in the country's long-term plan of industrialization due to the challenges stemmed from growing demand for energy, worsening environmental pollution, and opening to

[4] There is no one agreed definition for "alternative energy". This research uses this term interchangeably with "non-fossil energy", "clean energy", "green energy", "new energy" or "new and renewable energy". In China, the term generally refers to energy resources alternative to fossil fuels, including both renewables (such as solar, wind, hydroelectric, tidal waves and biofuels) and non-renewables (such as nuclear, geothermal, and hydrogen). Similarly in the China Energy Statistical Yearbook, the category of "non-fossil energy" encompasses nuclear energy in addition to the "renewable energies", which means energies that come from naturally replenishable resources.

the global economy. China entered the new century with two decades of rapid economic growth, which brought with it a huge cost in the form of environmental degradation. In addition, the growing appetite for energy to fuel its accelerating economic growth became a major concern looking to the future. Energy security was becoming increasingly a critical issue in China as its dependence on foreign oil increased over years after its oil self-sufficiency ended in 1993. In order to mitigate the problems related to energy supply and environmental protection, China joined many other countries in making the energy resources with little or zero emission a major component of its energy strategies. In doing so, the targeting of new energy sectors provided a new source of growth that might help buffer the negative impact of foreign competition on Chinese companies in traditional energy industries after WTO accession.

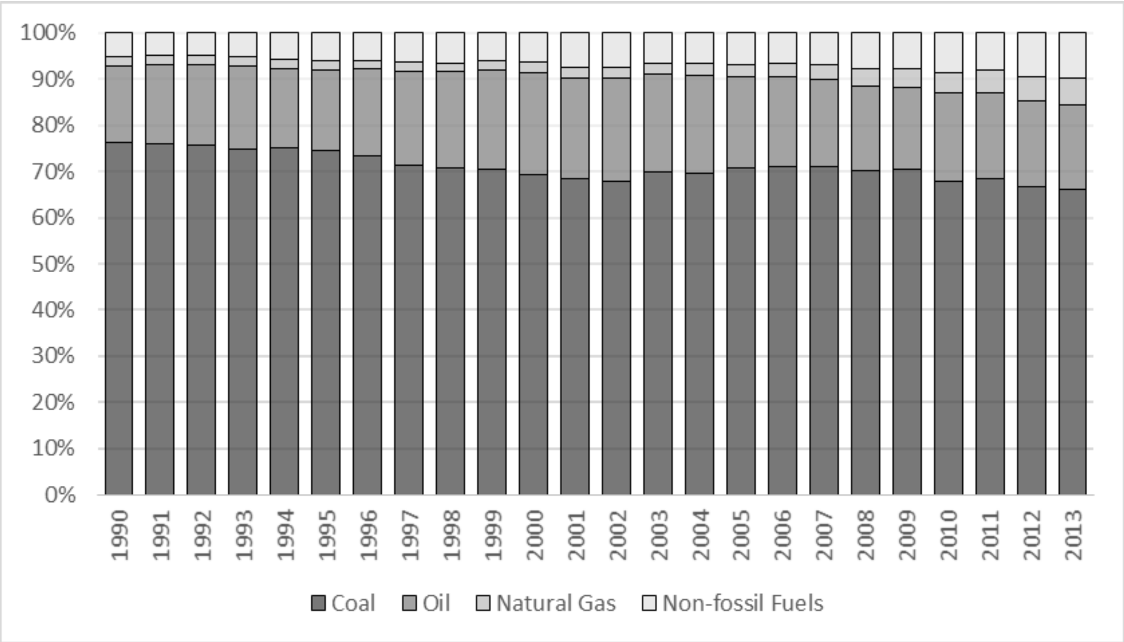
Among all the factors the concern over energy security was the major driving force for new energy development in China. Considering the oil crises in the twentieth century, the Chinese government regarded the possible interruption of sufficient supply of energy sources as one of the greatest challenge for the country to maintain sustainable economic growth in the new century. Along with the rapid economic growth was a surging demand for energy and other natural resources. Despite the improvement of energy efficiency, energy consumption in China increased annually by 15.3%, 16.1% and 10.6% in three consecutive years from 2003 to 2005, and the increase rate in 2003 surpassed that of GDP growth of 12.9% in the same year (NBSC 2014).[5] In the year 2003, fossil fuels accounted for 93.5% of total energy consumption in China, of which roughly 70% came from coal, 21% from oil and 2.5% from natural gas (Figure 3-2). Because of the heavy dependence on fossil fuels, China was vulnerable to the uncertainty of energy markets and political instability of energy producing countries (Andrews-Speed, Liao and Dannreuther 2002; Andrews-Speed, Liao and Dannreuther 2005; Downs 2000; Downs 2004; Downs 2006; Harris and Naughten 2007; Lieberthal and Herberg 2006; Zha 2005a; Zha 2005b; Zha 2006). Therefore, aside from the effort of securing traditional energy supply, the government made concrete steps to diversify the energy structure and buffer against fluctuations in global energy prices by promoting alternative sources of energy. In 2003, a decade after becoming a net importer of oil, China made a long-term strategic decision to reduce the dependence on energy import by developing alternative sources of energy, which are expected to become the mainstream power supply in China by 2050 (Sun 2009).

The pressing task of environment protection also pressed China to move toward a low-carbon economy fueled by clean energies. Apart from energy security, another concern related to the fossil-based energy structure was greenhouse gas emissions mainly from coal and oil. In China, the burning of coal contributed to around 85 percent of carbon dioxide (CO_2) emissions,

[5] Calculated based on Table 9-2: Total Consumption of Energy and Its Composition, and Table 3-1: Gross Domestic Product.

74 percent of Sulphur dioxide (SO_2), 60 percent of Nitrogen oxides (NO_x) and 70 percent of soot in the air (Shi 2009). As coal consumption continued to grow, oil consumption also increased as a result of the rapid expansion of automobile production and sales since the 2000s, which made China the largest automobile market in the world. One direct result of the rising energy demand was deteriorating air quality that exceeded safe levels and put people at health risks. As shown in Figure 3-3, China's CO_2 emissions more than quadrupled from 2,473 million tons in 1990 to 10,281 million tons in 2013, and the share of global total CO_2 emissions increased from 10.9 percent to 29.1 percent during the same period. Environmental problems became politically sensitive and incited growing mass protests, especially against the building of coal-fired power plants, chemical plants, oil refineries, and so on. The number of complaints to the environment authorities increased by 30 percent annually from 2002 to 2007 (Ma 2007),[6] and pollution replaced land disputes as the main cause of social unrest in China since 2013 (Bloomberg News 2013). In order to "maintain stability", the Chinese government had to decarbonize its energy consumption structure by encouraging the use of non-fossil fuels in power generation, residential heating, industrial production and transport.

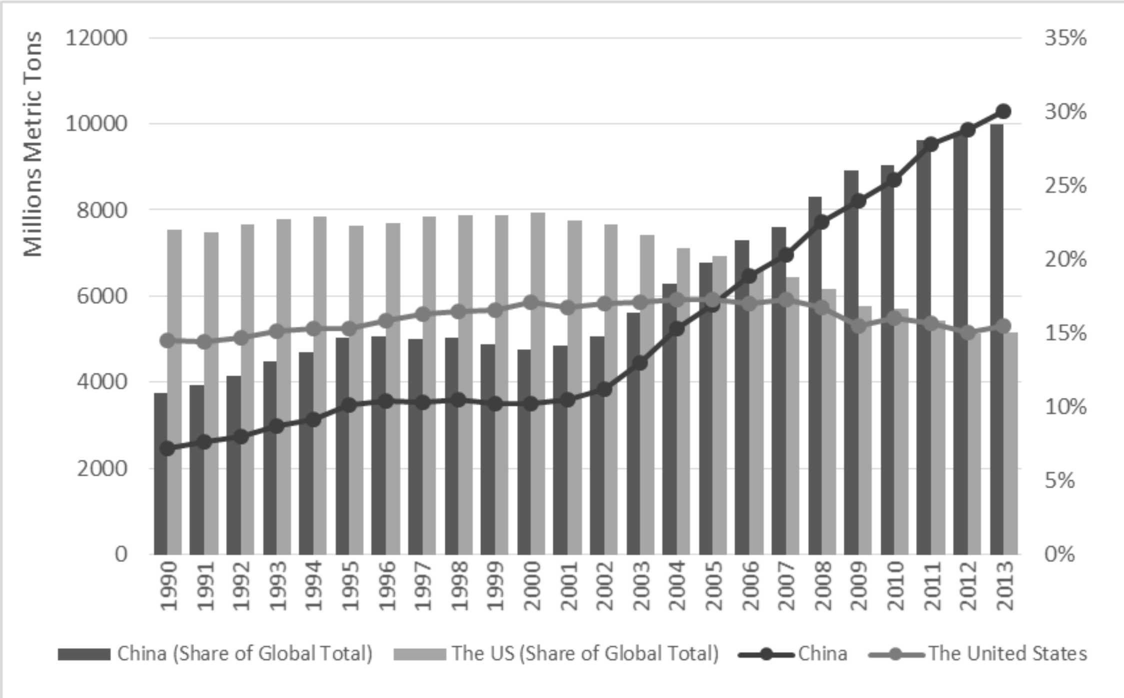
Figure 3-2 Structure of China's energy consumption, 1990-2013



Source: National Bureau of Statistics of China (NBSC), China Statistical Yearbook 2014, available at http://www.stats.gov.cn/tjsj/ndsj/2014/indexeh.htm, accessed on 25 May 25, 2015. See Table 9-2: Total Consumption of Energy and Its Composition.

[6] Ma Jun is a Beijing-based environmentalist and founder of the Institute of Public and Environmental Affairs.

Figure 3-3 CO2 emissions from fossil fuel use and cement production, 1970-2013



Source: Emission Database for Global Atmospheric Research, release version 4.2 (EDGARv4.2), European Commission, Joint Research Centre (JRC) and PBL Netherlands Environmental Assessment Agency, available at http://edgar.jrc.ec.europa.eu/overview.php?v=CO2ts1990-2013, accessed on 25 May 2015.

Aside from domestic environmental crisis, China has been under enormous external pressure to cut CO_2 emissions because of the new agenda on global climate change. With a succession of double-digit growth rates since the 2000s, China overtook the United States to become the world's biggest CO_2 emitter in 2006 and the top energy consumer in 2009.[7] While greenhouse gas emissions were believed to be responsible for global warming, China "has become the focus of scrutiny as climate change has become ever more important as a global issue" (Dai and Ren 2005: 6; Lewis 2008). As a result of the increased international attention, the Chinese government had to take on onerous targets of emission cuts through international negotiations surrounding the United Nations Framework Convention on Climate Change (UNFCCC). China has ratified the primary international treaties including the Kyoto Protocol in 1998 and the Copenhagen climate change conference in 2009. In particular, the country pledged in the Copenhagen summit to reduce its "carbon intensity" (carbon emission per unit of GDP) by 40-45 percent by the year 2020 based on the 2005 level (Eilperin 2009). In order to achieve the goals, the Chinese government adopted measures to enhance energy efficiency and green the energy structure through the use of clean energy.

[7] According to the data from PBL Netherlands Environmental Assessment Agency and the International Energy Agency.

Most importantly, clean energy was a new growth point to make up for, at least partially, the opportunity cost related to alleviating environmental damages. The greatest predicament of the Chinese state was seeking to implement the obligations and fulfil the commitments without sacrificing economic growth. A “growth-first” philosophy was at work here because “a major slowdown could incite social unrest, alienate business interests and threaten the party’s rule” (Kahn and Yardley 2007). And the development of alternative energy resources was a potential way out. For Beijing, the commercialization of new energies was expected to help reduce the reliance on fossil fuels and rein in the damaging environmental effect, and more importantly, it had the potential to become a powerful new boost to industrial upgrading and economic growth. At a time when industries were largely driven by inefficient energy consumption and low value-added production activities, emerging industries such as new energies could increase the chance of making breakthroughs in this sense, let alone the other effects such as job creation and revenue generation (Dai and Ren 2005: 7; Zhang 2011). In particular, these industries were expected to facilitate the “Western Development Program” because the western regions of China accounted for over 70 percent of the country’s renewable energy resources, and development of the industries would bring stimulus to the region’s economy (Zhou 2005). Improving living standards through electrification was another consideration: renewable power generation would help make electricity available in remote areas where there was no access to electricity (Wang 2002).

Like other emerging industries, new energies were expected to provide a cushion to absorb the impact of WTO entry on traditional energy sectors. With opening to the outside world, barriers were gradually removed and domestic energy markets were exposed to the increasing pressures of competition from transnational oil corporations. Chinese production of coal, oil and natural gas was not competitive compared to other countries because of outdated technologies, low productivity and poor management (Zhang *et al.* 2002). While the loss of industrial competitiveness might be the cost, the commercialization of new energies could be a cure to the problems during the transitions. It might bring new job opportunities and close the gap with industrialized countries by diverting the focus of competition to something new (Li *et al.* 2004). Admittedly, in a short period of time the country could not count on new energies as a panacea for all the tasks of climate change mitigation, energy mix optimization, and sustainable economic growth. However, these adverse circumstances were indeed the considerations that drove China onto the national development of new and renewable energy sectors: the Chinese government expected that these sectors would make significant contributions to the country by addressing the above-mentioned problems (NDRC 2007b; SETC 2001b).

3.2 Beijing's commitment to a nationalist agenda with regard to new energy industries

Considering the vulnerabilities discussed above, the Chinese government selected new energy as one of the key industries for support. Because of its prospects for energy self-sufficiency, energy mix optimization and climate change mitigation, new energy was targeted to push forward a low carbon economy that was oriented to "resource-conserving" (*Ziyuan Jieyue*) and "environment-friendly" (*Huanjing Youhao*). This happened against the background of a resurgence of techno-nationalism and new energies occupied an important part in the visions of China's technological future (Kennedy 2013). Accordingly, the Chinese state under Hu-Wen leadership launched a green campaign to integrate the task of modifying its polluting economic structure into that of building China into a technological power in future. In making new energy a strategic priority, the Chinese government sought to reduce its dependence on foreign energy technology and build a new growth engine driven by domestic firms with indigenous technology and production capabilities. The Chinese state has tried to dominate the process through the continuous efforts of centralizing the fragmented energy policy-making. In addition, Beijing unveiled a multitude of programs and policies to support the growth of domestic firms and their control of market share, domestically and internationally. Despite the liberal practices in consequence of decades' opening up, a nationalist legacy persisted in national energy policy-making and served as a fundamental guideline for China's energy planning.

In order to turn the fossil fuel dependent energy system to a healthier one, China resumed the efforts to establish a centralized authority over the energy sector. For a few decades China's energy governance was splintered among over a dozen government agencies and several attempts to create a ministry of energy failed. The first and the only one established in 1988 was dissolved only five years after its creation. The major obstacle had been inter-agency conflict as a result of overlapping bureaucratic functions and bickering group interests among state-owned energy companies (Liu 2012; Xu 2010: 78-82). There was a new round of efforts consolidating energy governance since 2003: out of the institutional restructuring came the NDRC's Energy Bureau that was later upgraded to a vice-ministerial body in 2008, but it remained constrained in the authority of coordinating the interests of state-owned energy companies and various agencies with jurisdictions over the energy sector (Downs 2008). The wrestling interests fueled a step further toward centralization in 2010 when National Energy Commission (NEC) was established under the State Council in 2010. Since then attempts have been made to include other agencies under the NEC's umbrella and move toward an energy "super ministry", but the process met with challenges from powerful players in the sector. Despite the tortuous path of China's energy institutions, the country have been generally working toward a centralized energy monitoring system with a greater level of control and regulatory efficiency than before (Liu 2012).

On top of streamlining energy governance, China established the strategic importance of new energy in industrial upgrading and national energy strategy through legislations, regulations and plans. The first legislation for new energy, the Renewable Energy Law (REL) was passed in 2005 and put into effect in 2006. The comprehensive law was designed to establish a framework of strategic plans, development targets, financial support, and economic incentives for the development of renewable energies. It was the landmark of new energy becoming a national energy strategy and served as an overall guidance for the industry's future development. In the Medium and Long-Term Plan for Renewable Energy Development (2007-2020), China aimed to increase the share of non-fossil fuels in primary energy needs to 15 percent by 2020; and later the target was raised to 15 percent of final energy, meaning a larger increase compared to the share of primary energy (Martinot and Li 2010; NDRC 2007b). Later in 2010, the State Council listed new energy, including wind, nuclear, solar and biomass, as one of the seven Strategic Emerging Industries (SEIs) and a potential "pillar industry" in the ten-year program (2010-2020) (The State Council 2010).[8] Through the national legislations and plans new energy was elevated to a strategic height in China's energy policy as well as technology-driven industrialization.

In consequence of a historical legacy and new trends in the 2000s, a nationalist theme ran through the policies, standards, laws and regulations that China have used to promote new energy. Even though the Chinese government generally welcomes an open market for trade and investment, it attaches greater emphasis on self-sufficiency and formation of national industries, which was known as "green mercantilism" (Stepp and Atkinson 2012). As in most industrializing countries, industrial policies commonly seen across the whole economy were applied to promote the development of new energies in China. Many of them directly supported domestic production, including subsidies, low-interest loans, tax incentives, and discount in the use of resources such as land, electricity, water and raw materials. Some others were policies related to trade and investment, where customs duty exemption or reduction was applied to facilitate key component import or whole unit export. Sometimes restrictions on imports and foreign investment were applied to limit foreign competition. In addition to the traditional industrial policies and government R&D funding, other programs and policies were unveiled to encourage local manufacturing, purchase of locally manufactured parts, indigenization of

[8] Energy saving and environment protection, next generation information technology, biotechnology, advanced equipment manufacturing, new energy, new materials, and new-energy vehicles were identified as the seven emerging industries of strategic importance in the future. It is expected that the industrial added value of these industries will contribute 8% to China's overall GDP by 2015 and 15% by 2020.

foreign technologies, and promotion of domestic technology products through government procurement (Buijs 2012).

The Renewable Energy Law (REL) set the foundation of supporting local companies in new energy sectors through the provisions related to financial support, independent research and market creation. One important part of the REL was the establishment of a financial system and the commitment to a 1.5 trillion-yuan investment to new energy development, to support research, pilot projects, commercialization, and equipment production. A dedicated fund for renewable energy was established under the Ministry of Finance in 2006 and allocated in the form of grants and subsidized loans. In the wake of the 2008 global financial crisis, the Chinese government also developed a 5-trillion-yuan stimulus package (2011-2020) to promote alternative energy, including nuclear power (People's Daily Online 2010). In addition, Beijing has devoted massive financial resources to research and innovation in new energy sectors, and the R&D funding was meant to equip domestic companies for a future in the international market. In 2006, new energy technology and its utility-scale use were incorporated in China's Medium and Long-Term Plan for Science and Technology Development (2006-2020) as one of the principle areas and priority subjects (MOST 2006). The plan's guideline spelled out policy incentives encouraging innovations by domestic firms, such as pre-tax deductions for R&D investment, depreciation of R&D facilities, and loans to encourage innovation-related activities.

Another important element of the REL was to create a demand pull for the new energy sectors by ordering mandatory connection to the state grid. There was a mandate that state utility companies purchase the full amount of renewable power generated within the coverage of their grids and generate specific share of their total power from renewable sources. The mandatory grid connection has been supported by national feed-in-tariffs, a pricing mechanism that set fixed premiums above conventional electricity production costs so as to subsidize new energy power producers for the amount of electricity they contribute to the grid. It equals to a national cost sharing system through which the extra costs of new energy power are distributed over all electricity users. The follow-on measures of the REL required utilities to pay renewable energy developers full price for their electricity and gave consumers of renewable-generated electricity discounted rates. In addition, the 2009 update of REL strengthened the provision that state utilities must purchase all power generated from non-fossil fuel sources. These measures are meant to support production indirectly by boosting domestic market demand and deployment of new energy power generation facilities. Some of these policies are also prevalent in other countries engaged in the development of alternative energies, particularly Europe, Canada, and Japan (González 2008; SETC 2001a; Stokes 2013; Zhou 2005).

There were also mandates and incentives to encourage the use of domestically manufactured components and support the development of indigenous technologies. Despite the fact that local content requirement was mandatory in some sectors (wind) but not in others (nuclear) and even mandates were later abolished because of external pressure and compliance with WTO rules, local sourcing became a norm in the industry society and was acclaimed by domestic companies.[9] It has been popular among domestic firms to boast their local content rate, for which they could sharpen their edges by building a “national image” in addition to competing on price. This was because a “national champion” was more likely to attract attention and preferential treatment from the government. Therefore, no matter local content requirement is an obligation or not, it has been an important incentive scheme that the Chinese government uses to nurture domestic producers of components and parts. The bias toward “buying local” did not only protect domestic firms from foreign competition but also forced foreign firms to train local firms in providing quality products. In order to secure market access, foreign firms were forced to source components and parts locally and develop networks of local suppliers with desirable capabilities.

In addition to independent research, the indigenization of foreign technologies has been another important approach to technology acquisition in China’s new energy sector. In most emerging industries, the Chines government has emphasized the role of introducing foreign technologies in the formation of Chinese IPRs, or re-innovation. New energy is not an exception. In the initial stage of clean energy development, especially in the 1990s, the Chinese government required overseas producers to be paired with Chinese companies in exchange for market access, which was normally followed by technology sharing with local partners.[10] More often than not, the government imposed foreign investment restrictions by limiting total ownership of foreign firms in domestic firms. By equipping Chinese new energy firms with know-how they otherwise would not have access to, Beijing sought to promote the development of independent IPRs and prepare indigenous firms for gaining global market share. Throughout the process, the Chinese state aimed to direct domestic firms’ learning-by-doing through the nurturance of upstream and downstream capabilities.

Preferences were also given to local innovations in the new energy sector by limiting government procurement to products with full Chinese IPRs. Early in 2002 when the Government Procurement Law was issued, a link had already been established to prefer

[9] For a detailed discussion of local content requirement, refer to Kuntze and Moerenhout (2013). Their definition for local content requirements is “policy measures that require foreign or domestic investors to source a certain percentage of intermediate goods from local manufacturers or producers. These local producers can be either domestic firms or localized foreign-owned enterprises”, p.5.

[10] This is what has been done in China’s infant industries at different stages, such as auto and wind power sectors. For detailed discussion, see Chapter 5.

domestic production in the purchases made by government agencies, institutions, SOEs and other public entities. As techno-nationalism received increasingly prominent place in the country as a whole and also in the new energy sector, China had made government procurement an important part to promote domestic technology products since 2006 (USCBC 2011). A series of administrative measures surrounding the linkage between government procurement and "indigenous innovation products" were announced during that period (MOF 2007a; MOF 2007b; MOF 2007c; MOF 2007d; MOF 2007e; MOST, NDRC and MOF 2006). The strategy culminated in the National Indigenous Innovation Product (NIIP) catalogue announced in 2009, which required that only products accredited as indigenous innovation products can have access to the government procurement market (MOST, NDRC and MOF 2009). To be qualified for the accreditation, the intellectual property associated with the products must be Chinese, and the trademark of the products had to be owned by a Chinese company. Foreign-invested enterprises might qualify but had to be wholly owned or majority controlled by Chinese nationals. Together with other SEIs, new energy and equipment were also included in the catalogue, where NIIP recognition promised priority in government procurement projects. Even though later the accreditation system was cancelled in 2011 due to external pressure, it set up a barrier for foreign owned companies to compete for clean energy procurement contracts in the years that Chinese new energy firms developed the fastest and domestically-developed technologies gradually came into being.

Apart from the mandate link between indigenous innovation and procurement policies, national energy projects have played a pivotal role in facilitating the sales of clean energy products. Under the direction of the Chinese state, these projects aimed to create opportunities for local producers and build up a national new energy industry. Early in the 1980s, the Chinese government launched off-grid projects in remote areas, such as the Brightness Program and the Township/Village Electrification Program (Yang and Pan 2011). In the 2000s, Beijing shifted the focus of new energy development from rural electrification to the commercialization programs for grid-connected power generation. Since then, China has approved a lot of massive scale-up projects to promote electricity generation from new energy sources as well as new energy equipment production, mostly remarkably in nuclear, wind and solar PV sectors. As for nuclear power projects, China has the world's largest foreseeable nuclear power capacity if counting in the operational projects and those under construction. In the wind energy sector, the Chinese government launched a few rounds of on-grid wind power projects under the national "Wind Concession Program" between 2003 and 2007. Similarly, Beijing unveiled several national programs to expand the use of solar PV, mainly building-integrated PV projects (BIPV including the Solar Rooftop Plan and the Golden Sun Program) and large-scale PV projects (LSPV under the Western Development Strategy).

3.3 The targeted support of nuclear and wind power sectors

Nuclear and wind energy were the two most important sectors targeted for strategic considerations in the Chinese state's initiative of building up a national new energy industry. The two sectors' development has been knitted into China's strategic move toward self-reliance in energy supply, technology, and equipment production during the same period. Both received massive national support in view of their great potentials in turning into backbone industries and contributing to energy security and environmental protection in future. Both sectors saw regional sporadic projects starting from the 1980s but entered into large-scale commercial development for national electricity generation around the same time. In terms of technology capability, both nuclear and wind energy sectors in China were at infant stage and relied on technology and equipment import in the beginning of the 2000s. Both became a strategic focus and experienced take-offs at the time when the techno-nationalist ideology underwent rejuvenation in China.

With respect to government administration, the nuclear and wind sectors share similar state structure especially after the institutional restructuring in 2003. From the first civilian use of nuclear technologies in the 1980s until 1998, the authority over the nuclear energy sector had gone through several changes and been diffused in many bureaucratic agencies. However, since then the sector largely remained under the auspice of SPC and later its successor NDRC until the National Energy Commission (NEC) was established under the State Council in 2010. As for the Chinese wind power sector, it experienced less bureaucratic changes and more consistent administration than the nuclear power sector. Despite a few changes in the authority, the wind sector has generally been in the hands of NDRC after 2003. Since 2005, both have witnessed strengthening state control as a result of the re-centralization of energy governance, and finally came under the NEC in 2010. Therefore, the nuclear and wind sectors are comparable in the sense that they are overseen by the same bureaucratic agencies.

The strategic targeting for national support was also not differentiated despite the fact that nuclear and wind energy sectors were promoted in separate initiatives. Because of the controversies of whether it is renewable energy, nuclear power generation was initially not included in the plans of renewable energy development until it was incorporated into the REL in 2009.[11] However, considering its low carbon emission, nuclear energy has been regarded as an industry of strategic importance along with renewable energies. Not in any sense receiving less

[11] There is a controversy with regard to whether nuclear power is renewable energy. For a detailed discussion, see Chowdhury (2012).

attention, nuclear energy was given equal weight, if not greater significance than wind and other renewables in China's energy strategy. As a counterpart to the Medium and Long-Term Plan for Renewable Energy Development (2007-2020), there was a similar ambitious plan purposely for the nuclear energy sector, namely the Medium and Long-Term Plan for Nuclear Energy Development (2005-2020) (NDRC 2007a). During the policy changes between 2008 and 2009, nuclear was included in the target share of alternative sources of energy, including both nuclear and renewables, in the final energy mix. According to the two medium and long-term plans, the total installed capacities of nuclear and wind are expected to increase respectively from 9.1GW and 4.2GW in 2007 to 40GW and 30GW by the year 2020.[12]

In addition to elevating nuclear, wind, and other renewable sectors to a strategic height, Beijing also initiated a national campaign of building large-scale energy projects to promote development in the two sectors. Since 2003, the NDRC launched several rounds of wind farm bidding projects under the "Wind Power Concession Program" for wind power commercialization and localization of equipment production in the sector, which was later extended from land-based to offshore projects (Lewis 2013: 52-58). For these projects, a particular rule was that wind farms had to source at least 70 percent of products from local producers, and those not meeting the requirement would not be approved (NDRC 2005). In 2009, the Chinese government started the "Wind Base Program" to establish seven wind power bases (Shandong base was added later), each with a capacity of over 10GW (IEA 2011). Comparatively in the nuclear energy industry there were not such programs, but during the same period the Chinese government had approved a large number of nuclear power plants with substantial power generation capacity. Since 2003, China nuclear energy sector experienced a new wave of plant construction, among which around 17.5GW has been connected to grid, 26GW is now still under construction, and 50GW in planning (WNA 2015a). Even though local content requirement is not obligatory in the nuclear energy sector, it has been a paramount mission that Beijing imposes on the nuclear energy firms since beginning (Hu 2005).

4. Conclusion

Security concerns and economic prosperity have long been the major sources of a nationalist strategy in China's techno-economic development. With different sets of situational imperatives setting in, the techno-nationalist ideology became more or less prominent at different stages. In

[12] For the figure in 2007, see NBSC (2014). The 2020 target of wind power capacity was already met in 2010 as a result of rapid expansion in the sector. This is not expected to happen in the nuclear energy sector in a short period of time due to long product lifecycle, see Chapter 4. The estimate of World Nuclear Association is that nuclear power capacity in China will reach 58GW by 2020, and some 150GW by 2030 (WNA 2015a). According to Shi Lishan, deputy director of the new energy department under the National Energy Administration (NEA), wind power capacity was expected to reach 100GW by 2020 (Wan 2009).

the early 2000s, the ideology experienced a revival in China when the country had to face the risks associated with an open market and the dependence on foreign technologies owing to the two decades of liberal economic reforms. Foreseeing a future relying on foreign technologies and an imminent threat related to the dependence, the Chinese state stepped up efforts to make a change to the status. The focus of the state activism has been mainly on promoting the development of home-grown technologies or the indigenization of foreign technologies through a faster pace of industrialization across the economy. In this sense, technology acquisition and industrial upgrading become crucial to China’s sustainable development in the new century. In order to make China into a technological powerhouse in the world, the Chinese government has made long-term plans and launched national megaprojects to accelerate the process. This includes a broad range of industrial policies providing traditional support and those concentrating on market creation, especially national programs with a bias toward “buying local”.

China has included many new emerging industries into the techno-nationalist initiative with an aim to build them into national industries of indigenous firms and independent technology capabilities. In particular, new and renewable energies are one of the industries targeted with strategic importance. Similar to the vulnerabilities related to technological dependence, the country has been under the pressure to address such problems as energy supply shortage, dependence on energy import and environmental degradation in the new century. Therefore, a mixed pursuit of self-sufficiency in energy, technology and production impelled Beijing to adopt a nationalist approach in developing industries of alternative sources of energies. Since 2003, the Chinese state began to advance in economic activities and aimed to dominate the development of new energy sectors by playing an increasingly stronger role in the process. In order to support indigenous R&D and production in the sectors, Beijing made efforts to centralize energy governance, establish the strategic role of new energy in the national energy strategy, and put a wide range of industrial policies into force. Nuclear and wind power are of particular importance among all the new energy sectors. Even though the two sectors have been promoted in separate initiatives, both receive a high level of political attention from Beijing: the Chinese government attaches strategic significance to the two sectors in achieving its techno-nationalist goals and provided almost all traditional and innovative means of industrial support to them.

The enormous push toward building a national new energy industry, however, may not translate into consistent business practices across sectors at the firm level. Nuclear and wind energy sectors under investigation are two cases in point. Firms in the Chinese nuclear energy industry were uncooperative with Beijing in its nationalist initiatives and in fact acted as barriers to the goal of technology autonomy; but those in wind turbine equipment production responded positively to Beijing’s protective policies and were devoted to the formation of independent technology capabilities. It is as interesting as puzzling that while both were targeted for national support, the two sectors saw distinct business responses to Beijing’s guidance. So what happened between the national initiatives and implementations at the firm level in different sectors? Or what factors related to the sectors were accountable for the varying incentive systems and domestic-foreign business relationships? Concerns over national security and economic wellbeing justified the nationalist approach to new energy development at the national level, but did not explain diverging firm behavior across sectors. The next two chapters are dedicated to answer these questions. Respectively looking into the nuclear and wind energy sectors, the two case studies attempt to explain why firms in some sectors cooperated with whereas those in others went against the central state’s promotion of technology autonomy.

Chapter 4
The shaping of "global partners" in the nuclear energy industry

> *"While foreign giants are feasting on the Chinese nuclear power construction market worth tens of billions of dollars, our intellectual property rights of proprietary nuclear technologies are increasingly marginalized. Why does China's indigenous innovation path become more restricted while the whole nation is hailing indigenous innovation?"*
>
> *-- Feng Lu (2009)*
>
> *Exiled "Chinese Innovation": Cracking the Chinese Nuclear Power Puzzle*

1. Introduction

Despite the prevailing tone of fostering indigenous technology capability across the nation, the Chinese government met resistance from the nuclear energy industry. In general, indigenous Chinese firms in the sector were keen on an open approach and unresponsive to Beijing's directions in the selection of technologies and the formation of indigenous capabilities. Even though they all claimed that they were national champions devoted to local production, in fact they preferred collaborating with international nuclear firms and helped promoting foreign nuclear reactors to Beijing. With respect to indigenous capabilities, they relied on their foreign partners and obstructed the central effort of building a technology platform based on domestic technologies. The resistance from nuclear firms was exacerbated in the early 2000s when Beijing pushed forward with a future of rapid growth of nuclear power capacity and decided to base the national grand program on a standardized reactor design. Divergent practices prevail in newly approved nuclear projects and the sector witnessed greater diversity in the deployment of reactor types, which in fact opened the gate wider for foreign vendors and technologies. Some Chinese scholars believed that similar to the experiences of the automobile and the civilian aircraft industries in China, the repeated introduction of foreign reactors suffocated domestic technological progress in the nuclear energy sector (Lu 2005; Lu 2009; Lu and Feng 2004).

Why did Chinese firms in the nuclear energy sector behave in an integrationist way while Beijing was trying to push through a nationalist agenda? Considering its links to military technologies and defense production, the nuclear energy industry should have seen a great chance for the presence of nationalist practices. However, findings from the chapter suggest that due to the special nature of nuclear power plants (NPPs), Chinese technology recipients formed long-term strategic business relationship with international nuclear vendors, which drove the

Chinese nuclear energy sector onto an integrationist path. First, nuclear energy is a typical industry featuring complex product systems (CoPS), where technologies centering on system engineering are not easily transferable among industrial actors and core capabilities are entrenched in a few long-established firms. Second, because of the stickiness of technology and production, Chinese nuclear firms and their foreign partners have to collaborate closely with each other not only in daily business activities but also in winning orders, and the relationships last long and strengthen overtime. Third, the convergence of domestic and foreign business interest results in rebellious business responses to nationalist initiatives at the center: Chinese firms have acted as the de facto sales representatives of foreign nuclear reactors and paid limited attention to the formation of indigenous design.

This chapter investigates the Chinese nuclear energy sector by largely following the theoretical framework developed in Chapter 2. The next section delineates how nuclear energy differs from mass-production industries in terms of system complexity, types of production capability, and technology transferability. Section three discusses how the CoPS nature of nuclear energy technology leads to the interdependence between Chinese technology recipients and international vendors, and how the intimate interactions translate into strategic business partnerships between them. Sections four and five look into the lobbying by the Chinese nuclear firms in the interest of transnational business coalitions but against the will of Beijing. The fourth section focuses on the Sino-French, Sino-Russian and Sino-Canadian nuclear energy collaborations in the first two decades, and the fifth dwells on the cooperation between Chinese and American nuclear energy firms in the recent decade. Section six reflects on the resistance of Chinese nuclear firms in their interactions with Beijing regarding technology selection and independent research. The last section reviews the findings from the Chinese nuclear energy industry and argues that the case study supports the hypotheses in the theory chapter.

2. Nature of the nuclear energy sector

Nuclear energy is a civilian high-cost industry sector distinct from most others based on mass-manufacturing. The differences are multifaceted and reflected in technological, economic and political aspects as well as in business management. This has been studied thoroughly in a particular body of work on "complex product systems" (CoPS), which resulted from a project lasting over a decade to examine the implications of the special group of industries (Hobday 1998; Metzler and Steinfeld 2014). The most significant features of the industries are that they are high in value, large in scale, long in product cycles, and cross-disciplinary technologies in use. In most cases, these industries have a particular focus on customized one-off projects in small batches and the emphasis of production is on the integration of multiple technologies, subsystems, and expertise. Nuclear power plants (NPPs) are known as having the characters of CoPS seen in some other industry sectors such as high-speed railway, telecommunications exchanges, offshore oil and gas drilling platforms. There is normally a very high requirement of safety and reliability for the delivery of CoPS projects, which is also typical of NPP projects.

The nature of nuclear energy as CoPS distinguishes itself from mass-production industries in the patterns of production, coordination, and competition. First, in the nuclear industry suppliers and users tend to develop long-standing strategic business partnerships. Because designs are tailored for individual users and markets, users are intensely involved in project implementation to convey their final requirements to the suppliers. Unlike conventional industries where the production process is highly standardized, innovation in NPP building is mainly user-driven and customized. In other words, there is normally a high-level of industrial coordination between vendors and customers in the sector with complex products and systems. With the need for “perfect or near perfect reliability, safety and timely delivery” (Metzler and Steinfeld 2014: 175), nuclear vendors require continuous feedback from users that needs to be done “on an ongoing, iterated basis” to make alterations to the overall or partial designs (Hobday 1998: 694). Due to the long lifecycle of nuclear power projects, the intimate interactions between suppliers and users tend to last over protracted periods. In addition, the “ever-rising demands on performance, capacity and reliability” and as a result the increasing complexity of the project system toward higher generations leads to long-lasting cooperation between buyers and sellers.

Second, the buyer-seller coalitions tend to strengthen and stabilize over time in the industry due to technology lock-in. As in many other CoPS industries, competition in the nuclear industry is not based on technology-based manufacturing, but rather on engineering-based systems integration capabilities. And the emphasis of competitiveness is on plant design, overall project management and systems integration. According to Metzler and Steinfeld (2014), these are still “the most difficult-to-duplicate skills” due to a distinction between conceptual designs and detailed designs: while the vendors are able to break conceptual designs down into workable packages, it does not necessarily mean that the recipients could be able to reverse the process. Therefore, technology transfer does not translate into the formation of capabilities at the user side, and nuclear vendors do not have to worry about creating their own competitors after they enter into such agreements with their local partners. This is why despite a high degree of user involvement in the process major nuclear vendors’ positions in the global market are not shaken. As pointed out by Metzler and Steinfeld (2014), only a handful of incumbent systems integrators compete in the world: even the successful new entrants such as Korea and Japan either rely on their technology transferors or lags internationally. In the case of Korea Electric

Power Corporation (KEPCO),[1] even though it has developed important capabilities of its own, it still relied on Westinghouse to provide intellectual property and engineering services related to the reactors' conceptual design (Metzler and Steinfeld 2014: 184; 187). In summary, the "stickiness" of systems integration capabilities determines that technology transfer is not easily achievable, and as a result recipients of nuclear designs tend to be tied to established vendors for future growth.

The deepening relationships between nuclear vendors and recipients are also reflected by the fact that the former also benefit from the latter through long-term commercial partnerships. By developing a presence and moving forward into service deployment in another country, lead firms could enhance conceptual design capabilities through the feedback loops in a different environment. Aside from the ambition of business expansion, they could brush up on systems integration skills and maintain their competitiveness in future growth areas. Metzler and Steinfeld (2013) argued that this will "insure themselves against the emergence of lower cost and often substantially state-supported entrants in their traditional areas of business". Therefore, it is necessary for them to be involved as much as possible in worldwide project builds so that systems integration skills "remain fresh, up-to-date, and increasingly tied to the kinds of knowledge-intensive, follow-on services that will be demanded for decades to come."

Heterogeneity of capabilities in the sector also reinforces the interdependence within the industrial networks. A closer look at the nuclear industry reveals that competitiveness in one particular area within the CoPS does not mean competitiveness in another. In a typical NPP project, a variety of firms, capabilities and services are involved, including conceptual design and engineering-based services, project management, construction, and equipment manufacturing. Research shows that even the most sophisticated global leaders in the nuclear power industry may not meet the challenges posed by project management (Metzler and Steinfeld 2014). While lead firms become less focused on large-scale infrastructure expansion in their home countries, they increasingly find themselves relying on the construction capabilities of their local partners. And even though manufacturing accounts for a large share in the nuclear value chain, equipment suppliers do not have the capability to manage and integrate the overall technology system. In addition, high entry barriers derived from the technology- and capital-intensive nature of the industry ensure that the positions of industrial incumbents remain unchallenged and industrial structure fixed over a long period of time.

The multidimensional nature of capabilities in NPP projects gives rise to the need for industrial actors to team up with each other to win new contracts. In CoPS such as those in the nuclear industry, "competition occurs among rival coalitions of firms at the bidding stage of

[1] KEPCO is a nuclear power design and engineering company in South Korea, formerly known as KOPEC.

projects" (Hobday 1998: 707). In the case of international bidding, nuclear vendors tend to unite with their local partners individually to enter the tournament for a limited number of NPP sites. Sellers and buyers pool their resources together to compete with their rival sellers and buyers in order to win the NPP projects in bid. While at the global level nuclear leaders compete with each other through the help of their own home governments, buyers in the same country are in a battle to gain favor from the central decision-makers. Therefore, the coalitional competition is between international vendors as well as between local recipients. In order to win bids, transnational coalitions are formed to mobilize political resources that are available to both sellers and buyers.

Third, transnational coalitions in the nuclear industry boast political clout in both supplier and recipient countries, and have access to the policymaking process. The CoPS literature shows that industries are largely concentrated in a few large firms that are partially contested, and the market tends to be highly politicized. Due to the significance of industrial output and "the need to prevent monopolistic abuse, and other strategic and military reasons", governments tend to "own, control or closely oversee" nuclear production, operation and transnational cooperation (Hobday 1998: 702). For that reason, governments tend to maintain a strong hand in CoPS projects such as NPPs, and markets in the sectors are likely to be bureaucratically administered. As Hobday (1998: 702) argued, "[T]the more complex and higher cost the product, the more coordination is likely to be based on fewer, more irregular market transactions, non-market pricing, biased purchasing policies and administered, regulated competition". This is particularly true for nuclear energy, where only a few large company groups are in play and have close links to the government. This is because of their strategic importance to the local economy as well as the military origin of nuclear power generation. In addition, safety and reliability are top priority, and as a result regulatory agencies are highly involved in the innovation and negotiation processes.

The positions of nuclear vendors and users respectively in their own countries make the partnership a significant part of bilateral relations. Since both governments place a high value on the stake of nuclear industry and both buyers and sellers have powerful influence over domestic politics, the strong will of coalitions at the firm level is readily reflected onto the state level. As for China, nuclear energy is envisaged as one of the future "pillar industries" that are aimed to address issues such as energy security, environmental protection and sustainable economic development. Similar to national oil and power companies, nuclear conglomerates actually came out from the government and are now directly owned by the state. Their proposed transactions with western nuclear vendors always fall within the purview of the central government. This in turn translates commercial deals into deeper diplomatic ties with supplier countries, in which nuclear firms enjoy enormous political influence that they can wield to lobby high-level decision-makers. Therefore, transnational nuclear coalitions politicize bid selection in the recipient as well as in the supplier country, which as a result elevates the negotiations to the state level.

Associated with the strategic role and potential contribution of the nuclear industry in each country, governments from both sides are influenced by business interests. On the one hand, nuclear reactor users want their preferred business partners to win a bid and package the deals into one that is consistent with national interests. They need to persuade the government that the deal is beneficial to the formation of a national industry, with such expectations that indigenous capabilities can be increased through the interactions with foreign partners and the construction of a national nuclear fleet. On the other hand, nuclear vendors also need to gain favor from their home governments, which in turn exert influence over decision-making in the host country. This is particularly true when there is a strategic yet sensitive relationship between the two governments and the supply side knows how to play the cards well under certain circumstances. As will be discussed later, almost all Sino-foreign nuclear power deals were signed along with other major economic and technological cooperation agreements during state meetings, and most of the business visits of nuclear venders accompanied government officials' state visits. More often than not, bid selection is made under the joint forces of domestic users, international vendors and their home governments.

3. Nature of cross-border business coalitions

The fact that nuclear energy differs from conventional industries bears meaning in the patterns of industrial relations and the formation of interest groups. Empirical studies in this section reveal that the CoPS nature of the nuclear energy industry leads to the formation of self-reinforcing business partnerships and policy coalitions. Because of the high intensity of user involvement, long product cycles and continuous feedback loops in NPP projects, nuclear vendors and recipients are likely to build up an intimate and long-lasting relationship with each other. And as a result of technology lock-in and the diversity of skills involved, nuclear firms need to join their forces for mutual benefit. While users rely on vendors for such skills as conceptual design and system integration, the latter also need the former to renew their capabilities through market expansion. Mutual reliance leads to the convergence of interests that reinforce the buyer-seller teamwork in existing and new projects. Cross-border cooperation like this means the formation of political coalitions intended to pursue mutual interests. As another attribute linked to the nature of the CoPS, they all enjoy high economic and political influence thanks to high industry concentration and direct channels to political power at the center.

3.1 Formation of transnational alliances

Transnational coalitions between domestic recipients and international vendors feature prominently in the three-decade history of the Chinese nuclear energy development. Key Chinese industry players have established long-term strategic business partnerships with world nuclear leaders through a few large transactions over the years. Starting from the Daya Bay project, the first large commercial NPP as well as the largest Sino-foreign joint venture at that time, China Guangdong Nuclear Power Corporation (CGNPC, now China General Nuclear Power Group, known as CGN) tied the knot with Framatome (now controlled by Areva) and went through thick and thin in the exploration of Chinese nuclear market. China National Nuclear Corporation (CNNC), despite being a company driven by the spirit of self-reliance, also entered into a similar type of relationships with AECL from Canada and ASE from Russia. The two powerful alliances had been the only rivals in the Chinese market until the formation of the State Nuclear Power Technology Corporation (SNPTC), a nuclear technology company created by the central government in collaboration with the US-based Westinghouse Electric Company. They are tied up in the same project but with different goals: while SNPTC was born with a mission to indigenize American reactors, Westinghouse intended to tap into a potential market as substantial as China, which now has the world's largest nuclear power capacity under construction.[2] History shows that these alliances need to do this to make NPPs commercially viable and sustainable, and work toward greater competitiveness vis-à-vis other alliances.

The extended transnational partnership in the Chinese nuclear energy industry is without exception attributed to the complexity of NPP projects. All of the three Chinese nuclear companies worked closely with their foreign partners in daily routines, and the high level of user involvement is also seen even in turnkey projects. In each project technological experts from both sides need to work together to remodel the abstract diagrams, drawings and calculations to a set of specific instructions for engineers and workers at the plant site. Cross-disciplinary knowledge and diverse subsystems make the process a tedious one, which was further exacerbated by the need for translating documents from a different language. A multitude of documents and human resources are needed to make this happen. In the selection of Gen-III reactors, China received over a hundred boxes of tender documents from each bidder, all transported by trucks; and some two hundred experts were assigned to evaluate the bids. According to a leader of the selection group, after winning the bid Westinghouse transferred 20 tons of materials, 320 software programs and a huge amount of electronic documents, making

[2] According to the World Nuclear Association (WNA), China is likely to have the world's largest nuclear power capacity in operation starting from 2030, and probably remains the number one for the rest of the century.

the Westinghouse deal the largest ever in China's history of technology introduction (Chen and Li 2014: 42).

The interactions between foreign vendors and Chinese recipients are further intensified by the need to materialize reactor designs into workable ones according to local conditions. The most remarkable fact is that local NPP sites may differ from those in the country where reactors come from, and local adaptations are necessary. Any changes in response to local conditions may incur overall alternations in the whole system, and therefore demand meticulous calculations, argumentations, and even experiments. For instance, modifications had to be made in the AP1000 reactor that was originally designed for soft ground to fit the rock mass ground in Sanmen and Haiyang (Chen and Li 2014: 51). Any other geological hazards such as earthquake and flood as occurred in the Fukushima nuclear disaster in 2011 in Japan also need to be taken into consideration. The recipient needs the vendor's help to make variations due to different legal requirements in their countries. In addition to the "grafting" of NPPs onto a local site, the two sides need to decide together which equipment should be sourced locally and which from overseas, and which suppliers should be chosen. In the process, there are always a wide range of issues involved, including those relating to price, lead time, reliability, and most remarkably a conflict between the sellers' aspiration of selling more and the buyers' need to use locally manufactured components.

Aside from the prolonged process of transplanting existing models into local ones, the long product cycle of nuclear power projects makes cross-border cooperation long-lasting. Both CGNPC and CNNC have been bound with their nuclear contractors for maintenance as well as planned and proposed projects in years or decades to come. A glimpse at the Sino-French nuclear cooperation gives us some ideas. Since the negotiations on nuclear cooperation started in 1978, the two-way interactions have always been ongoing no matter what particular point of time we are looking at. Both sides worked together until the Daya Bay deal was inked in 1985, which was connected to the grid in 1994 and followed by a new project at Ling Ao. Before the first phase of Ling Ao entered into commercial operation in 2003, the second phase was launched to localize the French M310 into CPR-1000. Now they are all in service and more units have followed. The loops are protracted as well as continuous. When the nuclear trumpet called for advancing from the second to the third generation reactors in the new century, the Sino-French league quickly made steps to the new front by introducing EPR into China.

One particular aspect of the transnational alliances is localization, through which nuclear vendors and local recipients consolidate their positions in the market. This is because the process is as complex as effortful, and once the efforts are made both sides tend to stay together for long. When considering local substitutions, the units of measurements for equipment and components need to be converted to the metric system. In many cases due to the requirement of accuracy it is hard to source components and parts approximate to the design. When the transnational partners finally manage to do so, things become easier for their future cooperation and their relationships tend to be reinforced in the course of time. Again because this involves elaborate details, the duration of localization may be further elongated by any improvements or upgrades made in the designs, which need to be synchronized in construction. And due to ever-growing needs for upgrading, such as greater capacity and better safety control, re-innovation and redesign involve a higher level of cooperation between the vendors and recipients. In this way CGNPC and Areva’s Framatome gradually improved the imported M310 into the local CPR-1000. When they moved from the initial collaboration at Daya Bay to Ling Ao, the localization rate increased to 30 percent in the first phase and to 50 and 70 percent in the second phase. The rate was further raised from 80 percent at Hongyanhe to 85 percent at Ningde, and finally to 90 percent at Yangjiang.[3] It takes around three decades for the progressive localization to unfold, and the goal was to forge CPR-1000 into a flagship reactor for China’s NPP array. Before its recent merge with CNNC’s CNP-1000, CPR-1000 had been widely deployed for domestic use. As of September 2014 six units of CPR-1000 were operating, with 16 units under construction (Table 4-1 and Table 4-2).

Owing to the heterogeneous technologies involved in NPPs and the barriers in technology transfer, nuclear recipients tend to rely on international vendors over an extensive period. The nature of nuclear technologies determines that reverse engineering is less likely than it is in mass-production industries. For complete equipment such as nuclear islands, it is impossible for recipients to disassemble them and track down the technical details before they are installed. Within the nuclear industry chain, Chinese nuclear companies rely on international Nuclear Steam Supply System (NSSS) companies at the midstream, and at the upstream depend on equipment suppliers for core technologies that cannot be sourced locally. They all have their own research capabilities but for a very long time were not independent designers, and largely remained owners and operators at the downstream.[4] For example, notwithstanding the localization progress made in CPR-1000, CGNPC still relies on Areva for intellectual property rights (IPRs) and has been restrained from overseas sales, which can only be done with Areva’s agreement on a case-by-case basis. Even though both CNNC and CGNPC recently came out with their own Gen-III designs, so far their research institutes have yet become recognized technology suppliers in the global arena.

[3] Localization does not equal indigenization, and localization rate does not necessarily mean the level of indigenous capability. Sometimes the parts and components are sourced from local suppliers but the value-added of the projects, for instance design and system integration, are still held by others.

[4] Both have their own research capabilities in such research institutes as the Nuclear Power Institute of China (NPIC) and the China Nuclear Power Technology Research Institute (CNPRI).

Table 4-1 Operating nuclear power plants in China

Units	Type	Design	Net capacity (MWe)	Designer (Country)	Operator	Commercial operation
Daya Bay 1&2	PWR	French M310	2x944	Framatome (France)	CGN	1994
Qinshan Phase I	PWR	CNP-300	298	SNERDI (China)	CNNC	April 1994
Qinshan Phase II, 1&2	PWR	CNP-600	2x610	NPIC (China)	CNNC	2002, 2004
Qinshan Phase II, 3&4	PWR	CNP-600	2x620	NPIC (China)	CNNC	2010, 2012
Qinshan Phase III, 1&2	PHWR	Candu 6	2x678	AECL (Canada)	CNNC	2002, 2003
Ling Ao Phase I, 1&2	PWR	French M310	2x938	Framatome (France)	CGN	2002, 2003
Ling Ao Phase II, 1&2	PWR	CPR-1000 (M310)	2x1026	Framatome (France)	CGN	2010, 2011
Tianwan 1&2	PWR	VVER-1000	2x990	ASE (Russia)	CNNC	2007, 2007
Ningde 1&2	PWR	CPR-1000	2x1020	Areva (France)	CGN & Datang	2013, 2014
Ningde 3	PWR	CPR-1000	1020	Areva (France)	CGN & Datang	2015
Hongyanhe 1&2	PWR	CPR-1000	2x1024	Areva (France)	CGN & CPIC	2013, 2014
Hongyanhe 3	PWR	CPR-1000	1020	Areva (France)	CGN & CPIC	2015
Yangjiang 1&2	PWR	CPR-1000	2x1021	Areva (France)	CGN	2014, 2015
Fangjiashan 1&2	PWR	CPR-1000 (M310+)	2x1020	Areva (France)	CNNC	2014, 2015
Fuqing 1&2	PWR	CPR-1000 (M310+)	2x1020	Areva (France)	CNNC & Huadian	2014, 2015
Total: 27			**24,196 MWe**			

Source: World Nuclear Association, "Nuclear Power in China (Updated August 2015)", available at http://www.world-nuclear.org/info/Country-Profiles/Countries-A-F/China--Nuclear-Power/, accessed on 10 Sep 2015.

Table 4-2 Nuclear power plants under construction in China

Plant	Gross Capacity (MWe)	Reactor model	Project control	Construction start	Operation
Hongyanhe 4	1119	CPR-1000	CGN & CPIC	8/09	late 2015
Ningde 4	1089	CPR-1000	CGN & Datang	9/10	early 2016
Yangjiang 3&4	2x1089	CPR-1000+	CGN	11/10, 11/12	2015, 2017
Sanmen 1&2	2x1250	AP1000	CNNC	3/09, 12/09	2017, 2017
Haiyang 1&2	2x1250	AP1000	CPIC	9/09, 6/10	12/2015, 3/2016
Taishan 1&2	2x1750	EPR	CGN	10/09, 4/10	late 2016, 2017
Shandong Shidaowan	210	HTR-PM	Huaneng	12/12	2017
Fangchenggang 1&2	2x1080	CPR-1000	CGN	7/10, 2011	2015, 2016
Changjiang 1&2	2x650	CNP-600	CNNC & Huaneng	4/10, 11/10	2015, 12/2015
Fuqing 3&4	2x1080	CPR-1000 (M310+)	CNNC & Huadian	12/10, 11/12	late 2015, 2017
Tianwan 3&4	2x1060	VVER-1000	CNNC	12/12, 9/13	2/2016, 3/2017
Yangjiang 5&6	2x1080	ACPR1000	CGN	9/13, 12/13	2018, 2019
Hongyanhe 5&6	2x1080	ACPR1000	CGN & CPIC	3/15, 7/15	11/2019, 8/2020
Shidaowan 1&2	2x1400	CAP1400	SNPTC & Huaneng	5/15, 8/15	12/2019, 2020
Fuqing 5&6	2x1150	Hualong-1	CNNC & Huadian	5/15, 2015	2019, 2020

Source: World Nuclear Association, "Nuclear Power in China (Updated August 2015)", available at http://www.world-nuclear.org/info/Country-Profiles/Countries-A-F/China--Nuclear-Power/, accessed on 10 Sep 2015.

On the other side of the same coin, nuclear vendors also rely on the local partners for continuous market access. They are essentially in the same boat with technology recipients, and mutual interests propel the business alliances further. When in the early 2000s Chinese firms were only confident about making Gen-II+ reactors, nuclear vendors started to promote their Gen-III designs. And the procurement of Gen-III technologies set their cooperation into reiterative loops that are described before. In the turf war of third generation reactors, the competitive bidders were "talking about more than a half-century commitment in a project like this—25 years of prior reactor design and engineering expertise, five years of development for the new PWRs, and then 40 years of operation by China" (Hibbs, Maclachlan and Dolley 2005). Now that China has its own Gen-III designs based on Gen-II plus technologies, a new round of enduring cooperation with nuclear vendors started and will not in any sense fade in short-term. CNNC now has more units with ASE, CGNPC introduced EPR from Areva's Framatome, and the new entrant SNPTC was created as a technology company to introduce AP1000 from Westinghouse. As for Areva, CGNPC was no doubt the ideal partner in forging the way for EPR to get into China, which in turn brought greater opportunities for Areva.

Though to a lesser degree, a similar pattern of mutual benefit is found in the team of CNNC and its Russian partner, ASE. The two have maintained an interdependent relationship since they started working on the first project at Tianwan in the 1990s. Now they have two units of VVER-1000/V-428 reactors in operation, two modified units (specifically for China) under construction (Phase II), and four units of VVER-1200/V-491 in plan (Phase III & IV). Through experiences of the first phase of Tianwan, CNNC is now able to contribute more to the second phase in terms of construction, auxiliary projects and equipment procurement. An OECD report shows that CNNC is responsible for about 70% of the project, increasing from 50% in the first two units (Sozoniuk 2014).[5] However, CNNC relies on its Russian partner for the design of nuclear islands and supply of the reactors and some related equipment. As the general contractor and equipment provider for Tianwan, ASE gained more experience through cooperation with China. With regard to V-428, the Chinese version of VVER-1000, ASE took specific Chinese requirements into consideration, such as the need for seismic resistance, and made adjustments according to local conditions. On top of that, the design ASE created for CNNC also incorporated suggestions from IAEA (International Atomic Energy Agency) expert reviews between 1995 and 2005. Compared to the standard V-320, V-428 features the addition of such safety measures as double containment, a core catcher, and passive hydrogen recombiners

[5] CNNC's subsidiary Jiangsu Nuclear Power Corporation (JNPC) is mainly in charge of Tianwan at the Chinese side. It was established in 1997 and is mainly responsible for the construction and operation of Tianwan NPP. JNPC consists of three shareholders: CNNC (50%), China Power Investment Corporation (30%) and Jiangsu Guoxin Group (20%).

(Rosatom 2015). Moving toward V-491, the advanced third generation (Gen-III+) reactor, ASE expects to develop greater competence through collaboration with Chinese.

Based on the same logic, SNPTC and Westinghouse entered into an alliance in 2007 for their long-term common interests. While the domestic user needed advanced designs and local adaptations, the nuclear vendor expected to develop global competitiveness through new plant builds in overseas markets. The two are a perfect match in the sense that SNPTC was naturally attracted to Gen-III technology and Westinghouse was eager to promote its "most advanced, yet proven" AP1000. To challenge the Gen-II reactors, SNPTC is dedicated to indigenizing and standardizing AP1000, which allegedly has a higher safety level, longer life cycle and improved operation attributes than Gen-II reactors. Despite the agreement on overall technology transfer, SNPTC needs to cooperate with Westinghouse in the indigenization of AP1000. And as discussed earlier, the process is by no means a clear-cut one that can be easily achieved in a short period of time. Furthermore, SNPTC also needs technical consulting services from Westinghouse in the development of CAP1400, a larger reactor with its own know-how. As for Westinghouse, winning an international deal is essential since its home country is no longer engaged in infrastructure expansion, and "developing a presence in China" that is integrated into global operations helps enhance its capabilities (Metzler and Steinfeld 2013). Amid a declining performance over the years, Westinghouse was afraid of not being able to find a buyer for its new model. Given that China was willing to be the first one to try the new model, Westinghouse would be happy to see AP1000 installed without operation track record anywhere else. The key consideration was that it found a home as big as China for AP1000 to flourish.

The joint force of SNPTC and Westinghouse became a challenge to the CGNPC-Areva and CNNC-ASE alliances in the industry. They worked together trying to make AP1000 the basis for China's move to Gen-III technology, aiming to elbow out the prevailing Gen-II reactors and unify China's nuclear industry. By October 2014, there were four units under construction at Sanmen and Haiyang, eight more planned but delayed post-Fukushima, and a lot more proposed to follow (WNA 2015a). Through Sanmen and Haiyang, SNPTC and Westinghouse focus on the joint development of CAP-1400, a local standardization of AP1000, with two demonstration units planned at Shidaowan. This is a larger model for which SNPTC will own the intellectual property rights and that will be used for large-scale deployment. Apart from being committed to domestic markets, they also went into agreement to expand their partnership in third-country overseas projects, which was meant to "establish a mutually beneficial and complementary partnership" (WNA 2015a).

3.2 Political economic power of the transnational teams

Aside from strategic interdependence, another attribute the cross-border coalitions share in common is the political clout derived from the positions in their own countries. Growing out of government initiatives, Chinese nuclear giants are all now centrally administered enterprise groups with a bureaucratic background. CNNC came from a military industry family called the Second Ministry of Machine Building (Second MMB, “*er ji bu*”), which oversaw the nuclear industry and has a glorious history of making “Two Bombs and One Satellite”.[6] With 45% owned by the Guangdong province when created, CGNPC largely represented the interests of the powerful provincial government before it was put under the State-owned Assets Supervision and Administration Commission (SASAC) of the State Council in 2003. As for SNPTC, it has its origin in the macroeconomic management agency, namely the State Planning Commission (SPC, “*ji wei*”), and was set up by the State Council. Despite being a technology company, SNPTC extended its business downward through merger with China Power Investment Corporation (CPIC), one of the five largest electricity producers. In terms of featured reactors, the three state conglomerates divide up the Chinese nuclear market, all with their own political resources drawn from the center.[7]

The three Chinese nuclear groups’ foreign suppliers are all global leaders in the design of nuclear reactors or the engineering of NPPs. And they all enjoy political clout thanks to the significant roles they play in their local economies. Russia’s nuclear power export is monopolized by ASE, which is a part of Rosatom, the state corporation overseeing the country’s nuclear industry and the only vendor in the world able to offer the industry’s entire range of products and services (Ernst & Young 2012).[8] China’s old friend Areva, the world’s largest nuclear energy group, is a French government-owned nuclear behemoth with over 45,000 employees (Areva 2014). Apart from government ownership, it derives political power from its predominant role in France’s number one position in nuclear equipment export, with almost six billion Euros in exports each year (Thomas 2014). In addition, Areva designed all French reactors in the industry, which provide about 75 percent of electricity for France and made the country the world’s largest net exporter of electricity (WNA 2015b). With regard to

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[6] These refer to the successful independent development of atomic and hydrogen bombs, which were regarded as the spiritual monument of self-sufficiency, national cohesion and patriotism. Under the conditions of serious external threats, weak industrial base and backward economy back in the 1960s, China was forced to develop atomic and hydrogen bombs on its own. The Sino-Soviet split and the termination of technological assistance in the critical moment taught the Chinese not to rely on others. So “Two Bombs and One Satellite” represented a great achievement for the whole nation and have been cited by the following generations of nationalists.

[7] One notable thing is that SNPTC is a technological company that normally does not take part in the ownership and operation of NPPs. In terms of ownership and operation, CNNC and CGNPC share the market with other five big power generation companies corporatized from the Ministry of Electric Power (later State Power Corporation of China).

[8] Atomstroyexport (ASE) belongs to Atomenergoprom, a subsidiary of Rosatom. Another subsidiary of Rosatom, Gidropress mainly focuses on reactor plant designs.

Westinghouse, an American-based, Japanese-owned (acquired by Toshiba in 2007 from British Nuclear Fuels, which had acquired the nuclear assets of the US Westinghouse Electric Company in 1999) nuclear power company, it is a world-leading supplier of NPP products and technologies. It led a nuclear consortium to supply the world’s first PWR in 1957 and its technology is the basis for approximately one-half of the world's operating nuclear plants, including those developed by Areva (PR Newswire 2007).

Granted the remarkable positions of nuclear power players, cross-national new power partnerships normally have political implications for diplomatic relations. The cooperation of CNNC and ASE is a case in point. Only taking a minor share of the Chinese market, VVER reactors actually speak for the strategic energy relationship between China and Russia. With the state-level cooperation as their backbones, CNNC and ASE managed to secure a small share of the cake when transnational coalitions were competing for the crown of the base model for China’s national nuclear power program. It is hard to say that VVER won the battle, but at least it received more orders and injected new blood to the energy relationship between the two countries. Similarly, out of the consideration of balancing diplomatic relations with nuclear energy powers Areva’s EPR was entitled entry into China in cooperation with CGNPC. With regard to the selection of Westinghouse’s AP1000, political interests were also in work on top of other considerations such as technology, security, and industrial interests.

4. Coalitional lobbying in the first two decades

Chinese nuclear giants pair up with their foreign partners to facilitate their business expansion in the Chinese market. Since the green light for a nuclear power project means straightforward access to the market, the central decision on project approvals is directly linked to business interests. Over the past three decades, the selection of reactor models in China has often been accompanied by struggles between competing transnational coalitions. The wrestles culminated when the central government decided to embark on a nationwide nuclear power expansion entering the new Millennium. Similar to technology standards in other industries, the central decision on technology unification to a particular reactor design means officially setting up a business kingdom for the transnational coalition promoting the design. This triggered greater political activism of transnational coalitions in national nuclear policymaking, which was repeatedly hijacked for business purposes.

Drawing their strength from internal and external sources, Sino-foreign coalitions have been engaged in having their reactors, either imported or localized, to be deployed in China. The battlefront was once largely between the CGNPC and the CNNC consortiums respectively with their foreign nuclear vendors. Derived from the Guangdong provincial government, CGNPC benefits from a relatively high degree of autonomy that Guangdong enjoys from the center to pursue a market-oriented approach to reform. And with the help of government agencies in charge of power supply and civilian machineries, the Guangdong government managed to push through the cooperation with French company Framatome, which later evolved into the CGNPC-Areva coalition that persists and thrives to the present. Another lineage traces back to the ministry responsible for defense industries and later the Ministry of Nuclear Industry (MNI), which was later corporatized into the CNNC. Despite its military origin and hence a determined nationalist, the CNNC had to learn from foreign nuclear reactors to develop its own designs and established business partnership with Russian and Canadian nuclear vendors.

4.1 Sino-French nuclear energy cooperation

Coalitional lobbying of the rival camps has permeated each one of the three rounds of technology selection in Chinese nuclear energy development. The first round of import is characterized by the Daya Bay project, a direct outcome of the Sino-French joint efforts in nuclear power generation. When China’s interests in nuclear energy became known to the world, the French approached China for the sale of a complete NPP project with two units of M310. In January 1978, French Premier Raymond Barre visited China, and the chairmen of two large French companies providing NPP solutions, Alsthom (now Alstom) and Creusot-Loire (Framatome’s parent company) were also in the team (Fountain 1979: 38). This trip ignited the enthusiasm for French reactors in the opening-up China, particularly in Guangdong. Blessed with a gift of “maverick” ideas and the propensity to take bold actions, Guangdong provincial government responded immediately to seek support from reformists at the center and promote the turnkey project in its territory (Zheng 2007: 237-8). In addition to the aspiration of leading China’s great transformation toward the use of foreign capital and technologies, Guangdong was also motivated by such goals as to ease power shortages and to inject new blood into the local economy. In the late 1970s, government officials from Guangdong made frequent trips to Beijing to lobby for greater local autonomy in decision-making and at the same time also fervently for the NPP project at Daya Bay (Xu 2010).

Guangdong’s passion met with the activism of ministerial agencies favoring the import of nuclear reactors, mainly those in charge of power supply and civilian machineries. At that time, nuclear energy was under the authority of the Ministry of Water Resources and Electric Power (MWREP), which vigorously proposed to replace the self-reliant project at Qinshan with a turnkey project using French reactors. The prevailing concern was that Qinshan was not economically viable compared to hydro and thermal power plants, and some expressed the view that they “were impatient with the domestically developed technology to meet the rising demand" (Xu 2010: 27). Similarly, the First Ministry of Machine Industry (First MMI) argued that it was meaningless to continue working on Qinshan when advanced reactors with greater capacity were readily available through import. In the same year that an agreement between Guangdong and Hong Kong was inked to finance the whole plant import project at Daya Bay,[9] the MWREP immediately sent a working team to Guangdong to discuss the specifics of carrying out the plan.

Externally, nuclear vendors and governments from Europe, especially France and Britain, stepped up the effort in making the NPP deal happen. After China experienced a cooling-off period due to finance and especially safety concerns after the Three Mile nuclear accident, French President Valéry Giscard d'Estaing made a trip to Beijing in October 1980 and pressed hard for the sale of two nuclear islands by Framatome and engineering support by Électricité de France (EDF), a French electric utility company largely owned by the French government. From then on, Daya Bay became the focus of Sino-French negotiations. At the same time, a British company, General Electric Company (GEC), was also involved in the negotiations for the supply of two conventional islands. As Guangdong had been in discussion with a utility company in Hong Kong (then under the British colony control) for funding solutions, the British government also tried every effort to get GEC into the deal out of such considerations as economic benefits as well as control over Hong Kong. Finally in 1983, France and Britain respectively secured contracts from China regarding the supply of reactors and turbine generators for Daya Bay (Xu 2010: 43-44).

4.2 The proliferation of Sino-foreign coalitions

China's second round of nuclear reactor import started in the early 1990s, which was featured by a greater degree of foreign participation. There was a few years' suspension for new projects due to the west's diplomatic and economic sanctions in the wake of the 1989 Tiananmen incident. When the ongoing NPP builds were about to finish and the external environment gradually brightened up, China's nuclear energy industry witnessed a boom of NPP project approvals. During this period, the Sino-French cooperation at Daya Bay further developed into the CGNPC-Framatome alliance (now CGNPC-Areva) to consolidate its position in the market through localization. Another highlight of the period is the official authorization of two more whole plant imports respectively from Russia and Canada. With executive functions and strategic considerations on its shoulders, CNNC continued the negotiations with Russians and Canadians that the MNI started in the early 1980s. Even though CNNC's collaboration with

[9] In 1979, the Guangdong Electric Power Company started negotiations with the China Light Power Co., Ltd in Hong Kong on forming a joint venture and they quickly came to an agreement. The idea was to build a NPP in Guangdong using foreign capital and repay the debt with the earnings of selling electricity to Hong Kong, which suffered from severe energy scarcity and was constrained by its small size to develop power generation projects (Wang 2011a).

foreign vendors was not so much related to business interests as to ministerial responsibilities, it later developed into a type of business partnership similar to the CGNPC-Framatome coalition.

The Sino-French nuclear energy cooperation went further in the time of crises, which as a result strengthened bilateral economic relations. One significant case was Ling Ao, through which the two worked together to tide over one of the most difficult times. When China was in near diplomatic isolation, France still saw "China as a long-term partner" and would "reassure China that it will continue to have access" to nuclear equipment for a second nuclear plant (Hibbs 1991). The promise materialized into Ling Ao in January 1995. As a duplicate of Daya Bay, it became the second turnkey project in cooperation with the French company Framatome and the British GEC. This time CGNPC was created in 1994 for the commercial operation of Daya Bay when it was put into service, and also for the construction of follow-up projects including Ling Ao. The deal was signed at a time when Framatome almost ran out of business due to the global drought in nuclear contracts (Xu 2010: 59). As the Framatome chief put it, thanks to the deal the French nuclear industry found "a new reason to live" (MacLachlan 1995a). The French industry minister also acknowledged that the contract not only recognized "the French nuclear industry's success" but also marked "a renewal and reinforcement of economic cooperation between China and France" (MacLachlan 1995b).

When the Sino-French affinity was growing in the industry, a separate initiative between CNNC and the Russian firm Atomstroyexport (ASE) came onto the stage. Starved of orders since the 1986 Chernobyl disaster, ASE was eager to sell nuclear reactors to China. Among the earliest to approach China in the 1980s, it could not go further until the Sino-Russian tension eased in the early 1990s. Seeing the opportunity, ASE managed to integrate the proposed deal into a broader cooperative framework and a warming relationship between China and Russia. The deal was packaged into a bond between the two countries, which provided the ailing Russian industries a way to survive amid the economic meltdown, and brought China an ally when China was in desperate need of one facing the hostile external environment. While China found that establishing "a strong partnership with the Soviet Union was politically and diplomatically important" (Xu 2010: 56), the Russian Federation regarded the deal as a lucrative incentive to rebuild the relationship. On his first official visit to China in 1992, President Boris Yeltsin signed a joint statement and memoranda of understanding on techno-economic cooperation across a wide range of areas, including selling two VVER-1000 PWRs to China (Hibbs 1992). This NPP deal located in Tianwan was the largest project in the comprehensive agreement, which actually lifted the curtain on Sino-Russian energy cooperation in recent two decades.

The Sino-Russian agreement also indicated the formation of a new business partnership between CNNC and ASE. When ASE resumed the negotiations with China in the 1990s, CNNC as the successor of MNI naturally took up the responsibility of working together with it to implement the Tianwan project. On the one hand, CNNC inherited bureaucratic functions from MNI, the former body in charge of nuclear industry, and continued to act as the official contact for foreign nuclear suppliers, including ASE. On the other hand, it had business interests and the need to make a living through the operation of NPPs. With only one small NPP trial-running in Qinshan since 1991, it needed revenues from large commercial projects to cover its loss. Since no additional small trial project was allowed and the second Phase of Qinshan was stalled due to the sudden withdrawal of German participation, opening arms to Russians would be a reasonable choice. The Janus-faced nature of CNNC decided that its partnership with ASE was as politically right as economically beneficial. In addition, CNNC at that time also suffered a setback in its negotiations with Kraftwerk Union (KWU) on Qinshan Phase II due to worsening diplomatic relations with Germany.

Bearing diplomatic meanings, the CNNC-ASE cooperation nevertheless saw a business rationale behind Tianwan. When Tianwan went into commercial operation in 2007, the Chinese side claimed that "we have fulfilled a political and diplomatic mission", whereas the Russian CEO commented that "Tianwan nuclear power station is fully justified as the crystallization of friendship and cooperation" (Shmatko 2007; Zhang 2007). At the national level, it became an integral part of the Sino-Russian relationship based on energy resources in consideration of their mutual geopolitical and strategic interests, particularly the supply of uranium, oil and natural gas. However at the industry level, the transnational partnership turned into a powerful interest group in China's nuclear energy policymaking, which in the next stage centered on the selection of third generation reactors.

Similar to the cooperation with ASE, CNNC started its relationship with the Atomic Energy of Canada Limited (AECL) when the international environment became less hostile against China. Following in the footsteps of French and Russian vendors, AECL resumed serious talks with CNNC in 1992 on the sale of two Candu reactors regardless of the opposition by the United States amid the embargo. The third phase of Qinshan came into being as a result of the rekindled NPP cooperation between China and Canada. Within Canada, AECL countered questioning about the government subsidies it received by citing the pending sale as a two billion dollar deal and "the equivalent of 12,500 jobs over six years"; and it managed to ramp up support of the Canadian Prime Minister Jean Chretien, from whom the deal received "intense promotion" (McCarthy 1994). As for CNNC, there was no reason to reject the deal in view of the financial arrangements that the Canadian side promised to make (Hibbs 1996). Moreover, the project was also one that China needed. Aside from the need for more friends in the international community and a reboot of the national economy, the country was also hastening installed capacity to address the critical electricity shortage that seriously threatened its economic growth. Therefore, unlike the first two phases using domestic reactors, Qinshan phase III became a third whole plant import project.

5. The intensification of coalitional lobbying since 2003

The Sino-American coalition went onto the stage at a time when Beijing felt the need to actively promote a nuclear power expansion nationwide but was troubled by the disputes over technology selection. It stemmed from a consensus in the nuclear community especially at the end of the 1990s that a standardized nuclear reactor based on a particular platform should be developed for future deployment. According to a report conducted by the Development Research Center (DRC) of the State Council, a unified technology route is necessary for the sake of cost and safety management.[10] While this is a rational choice for the central government, it is hard to carry out because neither the CNNC nor the CGNPC would take that step back and give way to the other. When CNNC made every effort to promote its CNP-1000, which it had worked on since the early 1990s, CGNPC insisted that its CPR-1000, an upgraded version of the French M310, should be chosen. In the beginning, Beijing intended to support the indigenous CNP-1000 but this was not what CGNPC wanted. For Beijing, both policy coalitions were established and hard to be reconciled. However, the clock was ticking and the decision had to be made due to a severe shortage of power supply and long-term planning for sustainable development.

Against this background, the advocates of Gen-III reactors quickly took the high ground amid CNNC and CGNPC’s fight over the future base model. There was a group of nuclear scientists and engineers that had long been interested in American nuclear energy technologies but did not have the chance due to a variety of reasons. They started their contact with Westinghouse for technology cooperation in the early 1980s and had since long been the major force of convincing the government to buy from it. At the same time, Westinghouse had never ceased the effort to sell its reactors to China but the deal had been put on hold for almost 13 years because of the US government’s concerns over nuclear proliferation. It was reported that China approached the United States and negotiated with every administration since the Reagan presidency but the deal had not passed the congressional review (Xu 2010: 144-5). Both sides had lobbied vigorously to implement the deal through the years especially after the ban was

[10] A meeting was convened with the presence of CNNC, CGNPC, BINE, Ministry of Machinery and SPCC to discuss the issue on a standardized commercial power reactor. The meeting was meant to pool the resources to work toward the goal.

finally lifted by the Clinton government in 1998. Since the external block was already cleared and Beijing had a headache with the inability to resolve the internal disputes, the stake of turning to Westinghouse's reactors increased.

The two-decade long futile efforts between Chinese nuclear experts and Westinghouse saw the prospect of a solution after the inception of the Hu-Wen government in 2003. The new administration was earnest to fulfil the ambition of becoming a future nuclear energy powerhouse by adopting "the most advanced technology in the world" and "achieve technology standardization". One important instruction was that this should be done regardless of the connections to Beijing, indicating the central determination to bypass the powerful domestic-foreign coalitions led respectively by CNNC and CGNPC. Later in the same year, six nuclear energy experts from the import camp signed a petition to the State Council in support of foreign advanced third generation technologies.[11] There were two of them with a background in the SPC system, mainly the Ministry of Machinery Industry, and two of them working in the National Nuclear Safety Administration (NNSA). Later the six experts, known as "the six gentlemen of import" or "the third generation club", became preparatory group members of the SNPTC, which oversaw the assessment and selection of third-generation reactors.

5.1 Lobbying by the import camp and Sino-American collaboration

Nuclear energy experts represented by the "six gentlemen" brought forward nuclear energy safety to justify the need to import third generation technologies. Many of them believed that the second generation reactors operating in China did not rival the most advanced reactors in the world, and that China failed to compete with other countries in nuclear energy technologies and lagged behind not only the industry leaders, but also late-comers such as South Korea. According to Yu Zusheng, a nuclear expert in SNPTC and NNSA as well as one of the "six gentlemen", the gap between China and those established nuclear powers is like the difference "between primary school students and PhD candidates" (Ma *et al.* 2011). The indigenously developed second generation reactor was regarded as "not coming up with the international nuclear safety standards" (Wang and Li 2005). This is also why CNNC's CNP-1000, a second generation plus reactor upgraded from CNP-600, did not pass the safety review by the NNSA. Another SNPTC expert that used to work in the First MMI, SPC and later NDRC believed that CNP-600, the domestic reactor modelled after Areva's M310, was not qualified as a "base model" due to the risks in incident prevention and fireproof design (Tang 2003).

[11] The six gentlemen are Tang Zide (used to work for the first MMI and SPC), Xu Lianyi (used to work for the first MMI), Lin Chengge (used to work in China Institute of Atomic Energy, NNSA, and International Atomic Energy Agency), Yu Zusheng (NNSA), Jin Jusun, and Xia Guojun.

The technology rationality of nuclear experts was complicated by departmental interests, in which the SPC system favored imports. On the surface was the disapproval of home-grown reactors, but behind the scene was a grudge that the electric power family (*dian li kou*) held against the military industry family (*neng yuan kou*) in the controlling rights of the sector. This is well known as a "cognitive difference" between the two systems.[12] Looking back, the sector used to be under the authority of agencies in charge of energy, electric power, and civilian machineries (MWREP and the First MMI in the SPC system) but fell in the hands of military production (MNI) from 1986-1988.[13] Since then the electric power system had largely been excluded from participation in the industry, and power generation companies were not allowed to enter the NPP market until 2007. Therefore, technology standardization became a long-awaited opportunity for the electric power family to stand up and win the decades-long political struggles within the sector.

The SPC's criticism of second generation reactors mainly pointed to CNNC's failure in the formation of indigenous technology capability. It was believed that China's backwardness in nuclear energy technology was attributed to CNNC and its predecessor MNI. According to the "six gentlemen", it was the "detour" into the military industry system that led nuclear power away from growing into a strong national industry. According to a book written by Tang Zide, the "mistaken step" when the sector was stripped from the MWREP to MNI in 1986 triggered a self-reinforcing vicious cycle in which the sector was delinked from the electric power market (Tang 2007). The argument was that under the jurisdiction of defense production, the sector "wrongly" embarked on an independent path—symbolized by CNP-300 at Qinshan—when MNI was not in a position to do so. According to Yu Zusheng, at that time trying to develop nuclear reactors mainly relying on domestic resources equaled to expecting "the Monkey King jumping out of stone", meaning that miracles would not happen out of nothing (Ma *et al.* 2011). And that was why the sector kept missing the opportunity of "standing on the shoulder of nuclear power giants" (Ma *et al.* 2011). As one of the fiercest critics among the "six gentlemen", Tang Zide argued that the localization of imported reactors CNNC boasted about was not the development of indigenous technology capability in the real sense, and its CNP-600 was simply an awkward imitation of the French M310. In their words, the CNP series were actually reactors relying on "foreign crutches" (Ma *et al.* 2011).

[12] Interview no. BJ171013, a former employee of CNNC, Beijing, 17 Oct 2013.
[13] There was a failed attempt to accommodate the opposition with the creation of the Ministry of Energy (MOE), which was dissolved in 1993 due to the bickering group interests. With a transitory return to the SPC in 1996, nuclear power was reassigned to the Commission for Science, Technology and Industry for National Defense (COSTIND) during a massive reorganization of the Chinese defense industry in 1998. Later there were efforts to recentralize energy policymaking. In the new century, the efforts include the National Energy Leading Group in 2005, the establishment of the National Energy Administration (NEA), a vice-ministerial body of the NDRC in 2008, and the National Energy Commission (NEC) directly led by the State Council in 2010.

Given the perceived incapability of CNNC, the import camp argued that the best alternative was to introduce foreign advanced technologies. For them, the fundamental problem in the sector was the military legacy that CNNC carried along from its predecessors, the Second MMB and the MNI. According to Tang Zide, overlooking the “energy nature” of nuclear power and the difference between civilian and military applications of nuclear technology was the reason why the sector went astray and kept falling behind. Unlike strategic defense industries that were expected to be developed at all costs, the commercial nature of the sector determined that it should be developed profitably. When domestic technologies failed to meet the rising demand in electric power, reactors should be developed through cooperation with international vendors. In their view, imports would save the sector from the inefficiency and incompetence of the defense production system represented by CNNC. The integrationists lobbied the central government to set up a new SOE to undertake the task and lead China’s nuclear energy expansion.

The proposition played right into Beijing’s hand because of the need to fulfil the ambitious goal of nuclear energy development. For Beijing, it was a stone killing two birds: the use of Westinghouse’s technologies made the prospects of the sector brighter than the original plan for second generation reactors, and the “six gentlemen’s” suggestion of establishing a new company was expected to resolve the conflicts between CNNC and CGNPC. As an NNSA high official said to describe the rationale behind the decision, “since both of the two sons are not submissive and fighting for their own interests, it is necessary to have another one” (Ma *et al.* 2011). It seemed that an integrationist approach through high-level intervention would provide a solution to the quarrels over reactor models, which were actually the fight over the leading position of the sector. In September 2004, the new NDRC restructured out of the State Development Planning Commission (SDPC, previously SPC) put two NPP projects originally planned to use the second generation reactors into international bidding for reactors pioneering third-generation PWR technologies. The decision was apparently one in favor of foreign reactors because at that time the best China could do was CNP-1000, which Beijing was not confident about. Canadian Candu was ruled out because it is not PWR. At the end, lobbying by the import camp crystalized into a new transnational coalition between SNPTC and Westinghouse through the introduction of AP1000.

5.2 A three-way contest among transnational coalitions

At the international level, the activism of the Americans met competition from the French and Russians for China’s mammoth nuclear power contract. Within China, the technology rationality of nuclear experts coupling the integrationist value of the electricity family caught CNNC and CGNPC on the defensive. After Beijing announced the plan of building a national

NPP fleet based on Gen-III reactors, Chinese buyers and international vendors quickly assembled to maintain their footholds in China. While CNNC and CGNPC turned their internecine conflict into an alliance against SNPTC, Westinghouse (AP1000) entered a fierce battle with Areva (EPR) and ASE (VVER-1000). As for the vendors, all had received support from their governments and a procession of political leaders from their home countries had pressed China before the decision was made in December 2006. International political factors further complicated the issue, in particular Toshiba's purchase of Westinghouse and its impact on the decision considering a strained Sino-Japan relationship. Internally, the import camp that had been interested in American nuclear technologies became the preparatory body of SNPTC. With the preparatory body appointed as the bid selection committee, Westinghouse's AP1000 finally won out, but soon after that CGNPC and CNNC's longstanding partners Areva and ASE also received orders from China.

Within China, SNPTC pioneers' attempt to determine China's future nuclear technology posed a threat to CNNC's inherited authority over the industry and its market position. First of all, the bid evaluation group that later became SNPTC was expected to be a central initiative prevailing over CNNC and CGNPC, even though all are centrally owned by SASAC. A second aspect is that the proposal to import whole plant from a different foreign vendor to form China's nuclear technology basis would elbow CNNC's CNP-1000 and CGNPC's CPR-1000 out of the market. As a result, the power struggle for turf originally between CNNC and CGNPC turned into the two's united crusade against the import proposal. They were unanimous in their concern that China would become a "proving ground" of Gen-III reactors since there was still not even one of such nuclear plants operating in the world.[14] In particular, CNNC challenged SNPTC's autonomy in guiding central decision-making and vied for control over the projects under bidding, originally at Sanmen and Yangjiang. It proposed to Chinese leaders that Chinese design institutes, all under CNNC at that time, should take a dominant role in the work of the two plants, and foreign vendors only supply partial systems or specific components (Hibbs, Weil and MacLachlan 2006). This is definitely not what SNPTC wanted, to start a whole new platform through the procurement of complete nuclear islands.

The rivalry was no less fierce in the global arena. Three vendors were shortlisted: Westinghouse, Areva and ASE.[15] Among the three finalists, ASE appeared to be at a disadvantage but derived its confidence mainly from the strategic energy relationship between Russia and China.[16] It had been sanguine in seeking to build more units at Tianwan. Areva as

[14] Interview no. BJ310812, a Caixin reporter, Beijing, 31 Aug 2012.
[15] CNNC's Canadian partner AECL was not in the run because its Candu is pressurized heavy water reactors (PHWR) but China opted for PWR as the cornerstone of its nuclear energy expansion plan.
[16] Interview no. BJ090812, researchers at the Chinese Academy of Social Sciences (CASS), Beijing, 09 Aug 2012.

China's major nuclear technology provider became Westinghouse's archrival in the contest for the multi-billion dollar contract. Both Westinghouse and Areva promised that if they won the bid, they would allow Chinese engineers to be involved in largely every step of the projects and help local companies to manufacture many of the parts in the future (Ortolani 2005). While Areva, the then Framatome cited "a long history of cooperation" with Chinese design institutes and manufacturers, Westinghouse tried to demonstrate that it would become "a dependable partner" in China (Nucleonics Week 2005). Hyping up its track record of technology transfer, Westinghouse wanted to convince the Chinese of its sincerity in helping build a nuclear-reactor program in China as it did in France and South Korea. To send out a clearer message to China, it agreed to share detailed engineering details with Chinese design institutes.

Along with the tournament among reactor vendors, a very heavy-handed engagement by supporting governments characterizes the competition. When Westinghouse, Areva and ASE filed bids on 28 February 2005, leaders from the three countries started lobbying China on behalf of their nuclear companies. It was reported that there was "a yo-yo movement since the bids were submitted, often in parallel with official visits by Chinese leaders to the US or France, or by Western leaders to China" (MacLachlan and Hibbs 2006). The White House was solidly behind Westinghouse. After Beijing announced the decision to call for international bidding, US Vice President Cheney and Energy Secretary reached Chinese Vice President Zeng Qinghong for formal talks addressing energy issues, including clean energy technologies. Later the Bush administration promoted the potential deal by linking it to the trade discussions with China. At that time, US pressed China hard to correct the trade imbalance between the two countries, and saw the AP1000 deal a golden opportunity to achieve the goal. The Westinghouse CEO Stephen Tritch had been a member of the trade delegation to China led by the US Secretary of Commerce Carlos Gutierrez. French President Jacques Chirac also lobbied for Areva during a visit to Beijing, warning that it would be risky for China to award the projects to Westinghouse because it had not built any nuclear plants for many years and its AP1000 existed "only on paper" (Sergeyev 2006).

A confluence of interest across the border gradually took shape as a result of internal struggles and external contest. On the one hand, the import faction led by NDRC and the evaluation group needed to maintain its control over the decisions, which was under threat because of CNNC's request for limiting foreign participation. On the other hand, in order to make its way into China Westinghouse entered into negotiations with Chinese planners and the preparatory office of SNPTC, the organization reviewing and assessing the bid applications. For the selection committee and Westinghouse, CNNC became a common roadblock to achieve their goals. There are two reasons that they had to deal with CNNC: one is that it would take up roughly half of the planned NPPs once the base reactor was confirmed.[17] The other is that almost all nuclear research institutes in China were under CNNC and foreign bidders had to cooperate with one of them to win the deal. However, the Nuclear Power Institute of China (NPIC), CNNC's design arm for CNP-600 and CNP-1000, had not been optimistic about whole plant import. According to a director of NPIC, history tells that core technologies could not be acquired through turnkey projects, and the design packages from foreign vendors are normally "black boxes" with essential features concealed (Wang 2006a: 29).

Facing common obstructions within China, Westinghouse and the Chinese nuclear experts supporting import stood together to push the course through. The evaluation group made of the "six gentlemen" and some other scientists and engineers from CNNC, CGNPC and academia only had eyes for AP1000 and repeatedly praised the passive safety systems and other features of the design. However, at that time Westinghouse was at a disadvantage when its controlling shareholder, British Nuclear Fuels Limited (BNFL) announced that it was going to sell Westinghouse. To make it more appealing to the Chinese, Westinghouse sent the "Father of AP1000" Howard Bruschi to China for "a strategic partnership" (Li and Zhu 2011). He stressed "complementarities" between the two sides, that China's strength in skilled personnel, manufacturing and construction was a perfect complement to the American design. The statement indicates that the deal was a win-win cooperation in which China would benefit from technological upgrading in many sectors. In a report to Beijing, Chen Zhaobo, head of the evaluation group, advised that China had greater leverage in negotiations because Westinghouse given its financial difficulties was more likely to agree with technology transfer, compared to Areva in view of its extant market position in China (Li and Zhu 2011).

At the same time, the Sino-American coalition also needed to deal with the divided preferences in CNNC's design institutes. CNNC once had three design institutes, respectively NPIC, China Nuclear Power Engineering Co., Ltd (CNPE) and the Shanghai Nuclear Engineering Research and Design Institute (SNERDI). The first two were extensively involved in the indigenization of French M310 (CNP-600 and 1000), whereas SNERDI designed CNP-300, the first home-grown NPP and the first export project to Pakistan. In general, some experts particularly from NPIC and CNPE preferred French EPR whereas others mainly from SNERDI were in favor of AP1000.[18] The decision was delayed because of prolonged negotiations with local research institutes regarding converting the reactor design from conceptual to workable packages. Westinghouse attempted to reach an agreement with NPIC but failed. At that time, CNNC's design institutes including NPIC were promoting the independently developed CNP-1000 and expecting its approval. Aside from technology transfer as a condition, CNNC

[17] Interview no. BJ171013, a former employee of CNNC, Beijing, 17 Oct 2013.
[18] Ibid.

requested a domestic content as high as 75% for the projects, which received objections from bidders that the local content scope was "too high" and "too risky" for the new advanced models (Hibbs and MacLachlan 2005). As a means of appeasing CNNC and the nationalists, Westinghouse and senior US officials expressed repeated pledges to transfer nuclear reactor technologies to China.

Aside from technological negotiations, Westinghouse and other nuclear firms also addressed diplomatic relations between the two countries. The US nuclear lobbying group led by Westinghouse mobilized the US governments for support. In response to the Chinese decision-makers' worry over the bilateral relationship in view of the specificity of NPPs, commitments were made alongside the Sino-American talks on nuclear energy cooperation, which involved the highest reaches of government in both countries. In the end of 2005, US Secretary of State Rice coordinated the Department of State, security, defense, commerce, energy, and Nuclear Regulatory Commission (NRC). to sign a joint guarantee that Westinghouse would comply with the technology transfer agreement, and the US ensured the continuity of the agreement (Li and Zhu 2011).

When the path was almost cleared within China, the import faction had to overcome a further hurdle. As it had support from most nuclear experts within the evaluation group and the political concerns were removed, it prepared for further negotiations with the US. In fact early in January 2006, almost eleven months before the final decision was made, the group had submitted a proposal based on Westinghouse's bid to the Chinese government.[19] However, a sudden announcement of the acquisition of Westinghouse by Toshiba in February stranded the decision. Because of this Westinghouse took on a Japanese identity. To some nationalists, the potential involvement of a Japanese company might bring uncertainties in China's nuclear security. According to an insider, there were concerns that due to the long life cycle of NPPs, these projects might be negatively influenced in case the Sino-Japanese relations deteriorated, and "it was hard to say that the two countries could maintain a stable and peaceful relationship in the long run".[20] The same interviewee also pointed out that because of the complex nature of NPPs, it was impossible for Chinese recipients to have an overall technology transfer in a real sense, and "the plants in China would become a latent source of nuclear radiance, if not a time bomb". Within CNNC some also warned that the use of AP1000 would strengthen a US-Japan alliance that might exercise strategic containment over China's nuclear energy development.[21]

[19] Interview no. BJ170812, a former researcher at the School of Public Policy & Management, Tsinghua University, Beijing, 17 Aug 2012.
[20] Interview no. BJ160812, researchers at the Development Research Center of the State Council (DRC), Beijing, 16 Aug 2012.
[21] Ibid; the concern was mainly based on the ambition of Japanese nuclear firms, which actively unveiled nuclear energy business cooperation around the globe. Another most significant move was Hitachi's announcement of cooperation with the American conglomerate General Electric in November 2006. Only a few weeks before that

There were reports revealing that the selection committee, referring to the preparatory office of SNPTC, was mainly made up of nuclear power technicians and thus did not have a fine sense of risk assessment in foreign relations (Suo 2006).

Westinghouse, its Japanese shareholder, and the US government reacted immediately to push the deal through. Westinghouse sent in an urgent letter to SNPTC promising that it would continue to follow all commitments it had made for the deal, including full technology transfer. Its CEO also claimed that Westinghouse would continue to be a US-operated company and the technology would remain in the control of the US government (Wan 2006). The CEO of Toshiba wrote in person to Chen Zhaobo that the management of Westinghouse remained unchanged and there would be only a vice president from Toshiba residing in the US. And upon China's request the US government issued another affidavit that after the Japanese purchase of Westinghouse, its export to China is still under the jurisdiction of the US government (Li and Zhu 2011). It is only after that the political concerns in China were largely erased.

At a time that the Sino-American coalition was going to win, CNNC and CGNPC joined hands to market Areva's EPR. In addition to a traditional affinity between CGNPC and Areva, CNNC also has a link with the French company. Like CGNPC's CPR-1000, its CNP-1000 was based on Framatome's M310. And before CGNPC had its own research institutes, it relied on CNNC in its local integration of Areva's conceptual design, which therefore had a fairly good understanding of French technologies. Even though initially the Russian model by ASE was preferred because of its competitive price, it was hard for CNNC to push it onto the stage because of the failure it showed up. So if CNNC had to make a choice among the three bids, EPR would be a better option because it had the same root with CNP-1000 and CPR-1000. Within CNNC, in particular NPIC, there was a group of nuclear scientists and engineers in favor of French Areva. A CNNC engineer said that if AP1000 was selected, China's nuclear technology accumulated based on M310 would be wiped out because AP1000 was a completely different design (Wang 2006b). Areva's CEO of the China region also cited this as the unique advantage if China opted for EPR, which had an "inherited coherence" with China's own Gen-III reactor in future. Moreover, he stressed that Areva had already gone through the details of indigenizing EPR with Chinese nuclear equipment manufacturers and design institutes.

The contention between the Sino-French and the Sino-American coalitions became white hot in 2006 and espionage was reportedly present in the competition. Revolving around the Gen-III bid selection at least three high-level officials from CNNC, CGNPC and another SOE fell from power and was put into prison due to disclosure of state secretes to foreign bidders. It was reported that they received bribes from a consultant firm, which in return had payment from

Japanese MHI signed MOU with French Areva for partnership in certain areas. It was suspected that the Japanese government was behind the ardent global reaches of the industry.

some "western and Japanese companies within their scopes of business activities" (Niu 2011). A nuclear expert taking part in the selection suspected that the purchase of Westinghouse by Toshiba was the direct result of an information leakage about nuclear technology introduction. In his opinion, Toshiba decided to buy Westinghouse at a price much higher than other bidders is because "someone let out the information that China decided to buy AP1000", which caused the subsequent turmoil surrounding the Japanese nature of Westinghouse (Lin 2014b).[22] This referred to Kang Rixin, the former general manager of CNNC. It seems that when they took part in the tender negotiations, the three secret agents worked for the benefits of Areva. Then the CEO of China National Technical Imp & Exp Corp. (CNTIC) disclosed the base price in the negotiation with Areva. Similarly, Areva's chief representative in China had been in close contacts with Shen Rugang, the deputy general manager of CGNPC that was a member of the Chinese delegate to negotiate with Areva and EDF before 2004 (Niu 2011). A report by Agence France-Presse (AFP) revealed that the Areva representative was involved in a consultant firm suspected of bribing some executives of CGNPC.

As an outcome of the activism, CNNC and CGNPC were largely excluded from the decision-making process at the late stage. This is because at that time joint efforts of the two incumbents impeded a final decision at the center. Worn out from the coalitional competition, Beijing granted nuclear technicians and technocrats greater power and as a result the evaluation group dominated the process. According to the first general manager of the Sanmen project, in the beginning nuclear operators had a role in the evaluation and negotiations but gradually were removed from the process (Zheng and Zhang 2014). Therefore, the final decision was left in the hands of NDRC and the nuclear scientists and engineers from design institutes and universities. In October 2006, Zhang Guobao, the deputy director of NDRC, convened a meeting with the nuclear energy community and the voting result was AP1000, which was approved by State Council in November (Wang 2006b). With the bid evaluation group including the "six gentlemen" as its major component, SNPTC was officially established to indigenize AP1000 to a standardized Chinese model. The meeting also decided to reassign SNERDI originally under CNNC to the newly created SNPTC to augment its research capability.

Regardless of the defeat their local allies suffered, Areva and ASE did not give up the strivings. The most eye-popping thing is that only a few months after AP1000 became the jewel of the crown Areva obtained an order from China for two units of EPR to be built at Taishan, without bidding and technology transfer. When Areva still held on fast to its principle of refusing to sell technology without building a plant, French President Jacques Chirac stated that they were "still in the race" to sell Gen-III reactor units to China. On the one hand, Areva's

[22] Aside from Toshiba, the bidders to buy Westinghouse are the leading nuclear firms in the world, including General Electronics (GE), Areva, MHI and Hitachi.

nuclear-reactor arm did not want to take the risk of creating its own competitor because Framatome itself grew out of a Franco-US joint venture with Westinghouse license and later became a major challenger to Westinghouse (Gauthier-Villars 2006). As a French executive said, “When it comes to technology transfer, there are limits we won't go beyond” (Pogam 2006: 22). Then after a while it was believed that the above-mentioned cross-border collusion opened doors for the French. On the other hand, the French government helped with the deal. Zhang Guobao explained that China bought EPR because of “the perseverance of the French and a need of balance in diplomatic relations” with US and France; and France helped China a lot in the past so China should care for France in this case (Ma 2011). As for the Russian side, ASE also managed to expand its business with China and was awarded an order of more units of VVER to be installed at Tianwan. It was widely accepted that China’s procurement of Russian technology and equipment was mainly out of the consideration of “resource exchange”. It followed the rationale of the previous projects at Tianwan, which were embedded in the strategic energy cooperation between the two countries. And of course, CNNC is in charge of the cooperation with ASE.

6. Negative business responses to Beijing

From the three decades of China’s nuclear technology selection it is not hard to see that the central government’s efforts of building up a strong indigenous nuclear power industry were greatly undermined by transnational interest groups. For each of the three turning points centering on technology routes, a confluence of internal and external forces dictated the decisions regardless of a nationalist orientation at the center. In the first round, the materialization of Daya Bay not only kicked off the decades-long cooperation between CGNPC and Framatome, but also created a historical precedent for foreign participation in the industry. During the economic renaissance after Tiananmen, technology selection in the nuclear industry revolved around the reconstruction of diplomatic relations in an ominous external environment. And on the eve of a great nuclear expansion within the country, the selection of Gen-III reactors staged a climax of the “grand finale” among the cross-border coalitions. However, the finale did not wind up the coalitional competition but rather unveiled a much more persistent and intense one with the addition of a new powerful team. Particularly in this most recent contest, no one group suffered a defeat but instead each gained a better position than before in the market. SNPTC and Westinghouse won a Gold medal in the paired games, CGNPC and Areva earned a Silver, and CNNC and ASE got a Bronze. However, when the multinational team players held their trophies smiling on the stage, the race organizers in Beijing became fluttered in their heart, contemplating how to accommodate the three teams in one playing field (a standardized nuclear power system) in future.

6.1 Government-business compromises in technology selection

The constraints of transnational business interests on central decisions are far more extensive than traditionally examined within the national border. Not only did Beijing need to cope with the group interests from within, it also had to handle international relations outside, which made decision-making even more complicated. Macroeconomic and strategic considerations with other countries were intricately involved when foreign firms drummed up support from their home governments, which was always the case. And this is particularly true when there were more than one foreign teams canvassing at the same time. Due to the stickiness of nuclear technology cooperation, oligarchic competitions within the country gradually translated into coalitional struggles across borders. As a result, Beijing's attempt to create "national champions" turned into the nurturance of "multinational teams" and "global partners". After the 2007 grappling, China's nuclear industry became a battlefield of the three cross-border alliances. It was believed that the polarization of the "three kingdoms" would be a serious impediment to gather China's nuclear R&D strength in building a national industry steered by national firms with independent technology capabilities.[23]

From the previous experience of Beijing, it had a hard time to break the curse of domestic-foreign leagues, which tied up its hands in technology unification. It met resistance because no one wanted to give up their own models that they had developed or collaboratively worked on with their foreign partners over the years. Due to their bureaucratic background and oligopolistic power, the central SOEs have strong political and economic clout to intervene in the agenda and drive the trajectory further from a unified and indigenous one. Being in the line of military descent CNNC can be seen as a commercial incarnation of the self-reliance spirit, but even the determined nationalist used Russian and Canadian reactors, and learned from the French in reactor design. CGNPC, mainly an offspring of the Guangdong provincial government, inherits an "open mind" from its local authority: it has forged a close tie with its French partner Framatome, now under Areva, and actively promoted the models designed by Areva since 1980s. Areva to CGNPC is what water is to fish, and CGNPC's challenge of CNNC in the standardized reactor design put Beijing in a dilemma.

Since both were unyielding to one another, Beijing had to form a new united front out of the scope of the two incumbents. This is where a bid evaluation committee was brought in to select a different international nuclear vendor. Beijing meant to rein in the internal defiance by

[23] Interview no. BJ070912, researchers at the Institute of Nuclear and New Energy Technology, Tsinghua University, Beijing, 07 Sep 2012.

borrowing more external forces. When Westinghouse was confirmed in 2006 as the technology roadmap and SNPTC was delegated to the indigenization of AP1000, the two forged a new alliance that became a powerful challenge to the two existing ones. Even though SNPTC was created into a position of commanding future technology, it has been actively seeking to penetrate downstream to compete with CNNC and CGNPC. In July 2014, it submitted a restructuring plan to the SASAC requesting to bring China Power Investment Corporation (CPIC) into the SNPTC-Westinghouse alliance (Lin 2014a). This is a logical choice because SNPTC could only step into the realm of NPP ownership and operation through a power generation company, not to mention that CPIC as one of the five big electricity companies shares deep ties with SNPTC.[24]

Ironically, the creation of a new central SOE to unify the Chinese market brought Beijing further away from its goal of standardization; and having one more team into the game did not weaken the existing interest groups but provoked them instead. None of them wanted to be at a disadvantage in the distribution of business interests. The fact that both Areva and ASE obtained orders from China after Westinghouse’s triumph illustrates the point. In view of the long relationship between CGNPC and Areva, it is hard to pacify the duo without buying EPR. At the end, French reactors came to China without whole technology transfer. The reason that Areva could maintain technology control is mainly attributed to its long-standing position in the market through CGNPC and the first mover advantage compared to other international vendors. Till now, CPR-1000 is still prohibited for export because Areva holds its IPR. Most importantly, the Taishan project with a new design is contrary to Beijing’s initial goal of building a uniform array of plants. As for ASE, even though it was out from the very beginning, it also secured an order for the sake of bilateral nuclear energy collaboration and strategic relationship since the early 1990s. As a result, the sector witnessed a proliferation of players and greater diversity in reactor models.

Beijing was resolute to restrain the coalitional disturbances, but in fact involuntarily or intentionally stood up for a stronger transnational team. Taking a closer look at the decision on AP1000, “technology rationality” became the supreme measurement for bid evaluations because there were also divergences within the top leadership.[25] When Beijing left CNNC and CGNPC as nuclear operators out in the cold, it temporarily dissolved the existing alliances that derived

[24] CPIC came from the agency in charge of electric power generation and SNPTC has its origin from the SPC system. In history, they all were in favor of technology import, known as the “electricity family”. In addition, SNPTC’s chairman of the board, Wang Binghua, was the first general manager of CPIC. Limited by a lack of nuclear technology, CPIC could not take participate in NPP projects on its own. For CPIC, joining the alliance of SNPTC and Westinghouse would unleash its great potential. Moreover, with the help of SNPTC, CPIC now has two units of AP1000 under construction at Haiyang. Therefore, a merger between CPIC and SNPTC would be an optimal choice for both.

[25] Interview no. BJ121012, a government official at the National Development and Reform Commission (NDRC), Beijing, 12 Oct 2012.

their power from the center. But at the same time, an assembly of nuclear experts, technocrats and state leaders eventually emerged as a state enterprise that is even higher than central SOEs. Unlike CNNC and CGNPC that both start with C (*zhong zi tou*), meaning "China", SNPTC has "an initial of S (*guo zi tou*)", standing for "State". The combination of a state company and the "most advanced technology" in the world served as an expedient policy under the circumstance. Technology, finance, and trust were three keystones to the selection, which were complemented by "political intangibles" between the countries (Hibbs, Maclachlan and Dolley 2005). It was said that foreign affairs officials also played a significant role in lobbying Beijing for the countries to which they were appointed.[26] So as for the decisions on EPR and VVER, if they were voted out in terms of technology, we can still safely say they won in the other dimensions.

But it is hard to say whether the new transnational team would rein in the coalitional conflict when the Sino-American coalition in China becomes increasingly powerful overtime. Now with the addition of CPIC into the SNPTC-Westinghouse union, the alliance may potentially portend the rise of a big "electricity family" that would bring it greater leverage than others. Together with other power generation companies CPIC was structured out of the State Power Corporation of China (SPCC), previously the Ministry of Electric Power, which traced further back to MWREP. It had tried hard to set its feet in the nuclear industry before it was finally approved in 2007 as a third NPP owner and operator in addition to CNNC and CGNPC. With CPIC limited by technology and SNPTC constrained by its business scope, a merger would mean potentials unleashed and a great strengthening of the SNPTC-Westinghouse partnership. However, it remains to be seen whether the combination would help build up a national industry. If yes, Beijing would be free of worries. But if not, the colossal kingdom would add to the turmoil seen over the decades, and the central government would be further weakened in its authority of making policies. Again due to the special nature of nuclear technology cooperation, once a transnational alliance secures footholds it tends to become self-perpetuating.

6.2 Firms' negligence in R&D

The hustle and bustle of coalitional rivalry distracted Beijing from a nationalist course, and also diverted the attention of Chinese nuclear companies from the formation of indigenous IPR. As in the first three decades China's indigenous efforts were done by CNNC's research institutes, CNNC is the observation port. As a partial result of the coalitional competitions, CNNC only intermittently came out with a few home-grown models. Due to its hostility against the CGNPC-Areva group, CNNC has reportedly contained NPIC because of its technology ties with

[26] Interview no. BJ040912, a former employee of CGNPC, Beijing, 04 Sep 2012.

CGNPC and Framatome originated from CNP-600.[27] The containment includes forcing the transfer of NPIC's CNP-1000 to SNPTC, hindering NPIC's cooperation with CGNPC, depleting its core technology capability (civilian nuclear engineering), and abruptly terminating a proposed joint venture project between NPIC and Areva in the concern of "possible interference into the Gen-III selection" (Nanba Huofu 2009). All these moves were meant to avoid an amalgamation with the French followers in China's nuclear industry through the suppression of NPIC within CNNC. This is so because NPIC was known as having an ambition to become a NSSS company like Areva and Westinghouse, and finally build a national platform for nuclear power research that surmounts business interests. Deeply entangled in the competing interests, CNNC had its research strengths scattered, with some flowing into CGNPC. As a result, before 2007 China was left with only three indigenous models, two (CNP-300 by SNPTC and CNP-600 by NPIC) installed and one (CNP-1000) disapproved.[28]

Despite the improvements in independent R&D, Chinese nuclear firms stood in the way of building a national nuclear energy technology platform. One positive change after the nuclear "three kingdoms" came into being was that competition stimulated the Chinese nuclear firms to engage in developing their own models of indigenous IPR. This is mainly because CNNC now had competition from both SNPTC and CGNPC. A few years after the upheaval, CNNC updated CNP-1000 into ACP1000 and CGNPC developed its CPR-1000 into ACPR1000+. However, both became obstructions to the national goal of merging the two models into one indigenous Gen-III reactor, namely Hualong-One (China Dragon-Number One). As the cores of the two models were very different and both received approvals from IAEA, neither CNNC nor CGNPC wanted to abandon their own designs. While CNNC derived its nuclear reactor technologies mainly from Canada and Russia, CGNPC had French blood in its core technologies. Since the central order of rationalizing the two models in 2013, there had been several rounds of negotiations between the two nuclear giants. Both challenged the unification to a single model but had to start cooperation with each other because Beijing set the merging as a precondition for any new project approvals (Zhang 2014). As a result, they became partners only on the surface. Even though Hualong-One finally came into being, the merging remained only in name, not in technology, and the two firms had different target markets in terms of

[27] A second independent project in China was CNP-600 by NPIC for Qinshan II, which was originally put on agenda as a cooperation project with Siemens AG subsidiary Kraftwerk Union (KWU) but was forced onto an independent path due to the withdrawal of German participation after 1989. Through CNP-600, NPIC developed a technology cooperation relationship with Framatome.

[28] According to an interviewee (no. BJ171013, with a former employee of CNNC, Beijing, 17 Oct 2013), the failure of CNP-1000 was attributed to the interruptions in R&D as a result of the restructuring CNP-1000 out of NPIC.

export (Zhang 2015).[29] This remains an obstacle to Beijing's effort of building up a "national team" to expand business overseas.

Alongside the infighting among nuclear SOEs, the competition among transnational coalitions became even fiercer. CGNPC created its own research institute in 2005 and had a deeper relationship with Areva through EPR. And because of Areva's negative experiences in the cooperation with CNNC, it found CGNPC to be the most trustful. In addition, the strategic partnership between their turbine and generator providers, namely Dongfang Electric (DEC) and Alstom, also strengthened the CGNPC-Areva alliance. At the same time, SNPTC and Westinghouse have been committed to the construction of AP1000 reactors and the development of CAP1400 (the localized version of AP1000, with C standing for Chinese), which is expected to unify the Chinese market through a "standardized blueprint" (Suo 2012). Especially after the Fukushima Crisis in Japan, the passive safety system of SNPTC-Westinghouse becomes more popular than others due to its simple design with less equipment. As for CNNC, it is no longer the "big boss" despite its identity as the "first son" in the nuclear family.[30] It felt particularly challenged by the expansion of SNPTC-Westinghouse alliance with the addition of CPIC, and CGNPC's purchase from France of recycled nuclear fuel, which has been monopolized by CNNC within China. Now since "going-out" has become China's national strategy for nuclear power development, the three nuclear giants are still engaged in "vicious competition" and "serious internal frictions" (Lin 2014c). In fact, it is not only when Chinese enterprises go out that the internecine becomes a problem: it has always been so since international vendors came to China and forged alliances with them.

7. Conclusion

The chapter has argued that due to nuclear energy's distinct attributes compared to traditional mass-production industries, nuclear companies tend to develop long-standing strategic business relationships with international vendors; and a confluence of domestic and foreign business interests is likely to form policy coalitions across borders. In China's case, all the nuclear giants came into such type of partnerships with their chosen nuclear lead firms in the world, which pooled their resources together to make their preferences heard in the central policy agenda. Chinese nuclear state companies derived their power from their bureaucratic background and economic significance, and international vendors sought support from their home governments. In over three decades, the powerful domestic-foreign symbiosis grew increasingly powerful and diversified, and became a major force propelling China's nuclear energy industry onto an

[29] CNNC is looking at Pakistan, Argentina, Egypt, and Algeria, whereas CGNPC targets UK, Romania, Ukraine, Hungary, Thailand, and Vietnam.
[30] Interview no. BJ280812, a researcher at the Energy Research Institute (ERI), National Development and Reform Committee (NDRC), Beijing, 28 Aug 2012.

integrationist path. Despite a nationalist orientation at the center, the divergence of cross-border group interests led Beijing away from its intended course, and turned Beijing’s efforts of fostering national champions into global partners over and over again.

In China’s nuclear energy industry, the way that domestic business identified with international nuclear vendors and with the Chinese state remained largely consistent in over three decades’ of time. Chinese nuclear firms have shown a continuing preference for strategic collaborations with international vendors due to technology lock-in. This is particularly so when the protracted interactions with foreign partners were intertwined with introducing new generations of reactors that differ greatly from earlier designs, which made the cross-border business relationships even stronger. This explains the three rounds of nuclear reactor imports over the past three decades. Chinese nuclear firms led the import of the first and second generation nuclear reactors respectively in the 1980s and 1990s, and helped promote the third generation reactors made by their foreign partners to Beijing in the 2000s. The passion of Chinese nuclear firms in cooperating with international vendors and introducing new foreign nuclear reactors into China did not subside even when Beijing made technology autonomy the top priority in the country’s industrial development in the new century. When political winds blew in the direction of technology independence after 2003, the pro-foreign stance of Chinese nuclear firms and their preference for a more open policy environment did not change.

Chinese nuclear firms have been bound together with international vendors over the years and their common interests of obtaining greater market share outweighed those at the center of achieving technology unification and indigenous R&D. Due to a high degree of user involvement and long product cycles of nuclear power projects, the transnational alliances are long and serious, and they tend to persist because of technology lock-in and the heterogeneity of capabilities involved in the projects. Unlike in commodity manufacturing, nuclear reactor technologies and skills cannot be easily acquired through transfer. In addition, the cross-border coalitions enjoy great political and economic power as a result of high entry barriers, and have a ready access to policy process. Because of these characters seen in the nuclear industry, internal conflict among Chinese buyers easily transforms into coalitional rivalry across borders. So when efforts are made to standardize the nuclear energy market with a unified reactor technology, it is natural to meet resistance from the transnational coalescences.

There are three transnational coalitions now operating in China, chronologically CGNPC-Areva, CNNC-ASE and SNPTC-Westinghouse. They played different roles at different stages but all managed to introduce international vendors and their nuclear reactors into China. Guangdong provincial government and its supporters in Beijing brought in Framatome, which exerts the greatest influence over China’s nuclear technology development. The Sino-French cooperation later became the coalition between CGNPC and Areva. The case of CNNC is different: stemming from the nuclear energy authority, it was in charge of negotiations with Russian and Canadian nuclear vendors and imported reactors from both. At the same time, CNNC also cooperated with the French because all nuclear research institutes were in its control and had to help CGNPC in reactor design. The experience polarized CNNC in terms of technology preferences. When it came to the international bidding for the third generation nuclear reactors, Westinghouse's pressurized water reactor was chosen because the coalition that later became SNPTC-Westinghouse had the most powerful lineup to support its bid. Within China it had support from nuclear experts, technocrats and some central leaders; and within its own country, it lobbied the United States government through the help of other nuclear companies in its consortium. The decision strongly touched the nerves of existing transnational alliances, and the repercussion is that they brought in more foreign reactors and further diversified the nuclear energy market.

As a result of the shared cross-border business interests, Chinese nuclear firms were unresponsive to the nationalist initiatives in the interactions with the central government. While the aim of Beijing was to nurture indigenous technologies, indigenous Chinese firms acted as the loyal "global partners" of international vendors and were keen on promoting the nuclear reactors of their foreign partners. When Beijing called for the indigenization of foreign technologies, the firms worked toward stronger transnational teams even in the localized versions of foreign nuclear reactors. Because of this, research and development resources have been scattered, which distracted the industry from pursuing an independent path through technology unification. Being engrossed in coalitional contests, Chinese nuclear firms spared limited energy in independent design and had limited interests in domestic cooperation. In fact, early in 1999 the State Planning Commission had proposed that CNNC and CGNPC should jointly develop nuclear reactor technologies with Chinese intellectual property rights (Zhang 2014). However, the proposal received lukewarm responses from the two firms, and this continues today in the rationalization of Hualong-One. Technology diversification may persist until someday all firms agree to bury the hatchet or sever the ties with their foreign partners. For the firms, growing completely independent from foreign partners may mean decades. For Beijing, turning China into a not only big but also strong country of nuclear power technology is by no means easier than that.

Chapter 5
The making of "national champions" in the wind power industry

"Foreign firms attempting to go it alone in China's wind power market without a local partner risk being frozen out when domestic turbine makers become strong enough to compete".

--- *A senior executive at German REpower Systems AG, 2006 (Winning 2006)*

1. Introduction

In contrast to what was seen in the nuclear energy industry, most top Chinese wind firms responded actively to Beijing's call of working toward a national industry driven by Chinese-owned technologies. In spite of importation at the initial stage and later production relying on foreign licenses, the government-selected producers of wind turbine generators (WTG) coordinated with Beijing in marginalizing foreign products manufactured overseas and at home. From there being merely no local manufacturing to domestically made wind turbines taking a lion's share of the Chinese market, took only five years. In response to the national support of wind power development, especially the requirement of locally manufactured wind power equipment in new wind farms, local turbine producers quickly flourished over the entire country. Generally Chinese firms have been engaged in independent production albeit making use of foreign technologies, mostly through technology licensing. Some of them followed Beijing's will in shifting foreign technology acquisition to indigenous research and development (R&D). There were a large number of small firms that were only interested in cost competition but not in indigenous innovation, but they did not gain support from Beijing and found themselves ostracized. Those who were favored by Beijing and in return obeyed Beijing in turning policy support into advantages over foreign competitors became the so-called "national champions". For the most part of their catching-up process, they generally focused on the formation of proprietary technologies and gaining competitiveness in not only the domestic but also the international market.

Why was Beijing's intention of building an indigenous industry with technology autonomy well received by firms in the wind power sector? By looking into government-business interactions in the sector, the chapter argues that due to the standardized nature of wind turbine manufacturing, the idea of collaboration in production was neither necessary for Chinese late-comers nor appealing to world-leading wind turbine makers, and the divergence of domestic-foreign business interests made local firms committed followers to Beijing's nationalist initiatives. First, the wind power sector resembles many other mass-manufacturing sectors in the sense that production is codified and competition is mainly based on economies of scale, so that technologies are easily transferable among industrial players and skills can be obtained through learning-by-doing in a short period of time. Second, because of the ease of technology acquisition, the domestic-foreign business relationship in the sector was one of mutual-exclusive market competition. Chinese wind firms did not need technologies from foreign established producers, which also avoided to be involved in the production of local firms for the fear of losing technological competitiveness. Third, in order to fend themselves off foreign competition, Chinese indigenous firms chose to cooperate with the central government in the effort of strengthening indigenous manufacturing and designing capabilities, and increasing competitive advantages over foreign competitors.

Similar to the preceding chapter, this chapter analyzes the Chinese wind energy sector by testing the hypotheses developed in Chapter 2 but illustrates a completely different story in comparison to the nuclear case study. The next section demonstrates that WTG is a typical mass-manufacturing sector characterized by relatively simple components interfaces, medium to low technology barriers, and relatively high possibility of technology transfer. Section three focuses on the competing interests between Chinese and foreign WTG producers, and stresses that there was a void of transnational coalitions in support of open policies in the sector. Sections four and five discuss the proactive responses of local wind firms to the central initiative of building up an indigenous industry, with section four focusing on those in the state-led R&D and technology acquisition in the first two decades, and section five on those in the state-directed wind power expansion since 2003. Section six reviews the state-industry coordination in local manufacturing, technology indigenization, and foreign market entry. The last section sums up the chapter and shows that the findings are consistent with what are hypothesized in the theory chapter.

2. Nature of the sector

Unlike the "complex product systems" (CoPS) represented by nuclear power plants, the wind power industry is typical of automated and systematized manufacturing that benefits from economies of scale. In the category of mass-production, WTG production is represented by a relatively low unit cost, is made of standardized components, and produced in high volumes and large batches. With medium or low entry barriers in terms of technology and capital, competition in the production of wind power equipment is based on cost minimization. Due to the short product life cycle and simple product systems compared to CoPS, technology transfer is relatively easier for wind power and catching-up is likely to happen in a shorter period of time. Most manufacturing industries, including WTGs, are in this category, even though they vary wildly in many dimensions. For example, solar photovoltaic (PV) is characterized by lower entry barriers, shorter product cycles and a more straightforward production process than the wind power industry. Other examples include auto assembly that is similar to wind turbine manufacturing, as well as electronics and semiconductors resembling solar PV.

The nature of wind turbine manufacturing as an industry of mass-production determines that it displays certain patterns in technology acquisition, industrial relations, and connections to the government. First of all, it is possible for wind turbine manufacturers in emerging economies to challenge leading international firms through technology outsourcing. For mass-manufacturing industries such as WTG manufacturing, production processes are highly standardized and the chances for firms to grow through learning are high. As technology matures overtime, manufacturing starts moving to developing countries to take advantage of low costs. And this is when pioneering manufacturers soon lose their competitiveness to those in the local market, which move rapidly to the acquisition (duplicative imitation) and assimilation (creative imitation) of foreign technologies, and improvements in productivity (process innovation) (Kim 1997: 88). Using borrowed technologies, firms in late-industrializing countries are able to challenge long-established manufacturers thanks to "lower wages, higher subsidies, as well as intense efforts to raise productivity incrementally" (Amsden 1989: 5). This cost advantage also results from the fierce competitions between the large number of industry players that enters the industries with relatively low technology and capital barriers.

The existence of a particular group of companies providing technology-based services makes catch-up possible for new entrants engaged in wind turbine manufacturing. Instead of in-house development, WTG manufacturers could choose to collaborate with engineering design firms from industrialized countries, most of which are small producers, research institutes, laboratories, universities and consulting firms that are not capable of or not interested in large-scale manufacturing. These firms normally focus on a specific spectrum of expertise and offer such R&D services as design, engineering, prototyping, testing, training, and technical consultancies to their clients, known as knowledge-intensive business services (KIBS) (Miles *et al.* 1995). As "one of the most dynamic components of the service sector in Europe and in most highly industrialized countries", KIBS also extend their reach to industrializing economies and sometimes collaborate with recipients in multiple countries (Rodríguez and Nieto 2012; Strambach 2001: 53). They are seen as complementary innovation assets to the technological obstacles that late-comers face in production, and their interactions with users facilitates knowledge accumulation and innovation for both (Muller 2001). On the one hand, their clients are able to start manufacturing, gain experience and obtain technological capabilities through external acquisition of technologies; on the other hand, KIBS suppliers develop their own innovation capacities by integrating the production process and making continuous adaptations to the needs of their clients (Hertog 2000; Muller 2001).

Because of the philosophy of focusing on core competencies, wind turbine manufacturers tend to develop a complementary relationship with design firms. Normally small in size, companies providing wind turbine designs do not set up their own manufacturing facilities and hence do not have concerns about losing market share to their local recipients. Compared to well-established firms having in-house R&D and being engaged in production themselves, these KIBS providers have less to lose and therefore are more willing to transfer their technologies. Royalty fees from the products manufactured by their local partners, integration into a thriving production environment and access to local innovation resources are what they are after. In exchange for technology know-how, producers in developing countries only need to pay fees without sharing the market with their technology suppliers. Despite limited capabilities in internal R&D, they are able to concentrate on reducing costs in manufacturing and on competing with others.

These complementary relationships translate into business alliances to secure surviving spaces from the market dominated by manufacturers at the technology frontiers. Without technology cooperation, both developing-country firms and wind turbine designers are in an inferior position if they compete individually in the international market. Known as “laggards” in terms of developing new technologies and techniques, KIBS providers, in this case design firms, lag behind top industrial players due to the lack of manufacturing experience (Miles *et al.* 1995). If not collaborating with startup manufacturers their professional knowledge cannot travel from lab to market and turn from design to products. As for manufacturers in late-industrializing countries, lack of innovative capacity is the major blockage for them to enter the market and become active industrial players. The acquisition of wind technologies from KIBS providers gives them greater flexibility and cost efficiency than in-house R&D does. Through the production of acquired technologies, they could develop innovative capacities in the production process and collaborate with their KIBS providers for future designs. Moreover, they could also consider entering into long-term strategic collaborations with, or even acquiring, their design partners for greater competencies.

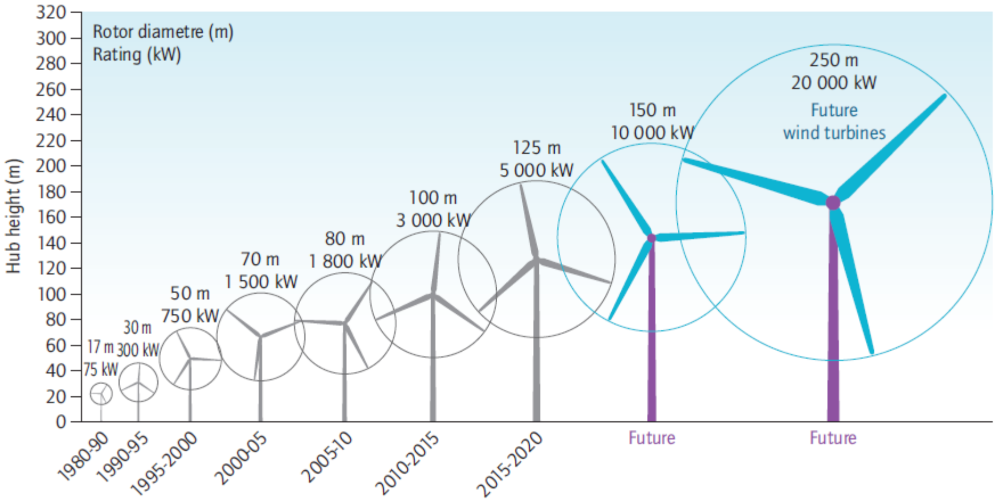
Due to relatively simple product systems and standardized production, the KIBS supplier-user combinations may be able to achieve economies of scale in a short period of time.

Compared to the CoPS industries, mass-manufacturing industries involve fewer subsystems and narrower knowledge, and the formation of competencies largely rests in production rather than system integration. Technology transfer is more straightforward in wind turbine manufacturing because product designs are simpler and codification of processes is easier than it is in nuclear power projects; and as less equipment and more standard components are involved in production, it is easier to develop local supply chains or sources from overseas technology suppliers. And instead of focusing on the integration of multi-disciplinary expertise and comprehensive subsystems, traditional manufacturers gain competitiveness through process innovation and cost minimization. As production-related activities are more relevant in WTG manufacturing, wind firms in industrializing economies are able to make use of transferred technologies and scale up production quickly.

On top of rapid commercialization, the design-production alliances could engage in continuous interactions that help develop innovation and manufacture capacities. As is the same for traditional manufacturing industries, WTG is typical of a short product lifecycle and wind firms are under constant pressure to develop new models with larger capacity and make continual modifications to the acquired designs. While the upgrading of nuclear reactor technologies lasts decades, the cycle in WTG manufacturing lasts only a few years. Since the first civil nuclear power reactors started operation in the 1950s, the second generation reactors went into commercial use in the 1970s, and the third did not come to light until the 1990s. While the evolutionary third generation reactors are expected to dominate until the 2020s, the commercial construction of the revolutionary fourth generation designs may not be available until the 2030s (European Commission). In comparison, wind technology has seen an ever-increasing growth in turbine capacity, and the prototyping of larger turbines with improved performance occurs every few years. Early commercial wind turbines in the 1980s only had an average per unit capacity of 50kW, but have reached 750kW in the 1990s, 2MW in the 2000s and 5MW in recent years. Future turbines are expected to be as large as 10MW or even 20MW (see Figure 5-1). Moreover, because of the relatively low entry barriers firms are challenged by new entrants that are engaged in price wars and compete on undifferentiated products, and hence are always driven to introduce diverse turbine models with better quality control in a timely manner. For that reason, adaptations and incremental improvements help reinforce the relationships between manufacturers and designers, and keep them up with frontier technologies.

While developing-country firms in manufacturing industries could climb up technological ladders with the help of KIBS firms and compete with their larger international counterparts, it is impossible for those in the CoPS industries to form their own capabilities in conceptual design and system integration through the collaboration with one or more KIBS providers. They need to rely on companies at the upper echelons of the industry through long-term strategic partnerships, from which they may develop their independent capabilities in a few decades' time. In comparison to Framatome, which became one of the top industrial players in nuclear energy after about 50 years of cooperation with Westinghouse, it took only a few years for General Electric (GE) to become one of the world's largest WTG producers after it tapped into wind turbine manufacturing through the acquisition of Enron Wind in 2002.[1] If the American electric colossus' story is not convincing, the experience of WTG firms from China, India, and South Korea tells the same story: mostly with an industrial base in other areas, firms from these countries realized a remarkable turnaround from no WTG manufacturing experience to compete in the global market within a limited amount of time. It took Suzlon only five years to get on the world top ten list of wind turbine manufacturers and has remained there since (Lewis 2013: 150). Chinese WTG firms as newcomers delineate a bolder version of the process: in the space of only a couple of years some of them became the top ten WTG manufacturers and together made China the largest wind power producer in the world.

Figure 5-1 Growth in the size of wind turbines since 1980 and prospects



Source: International Energy Agency (IEA), Wind Energy Technology Roadmap, 2013 edition, p.27

Firms in emerging economies can choose from a wide range of solutions to technology acquisition through a panoply of partnerships with KIBS providers. Licensed production is the most popular approach among latecomers to establish WTG production operations. Despite certain constraints in the use of technologies, wind turbine designers are seldom involved in the

[1] After the acquisition of Zond and Kenetech, Enron became the only remaining major American wind turbine manufacturer in the 1990s. GE made the purchase of Enron during its bankruptcy proceedings. For a detailed discussion of the evolution of wind turbine technologies in the United States, GE Wind and its business activities in China (Lewis 2013: 93-105).

business activities of licensees. While technology users are temporarily content with existing technologies, providers earn royalties from overseas manufacturing and reduce risks through multiple licensing agreements. In addition to the link between technology transfer and license fees, both parties benefit from the highly interactive processes in terms of innovativeness. As the relationship deepens, the mutually beneficial partnership sometimes moves on to joint development and becomes co-innovators of each other, with WTG manufacturers seeing a better prospect in forming their own IPRs in the process. However, this does not necessarily mean that the manufacturers become independent from KIBS providers in view of the rapid pace in technology upgrading. Therefore, some highly competent manufacturers go for the purchase of ownership rights in KIBS firms in order to gain greater technology independence. Wind turbine manufacturers in China and India made use of almost all of the solutions discussed above to achieve a legendary rapid rise. All these available solutions coupled with low factor costs, large market size and specialized manufacturing capabilities account for the phenomenal growth of wind industry in both countries.

The interests of KIBS firms stands in sharp contrast to international frontier companies, for whom the most important thing in overseas business expansion is to avoid technology spill-over as much as possible. As they have achieved supply chain integration from R&D to production, marketing and management, technology transfer is in their least interests because this may mean creation of competitors that encroach on their market shares. The case of Denmark-based Vestas sounded an alarm bell for all wind firms: in ten years' JV partnership it personally trained its own competitor Gamesa, which manufactured wind turbines with Vestas technology in the Spanish market and became a major challenger in the global arena, including in China.[2] Therefore, most lead firms prefer international trade or wholly owned FIEs, which give them greater control over intellectual property rights (IPRs) and overseas operations. In comparison, KIBS providers allow a much higher degree of local control over technologies and domestic participation in the innovation process. Therefore, the rivalry is between local subsidiaries of multinational wind corporations and developing-country firms that are in collaboration with KIBS providers.

In many cases global lead firms are forced to enter into JV enterprises with local partners, either by the home government for market access or due to limited knowledge about local operations. They tend to be strange bedfellows because one side focuses on gaining technological autonomy while the other needs to protect their know-how. From the perspective

[2] Lewis (2013: 84-86) had a detailed discussion of the process: following a separation deal between the two companies, the technology transfer agreement was phased out and Gamesa "acquired the right to sell anywhere in the world". It then immediately expanded its presence globally, with manufacturing operations set up in many countries including China.

of international frontier firms, both risk-aversion and control over operations are essential when building up their business in overseas markets. However, the two goals are at odds with each other because the former brings about compromises but the latter creates conflict with local partners. Aside from technology acquisition, the high cost of imported components stimulates local partners to seek establishing alliances with component suppliers locally. However, foreign established wind firms favor the purchase of wind power generation units or components manufactured in their home countries, from which they can benefit from export sales. Some even see their local partners as sales offices in the local market. The divergence of interests always put JV cooperation to the test in daily business routines. For all JV partnership is about, domestic and foreign partners in WTG manufacturing are at best quarrelsome lovers that disagree on many situations.[3] The situation is mitigated when it comes to the production of components and parts because less technology know-how is involved and local manufacturing means lower costs.

Subject to market competition and protection of their proprietary technologies, international lead firms have a very thin chance of influencing local industrial policy. Local operations of large foreign firms, wholly owned or through a JV partnership, have their voices heard through the chambers of commerce representing businesses from their home countries. However, it remains uncertain that their voices will be channeled into the policy process because they either do not have a partner at all or even if they have one they harbor different thoughts about cooperation from their local partners. It is not in global top producers' interest to transfer technologies especially when they are individually seeking to build up their own business kingdoms in the host country. In many cases foreign firms accept the terms for entering the target market, technology transfer for instance, even though they choose to transfer the older designs that would not become a direct challenge to their prevailing turbine models. Their home governments also have nothing to do until certain disputes falling into the purview of international regimes are involved. Foreign pressures can be strong under certain circumstances but remain limited if they are not in alliances with local industrial players.

In contrast, native wind firms in catching-up economies have their preferences aligned with local industrial policy in the pursuit of expanding market share. This is because alliances with foreign KIBS providers and local suppliers are strong enough to confront international lead firms rather than relying on them as seen in CoPS industries. Local parts suppliers share a common interest with wind turbine manufacturers when it comes to participating in the bids for wind farm projects. With available technology know-how and cost advantages in production, local manufacturers cater for the demand of wind farm developers with better prices than their

[3] The discussion on JV partnership is mainly on wind turbine manufacturing but not applied to JV plants producing components and parts, which are normally set up by FIEs.

foreign counterparts. With regard to wind engineering and design firms, complementary capabilities lead them to claim the benefit of supportive policies that their partners enjoy in the local market. Even some that become co-developers of their local partners are much less ambitious than larger manufacturers: through the development of a new model they are not going to set up their own local plants but rather seek a union with their local partners. Some of them are even allowed to license the jointly developed designs to manufacturers in a third country after being purchased by their local partners.

Despite the use of developmental policy tools, wind turbine manufacturing is less politicized than it is in CoPS industries and largely follows market mechanisms in regular transactions. Due to the nature of mass-production, the industry is diffused among a large number of firms and characterized by frequent business transactions. With the exception of global conglomerates such as General Electric (GE), most companies specializing in WTG are not that large in terms of industrial output and the market is largely contested. Even though government support and industrial policies are widely used around the world when this industry is still in its infancy, most business activities and technology transfers take place through commercial channels rather than government initiatives. Changes can be seen with the growing salience of energy geopolitics, where countries have been engaged in the framework negotiations of clean energy and climate change cooperation incorporating related manufacturing industries. However, the politicization of WTG production is limited and the selection of business strategies remains in large part in the purview of corporate behavior.[4]

3. Cross-border industrial relations

As seen in traditional manufacturing industries, the logic of market competition in wind turbine production places new entrants under constant threat from well-established companies. To compete with international frontier companies, wind firms in latecomer economies borrow foreign advanced technologies from KIBS providers. Chinese wind firms started their businesses using licensed production and furthered their capabilities through joint development or even purchase of a design firm with its proprietary technology designs. In view of the standardized process in WTG production, technology transfer can be separated from the production process and foreign participation is not a necessity. The fact that wind firms in emerging economies are able to set up production operations and gain a high degree of autonomy results in a highly competitive relationship with leading international firms. In addition, the relatively low entry barriers and short product lifecycle make possible rapid industrial upgrading before the formation of independent technological capabilities. As cross-

[4] See Lewis (2013) for a discussion of the limited impact of bilateral climate and energy cooperation agreements on the market mechanisms in the wind energy industry.

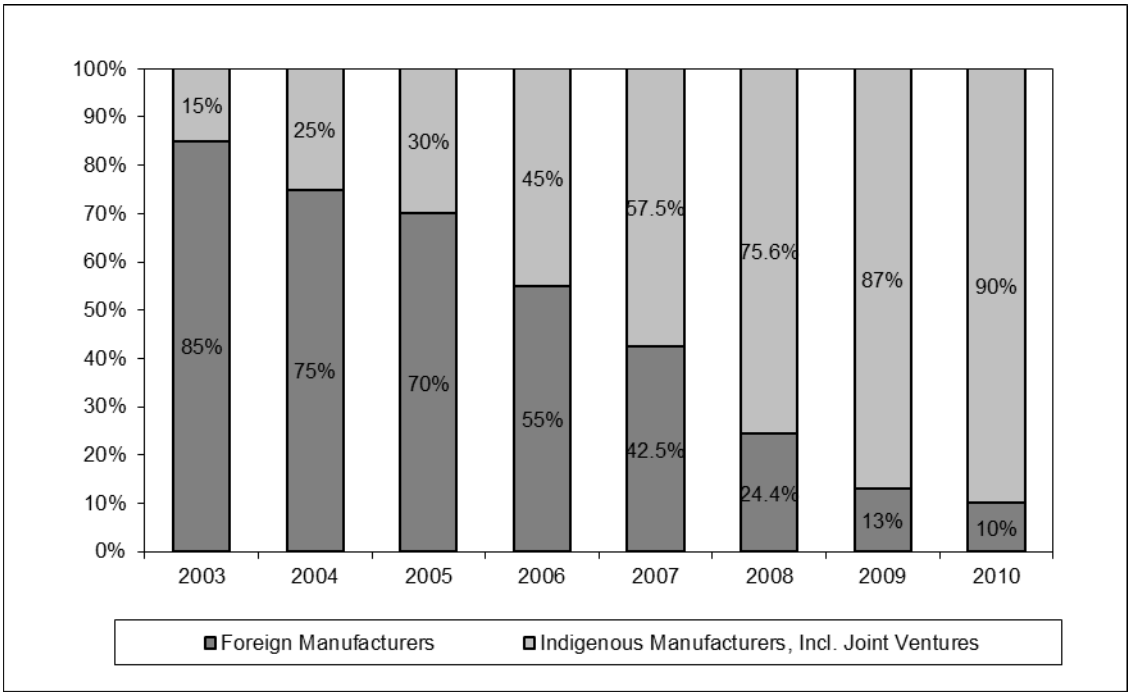
border learning is readily achievable, most international lead firms are indisposed to share their knowledge with local firms even at the expense of market share in host countries.

3.1 Technology acquisition from KIBS firms

In China's wind energy industry, a fundamental change in the business relationship between domestic and foreign firms was accompanied by a dramatic shift in the market structure. The Chinese wind market used to be dominated by the import of complete WTG units in the 1980s and JV partnerships in the 1990s. It became fraught with locally manufactured wind turbines since licensed production prevailed in the 2000s (Figure 5-2). Unlike the complete dependence on import or limited technology transfer through JV cooperation, Chinese wind turbine producers gained greater autonomy in daily operations by entering into licensing agreements. In doing so, indigenous Chinese firms achieved rapid scaling-up using foreign advanced designs with technology suppliers not interfering with their business activities. In this type of cooperation, Chinese firms overcame their weakness when making up for the weakness of small engineering design firms, which are strong in design but lack manufacturing capability. While the former are more interested in the downstream of the chain from lab to market and competitive in commercialization, the latter profit from overseas manufacturing and reduce risks through multiple licensing agreements in the local market. The direct link between them is found in technology transfer in exchange for license fees.

The availability of alternatives to foreign partnership made possible technology acquisition by Chinese wind firms. Instead of waging a head-on fight with world wind leaders, Chinese firms sought alliances with small WTG manufacturers or engineering design firms from Europe. The major sources of licensing have been Anerodyn, Fuhrlander, and REpower from Germany, Windtec from Austria, and Norwin from Denmark. Some deepened the collaboration with Chinese firms to engage in "assisted reverse engineering", which facilitated learning by Chinese in developing larger and more reliable wind turbines (Lewis 2013). There is little concern over market competition between foreign design firms and Chinese firms, with the former focusing on R&D and the latter on manufacturing. By licensing the right to manufacture its technology, these overseas partners maintain a low degree of involvement in local business and have minimum interest conflict with local firms. Some even share licenses or carry on joint development with multiple firms for profit maximization, which in fact provided high quality engineering services to more Chinese firms. One typical case is Aerodyn from Germany, an engineering design company that has signed technology transfer agreements with more than ten Chinese firms since it entered China in 2004, most of which became major players in the industry (Zhang and Su 2012: 83).

Figure 5-2 Market share of newly installed capacity, by ownership type, 2003-2010



Source: For 2003, National Action Plan for China's Wind Power Industry Development, 2005, p8; For 2004-2006, China Wind Power Report 2007; For 2007-2008, Global and China Wind Power Industry Report 2008-2009; For 2009 and 2010, Li et al., 2011, China Wind Power Outlook 2010 (in Chinese), Hainan Press, Haikou.

Because of the many choices they have, Chinese wind firms benefit from collaboration with European KIBS companies without too many constraints. The industry witnessed almost all types of technology solutions that local wind firms could choose to acquire designs from their foreign partners. While JV partnership turned out to be less effective in China's WTG manufacturing, licensing and joint development became popular because Chinese wind firms could make full use of their manufacturing capabilities without too much interference from foreign partners. Almost all top Chinese wind firms started their businesses through licensing or joint development. To reduce restrictions on accessing foreign technology, some purchased ownership rights of a company with technology. China's top wind turbine manufacturer, Goldwind, acquired a majority stake of Vensys in 2008 and gained greater control over the use of its turbine designs. This was seen as a reasonable move after REpower, another key technology provider for Goldwind, was purchased one year earlier by Suzlon, a leading global wind firm from India.[5]

With various partnerships available and ready access to foreign advanced technologies, WTG producers in China developed competitiveness through economies of scale. On the one hand, due to the relative low entry barriers to WTG manufacturing, Chinese firms focused on a

[5] Interview no. BJ251113, a manager of the China Wind Power Center, Beijing, 25 Nov 2013.

competition based on productivity and cost minimization. On the other hand, they engaged in "manufacturing-related innovation", or "innovative manufacturing", on top of the duplication of foreign models (Nahm 2014; Nahm and Steinfeld 2014). Like in many other industries such as solar PV, wind technologies "were easily accessible in global production networks" so that Chinese firms could grab market share through "the rapid and cost-effective translation of such technologies into mass-manufacturable products" (Nahm 2014: 18; 39). Despite limited capabilities in radical product innovation, creativity in the production processes has been the secret weapon that Chinese firms used to translate technologies into commercialization.[6] Aside from cost advantages, a specialization in shop-floor innovation following technology acquisition also contributed to the rapid rise of Chinese WTG manufacturers.

Thanks to the simple product systems, Chinese wind firms were able to benefit from local sourcing and closely follow the steps of frontier firms. As components and parts are standardized in WTG manufacturing, most Chinese firms established their supplier networks and achieved mass-production within a few years after their foundation. Some of them, namely Sinovel, Dongfang and United Power grew up to become one of the world top ten wind turbine producers within a couple of years (Table 5-1). The most outstanding of them is Sinovel, which started from seizing the commanding height of MW-scale turbine market by licensing the 1.5MW turbine from Fuhrlander, and surpassed Goldwind to become the number one wind turbine manufacturer in China by 2008 and the third largest in the world by 2009. Within three years it had gained the titles of many "firsts" in China: the first to forge a near-complete domestic supply chain for MW-scale WTGs; the first to realize mass-production for MW-scale WTGs; and the first to develop a 3MW onshore and offshore turbine with proprietary intellectual property (Liaowang 2009). Notwithstanding its slowdown since 2010, the experience of Sinovel showcases a latecomer's leapfrog over incumbents relying on licensed technologies.

And because of the short product life cycle in WTG manufacturing, Chinese firms have never stopped the pursuit of technological upgrading. As "Run of the Red Queen" illustrates, generally China has been running a race "in perfect tandem with the technological frontier" "without actually advancing the frontier itself" (Breznitz and Murphree 2011: 3). This is also reflected in the wind industry, where Chinese firms remain sustainable and lucrative by keeping up with the state-of-the-art designs in the international market. They started to negotiate import or licensing of 1MW, 1.5MW or even larger designs when 750KW turbines dominated the market; and the collaboration on the development of multiple, or even double digit, -MW designs was already underway when MW-class turbines just prevailed. On top of the size,

[6] Breznitz and Murphree (2011) had a discussion about China keeping up with the technology frontier without pushing the frontier forward in the IT industry.

modifications have to be made to adapt to local conditions, such as extreme weathers, high altitudes and grid connections. As wind farms moved to the sea, coastal conditions such as water depth, seabed conditions, currents, corrosion, migration, waves, high wind speed and typhoons need to be taken into consideration. Accordingly, offshore and intertidal turbines or universal designs adjustable to all conditions went onto the stage to meet the requirements. The follow-up of advanced designs keeps Chinese manufacturers lucrative without becoming novelty innovators themselves.

Table 5-1 Top 10 Wind turbine manufacturers by global market share, 2008-2013

	2008	2009	2010	2011	2012	2013
1	Vestas	Vestas	Vestas	Vestas	GE Wind	Vestas
2	GE Wind	GE Wind	**Sinovel**	**Goldwind**	Vestas	**Goldwind**
3	Gamesa	**Sinovel**	GE Wind	GE Wind	Siemens	Enercon
4	Enercon	Enercon	**Goldwind**	Gamesa	Enercon	Siemens
5	Siemens	**Goldwind**	Enercon	Enercon	Suzlon	GE Wind
6	Suzlon	**Dongfang**	Suzlon	Suzlon	Gamesa	Gamesa
7	**Sinovel**	Gamesa	**Dongfang**	**Sinovel**	**Goldwind**	Suzlon
8	**Goldwind**	Suzlon	Gamesa	**United Power**	**United Power**	**United Power**
9	**Dongfang**	Siemens	Siemens	Siemens	**Sinovel**	**Mingyang**
10	Nordex	REpower	**United Power**	**Mingyang**	**Mingyang**	Nordex

Source: Renewables Global Status Report, REN21 (Renewable Energy Policy Network for the 21st Century), consecutive years. The companies in bold are indigenous Chinese firms.

In the process of upgrading to larger capacity and local adaptations, European design firms continue to play a significant role as indigenous research capability grows. While Chinese firms accumulated experiences through learning by doing, joint research and acquisition became increasingly popular (Table 5-2). With the help of design firms such as American Superconductor (AMSC/Windtec) and Aerodyn, some indigenous wind manufacturers, including Dongfang, Windey and Mingyang, improved their capabilities by making accumulative and radical changes to the existing models. Some of the cross-border collaboration also led to the formation of proprietary know-how: United Power did the major part of detailed R&D using the basic design and technical assistance of a UK firm, Garrard Hassan; Sinovel obtained IPR of the geared turbines as a result of cooperating with AMSC/Windtec;[7] CSIC Haizhuang also managed to develop proprietary designs by collaborating with Aerodyn. Other than that, the acquisition of Vensys by Goldwind and of Darwind by XEMC pushed the Chinese wind industry further up technological ladders. Some leading firms, primarily Goldwind, Sinovel and United Power established large R&D centers that became national key laboratories of wind power generation systems.

[7] Sinovel was in a lawsuit of alleged IP theft reported by AMSC/Windtech in 2011.

Table 5-2 Technology solutions of top 15 Chinese wind turbine manufacturers by 2013

	Manufacturers	Year	Licensing	Joint Development	Acquisition
1	Goldwind	1998*	Repower/Jacobs (Germany)	Vensys (Germany)	Vensys (Germany)
2	United Power (Guodian)	2007**	Aerodyn (Germany)	Garrad Hassan (UK)	
3	Mingyang	2006	Aerodyn (Germany)	Aerodyn (Germany)	
4	Envision	2007		Danish research arm (EU)	
5	XEMC	2006*	Zephyros/Lagerwey (Netherlands)		Darwind (Netherlands)
6	Sewind	2006***	DeWind/EU Energy (Germany/UK); Siemens (Germany)	Aerodyn (Germany)	
7	Sinovel	2006***	Fuhrlander (Germany); AMSC/Windtec (US/Austria)	AMSC/Windtec (US/Austria)	
8	CSIC Haizhuang	2004***	Frisia (Germany); Aerodyn (Germany)	Aerodyn (Germany)	
9	Dongfang Electric Corporation (DEC)	2004***	REpower (Germany)	Aerodyn (Germany); AMSC/Windtec (US/Austria)	
10	Windey	2001*	REpower (Germany)	Aerodyn (Germany); Zhejiang Institute of Mechanical and Electrical Engineering (China)	
11	Huachuang (Datang)	2006**		Shenyang University of Technology (China)	
12	CSR Zhuzhou	2006***	AMSC/Windtec (US/Austria)		
13	Hewind (Huayi Electric, or HEAG)	2002		Aerodyn (Germany); MECAL (Netherlands)	
14	Taiyuan Heavy Industry	2006***	Renk (Germany)		
15	Beizhong (now Jingcheng New Energy)	2005***	Fuhrlander (Germany); DeWind (Germany)		

Source: Author's compilation, mainly from interviews, company websites, Lewis 2012, and other secondary documents. Notes: "Year" refers to the year that a company started wind turbine manufacturing; * indicates that the companies started wind energy research long before the year, mostly public research institutes in the 1980s or the 1990s; ** refers to the companies established or owned by wind power generation companies; *** are the wind energy subsidiaries or divisions of large SOEs in the heavy industry; others are small SOEs or private firms.

Despite the growths of independent technology capabilities, Chinese wind firms continue to rely on foreign consultancies in their designs and technology suppliers for certain parts. As a study of wind turbine development in China shows, wind firms accessed foreign technologies through the sourcing of key components abroad, licensed production, and purchase of small foreign design firms (Lewis 2007; Lewis 2013). This relationship with smaller foreign wind firms is more strategic in offshore wind technology, which involves “significant scope for innovation” because of the stringent requirement for technical performance and challenges in increasing capacity and reliability (Wyatt *et al.* 2014: 39). For offshore turbines, the top Chinese wind producers continue to outsource a diverse range of components from foreign suppliers to “protect against problems in the production line” (Wyatt *et al.* 2014: 44). Similar is also true in the production of small standalone wind turbines for small amount or household-based electricity demand, which is still at its infancy stage. Other than that, a technology gap remains between indigenous and foreign technologies, and problems plagued the wind turbines made by indigenous firms. With the steady inflow of technology assistance from overseas, indigenous firms were able to keep up with the global race in WTG manufacturing.

3.2 Competition with top global producers

The ease of technology acquisition discussed above partly attributed to the fierce challenge that international wind turbine manufacturers experienced in China. Leading global companies used to dominate China’s wind energy market with imported wind turbines and later established wholly-owned local manufacturing facilities compelled by the localization rules. Some of them set up JV plants with indigenous firms for the production of components and parts but not for complete units. So far there are four major multinationals producing wind power generation units in China, namely Vestas from Denmark, Gamesa from Spain, Suzlon from India and General Electric (GE) from the Unites States. These locally invested MNCs are the major rivals of indigenous firms within China, and the intensive competition reflects “the fight for the middle” that can also be seen in many other industries: while domestic firms are dedicated to avoid cut-throat price wars in the low-end of the market by improving manufacturing skills, foreign invested firms in the high-end are engaged in cost reduction to meet the local price demand through localized operations (Brandt and Thun 2010: 1556). The competition urges Chinese indigenous firms to keep running toward the global technology frontier through alliances with European KIBS providers, which further intensified the competition with FIEs.

Despite extensive new energy cooperation efforts across countries, technology partnerships were impeded by the competition between domestic and international wind turbine manufacturers. With climate change becoming one of the most pressing challenges of all countries, many have undertaken bilateral collaboration on clean energy R&D in an effort to influence cross-border business activities. China has signed agreements on energy and environmental cooperation with other countries via official and unofficial channels, especially the European Union and the United States. However, under the umbrella of larger bilateral negotiations remains the competition of manufacturers for technologies, resources, and access to markets. A global public interest in the sharing and dissemination of climate change mitigation technologies was undermined by the opposing logic of market: while Chinese firms strived to secure a technological edge without incentives to share the market with foreign partners, international business actors tried to gain access to the Chinese market without a real intention to nurture local technology capabilities (Conrad and Meissner 2011: 8). Moreover, because "it is hard for any country to put long-term global interests ahead of near-term domestic interests", implementation of the framework agreements were not accompanied by high-level political support (Lewis 2013: 180). In the case of China and the US, technology cooperation is hampered by the increasingly competitive relationship between the two countries in the global economic market place (Lewis 2013: 178).

In spite of the domestic-foreign contest, international frontier firms' competitors are actually not purely Chinese manufacturers but another group of foreign firms. While in early days wind pioneers only sold China wind turbines manufactured overseas, they now have to face the competition from Chinese new entrants, whose advantages in cost and skills were unleashed through the coalition with foreign KIBS providers. Hence it is necessary to distinguish the interests of large international WTG manufacturers from those of small design firms: the former slobber over China's vast wind market without incentives to share know-how with local firms, whereas the latter actually benefit from local manufacturing through technology transfer. While technology spill-over remains a controversial topic, this is not to make a judgement in that sense but to tell apart different types of foreign companies and their roles in an industrializing economy. Most existing studies fail to acknowledge the distinction and underline a simplistic conflict between domestic and foreign industry actors. In fact, the antagonism is complicated by the existence of Europe-based small design and consulting firms, which are indifferent in manufacturing but passionate about technological advancements.

The opposite standpoint of small design firms makes them outright matches for Chinese firms, and makes the alliances competitors to leading international WTG producers. European design firms and laboratories were attracted to China considering the profit-making potentials as well as the operating experiences in the co-development of sophisticated large turbines. Together with Chinese WTG producers, they also hope for a flourishing national wind industry that spells greater opportunities for both, which are aligned in the pursuit of government support and in the defense against external competition. This is why Beijing never met resistance from foreign design firms with regard to nationalist policies; and we also could not hear the voices of foreign design firms internationally when leading international wind and solar manufacturers accused China of protectionism and discrimination. Therefore, the divergence of interests underlined by traditional studies coexists with the convergence of interests seen in the domestic-foreign alliances in China’s wind energy industry.

Chinese wind firms in the alliances applauded and actively chased up the central government support in building up local manufacturing capabilities. Together with local parts suppliers and wind farm project developers, Chinese WTG manufacturers benefited greatly from China’s “three-pronged strategy”: market creation through the concession tendering for wind projects, incubation of indigenous firms through the local content requirement, and support of local R&D efforts through government funding (Nahm 2014). In fact many of them came into being upon seeing the policy signals that the sector was targeted for government support. Companies began to flood into wind power following the issuance of supportive programs and policies, which were officially launched between 2003 and 2005. Aside from those involved in wind energy research from beginning, most currently active industrial players started their businesses around that time (see Table 5-2). WTG manufacturers mushroomed from six by the year 2004 to over 80 by 2009, not to mention the producers of components and parts, mainly gearboxes, bearings, power converters, control systems and blades.[8] Alongside the dramatic rise in manufacturing, demand pull policies also spurred the cooperation between producers and large power generation companies such as Huaneng, Guodian and Datang in winning wind farm projects.

Like in many other manufacturing industries, Chinese wind firms could leverage the opportunities presented by governments at different administrative levels. Aside from Goldwind and Windey that originated from public research institutes, many of the new entrants are state-owned or controlled heavy industry enterprises that diversified their business into WTG manufacturing. Sinovel was partly owned by Dalian Heavy Industry (DHI), Dongfang by Dongfang Electric Corporation (DEC), and Haizhuang by China Shipbuilding Industry Corporation (CSIC). As provincially or municipally administered enterprises, they received support from both central and local governments, and benefited from the divergence of policy goals at different levels (Nahm 2014). Surfing on the policies for an emerging strategic industry like wind power, these enterprises made use of government support but did not necessarily follow the policy goals, especially the central goal of building up knowledge-intensive capabilities. Similarly, private firms also joined the flourishing wind power sector through the help of KIBS providers and government support, with the meteoric rises of Mingyang and Envision as most noteworthy.

[8] Interview no. CA200612, a researcher at the National Climate Strategy and International Cooperation Center, Canberra, 20 Jun 2012.

4. Compliance with state-directions at early stage

Under the directions of the Chinese state, the wind power industry took on an open stance in the first two decades of demonstration and early commercialization. At that time domestic manufacturing was still at its infant stage and most wind turbines were imported using foreign government grants and loans. In general, Chinese wind industry players cooperated with the central government to carry out a dual-track strategy: introduction of foreign wind technologies and independent development of wind turbines at the same time. However, the independent efforts lagged behind those in the international market, where dominant wind turbines always had larger capacity than domestic designs in research (Li *et al.* 2007: 12). Coupled with the high cost for import, Beijing decided to acquire technologies by making matches for state-owned and foreign enterprises to enter into JV partnerships, traditionally known as “trading market for technology”. Domestic firms engaged in other areas of manufacturing accepted the arrangements considering the “special care” and favorable policies that they could receive from the government.

In the first two decades, the presence of domestic wind turbine manufacturers was limited and development of the industry remained at the steering wheel of Beijing. At the time of revitalizing a national industry, the Chinese state took the initiatives in wind power development due to the absence of entrepreneurship and market mechanisms. Until the end of 2003, only a few partly state-owned and Sino-foreign JV enterprises were active in the market and largely docile to the government for the sake of nurturing policies. Unable to confront long-standing and well-developed foreign competitors, these early industry players founded in the end of 1990s relied on infant industry protection to survive. Unlike in the nuclear power industry where industry players had bureaucratic affiliations that were typical of a split between the military-defense and energy-economy camps, wind turbine manufacturers originated from existing business actors or public research institutes and were all under the jurisdiction of economic planning bodies in charge of energy and industry development. Without the divergence of bureaucratic interests and connection to the ministerial departments, domestic business actors faced similar circumstances in terms of following state directions and fending against foreign competition. And because of the access to technologies through licensing, they did not have to go into coalitions with international frontier firms to compete with each other.

4.1 Government-led import and R&D (1984-1993)

Wind power development in China did not generate stark contrasts in departmental interests, which left no historical roots for fundamental divergences in business interests. During the first ten years of wind power development, fewer government agencies were involved in the use of wind energy than in nuclear power projects. Since the beginning, the development of wind pilot schemes has been in the hands of macroeconomic agencies and categorized in civilian energy use. As early as in the 1980s when the Chinese government set scientific research on wind energy as one of the national priorities, the State Planning Commission (SPC), the Ministry of Electric Power, the State Science and Technology Commission (SSTC), and the Ministry of Farm Machinery were involved (Williams 1982: 10). In 1993, the Ministry of Electric Power proposed a wind power industrialization program at a national wind power work meeting (IRENA 2012: 49). We cannot conclude that all these agencies were in perfect harmony as for wind power development, but definitely there were no observations of tensions between military and civilian camps that were seen in nuclear energy. Import of foreign wind turbines was generally accepted when public research institutes led by SSTC were developing their own WTG systems. While the independent stream of efforts developed into first WTG manufacturers that were regulated by SPC, SETC and later NDRC, among domestic business actors there was no conflict that can be traced back to bureaucratic conflicts.

Aside from the coherent governance over wind power generation, the Chinese state did not face the same level of external pressure as seen in the nuclear energy industry. As a mass-production industry, WTG manufacturing involves a large number of sellers in the international market that Chinese could choose from. And due to the relatively short product life-cycle and simple installation interface, wind power projects could be realized through international trade and foreign technical assistance in a short period of time. Certain buyer-seller interactions were needed in the process but the link between them was mainly through trade, not the intimate collaboration seen in nuclear power projects. Moreover, as continuity in the selection of wind turbines is not necessary for newly planned projects, Chinese recipients bought a variety of WTG systems from many different foreign manufacturers. By the year 2003, over 20 foreign WTG manufacturers from six countries took up 85 percent of the Chinese market (See Table 5-3). With the abundant supply of wind turbines, Chinese could shift among trade partners and did not have to worry about technology unification that is necessary to the CoPS industries such as nuclear power projects. In addition, the state-owned WTG manufacturers that originated from the early government initiatives could later enjoy the freedom of choosing other approaches to technology acquisition.

Table 5-3 Total installed capacity in China by WTG manufacturers through 2003

Manufacturer	**Home Country**	**Installed Capacity (kW)**	**Market Share**
NEG Micon	Denmark	170,390	30.07%
Vestas	Denmark	95,920	16.93%
Nordex	Germany	88,550	15.63%
Goldwind	**China**	**50,100**	**8.84%**
XAEC-Nordex	**Sino-German JV**	**21,000**	**3.71%**
Gamesa	Spain	20,800	3.67%
MADE	Spain	18,480	3.26%
Nedwind	Netherlands	17,500	3.09%
Zond	USA	16,500	2.91%
Bonus	Denmark	13,550	2.39%
Bazan-Bonus	Spain-Denmark	12,000	2.12%
AN Bonus	Germany-Denmark	9,600	1.69%
Windey	**China**	**6,150**	**1.09%**
Yituo-Made	**Sino-Spain JV**	**5,280**	**0.93%**
HSM-250T	Unknown	4,500	0.79%
Tacke	Germany	4,500	0.79%
Dewind	Germany-UK	3,000	0.53%
Beijing Wandian	**China**	**2,400**	**0.42%**
Jacobs	Germany	1,500	0.26%
Shanghai Shenxing	**China**	**1,200**	**0.21%**
Windmaster	Netherlands	800	0.14%
FD28-300	**China**	**600**	**0.11%**
AWT-275	Unknown	550	0.10%
US Windpower	USA	500	0.09%
Darrious	Unknown	350	0.06%
FD31-300	**China**	**300**	**0.05%**
Newind	Canada	300	0.05%
Aeroman	Germany	300	0.05%
Wincon	Denmark	100	0.02%
	Total	**566,720**	**100.00%**

Source: Shi Pengfei, 2003 nian Zhongguo fengdianchang zhuangji rongliang tongji (The installed capacity of wind farms in China in 2003) and CRESP, 2005, National Action Plan for China's Wind Power Industry Development

Despite the reliance on imported WTG systems in the initial stage, local industrial players did not develop long-term strategic coalitions with foreign suppliers. This is because WTG installations are much simpler than CoPS projects and can be done without a high level of buyer involvement. Unlike complex nuclear power projects, WTG systems do not involve cross-disciplinary expertise and long-term, large-scale system integration that require day-to-day collaborations from the demand side. Therefore, well-established sellers do not need as much local support as seen in the nuclear power industry and only need Chinese buyers' cooperation in peripheral installations and wind farm construction. Moreover, as wind turbine production is codified and can be easily copied, foreign suppliers hoped to reduce the risk of creating potential local competitors by simply making profit through the sales of WTG systems instead of engaging closely with local firms. As a result, utility developers acted as major industrial players whereas Chinese manufacturers were absent from China’s first utility-scale wind power projects. For power utilities in Xinjiang and other areas that are rich in wind resources, they aimed to fulfil Beijing’s initiative of building wind power projects in a short period of time and easing power supply shortage in these areas. Due to short product-life cycle and simple component interface, they could achieve the goal through one-off import and technical assistance from foreign suppliers; and due to the large number of suppliers available in the market and limited cost associated with changing trade partners, they did not have the incentive to come into strategic coalitions with foreign suppliers.

When China’s wind power development in the beginning relied on buying foreign wind turbines, independent research of wind turbines was underway under the direction of central government. To facilitate the learning process, the Chinese government designated some departments of provincial governments and public research institutes to develop indigenous wind turbines. The predecessors of Goldwind, the Xinjiang Wind Power Research Institute and the Xinjiang Wind Energy Company (XWEC) were established in 1986 and 1988 for the introduction and absorption of Danish wind technologies. Earlier than that, Windey’s predecessor, Zhejiang Electromechanical Design and Research Institute developed China’s first wind turbine (18kW) in 1972. It was affiliated to Zhejiang Machinery and Electrical Group, formerly the Machinery Industry Department of Zhejiang province, and was the first organization specialized in the research and development of home-grown wind turbines (Jia 2013). However, both were constrained in commercializing their own models due to the limited capability in catching up with WTG systems dominating in the market. For example, when Windey’s predecessor developed the prototype of a 200kW wind turbine in 1997, 600kW turbines dominated the international market already; and when three units of the 200kW turbines were installed in 1999, 750kW prevailed.

4.2 Government-arranged JVs and first entrepreneurial attempts (1994-2003)

As pioneering manufacturers did not have to tie up with local partners in the sales of WTG systems to China, Beijing forced them to. In 1997 the former SPC launched the “Ride the Wind” program to encourage domestic firms making use of foreign technologies, or in other words, to persuade foreign suppliers pairing up with Chinese firms on the conditions of technology transfer and majority Chinese ownership, which was also seen in the auto industry. This was meant to increase Chinese exposure to wind turbine production and add to the chance of technology spill-over. MADE (Spanish) and Nordex (German) were selected by the Chinese government and two JV enterprises were established, respectively Yituo-MADE and XAEC-

Nordex.[9] They accepted the terms for a variety of reasons, mostly for a good relationship with the Chinese government, minimization of upfront investment, and "name recognition and reputation" in a potential market as large as China; for them, these benefits outweighed the "costs and concessions associated with the technology transfer and a minority ownership share of the company" (Lewis 2013: 90).

The official arrangement became wishful thinking: these JV enterprises did not work out well as the result of diverging business interests and internal conflict between domestic and foreign partners in day-to-day operations. Research shows that foreign partners in the JV enterprises were half-hearted in their local operations: the compromises they made for market entrance are embedded in a larger business strategy and their real intent was to promote the sales of more advanced turbines manufactured in their home countries (Lewis 2013: 119). They did not submit to Beijing's desire for JV partnerships, and "there were often conflicts between foreign managers and local managers operating in joint-venture enterprises, contributing to mutual frustration, resentment, and sometimes failure" (Lewis 2013: 119). Transferred technologies were mostly outdated ones compared to those leading the international market. For example, Nordex started selling 1.3MW turbines to China immediately following the JV agreement and a license for the production of 600kW turbines; soon afterwards, it founded a wholly owned company separate from the JV enterprise to conduct service on the imported turbines (Lewis 2013: 90). As a wholly owned German company, the Nordex headquarters did not want less expensive turbines produced in China to challenge those in its German factory; and as a minority shareholder of XAEC-Nordex, it saw the JV partnership as simply a strategic move in the larger chess game through the deployment of a broad network of "Chinese outposts for Nordex Germany" around China (Lewis 2013: 90). While XAEC-Nordex's fortune started and ended with the 600kW turbines from 1998 to 2004, Nordex Germany continues to provide larger turbines and remains active in the Chinese market.

The experience of Sino-foreign JV enterprises in China's wind industry is a strong proof of the domestic-foreign business tension found in mass-manufacturing industries. The concern over losing technology competitiveness in codified manufacturing gives well-established firms disincentives to collaborate with local companies in WTG production. The nature of the WTG industry determines that foreign companies tend to hold back from sharing all their technologies and try to maintain control over important decisions in the Sino-foreign partnerships. Chinese government intervention failed in the effort to create harmony within the JV firms because the ties with local firms that are necessary and in the interest of CoPS providers are naturally conflicting with foreign business interest in WTG manufacturing. As nuclear reactor vendors

[9] The two Chinese SOEs were respectively China First Tractor (Yituo) and Xi'an Aero-Engine Company (XAEC).

did not have to worry about losing competitiveness in a short period of time even when building the most advanced nuclear power plants in recipient countries, they relied on the unity with local partners to negotiate with Beijing and make profit. In contrast, because of the concern over losing technology advantage, foreign WTG suppliers hoped to do it alone with their Chinese partners shelved, not to mention that these partners were not “too big to fail” and not as powerful as nuclear industrial players to influence Beijing. Accordingly, Chinese partners felt that they were marginalized and JV partnerships were hijacked for other purposes.

At the time when JV partnership was encouraged, the Chinese government kept up with the support of independent research and promoted local manufacturing. During the Ninth Five-Year Plan beginning in 1996, Beijing incorporated wind energy research into the National High-Tech R&D Program (863 Program) and allocated funding for the development of indigenous 600kW turbines with a local content of 40 percent, which were facilitated by the Ministry of Science and Technology (MOST) and the former State Development Planning Commission (SDPC). In order to reduce production cost and encourage local manufacturing, the Chinese government raised tariffs for the import of complete wind turbines and lowered them on imported components in 1996, and exempted the value-added tax (VAT) for components in 1998. When Beijing recognized that JV partnership and import could not be tamed and domesticated for local manufacturing capability, it imposed a 17 percent VAT on imports in addition to the existing seven percent customs duty for wind turbine import in 2001 (Danish News Digest 2001). Around the same time, the State Economic and Trade Commission (SETC) and SPC launched the “National Debt Wind Power Program” to support complete WTG manufacturers in the formation of independent IPR. In general, the SPC system, including the former Ministry of Electric Power and later the State Power Corporation, continued to lead the wind power industry planning at this stage.

Chinese industrial players worked in a responsive mode to Beijing’s initiatives of getting domestic WTG manufacturing out of stagnation after ten years’ development through relying on import. Xinjiang Wind Energy Institute was encouraged to build an assembly factory, which was later reorganized into Goldwind in 1998 and became the first Chinese company for the commercial production of WTG systems. Similarly, Windey was set up by Zhejiang Machinery and Electrical Group and Zhejiang Electromechanical Design and Research Institute in 2001 to start domestic production while continuing with the independent research. Compared to the initial R&D funding from central and local governments, the early wind turbine firms made a much larger amount of investment in the development of 600kW and 750kW turbines, mostly through bank loans and international investors.[10] Recognized as the key 863 projects, both Goldwind and Windey together with some universities and research institutes were integrated in the development of MW-scale turbines starting from the Tenth Five-Year Plan in 2001.[11] In addition, Goldwind also benefited from the "Western Development Strategy" favoring the economic growth in China's west regions, including Xinjiang. For Goldwind and the Xinjiang government, local wind power and industry development were consistent with Beijing's desire of creating a balanced national economy and easing social unrest in underdeveloped areas. While there were already a few wind turbine R&D centers available in China, the one in Urumqi, Xinjiang's capital, was designated a National Wind Power Technology Engineering Research Centre.

As learning is a necessary process for new entrants in most emerging industries, the early independent development of wind turbines was actually a complement to the domestic production of internationally advanced models. While home-grown models were still in laboratory and JV partnership did not help building domestic manufacturing capability, the early Chinese wind turbine plants could only start commercial production using licensed technologies from KIBS providers. Unlike their counterparts in JV partnerships, Goldwind and Windey could maintain their control over business operations without facing challenges from their technology suppliers. Therefore, the emergence of KIBS firms increased the chance for indigenous Chinese firms to grow up as a challenge to international firms at the frontier of WTG production. Aside from imported wind turbines, the last few years of this period witnessed the beginning of domestic WTG assembly, mainly licensed production by Chinese-owned and Sino-foreign JV firms, and manufacture of home-grown 200kW turbines by Windey.[12] In particular, Goldwind bought a license from Jacobs (later acquired by REpower) for the production of 600kW turbines in 1996 and from REpower for 750kW turbines in 2001, after which Windey also started the production of REpower turbines through a license agreement. From then on the Chinese wind energy industry departed from the hundred percent of reliance on imported wind turbines.

5. Exploitation of government support since 2003

At this stage a domestic-foreign rivalry came into being since the emergence of indigenous wind turbine producers with access to technologies through the purchase of licenses. At the same time of developing MW-scale turbines, new Chinese entrants rapidly filled the market using these

[10] Interview no. CA200612, a researcher at the National Climate Strategy and International Cooperation Center, Canberra, 20 Jun 2012; international investors include the International Finance Corporation of the World Bank.
[11] The other participants of the R&D of megawatt-scale wind turbines include Shenyang University of Technology, Chinese Helicopter Research Institute, and Longyuan Power Group.
[12] There were some other Chinese wind turbine manufacturers such as Wandian and Shenxin but the volume of their production was not significant.

licensed technologies and managed to break from the sole dependence on import. Because of the overseas KIBS firms that have decided not to venture into the market themselves, Chinese firms could churn out wind turbines that left the world's largest turbine makers aside and become key industrial players in the Chinese market. The licenses made economies of scale and local manufacturing possible, and helped achieve Beijing's goal of building a local wind turbine industry at lower manufacturing costs. The major foreign producers that had sold wind turbines to China had to seek other means to get into the market due to the price disadvantage and Beijing's policies in favor of indigenous firms. Out of the concern of technology spill-over, many of them went into China by setting up fully owned assembly plants and nurturing their own supply chains. Therefore, when Beijing emphasized the development of wind power, Chinese and foreign turbine makers went all out, individually, to vie for a slice of the booming market.

Due to the relative independence and exclusive interests of each other, local and foreign producers took actions separately in taking advantage of Beijing's support. Chinese firms could seek their own fortunes without clinging on to prominent world producers, which on the other hand were indisposed to work with local partners particularly in the assembly of WTG system. Therefore, at that time in China cross-border coalitions in wind equipment production were neither necessary nor attractive. When Chinese firms were caught up in a craze of making use of government support to crank up production, large foreign firms were also eager to join the race to grab a share of the industry's biggest new market. Considering local content requirements and their aversion to associate with local firms, foreign turbine producers lost no time to build factories in China since Beijing sent out a clear sign that the country was committed to develop wind power in 2003. Without alliances with domestic firms, which are essential in the nuclear energy industry, they had to change their identities into Chinese to occupy a share of the uncultivated land. Though wholly foreign-owned, their local plants were regarded as domestic firms so that they could bypass the local content barriers and benefit from the support of local firms.

Beijing's commitment to throw its weight behind wind power received overwhelming support from domestic and foreign turbine makers. Since 2003, the Chinese government shifted its focus from demonstration projects to market creation and started to encourage the construction of large-capacity wind farms. Particularly in 2005, NDRC introduced a system of intensive financial and policy support for the use of wind power, creation of domestic demand for wind turbines, and nurturance of local manufacturing capability. With the business expansion of existing producers and proliferation of new entrants to the market, the infant industry went in full swing and competition quickly heated up among domestic firms and foreign players. As a result, China saw a surge of total wind power installations that doubled annually between 2004 and 2009 (CWEA 2011). In the fight for supremacy in China's wind market, domestic firms and global leaders were not inclined to go into coalitions and all tried to get the best out of government support for their own business interests. Though in different ways, they all played the rules written by Beijing and hoped to outpace their competitors by following Beijing's dictates. However, this does not mean complete compliance with the central government because it could not extend its reach into every aspect of business activities.

5.1 Domestic carnival in response to policy incentives

Indigenous Chinese firms underwent an aggressive expansion in response to Beijing's promotion of wind power and local governments' push behind the scenes. Since 2003, the central government launched a few rounds of bidding projects for large-scale wind firms and economies of scale, namely the Wind Power Concession Program. NDRC, China's central planning agency and industry regulator, further reinforced the use of home-made wind power units in 2005 mandating that at least 70% of wind power equipment must be manufactured domestically, and wind farms not meeting the requirement of localization rate shall not be allowed to be built (NDRC 2005). The Renewable Energy Law enacted in 2006 required a mandatory grid connection to encourage power generation companies to invest in the projects making use of renewable energies. In addition, NDRC also required wind farm developers bidding on the concession projects to bundle their tendering with chosen whole unit producers, which was meant to promote wind power development as well as a Chinese wind power equipment industry. At the same time, the market could see that the backing of Chinese banks and tax incentives also turned to focus on wind power related business activities.

Public and private investment poured into the industry because wind power delivered on all these parameters: government support, low entry barriers, rapid implementation and quick returns. Many industry players flooded into the production of wind power equipment without any experience or technology expertise: most built factories and devoted themselves to the single-minded pursuit of scale production by making the shortcut of buying licenses from overseas KIBS firms. They could simply assemble the mechanical parts bought from local and high precision parts from overseas according to the purchased blueprints. In view of the relatively simple preparatory work for assembly, short production cycle and construction period for wind projects, it is possible for whole unit producers to make profit in a short period of time without relying on global wind power giants. And because of the policies favoring local firms and direct sales channels created by the government, they were able to bring these characteristics into full play for their own benefit.

With all the factors in place, the most important element for Chinese turbine makers to prosper and the market to heat up was foreign licenses. In addition to Goldwind and Windey that expanded production capacity using foreign licenses, a multitude of new entrants set up their plants by signing licensing agreements with KIBS providers, which stood indifferent from the strategy of building turbines and delivering finished products to wind farms. Dongfang entered the market with the license from REpower, Sewind from DeWind, XEMC from Zephyros, Sinovel and Beizhong from Fuhrlander, and CSIC Haizhuang, United Power and Mingyang from Aerodyn. During the same period, dozens of small and medium-sized firms swarmed into the market wanting a share of the big cake. "It seems that every day there was a new company springing up and starting up operations, like bamboo shoots after a rain."[13] Within the five to six years between 2004 and 2009, the number of whole unit producers increased rapidly from six by 2003 to over 80 in 2009, and 70 out of the 80 firms started manufacturing through the purchase of license. Therefore, there was no need for imported turbines in China because domestic manufacturers were building up capacity that could meet the demand of market growth on their own.

Following the tradition of picking winners, established producers such as Goldwind and Windey continued to benefit from government selection at this stage. Both had ramped up production for a greater market share when the big wind power cake was still in baking. Not counting the imported wind turbines, Goldwind was already the largest wind turbine maker by market share (8.8%), and was selected for one of the first concession projects started in 2003. Aside from that, Goldwind was awarded such projects as a contract for "Green Olympics" in 2006, the first demonstration for China's offshore wind power plant in 2007, and projects in GW-scale wind bases in 2008, which not only brought profit but also consolidated its position as the industry leader. In those years, its turnover doubled annually and even tripled in 2006, and before it went public in 2007 its market share in China already hit 33%. For the sake of the privileges it received from Beijing, it showed a high level of respect for the government restrictions on manufacturing companies listing on foreign stock markets. Originally intended an initial public offering (IPO) overseas, Goldwind decided to go for a domestic listing at the Shenzhen Stock Exchange in December 2007 (China Energy Newswire 2007; SinoCast 2006b). It was said that the company met objections from regulators and made the change due to "unstated reasons".[14]

Among all the new entrants, the most eye-catching players were mainly SOEs with a national or international reputation in equipment manufacturing. They all prospered in a policy

[13] Interview no. CA200612, a researcher at the National Climate Strategy and International Cooperation Center, Canberra, 20 Jun 2012.
[14] Interview no. BJ170912, an employee of Goldwind, Beijing, 17 Sep 2012.

environment highly supportive of domestic firms, especially those with a SOE background. With a strong industrial base, most of them could make use of existing resources such as fixed assets, relationships with component suppliers and with the big utility companies, and connections to the government. They all boast strong backing in Beijing relying on the strategic role they played in energy and China’s whole economy. For example, Dongfang and Sewind were spin-offs from China’s state-owned backbones of producing power generators, respectively DEC and Shanghai Electric; CSIC Haizhuang came from CSIC, China’s largest shipbuilding group; XEMC, a large electromechanical equipment maker, also started the development of wind power generators early in the 1990s and established its wind division in 2006; Similarly, CSR Wind originated from the former Zhuzhou Electric Locomotive Research Institute (now CSR Zhuzhou institute), a subsidiary of CSR focusing on railway locomotives, mass transit vehicles and freight wagons (CSR Zhuzhou 2015); United Power and Huachuang were respectively affiliated to Guodian and Datang, two of China’s five big power companies. Among them, DEC, CSIC, CSR, Guodian and Datang are all members of the 112 centrally owned companies directly administered by SASAC. Lying back against the giant SOEs, the new entrants experienced a rapid rise by responding to the call of Beijing to localize wind turbine production.

Sinovel can be regarded as the most dazzling case of all the wind turbine producers that contributed to the explosive growth by being anchored to large SOEs. It made every effort to maximize the resources it could get from Beijing and successfully convert them into turnovers that once made it the largest wind power equipment producer in China and the second largest in the world. Like other domestic competitors, Sinovel derived benefit from the inherent advantage in ready access to upstream component supply because its root in Dalian Heavy Industry (DHI), the strategic equipment base in Northeast China good at producing customized equipment. The licensing of Germany wind turbines from Fuhrlander made it into a “flash championship” and an epitome of the use of supportive policies in setting up large-scale manufacturing base with a lightning speed. It took only two years for Sinovel to become the second largest Chinese turbine maker in 2006 and another two years to become the largest one in 2008. By the year 2009, it took 25.3% of China’s wind turbine market, with Goldwind accounting for only 19.72% of the new installed capacity in that year. With the state-owned equipment base at its backyard and large power companies waiting to pick up its products, Sinovel’s success was an indisputable result of its proactive reactions to government policies.

While the new wind firms backed up by SOEs were all well versed in making use of policies and government resources, Sinovel tells a radical version of the story, by fair means or foul. It consummated the proactive reactions to Beijing and did all it could to cling to the powerful in the government. It was reported that Han Junliang, the founder of Sinovel and the former General Manager of Dalian Heavy Mechanical & Electrical Equipment Engineering Co., Ltd, was expert in linking with government leaders in NDRC and localities. Zhang Guobao, deputy director of NDRC and later secretary of the National Energy Administration (NEA), had been leading the northeast revitalization office under the State Council since 2004 and fostering the company that came from northeast China to some extent added to the performance of the office (Chen and Yu 2010). In addition, Qi Yumin, the then Vice Mayor of Dalian who used to work in DHI also showed his preference to Sinovel: he proposed to develop Dalian into a R&D and manufacturing base for wind power equipment when Sinovel was actively seeking the support of NDRC as well as provincial and local governments in building such a base (Chen and Yu 2010). There was an anecdote that in order to build relationships with the senior officials in charge of the strategic planning of new energies, Han used to buy all the first-class air tickets for them and lead his subordinates to sit around them; in 2012, he also chartered a cruise ship on the River Danube for one of the NDRC leaders visiting Europe when Han attended a wind power exhibition there at the same time, even though the invitee did not come (Wang 2012).

With the contacts in government leadership, the company developed astuteness in assessing policy trends and acted skillfully in concert with Beijing. Sinovel showed an ability to accurately assess situations and connections and turn these resources to its own advantage. An interviewee said that the company was a perfect example of "policy speculation" and always able to prepare in advance and dance to the beat of wind power development policies in China.[15] Sinovel already started to prepare for the production of large-capacity wind turbines as early as in 2004, and it just so happened that the company came out with the first 1.5MW wind turbine when Beijing announced a string of policies to encourage the use of large Chinese-made turbines in large-scale wind power bases. As for its official foundation in year 2006, one year earlier or later would not work out well because there were not so many support policies in 2005 but the market would be crowded with too many competitors in 2007 (Chen and Yu 2010). Looking back, the company was always well prepared and deployed for all opportunities, be it the local content rule in 2005, the connection mandate, or the bundled tendering in 2006. According to a *Caixin* article, "from its foundation in 2006 to 2010, Sinovel walked almost each of its steps in advance of policy and market, and became the largest beneficiary of China's great wind leap-forward" (Pu and Yu 2013). The same article alluded to Sinovel's intimate interactions with the government agency in charge of wind power when mentioning the following facts that happened in just the right time (Pu and Yu 2013):

[15] Interview no. BJ090812, researchers at the Chinese Academy of Social Sciences (CASS), Beijing, 09 Aug 2012.

> In 2006, before the Chinese wind energy industry entered the era of MW-scale models, Sinovel went for 1.5MW models right after it was first founded while other major producers such as Goldwind still had their concentration on 750kW wind turbines; it announced a localization rate of over 80% immediately after the official requirement of a 70% local content was made public; it waged a price war and quickly seized the market when Beijing hoped to drive down the wind power tariffs through bidding for the concession projects; it also took the lead in developing 3MW offshore wind turbines when NDRC saw the development of 3MW turbines and offshore wind power projects as a national honor; therefore, the Shanghai Dongdaqiao 3MW offshore wind power project became the symbol that Sinovel established its industry position.

Sinovel was proficient in image-making and winning favor from the government by making itself into a national champion. In return, the central government also took the company's business interests into account in policy-making. According to insiders, when China was planning for the Shanghai Dongdaqiao 3MW offshore wind power project, both NDRC and the Shanghai municipal government wanted indigenous firms to undertake the project considering not only cost factors but also the national image.[16] When Goldwind and Sewind hesitated to take the challenge in view of technology constraints, Sinovel stepped forward despite the pessimistic anticipation of wind power experts at that time. Eager to make itself into a national hero, it started joint development with AMSC-Windtec on 3MW offshore turbines and finished the installation of 34 units of these turbines in two years' time, which were connected to grid in June 2010. Even though cost greatly exceeded the initial budget of the project, the leaders were very pleased with it and felt having "face" because of the 3MW offshore turbines when the United States still did not have one (Chen and Yu 2010). As a reward, the central government gave Sinovel 50 million yuan of special R&D grants and extra 77 million yuan of subsidies for the establishment of an offshore wind power R&D center in Han Junliang's hometown, Jiangsu, as the only national one approved by NDRC and NEA at that time (Chen and Yu 2010).[17] And according to a sales person working in the industry for many years, "more than once the government mentioned to build China's Vestas, and everybody knows that this refers to Sinovel" (Pu and Yu 2013).

Having a good nose for inside news, Sinovel could always enjoy first-mover advantages through the overall coordination of all resources well in advance. This included not only the control of a supply network but also a good relationship in downstream with state utility companies. As other new SOE entrants, Sinovel was strong in assembly because of the capability in sourcing key components and parts from its backing company, DHI. It also

[16] Interview no. BJ220812, researchers at the Chinese Academy of Science and Technology for Development (CASTED), Ministry of Science and Technology, Beijing, 22 Aug 2012.

[17] Sinovel's offshore wind power R&D center was the first one in China at that time, but later the Ministry of Science and Technology approved a similar center to be built by CSIC Haizhuang. As these centers were supported by different government agencies, both companies claimed that they are the only one with a national R&D center on offshore wind. This case is a reflection of the bureaucratic fragmentation and misalignment between agencies in charge of industries and those of science and technology, typically between NDRC and MOST.

incorporated the blade factory founded by Wei Wenyuan, one of the first investors of Sinovel and later its acting CEO, into its supply system.[18] In terms of winning orders, Sinovel relied on DHI’s long-term strategic relationship with state-owned power companies, particularly Huaneng, which played an essential role in bringing up Sinovel. Before Sinovel came into being, Huaneng bought 1.5MW turbines from Dalian Heavy Mechanical & Electrical Equipment Engineering Co., Ltd, where Han Junliang was the General Manager, for DHI’s pilot wind power project in 2005. Sinovel went further to hire family members of the staff in the five central power companies with low workload and high salaries: this is why salespersons in the company received fixed salaries instead of incentives based on commission, which was a rare phenomenon in the industry (Wang 2012). As a result, in the concession program dominated by state-run utilities, Sinovel became the biggest winner, gaining a portion of 40% of all wind equipment orders.[19]

In addition to business operations, Sinovel also integrated the skills of public relations and government affairs into capital management. As a typical case of the combination of state enterprises and private equity (PE), its stake in the beginning was held jointly by DHI’s subsidiary, the state-controlled company overseen by Han taking 30% of the stake, and four venture capitals, each taking 17.5%. The profit-making company quickly attracted the eyes of investors and went on the most important capital increase in 2008, from which the mysterious New Horizon Capital registered in Cayman Islands reaped the most. Before its IPO in 2010, more secret “free-ride” capital came into the company for profit. According to an insider, these small shareholders were the so-called “Red PE” that were able to “assist with IPO”.[20] Most of the secret PE could not be identified because the contact numbers and addresses for company registration were all fake (Chen and Yu 2010). On the outside the capital was used for expansion and new-product development but actually acted as the conveyance of profit to the company’s connections in the government.

Even though there were a lot of reasons behind the fall of Sinovel, the most cited one was the broken link to Beijing it used to have in the first few years. With regard to the particular favor it had from NDRC, Sinovel’s business expansion was a perfect fit of the principle of “aiming high and going all out” (*Dagan Kuaishang*) of Zhang Guobao, the primary promoter and policymaker of China’s wind industry. Even in the last year of his office Zhang continued to add fuel to the flames of China’s wind power development and confirmed the plan of building up seven “Ten-GW Wind Power Base” across the country. An article named “Mutual

[18] Wei Wenyuan established Kunshan Huafeng Wind Power Science and Technology Co., Ltd and became the acting CEO of Sinovel when Han Junliang stepped off on 28 August 2012.
[19] Interview no. BJ090812, researchers at the Chinese Academy of Social Sciences (CASS), Beijing, 09 Aug 2012.
[20] Interview no. BJ111012, a former employee of Sinovel, Beijing, 11 Oct 2012.

Accomplishing" mentioned that Zhang retired six days before Sinovel's IPO, alluding that the company tried to have things sorted out before Zhang left his position of power on 7 January 2011 (Pu and Yu 2013). Zhang's retirement marked not only an end of the special favors Sinovel received but also a turning point in China's wind industry development, which shifted from a frenetic pace to a sensible one. One direct result of the shift was raising barriers and tightening the approval of new projects, and when the market slowed down in 2012, Sinovel saw an avalanche in its performance and market share: in the same year of its IPO Sinovel's net profit slumped by 72.8% and went to deficit in the following years (Pu and Yu 2013). From 2011 to 2014, Sinovel fell from top one to the tenth whole unit wind producer in China, taking only 3% of the new installed capacity that year (CWEA 2012; CWEA 2015). Many sources pointed to the same fact that NDRC's favor of Sinovel heated the industry up, and the leadership change in NDRC cooled it down (Luo 2013).

Aside from Sinovel and other SOE-backed wind turbine makers, a group of privately-owned firms joined the game, all with different mindsets of technology but the same purpose of grabbing a share of the prospering market. Grown up from grassroots with less superiority in resources, these private firms developed along two contrasting paths: innovative enterprises focusing on their own intellectual property rights versus traditional workshops relying on the extensive use of labor and energy. The former devoted to "learning by doing" through international cooperation whereas the latter were typical policy speculators that aimed for a quick start by licensing. Despite the distinct approaches to technology acquisition, all private firms took the express train of government support in their growth. Local governments favored most of them, even those that were least efficient, as long as there was encouragement at the center and the firms contributed to local economy. Sometimes local governments lowered the standards for SMEs to remain in the market even if they did not meet such requirements as emissions or minimum wage. This type of firms survived taking advantage of the misalignment between central policies and local support, and later became the target of industry consolidation after the revocation of localization content requirement.

The technology-driven type of private firms also derived benefit from government support but in a positive way, one that catered to the GDPism of local governments and pleased Beijing in the formation of indigenous innovation and national firms. One of the most significant cases is Mingyang, another typical case of a rapid rise in the mass-production industry though in a different way. Instead of licensing, Mingyang started from the joint development with a Germany design firm Aerodyn, with Mingyang responsible for detailed design and commercialization and Aerodyn for conceptual design. While Aerodyn cooperated with other Chinese firms by licensing its technologies, it agreed to joint design and shared IPRs considering Mingyang’s capability in electronic control system, the core of WTG technologies. Without the constraint of licensing, Mingyang could tap into the international market after the “Chinese turbine with Chinese surname” received the Germany GL certificate and won an order of 72 wind power units from the United States in 2007 (Zou and Xu 2008: 42-43). It took Mingyang only two years to successfully develop its first 1.5MW prototype with Chinese IPR and another three years to get listed on NYSE in 2010. Even though Mingyang differs from others in terms of the degree of autonomy in the cooperation with KIBS providers, it resembles most Chinese wind firms that it also did not have its destiny tied to the world wind giants but still could become a high-performing player in the arena.

As the first private firm edging into the top five in China and listed overseas, Mingyang like others also started its entrepreneurship from gaining recognition of governments. According to a MOST study on Mingyang, the company started the cooperation with Aerodyn with seed money from the department of international science and technology cooperation at MOST (Shi 2013). Mingyang had its first operational capital by seeking the help of local government, which boosted the land mortgage of Mingyang’s founding company, Mingyang Electric, by increasing the price of its land from industrial to commercial use (Ding 2011). When Mingyang went further on the development of 2.5/3.0MW and later larger offshore turbines, it attracted the eyes of decision-makers in Beijing and a visit by Premier Wen Jiabao in 2009. Relying on the quality products and official support, the “black horse” developed a strong customer base consist of state-run utilities such as Huaneng, CPI, Huadian, Datang and Guodian, and the base later expanded further to CNNC, CGNPC as well as China Three Gorges New Energy Corp (Xue and Zhao 2014). Between 2011-2012, Mingyang’s proposal of building a Guangdong new energy industrial cluster led by the company also received support from the Guangdong provincial government, which helped it establish alliances with South Grid and Guangdong Yudean for strategic cooperation on wind development (Hou and Zou 2012). And coordinated by the Guangdong government, it was offered a loan of 5 billion US dollars from China Development Bank (CDB) for its venture overseas. Even the founder of Mingyang, Zhang Chuanwei, stressed the role of the three forces of government, customers and suppliers in the company’s growth, with government support the most important in the beginning (New Economy Weekly 2009).

A similar but more significant case is Envision. Founded by a LSE graduate that used to work in Barclay, the private firm climbed to the upper rank of the wind industry among SOE-backed wind firms and took the fourth largest market share of new installed capacity in 2013 and 2014, which was close to United Power and Mingyang, which occupied the second and third positions. Compared to Mingyang, Envision also shunned licensed production but adopted a more novel approach to independent design: integrating technological and managerial expertise by hiring foreign designers and senior executives all around the world. With a global view, it undertook wind turbine production but attached greater emphasis on electronic control system than on assembly; it did not want to be mentioned on a par with other wind turbine makers and brought forward the concept of a smart energy enterprise committed to software and a future of “energy internet”; and its intelligent wind power generator “Game Changer” increased the power generation efficiency by 15-20% (Nan 2013; Qin 2014). Positioning itself at the high-end of the industry chain, the company challenged the traditional ways of turbine making and operating (Wang 2011b). Because of the excellent performances of its prototype, Envision received high praises as well as the first order from Longyuan, the largest wind power developer in China.

Even Envision, the innovative nova that experienced a meteoric rise relying on indigenous technology capability, knew well to leverage government resources for competitive advantages. Its founder, Zhang Lei, acknowledged that even the “Game Changer” derived benefit from central and local governments. In addition to the financial and policy support from Wuxi municipal government and Jiangsu provincial government, CEO Zhang Lei was listed by Beijing as one of the outstanding entrepreneurial innovators of the “1000 Plan” in 2010. The recognition is the highest honor for overseas returnees that devote to entrepreneurship in China, which is headed by the Central Organization Department, the central human resources body of the Chinese Communist Party. Zhang Lei believed that getting into the list added up to an endorsement from the central government, which helped build reputation for the company and earned patronage from state-owned utilities (Yu 2013). Since the CCTV report on his innovative development in 2012, Zhang Lei had appeared in all sorts of official media such as People’s Daily and Xinhua, and Envision since then participated in many more projects operated by state-owned power companies. In terms of the discussion of business interactions with governments, the cases of Mingyang and Envision underline the fact that above all the capabilities they have, they all cooperated with government and made very good use of the policies, not to mention the private “policy speculators” who are not strong enough and purely relying on the supportive policies.

5.2 Overseas wind turbine makers went local

Before domestic industry players were preparing for the wild frenzy of capturing the Chinese wind power market, large foreign wind turbine makers did not sit and miss the boat. When China decided to go on full steam for wind power development in 2003, the global giants such as Vestas and Gamesa that had been selling to China started to rethink their business strategies and consider moving production to China. The American newcomer, GE entered the wind power equipment industry through the purchase of Enron and prepared to game for the Chinese market. Nothing could stop the pace of foreign wind turbines entering China, even discrimination: the enthusiasm did not in any sense fade after Beijing elevated the 50% localization target in 2003 to the 70% local content mandate in 2005. With no complaints related to fair competition and no time to press Beijing to make any changes, a dozen foreign manufacturers piled into China, including Vestas of Denmark, GE of the US, Gamesa of Spain and Suzlon of India, because they had already fixed their eyes on the biggest new market the industry had ever seen and made up their minds to take a part in it at all costs.

The global wind turbine suppliers were not so much forced as they were willing to set up facilities in China, wanting a piece of the cake as well as creating a base for their international business. Aside from the local content rule and raised tariffs, the foreign magnates were ready to invest in factories in China: they knew that only local production would help them profit from the potential market because imported wind turbines cost on average 30% more than Chinese ones and some of them proved to be incompatible with domestic projects. As a senior official from one of the world's top turbine makers based in Beijing said, "The cake is so big that I could afford an office made out of gold," and "There will be orders for everyone" (Nakanishi 2006). Moreover, local plants would help reduce production cost and maintenance fees, and some were turned into regional production bases supplying not only the Chinese but also international markets (Graham-Harrison 2007). Even though there are a variety of views among commentators on what the companies' motivations were, the fact is that these companies have set up their own entities in China and integrate the Chinese market into their strategic planning. A New York Times article pointed out that these firms did not cry foul for the fear of business retaliation by Beijing, whereas a Chinese report revealed that some new energy WFOEs tried to contain Chinese competitors using their home governments' anti-dumping measures while benefiting from the supportive policies made by the Chinese government (Bradsher 2010; Yuan 2010).

GE entered the Chinese wind market in 2004 and became the first multinational to embrace Beijing's rule of localized production. Relying on its long presence and recognition in a variety of industries in China, the company made its first 1.5MW wind turbines with up to 90% of locally manufactured components and minimal use of imported parts, which outperformed Beijing's localization requirement. It opened its first Chinese wind turbine assembly plant in Shenyang in 2006 and later entered into a series of JV arrangements specifically for wind parts production. These helped GE build a locally sourced production line exclusively for wind turbine manufacturing without the transfer of IPR associated with the wind turbine technology. Without any complaints, GE even praised China's new energy policies and criticized the U.S.

policy that did not provide enough support in new energy fields. When most companies remained silent after the United Steelworkers Union (USW) filed a petition accusing China of discriminatory government policy support in 2010, GE dissented. In “sharply worded comments”, Jeff Immelt, Chief Executive of GE, expressed his frustrations about the “stupid” current structure of the industry and a lack of government support for new energy technologies (Glader 2010). GE’s entry and sales strategy for the Chinese market boosted credibility of the industry: the move of a magnate like GE represented the growth potential of the wind power industry as well as the Chinese wind market, and many foreign firms followed suit and built Chinese factories, including Vestas, Gamesa, Suzlon and Nordex (Lewis 2013: 96; SinoCast 2006a).

Like others, the global leader in wind energy, Vestas started its manufacturing in China for the prospect of a big potential market that would support its regional operations. It is in the interest of Vestas to build manufacturing facilities in the country because it was very important to develop an Asia supplier base for it to be competitive in China (Bradsher 2010). Based on the rosy picture drawn by Beijing, the company opened a wind turbine production plant in Tianjin Economic-Technological Development Area (TEDA) in 2006. It later established many more factories in major Chinese cities focusing on component production. As Vestas Chief Executive Ditlev Engel said, “It has been a very important driver for us in setting up these plants, with the long-term commitment and goals which have been laid out by the central government and the National Development and Reform Commission” (Dow Jones 2007). Since Vestas long regarded China as its largest foreign market, it saw China as part of its global supply chain and had plans to build Tianjin into its logistic center for the Asia-Pacific region (Nakanishi 2006; Wan 2007). In doing so, it had established a good relationship with the local government in Tianjin (China Daily 2007). The company believed that it would stand firm despite the pessimistic expectation of a “race to the bottom” in the Chinese market: according to managing director of Vestas China, “the market is so big that there is room for both local and international players” (Miller 2007).

Other leading foreign producers were also very open about their motives for manufacturing in China and playing by Beijing’s rules. Among them Suzlon was the most direct: “We came to China because this is a big market and because of government requirements we have to be here. There are no real cost advantages over manufacturing the equipment at our main factory in India,” said Paulo Fernando Soares, chief executive of Suzlon’s mainland operations (Dueck 2007). Suzlon’s Tianjin factory cost USD 80 million, which was the single largest investment by Indian businesses in China as of July 2006. Similarly, Gamesa and other leading multinational wind turbine makers opted to build plants in China and help train local suppliers without fight because they would sooner or later make this happen regardless of the localization mandate: "If you plan to go into a country, you really need to commit to a country" (Bradsher 2010). For Gamesa, the Chinese plant was the first one out of Europe, from which it planned to cut costs by about a quarter by focusing on China for components production (Nakanishi 2006). The local content rule was not a problem for Gamesa because a large part of the components that it assembled were made by the local suppliers trained by Gamesa, which in essence undercut Gamesa by selling the same parts to its Chinese competitors. So what is the point of getting into China in the first place? It is not hard to see from historical statistics that despite the declining market share overtime, these locally operating foreign firms now have a much larger sales volume than when they sold complete wind turbine units to China.

As time goes on, these first-tier wind turbine MNCs did make their commitment to the Chinese market by expanding manufacturing presence and R&D activities in China. GE adopted a more aggressive strategy since 2009 and built more jointly-owned factories mostly for parts production. As part of its increasing investment in R&D, it made its ten-year old Technology Centre in Shanghai the key to wind power technology development, including electronics hardware and software that allowed for various kinds of bad weather (Bullis 2010). In order to remain competitive in China, Vestas even developed a model specifically for the Chinese market in 2009, reportedly the first "ever developed by Vestas for any domestic market" (Lewis 2013: 83). It also launched its China Technology R&D center of USD 50 million in Beijing, which was seen as "a natural step" of the company's development in China and an important part of its global innovation network (Wan 2010). All these moves helped them put on more of a Chinese identity. Although these moves to some extent promoted Beijing's aim to strengthen domestic innovation capability by bringing leading technologies and fostering local experts, fundamentally they were meant to serve their own company, which transferred minimal and rather basic technology to the local firms.[21]

While all overseas firms had the freedom of choice in terms of the strategies to play the Chinese rules, most opted to establish wholly owned plants for assembly and JVs for parts production. The 1999 policy change of allowing foreign firms to create wholly owned subsidiaries is only part of the reason. Aside from the fact that indigenous Chinese firms did not rely on the wind giants, the main concern of moving manufacturing to China was technology transfer. Therefore, most of the overseas firms established wholly owned foreign subsidiaries to maintain full control over ownership and intellectual properties. The global wind leaders including GE, Vestas, Gamesa and Suzlon did not team up with Chinese firms when they entered China. As for GE, there were not worries about losing its comparative advantage in

[21] Interview no. HB120912, a government official at the Science and Technology Department of Hebei Province, Heibei, 12 Sep 2012.

China because the model of procuring locally from the JV parts suppliers controlled by GE would not result in direct transfer of core technologies to Chinese firms (Lewis 2013: 104). With its expertise in cross-national operations and particularly its experience in China, GE was skillful in cultivating goodwill in Beijing through local manufacturing at the same time of exclusively owning its IPRs. Even though it might have trained Chinese firms in supplying parts for its turbines, GE largely retained its control over Chinese business through the complete ownership of assembly plants.

The concern of leading wind turbine makers about losing technology competitiveness was not groundless. The independence of Gamesa from Vestas after a few years of JV partnership served as an alarm to all players in the manufacturing of whole generator units. Many have chosen to go it alone to keep operational control out of the concern that they might have the same fate with Vestas and create their own competitors in China. Technology theft and illegal replication are also one of the concerns. As core technologies of wind turbine systems could be migrated in the form of software, foreign firms saw the protection of IPRs as the most important aspect of their collaboration with Chinese partners. One of the most sensational cases is AMSC-Windtech's charge against Sinovel in April 2011 and the following long-running legal battle between the two companies dedicated to joint development. Some did form JV enterprises with domestic firms to please Beijing but actually they were not optimistic about the partnership and mainly counted on their own subsidiaries in China selling larger and more advanced wind turbines. For fear of losing competitiveness in the market, technology transfers to the local partners were limited and not up to date.

Because of the estrangement between domestic and foreign parties, most JV wind firms' business in China was lukewarm or did not last long. One of them was CASC-Acciona, a jointly owned firm by Spanish Acciona and China Aerospace Science and Technology Corporation (CASC). The company did not have large production capacities even after years of operation in China and its market share remained below 3% after its creation in 2006. Yituo-Made, one of the two early JV firms designated by Beijing, stopped production after the purchase of MADE by Gamesa. As for Nordex, although it came to China earlier than many other turbine makers, it did not manage to boost the business of XAEC-Nordex because of the resistance to local manufacturing. Even though since 2005 the stiff-necked Nordex changed its strategies and started to build manufacturing facilities for both wind turbines and components in many Chinese cities, it did not manage to increase its market share or sales number in China. In addition to the tepid performance commonly seen in Chinese wind JVs, some of them broke up simply because different parties inside the firms were not like-minded. GE used to partner with Harbin Electric for the manufacturing of complete generator sets from 2010, but the two companies broke up in 2013 because of "fundamental differences in business priorities and strategies" (Wu 2013). There was speculation that it was because of the minority share of 49% that GE felt constrained in the participation in offshore wind farm projects and other issues related to production.[22]

Even the KIBS companies providing licenses to Chinese firms had their own thoughts of building their own manufacturing facilities or seeking takeovers by large manufacturers. For example, REpower licensed its technologies to a dozen local wind turbine makers, including Goldwind and Dongfang, as its lucrative business in the beginning, but when it became stronger and attracted by Beijing's support it set up its own JV to advance into the field of wind turbine manufacturing on top of design. As the company believed that foreign firms would be frozen out without a local partner, it decided to make wind turbines in partnership with Chinese steel maker North Heavy Industry Corporation (NHIC), namely REpower North. As REpower looked forward to a bright future in China when awarded a 150MW wind project in 2007, it immediately accepted an offer of acquisition by Suzlon in 2008 and announced it would withdraw from China in 2011, citing protectionism and price competition (Knight 2011). Before the strategic move, REpower expressed its reluctance of building the first 3MW offshore wind turbines in China out of the concern of technology transfer and insisted to locate the main server in Germany.[23] Aside from the razor-thin margins in the Chinese market, REpower did not complain about the policy environment in China until it retreated from China. Except for the withdrawal of Suzlon and its subsidiary REpower, the other three large industry players, GE, Vestas and Gamesa remained committed to the Chinese market without complaints, regardless of their private thoughts.

6. Business cooperation with Beijing

Over the three decades of wind power development in China, domestic producers became independent players as well as faithful followers of Beijing's policy due to the divergence of internal and external business interests at the firm level. All companies responded enthusiastically to Beijing's massive push in the use of domestically manufactured wind turbines and for making wind power a commercially viable technology in the country. Due to the ease of technology transfer, indigenous Chinese firms could make full use of government support policies separate from leading global wind turbine makers, and overseas firms lost no time to enter the Chinese market without complaints, though not teaming up with local companies. When Beijing made clear its strong political will of supporting clean energy development, including wind energy, it met with zest of both domestic and foreign firms and

[22] Interview no. BJ310812, a Caixin reporter, Beijing, 31 Aug 2012.
[23] The project was later taken by Sinovel.

saw an unexpectedly fast expansion in the industry. As a result, the central government remained strong-handed in the industry's decision-making and as a result its initiatives to build a home-grown wind industry were fulfilled to a great extent.

6.1 Government-business cooperation in local manufacturing

When thinking about the commercial use of wind power generation, Beijing never forgot about nurturing an indigenous wind power technology industry. Through government support policies, "China always intended for its wind industry to ultimately consist of Chinese-owned firms and Chinese-owned technology" (Lewis 2013: 43). In the whole process, decision-making for the wind equipment industry has largely been centralized in the macroeconomic planning bodies, mainly SPC, later SDPC and NDRC, and finally NEA both as a sub-ministerial body as well as a supra-ministry (*da bu wei*) above all other ministries coordinating overall energy development in China. However, because of the multilayered aspects of the formidable task of building up a national industry and separate functions of different agencies, sometimes it takes a few steps to achieve the ultimate goal. If building up a national industry requires two major steps, the incubation of indigenous firms and the formation of indigenous technologies, then the government support policies from 2003 to 2009 only achieved the first goal.

Moving toward the ultimate goal, the Chinese government has been relatively autonomous in putting support policies into force as well as making changes to them when necessary. When in the beginning China did not have any experience in the commercial use of wind power, Beijing encouraged independent research and at the same time supervised the import of foreign turbines for demonstration projects. When China's wind power projects were dominated by high-cost turbines manufactured overseas, Beijing started to encourage cross-national cooperation for local manufacturing capabilities using local content requirements. When the local content rule was no longer relevant to the second goal of technological upgrading and even derailed the industry, Beijing placed greater emphasis on the promotion of indigenous technology capability than before. When in 2010 the bottleneck of domestic demand became serious and the local content policy met external challenges, Beijing ended the policy. In the whole process, Beijing barely met resistance inside the Chinese market, regardless of whether it was domestic or foreign-owned firms. Although business organizations such as the American and European chambers of commerce voiced criticism of market barriers and poor transparency for project approvals, there was no public resistance from the existing foreign-owned Chinese firms. Concerns and accusations were only made by foreign enterprises after they decided to exit the Chinese market.

In line with the nation-wide indigenous innovation campaign, Beijing’s support of a wind industry had been lauded by all new and existing industry players. Scrambling for the prospect of a huge market demand, domestic turbine makers reveled in the nurturing of local capability while overseas manufacturers grabbed a share of the market by establishing local manufacturing capabilities. As a result of the strength of policy intervention, the Chinese wind equipment industry experienced a rapid expansion with a dozen of foreign companies moving manufacturing facilities into China and the number of Chinese WTG manufacturers surging from six to almost 80 in 2009. Even the JV companies hesitating to answer Beijing’s call started to build factories in China after others had done so. The installed capacity increased over 45 folds from 566.7MW by 2003 to 25,827.7MW by 2009. The pace quickly exceeded the 2020 target of 30,000MW, which was outperformed by the total installed capacity of 44,730MW by 2010, only three years after the target was specified in 2007 (CWEA 2011).

The active response, however, does not mean complete compliance with every aspect of Beijing’s policy goals. The manufacturing of wind turbines could be achieved right away but technology and management transfer could not be rushed through. Many companies manipulated the policies for quantitative growth but left reliability of the products aside, which led to massive failures and vicious competition especially at the looming tipping point of new capacity overwhelming demand (Dueck 2007). One principle among many local firms was that it was good enough “as long as the wind turbines could be erected and begin to spin” within the shortest possible time.[24] As many of the problems could not be spotted in short-term, massive expenditure on operation and maintenance were needed because the turbines are expected to continue turning for 20 years. For those relying on licensed production, there were core technologies for electronic control and precision production that firms could not buy along with the blueprints. One major discrepancy is that before the foreign models were proved suitable for Chinese terrestrial and environmental conditions, wind turbines based on the foreign designs had been produced and installed in a large scale in China (Xinhua News Agency 2009a). Moreover, many of the designs did not have proven track records even overseas.

After five years of blind pursuit of installed capacity and operating scale, the negative impact of the investment bubble started to surface. The market was overcrowded and overheated, and there was a structural overcapacity due to the bottleneck of grid connection. With 80% of the capacity concentrated in a few large firms, there were dozens of firms producing wind turbines with poor quality. Due to the limitation in technological and managerial capabilities, many of the copy cats of foreign designs still relied on the import of key components including electronic control system and had a high failure rates in their products. Without a focus on R&D,

[24] Interview no. HB120912, a government official at the Science and Technology Department of Hebei Province, Heibei, 12 Sep 2012.

many indulged in “binge eating” and then got “indigestion and obesity” but remained weak after years in the market.[25] “In China, irrational, speculative and herd-like investment behavior is not just endemic of retail investors in its red-hot stock markets. Erratic investment boom-bust cycles are also a hallmark of many industries, including wind power” (Ng 2007). Even Sinovel as a large SOE-backed firm was also known for this tendency. The General Manager of Longyuan, Xie Changjun, openly criticized the quality of turbines produced by Sinovel: “if I have other choices for offshore models, I will not buy from you” (Li 2011). Because Sinovel’s turbines went into a lot of problems only after two months in operation, its resident technicians had to stay in the wind farms all the time, which still could save some of them from collapsing.

Chinese firms’ overreaction to Beijing’s call and misuse of its support prodded the Chinese government to review existing policies. The reconsideration was concentrated on three aspects of the overheated industry: lack of indigenous designs, price competition and weak domestic market demand. Because of low entry barriers and short product life-cycle, many firms rushed into large-scale production without paying much attention to quality control and independent R&D, which brought the industry into a vicious cycle of excessive competition and a continual pressure of cost cut. According to Gu Weidong, Vice President of China Energy Society, it is meaningless for 100% of the components to be procured locally if most Chinese manufacturers do not own IPRs (Wu 2010). In 2009, Beijing started to think about eliminating the local content policy, and the consideration was supported by a few experts and a report by NDRC’s ERI, which concluded that since the country has already established in-country manufacturing, it was the right time to lift the restrictions (Gao and Luo 2009). Both Shi Lishan from NEA and Shi Pengfei from CWEA believed that eliminating the policy would compel indigenous firms to focus on R&D and free the competitive firms from price wars. Another point that was made was the limited domestic demand and a need to enter foreign market. “In view of the bilateral discussion between China and the EU over market access to solar PVs, it is not possible for China on the one hand to privilege Chinese companies in the domestic market, and on the other seek entry by Chinese companies into foreign markets”.[26]

Although there were different responses to the proposal for cancelling the local content rule, Beijing was able to implement it without much resistance from inside the country. The possible revocation was particularly favored by large Chinese firms that already had their own IPRs and could sell to other countries without any restraints. This would find an outlet for their products and free them from the inefficient price wars so that they could devote themselves to the development of more stable and reliable products. For firms that had set up assembly plants in China, the local content rule was no any longer a barrier in the sense that most of them had

[25] Ibid.
[26] Interview no. CA060813, a research fellow at the ANU, Canberra, 06 Aug 2013.

cultivated local suppliers and the percentage of local parts that GE, Vestas and Gamesa used for production had reached 90%. But for small private firms, especially those that were not well established yet and were not strong enough to compete with others in terms of technology, Beijing's intention was equal to throw a cat among the pigeons. With Beijing committed to consolidate the industry, these small firms' available choice was not to protest, but to withdraw, or to seek acquisition. As director of NDRC's ERI, Li Junfeng said, the turbine makers were facing an industry-wide reshuffle and in future we need 80% of the market to be concentrated in three to five manufacturers. At a time when the Commerce Secretary Gary Locke pressed China hard for it, China reached consensus with the US in the Sino-US Joint Commission on Commerce and Trade (JCCT) meeting in 2009, and announced it would abolish the local content rule in 2010 (Zhong 2010).

6.2 National Champions' independent R&D and overseas adventure

After a "wind power winter", the Chinese government continued with building a home-grown wind power industry of Chinese companies with indigenous technologies. Picking winners returned onto the stage after the explosive growth: Beijing increased R&D support through MOST, MOF and other ministries for the establishment of a network of national key laboratories, including those by Sinovel, Goldwind, Windey, United Power and XEMC. Apart from financial support, the main benefit for these labs was "the honor the firm received and the recognition which came with it". At the same time, government selection also turned to the support of R&D on offshore wind turbines, which are more complicated and require greater reliability than those on land. With higher technology barriers and greater needs for installation, construction, and operation and maintenance, the development of onshore wind turbines cannot be simply copied to offshore wind. In contrast to their attitudes in the onshore projects, foreign firms such as Vestas and Siemens were interested to cooperate with Chinese partners in the development of offshore wind plants (China5e 2012). Other than that, there were needs for indigenous firms to focus on modifications to adapt to the local environment as well as grid integration.

Thanks to the government support, many of the Chinese wind turbine makers now have their patented self-developed designs, and have successfully transitioned to become innovators in their own rights. According to the 2010 Chinese Wind Power Report, all of the top ten wind turbine producers had built their R&D teams and were gradually moving from joint development to independent R&D. Most of them have already had the capability to design and produce 1.5MW and larger wind turbines themselves (Li 2010). Private innovators such as Mingyang and Envision have ascended like bright stars especially after the 2010 consolidation, and respectively became the third and fourth largest wind turbine producers with their own IPRs. There were also other companies engaged in independent R&D from the beginning. By working together with Shengyang Industrial University, Huachuang started from a partly state-owned company and successfully developed the first indigenous 1.5MW wind turbine in 2006. After it was bought by the SOE utility Datang in 2011, Huachuang's business increased in the recent years. With a strong industrial base, Shenyang Yuanda started wind turbine design as its sideline business and finished the installation for the first large-scale use of its first prototype in 2013.

At the time of a slump in the demand of wind turbines, many Chinese producers started to use their success in the domestic market as a bridgehead to win market abroad. The total export of Chinese-made wind generation sets surged from 56.6MW by 2010 to 269.7MW by 2011, to 700.2MW by 2012, to 1,392.5MW by 2013, and to 1,761.3MW by 2014, amounting to a total thirty-fold increase within five years. With the backing of state-owned banks, Goldwind, Sinovel, Sany, Mingyang, United Power, Sewind, CSIC Haizhuang, and XEMC started international operations and sold their turbines to countries such as the US, Australia, France, India, Turkey, Iran, Chile, Ecuador and Ethiopia, with the US as the largest importer of Chinese wind turbines, totaling 357.8MW and accounting to 20.3% of the total export (CWEA 2015). While they all saw overseas markets as a new growth point, Mingyang was the most aggressive one among the pioneers of the international expansion. Unlike most other domestic firms, Mingyang started to eye the "going-out" strategy right after its foundation in 2005 because its joint development with Aerodyn gave independent IPR for its turbines that could be sold overseas. Since then, Mingyang has signed contracts with firms from a lot of countries; the most recent ones were with the Reliance Capital from India and Paunescu Corporation from Romania (Hou and Zou 2014; Smith 2013). It was reported that overseas markets would be the focus of Mingyang in the near future, and estimated that by the year 2015, exports will account for 30% of its overall business (Shi 2013).

7. Conclusion

The chapter has argued that in a mass-manufacturing industry like the production of wind power equipment, turbine makers in the emerging countries tend to develop their own business independently from world-leading companies; and the competition between domestic and foreign businesses makes them rivals in the local market. In the Chinese wind turbine industry, a large percentage of local firms started manufacturing through the purchase of licenses, which allowed them to achieve large-scale production in a short period of time and make full use of government support policies. At the same time, it was unlikely that overseas manufacturers would transfer intellectual property and proprietary technologies to local companies that could become competitors. While a transnational coalition was not necessary for local firms and not in the interests of foreign competitors, leading global companies opted to enter the market without teaming up with Chinese partners. Regardless of whether they were Chinese-owned firms or foreign-owned Chinese firms, they all tried to make a fortune playing by Beijing’s rules, which essentially contributed to the formation of a Chinese wind power equipment industry made up of indigenous firms. Although the goal of improving indigenous technology capabilities was not yet fully accomplished, Beijing’s intention to encourage local manufacturing and its assertiveness to consolidate the industry was implemented largely without internal resistance.

Throughout the past three decades, Chinese firms in the wind power sector have consistently maintained a defensive stance toward leading global wind turbine makers, and a cooperative mindset to coordinate with Beijing in the reduction of foreign dependence. Thanks to the ready access to technologies, Chinese firms were able to compete with foreign firms in manufacturing by making use of government support at the central and local levels. Even though both nuclear and wind industries started at the outset of China’s reform and open door policy, Chinese wind firms did not enter into long-term business coalitions with world-leading producers and challenge Beijing as seen in the nuclear power industry. And Chinese wind firms did not become national champions only in the new century: they have been so since their formation in China’s most open days. As discussed in-depth in Section 4, even in the 1990s when the Chinese government strongly encouraged domestic wind firms to pair up with foreign wind turbine producers, the domestic-foreign cooperation did not work out well. Throughout the whole process, Chinese indigenous wind firms did not develop strategic business relationships with well-established foreign manufacturers. On the contrary, some bought foreign designs for domestic manufacturing and others developed domestic models in collaboration with small foreign design firms.

Chinese turbine producers and foreign manufacturers at the frontier of wind technologies made their way into the Chinese market separately, and the competing interests of gaining more market share met Beijing’s intention of cost reduction through local manufacturing. Due to standardized production and short production cycles in wind turbine assembly, local companies could quickly scale up production and challenge foreign competitors even without core technologies. Unlike in the CoPS industries such as nuclear power plants, wind turbine designs and codified technologies could be easily acquired through licensing or joint development. In addition, because each single turbine maker is only one of the many players as a result of low entry barriers, the market is highly competitive and market share can be only obtained through a large number of transactions. Because of these features of wind turbine assembly, all industry actors need to compete for greater capacity and more orders, with wholly owned foreign subsidiaries participating in the game without local partners. So when the central government decided to develop large-scale wind farm bases, both local and foreign manufacturers went all out to fight for a share of the newly created demand.

There have been three categories of company producing wind power generation sets in China: indigenous Chinese firms, wholly foreign owned enterprises, and Sino-foreign joint ventures. They have played different roles in different periods but almost all built wind turbine manufacturing facilities and fostered component supply capabilities for the Chinese market. Aside from Goldwind and Windey, which set up wind turbine factories early in the 1990s, most other Chinese companies started their businesses after 2003. As many of the new entrants were linked to large state-owned enterprises, they benefited from strong industrial bases, relationships with existing parts suppliers as well as with state-run power companies. While most of them acquired wind turbine designs by buying licenses, a particular group of private firms joined the battle with an immediate focus on core technologies, mainly through joint development and independent design. Although working at a slow pace, some other Chinese firms diversified their business activities into the manufacturing of wind turbines based on their own capabilities or ventured into the field in cooperation with technological universities. Several wind power giants in the world also established their wholly owned subsidiaries and trained parts suppliers in China. Even the joint ventures with a majority foreign stake decided to move their manufacturing facilities after years of resistance.

Having ready access to wind power technologies, Chinese wind turbine makers cooperated with the state to compete against foreign producers. In response to Beijing's call of building a national wind power industry, Chinese wind firms played the role of "national champions" by enhancing local manufacturing and designing capabilities. Since Beijing launched the wind concession program, the firms started independent production with the help of small design firms. In collaboration with state-owned utilities, they also managed to sell their products to large-scale wind farms through government procurement. With the government's support, many of them were committed to the formation of proprietary technologies through joint development, independent R&D, or mergers and acquisitions. While only the companies with independent intellectual property rights and core technologies could weather the storm of industrial consolidation as well as a depressed market, production capacity started to be concentrated in the hands of several large and strong ones. As for large foreign producers, the greatest trials for them are the low sales margins and difficulties in getting orders, especially when a large supply exceeds the Chinese market demand and even local firms are seeking overseas outlets for their production. While it took only five years for indigenous Chinese firms to grow bigger and another five years to become stronger, it is likely that they will soon break free from the reliance on small foreign design firms and become global wind power leaders in terms of production and innovation, even though their foreign competitors never expected that they would lose their competitiveness in such short time.

Chapter 6
Conclusion

China in the western media has been treated as a stereotype of techno-nationalism but also as embracing global economic integration at the same time. Reports on subsidies, restrictions on foreign investment, and currency manipulation all depict a protectionist Beijing that struggles to prop up a national industry by leveraging the opportunities of the world market. With a different perspective, this thesis has stressed that the state-industry cooperation necessary for effective policy intervention is not always found in China, and state-directed initiatives do not always meet positive responses from industry. In this sense, the Chinese government is far from successful in carrying out its nationalist initiatives. Owing to the specific characteristics of production and technologies, Chinese domestic firms from different sectors associate with foreign counterparts and respond to state directions in different ways. Firms in some sectors submit to Beijing for “reciprocal consent” and insinuate their interests into state policy, but those in others test Beijing and devote themselves to the defense of the interests they share with their foreign business partners. Despite the lack of immediate evidence, industrial policy and its implementation have been driven by variant firm behavior in different sectors. One thing that cannot be denied is that the inconsistent capacity of the Chinese state in coordinating group interests is closely linked to business interests and firm behavior, which are in turn determined by the nature of industry sectors. The comparative case studies conducted in the previous two chapters support the argument.

This chapter begins by reviewing the argument and analyzing the findings from the case studies on China’s nuclear and wind energy industries. This reaffirms the linkages among production characteristics, domestic-foreign business relationships, and firms’ responses to state directions. The discussion then shifts to considering the implications of the findings for understanding state-industry relations and state capacity in policy coordination. Adding to the traditional notion of how bureaucratic structure affects state capacity and policy effectiveness, this thesis accentuates the impact of industry characteristics on the same set of institutions in different industry sectors. Then the chapter turns to discussing limitations of the study and what needs to be done for future research. The last section of the chapter puts the findings back into the wider context of issues in international political economy, mainly techno-nationalism, development, and international economic cooperation.

1. Findings

Two principal findings emerge from the preceding case studies on China's new energy industries. The first is that the distinct characteristics of production in nuclear and wind power brought about different domestic-foreign business relationships in the two sectors. While nuclear power plants (NPPs) exemplify complex product systems (CoPS) in which production is highly customized and engineering-intensive, wind power equipment represents traditional mass-manufacturing that is typical of standardized production and relatively simple component interfaces. One important aspect of the contrasting natures of the two industry sectors is that the transfer of technology and production capability is much less likely in nuclear than in wind power. For that reason, the ways that indigenous Chinese firms relied on foreign technologies have been different in the two sectors. As core capabilities of the nuclear sector lie in systems integration and engineering, which feature low technology transferability, Chinese nuclear firms need international vendors to play a large part in their daily business operations for a long period of time. On the contrary, Chinese wind firms can quickly undertake independent production and challenge top global producers through economies of scale and cost reduction. As a result, Chinese nuclear firms individually paired up with international vendors for long-term strategic partnerships whereas Chinese wind firms sprang up as cut-throat competitors to foreign producers.

Due to the CoPS nature of NPPs, all major nuclear firms in China developed long-standing business partnerships with top nuclear vendors in the world. As NPPs have to be tailored to user requirements and produced on-site, negotiations on all sorts of issues are necessary between sellers and buyers throughout all the stages of design, delivery, maintenance and upgrade. This is exactly what happened in China's nuclear energy industry. On the recipients' side, Chinese nuclear firms relied on international vendors for not only design and production but also management and services. Even in the case of SNPTC-Westinghouse where technology transfer was agreed, the Chinese firm still relied on its foreign partner throughout the whole process, especially in the conversion from conceptual designs to workable packages. On the suppliers' side, global lead firms need to oversee the NPP projects in China and in fact secured strong control over domestic production for a long period of time. Their partnerships with local firms are necessary for both project needs in China and self-improvement through experience accumulation. Due to the stickiness of core capabilities in NPPs, they do not have to worry about losing their competitiveness even through close interactions with Chinese buyers. And long product lifecycle in nuclear power projects also helped sustain the interdependence between Chinese nuclear firms and international vendors over the past decades.

As expected in mass-manufacturing sectors, Chinese and foreign wind equipment makers have seen no common ground between them. In contrast to the hard-to-copy capabilities in the nuclear energy industry, Chinese firms in the wind sector have ready access to technologies and skills and find it unnecessary to tie up with foreign producers. They could begin independent production with the help of foreign design firms providing knowledge-intensive business services (KIBS), generally through licensing agreements or joint development. And thanks to the advantages in cost and productivity, Chinese late-comers quickly came to the front challenging global lead firms in wind turbine production. Just as Chinese firms did not see the need to partner with top multinational firms, well-established turbine makers also tried to avoid close interactions with Chinese firms in local manufacturing. This is out of concern for losing competitive strength considering the relative ease of technology transfer in the sector and a lack of IPR protection in China. Therefore, transnational business coalitions in the sector are neither necessary for Chinese late-comers nor appealing to global lead firms. Indeed there has been domestic-foreign cooperation, in which Chinese wind firms rely on foreign technologies provided by small design firms, but these foreign partners have hardly anything to lose because they are not engaged in manufacturing and hence not taking part in the frantic scramble for market share.

Because of the lack of incentives to associate with each other in wind turbine production, transnational collaboration became ever more elusive in the sector. The hostility is best illustrated in Beijing’s failed attempt of bringing domestic and foreign firms into joint venture (JV) partnerships, which were meant to encourage technology sharing from the foreign producers that were interested in the Chinese market. Both domestic and foreign parties that followed the arrangements found it hard to sustain the relationship. As the foreign party within the JVs only transferred outdated technologies but sold to China the most advanced turbines manufactured overseas, the Chinese side did not have a chance to grow in capability and become equal matches to their partners. While foreign producers had no incentive to share their intellectual property, Chinese firms were not content with remaining subject to foreign control. This is why later most multinational producers and Chinese new entrants decided to build their own manufacturing facilities individually. When multinational corporations were forced to move manufacturing facilities to China because of the local content rules, they entered the market without teaming up with local partners. Most of them set up wholly owned assembly plants even at the cost of training local component producers and establishing a supply network that also benefited local competitors. Under the circumstances, Chinese indigenous firms acted as assisted challengers of their foreign-owned counterparts in the Chinese wind energy market.

The second finding is that contrasting business relationships between Chinese and global lead firms led to different firm responses to state policy in China's nuclear and wind power sectors. While Beijing attached to nuclear and wind energies roughly the same level of significance in achieving its techno-nationalist goals, the central targeting did not receive equal responses from the two sectors. Even though firms in the two sectors were similarly responsive to national support, those in the nuclear energy industry teamed up with international vendors and played into bilateral government relations to promote the use of foreign models, whereas those in the wind sector maintained a clear boundary between competition and cooperation with foreign firms, and seized market share from top global producers with the help of small foreign design firms. In both sectors, firms made use of foreign advanced technologies and equipment, and at the same time worked on home-grown innovations and localized foreign designs. However, the focus was different in the two sectors. As a result of the converging interests, Chinese nuclear energy firms entered into political coalitions with foreign firms and were unwilling to cooperate with Beijing in reducing the dependence on foreign technologies. In fact, despite the localized models Chinese nuclear firms have acted as their foreign partners' sales representatives in each round of deploying new-generation reactors. In contrast, indigenous wind firms ran after state policy and competed with foreign pioneering manufacturers making use of government support. Most top Chinese producers were dedicated to the formation of technological capability through joint development or acquiring design capabilities through the purchase of KIBS firms.

In the nuclear energy industry, Chinese firms had shown a systematic bias toward buying foreign technologies regardless of the significance of self-reliance in China's first NPP at Qinshan. No matter which faction the nuclear firms belonged to, they all went into coalitions with global lead firms to promote foreign nuclear reactors in the Chinese market. Even the company coming out of the independent faction depended for its competitiveness on collaborating with international vendors and helping to sell their nuclear technologies in China. Aside from a few home-grown models, most operating reactors in China were imported or modified based on foreign designs. In the three major rounds of NPP approvals each in the early 1980s, 1990s and 2000s, reactors from France, Canada, Russia and the United States were selected as the result of internal and external pressures, among which domestic nuclear firms played an important role in the process. Looking back at the history of civilian nuclear development in China, domestic firms and their transnational coalitions were accountable for the introduction of foreign nuclear reactors into China at different stages. As a result, many referred to China's nuclear energy industry as one featuring the "flags of all nations" or the "united nations" approach.

In over three decades, the coalitions of Chinese nuclear energy firms and international vendors drove the Chinese nuclear energy sector onto an integrationist path. Internally, domestic firms and their predecessors not only interfered with central directions but also joined up with their foreign partners to compete with domestic peers. Externally, international vendors lobbied their home governments to exert influence over Beijing through leveraging bilateral political and economic relations. The two forces worked together to promote the sales of foreign nuclear reactors to Beijing, through which the transnational coalitions hope to gain advantages vis-à-vis others in the Chinese market. The coalitional struggles were best reflected in Beijing's failed attempt at unification to a single model in the early 2000s. For the sake of management, safety concerns and cost control, the Chinese government decided that foreign advanced third-generation reactors should be the "technology roadmap" for China's grand nuclear energy expansion. Ironically, instead of being standardized, more reactors were introduced into China. Each transnational coalition managed to have its new model approved and the sector witnessed greater diversity in terms of the deployment of reactor types. As a result, the divergent practices opened the gate wider for international firms and further increased the use of foreign technologies in China's nuclear energy sector.

The transnational coalitions turned domestic firms into a barrier to Beijing's effort of building a technology platform based on domestically developed reactors. In the early days, the collaboration with international vendors in fact undermined the willingness of domestic nuclear firms to focus on independent designs. Even though later they were all under great pressure to dedicate themselves to the development of their own reactors, the indigenous efforts they made relied greatly on their foreign partners, and most importantly, were segmented among different cross-border coalitions. Since unification to an indigenous model was firm on Beijing's agenda, all hoped that their own models would become the future hegemon of China's nuclear energy industry. As each pair of domestic and foreign firms sought to generate advantages over other pairs, Beijing's order of consolidating domestic resources to develop a "national" nuclear reactor was repeatedly ignored. The coalitional fragmentation was well proven by the difficult birth of Hualong-One (China Dragon-Number One), the first third-generation reactor with Chinese IPR. While Beijing wished to "mobilize resources to get great things done" (*Jizhong liliang ban dashi*), all the pairs were moving in different directions because no one wanted to give up the future of their own reactors in national deployment. Owing to the continual interference, it took years for Beijing to merge two similar but separate strands of indigenization efforts into one, namely Hualong-One, which, however, did not guarantee the merge of interests among stakeholders.

As for the wind power sector, Chinese firms reacted positively to the state policy encouraging local production and limiting foreign technology control. Making good use of government policies, all have been engaged in a battle with foreign owned firms and unavoidably with each other for a larger share of the market. When Beijing made known its intention of promoting wind energy development in the early 2000s, many SOEs in heavy industries and private firms flooded into the industry, and strived to translate supportive policies and government resources into their own benefits. Most managed to scale up their productions through licensed production in a short period of time. In order to meet Beijing’s local content requirement, Chinese wind equipment producers actively sourced components and parts locally and developed their own supply systems within the country. In terms of bidding for national concession projects, they followed Beijing’s instruction to seek coalitions with wind farm developers, which helped them gain leverage over foreign competitors. In an effort to promote the sales of domestic products, Beijing made it obligatory for wind farm developers to bundle their tendering with wind turbine manufacturers in winning contracts. Because of cost competitiveness and their linkages with state-owned utilities, domestic wind firms were able to quickly grab market share making use of the policies. Between 2003 and 2010, the share of wind turbines made by Chinese firms and joint ventures overtook that of foreign producers and rocketed from 25 percent to 90 percent (CRESP 2005: 8; Li, Shi and Gao 2010).

Regardless of the initial dependence on foreign technology imports, most top Chinese wind equipment producers responded actively to Beijing’s call to develop indigenous technology capabilities. During the great expansion of the wind energy industry, some domestic firms were devoted to the learning-by-doing process that Beijing encouraged because they found that only companies with innovation capacity and quality awareness could maintain sustainable growth and secure a market position. There were many others temporally climbing up the ranks not through technological upgrading but through cost cutting and price wars, but they were not favored by Beijing and hence “deselected” from the support list. During the industry consolidation after 2009, most of the companies went bankrupt or were taken over by others, which were picked by Beijing as winners. For those selected, firms have been seeking to develop their own designs through joint development, independent R&D or the purchase of design firms so that they can sell to the overseas market. These included companies that Beijing targeted for support when they were still public research institutions, new entrants with a strong SOE background, and private firms with a strong focus on independent design. Regarded as national champions, this group of domestic firms dedicated themselves to indigenous innovation so that they could gain competitiveness in the global market, which fit the developmental goal at the center.

Drawing together the comparative analysis of the two case studies, this thesis comes to a firm judgement about the hypothetical linkages between industry characteristics, domestic-foreign business relationships, and firm responses to state policy. Chapter 2 sketches out the causal mechanisms that explain the opposing firm behavior presented in the title of the thesis: why Chinese firms in the nuclear energy industry act as global partners but those in the wind power sector live a life of national champions. The first category shows that the two industry sectors differ from each other along a variety of dimensions in production and are respectively the archetypes of CoPS and mass-manufacturing. Second, due to distinct industry characteristics and technology transferability, firms in the two sectors have associated with foreign firms and developed reliance on foreign technologies in different ways. While the domestic-foreign business relationship in the nuclear energy industry has been coalitional over a protracted period of time, it is outright rivalry in the wind power sector. Last, as the consequence of technology acquisition in nuclear is bondage but freedom in wind, firms in the two sectors reacted to Beijing's nationalist initiatives in different ways. Chinese nuclear firms were less responsive to state policy in the process of working toward strong partnerships with international vendors, but Chinese wind producers were generally more cooperative with Beijing in their competition with foreign firms.

Table 6-1 The making of global partners and national champions

Analytical Categories	Nuclear Power: Complex Product Systems (CoPS)	Wind Power: Mass-Manufacturing
Nature of Industry (Production)	- Complex component interfaces; - Customized projects, in small batches; - Systems integration and engineering; - Long product lifecycle; - Stickiness of technologies and capabilities.	- Simple component interfaces; - Standardized production, in large volume; - Economies of scale and cost minimization; - Short product lifecycle; - Relative ease of technology transfer.
Domestic-Foreign Business Relationships	- Interdependent, strategic partners; - Intimate business interactions; - Chinese dependence on international vendors; - Foreign involvement in local projects without worrying about losing competitiveness; - Teaming up to win contracts.	- Mutual-exclusive market competitors; - Disincentives to collaborate in production; - Independence with the help of KIBS firms; - Foreign producers avoid Chinese firms for the fear of technology transfer; - Competing for orders.
Firm Responses to State Policy	- Global partners; - Promoting foreign nuclear reactors; - Interfere with a national technology platform; - Ignoring Beijing's nationalist initiatives; - Politically powerful coalitions played into bilateral government relations.	- National champions; - Being engaged in independent production; - The formation of technological capability; - Assisting Beijing to build a national industry; - Foreign firms changed their "nationality" to Chinese by setting up local plants.

The nature of technology and production accounts for firm behavior in different industry sectors regardless of time variation. Some may propose that China's economic transformation is the explanatory variable, and argue that China's opening policies in the 1980s and 1990s made Chinese nuclear firms into global partners and the nationalist policies in the 2000s made Chinese wind producers into national champions. The argument is not valid because it is based on the false assumption that there is a difference in the timing of industrial policy formation in the two sectors. Wind power did not see spectacular growth before the 2000s, but this does not mean that there was no industrial policy in that sector. Both nuclear and wind sectors started roughly around the same time and went through the same period of national economic transformation. The two sectors in examination exhibited contrasting firm behavior against the same background, and firms in each sector responded to the Chinese state's directions in a consistent way even in the face of changing policy environment. By holding the general context constant, the thesis comes to conclusions that are not only specific to the two sectors in China, but also generalizable to other political economies and can be applied to other industry sectors.

2. A new perspective on techno-nationalism and industrial policy

The thesis has built on studies in the fields of techno-nationalism and the developmental state and sheds light on the understanding of late development. It contributes to the literature by explaining why firms in some industrial sectors proactively cooperate with the state but those in other sectors are unresponsive to state directions. Existing studies have argued that the techno-nationalist rationale of industrial policy in China and other countries originated from the fear of lagging behind others in economic development and national defense (Keller and Samuels 2003; Samuels 1994). According to this line of research, states intervene into economic activities for the sake of national security and prosperity, and a synergy between state and industry is essential to the implementation of state policy. Aside from the fact that the state is not all-powerful, national interests sometimes cannot be pushed through due to resistance from certain industry sectors. While most have recognized the impact of firm behavior on state capacity in policy-making and implementation, not much attention has been given to the explanation of why companies in different sectors respond to state directions differently. This study has argued that because of the varying nature of production, the responses of firms towards state directions in different sectors can vary from cooperative to uncooperative behaviors. Far from a nation-wide symphony directed by Beijing, one sector can look less "nationalist" than another. In this research, the nuclear power sector played out in a more open and integrationist way than the wind sector because of nuclear firms' global partnership and unresponsiveness to Beijing's nationalist initiatives.

By focusing on firm behavior, this thesis has aimed to divert scholarly attention from an exclusive focus on internal state structure to the linkages between variant business interests and state capacity. In the nuclear case, inter-agency rivalries prevented the Chinese central government from coordinating the interests of various stakeholders and working toward a nuclear energy program through long-term strategic planning; and the state capacity problem has been the major impediment to China's pursuit of a nationalist agenda in the sector (Xu 2010).[1] Agreeing with the above argument, this thesis has extended it by considering the impact of domestic-foreign business linkages on firm behavior, state-industry relations, and arguably policy effectiveness. In addition to state structure, this research has considered how business interests influenced state capacity in policy-making and implementation. It is necessary to acknowledge that the Chinese nuclear firms corporatized from state agencies have since been engaged in commercial operations and had their own interests in relation to foreign partners. Bureaucratic contentions might play a primary role in the first introduction of foreign nuclear reactors in the 1980s, but the central decisions on the second and third round of turn-key project imports were made in a context in which the interests of local nuclear firms were taken into account. The import bloom of nuclear reactors in the 1990s was driven by the need for large commercial NPPs and economic profitability in the midst of other concerns such as strengthening diplomatic ties and relieving energy shortages. As for the importation of third generation reactors, Beijing made the decision not only for safety reasons but also to break the ice among nuclear business coalitions. This is how Chinese nuclear firms managed to have their individual coalitional interests reflected in state policy and force Beijing to depart from its intended course.

Similarly in the wind sector, the explanation of firm behavior enriches the understanding of state capacity in policy coordination, which is traditionally based on state structure. Lema and Ruby (2007) underscored the fact that the poor results of China's wind power development in the early days were attributed to the coordination failures of the Chinese state and a lack of state capacity that stemmed from bureaucratic conflict and struggles between central and local authorities; but the reforms of energy bureaucracy toward centralization in the early 2000s contributed to a unified policy regime and brought about a take-off in the sector later on. Nevertheless, the importance of "collusion" between the Chinese state and wind firms in the effort of building a national wind industry of not only Chinese firms but also Chinese

[1] Decision-making in the nuclear power industry was fractured among a variety of government agencies and has gone through many changes in its governance. Since the civilian application of nuclear technologies was first spun off from the weapons program in the 1970s, jurisdiction over nuclear energy has gone through several changes and has been put in the hands of defense, electricity, economic development, and science and technology agencies before a vice-ministerial body for energy was created in 2008. Accompanying the bureaucratic changes were intense inter-agency rivalry and policy oscillations over various issues. One of the most contentious areas was whether foreign or domestic technologies should be used for China's nuclear projects.

technologies should not be overlooked. Throughout the process, Beijing has selected winners in the wind power sector and made them more competitive through policy intervention. Clear evidence for this is that during the industry consolidation in 2010, the Chinese government abolished the local content rule and put all wind firms, Chinese or foreign, large or small, on a level playing field in the local market. The release of control to the market benefited the firms following Beijing's will and devoted to the formation of indigenous IPRs and production capabilities. In this light, the move was meant to favor the national champions while weeding out the small inferior firms.

Just as state policy is sometimes driven by business interests, policy effectiveness is also subject to state-industry relations and particularly firms' responses to state directions. While existing literature highlights the negative impact of decentralization on effective state intervention, this thesis has stressed the influence of firm behavior, which is closely linked to the nature of industries. In the effort of fixing market imperfections through policy intervention, the state faces challenges from both internal conflict and business resistance. Even though in the nuclear sector the nationalist goal was partially achieved in Hualong-One, the domestic-foreign coalitions played a large part in preventing this to happen or at least in slowing down the process. Compared to the nuclear energy industry, it is relatively easy for Beijing to promote indigenous technologies in the wind sector. As discussed in Chapter 5, top producers such as Goldwind, United Power and Mingyang have developed their own wind turbines with Chinese IPRs. Even though they acquired the models mostly through collaboration with foreign design firms, these Beijing's favorites have been submissive to Beijing in technology acquisition.

With firm behavior and state-industry relations as vehicles, this thesis has established a link between state capacity and industry characteristics. Among a variety of factors, whether the state-led nationalist initiatives could bring desired results depends in large part on firm behavior (see Chapter 1). Based on findings from the case studies, this thesis has argued that firm behavior is determined by the characteristics of technologies and capabilities in a specific sector. In the nuclear sector representing CoPS, the Chinese state saw cross-border coalitions and business resistance, which had a negative impact on its capacity to push through a nationalist agenda in the sector. In the mass-manufacturing sector of wind power equipment, the Chinese state has been generally autonomous in building national capabilities because of the support of local firms and a public-private synergy in policy implementation. Of course, the stark contrast is not meant to define the Chinese nuclear sector as a complete failure and the wind sector a full victory. Rather, the comparison is made to stress the different firm behavior and its influence on policy-making and performance in the two sectors. It turns out that the level of state capacity and hence the effectiveness of policy intervention varies across industry sectors. As discussed in this thesis, the Chinese state has seen better coordination and coherence in its interactions with wind firms than with nuclear firms, and has had greater capacity in the implementation of nationalist policies in the wind than in the nuclear sector.

3. Directions for future research

With a special interest in China's nuclear and wind energy industries, this study suggests a few aspects in need of further investigation. In consideration of the need for comparison in case studies, it is always good to put more cases to the test and see whether the theory applies to other sectors. In-depth studies of other industry sectors would help establish a greater degree of accuracy on the arguments developed in the research. The cases do not have to be new and renewable energy industries but can be any sectors that are targeted by a developmental state. One major task in the selection is to differentiate the sectors according to their features and assign them into the two categories of CoPS and mass-manufacturing. Admittedly, within each category there are sectors with different types of production that vary along many dimensions such as scale, cost, and technical skills. In this sense, wind turbine production is more like assembly in the automotive (auto) industry than for solar photovoltaics (PV) and semiconductors. Compared to solar PV, wind and auto are typical of higher entry-barriers, technology complexity, and production costs. Notwithstanding the varying degrees of complexity, they are all mass-manufacturing sectors sharing such basic characteristics as standardized production processes, simple component interfaces, and high volume production. Likewise, NPPs and off-shore oil drilling platforms fall in the CoPS category despite the different features present in their production and construction.

A caveat in the selection of case studies is that some CoPS industries have a military origin and the focus should be on civilian industry sectors. The core capability of CoPS, systems integration, stemmed from the development of weapons systems during the Second World War, and many CoPS sectors are actually engaged in defense or aerospace production, such as nuclear weapons, ballistic missiles and rocket propulsion (Hobday, Davies and Prencipe 2005). Because in many countries these projects are undertaken directly by the government due to security concerns, business interests are not involved and there is no chance to observe firm behavior and state-industry interactions, not to mention the collaboration between domestic and foreign firms. In the case of China, the country boasts accomplishments in spacecraft and submarines but these were achieved through massive and continuous investment without the consideration of profitability. Most importantly, these projects are highly sensitive in terms of national security, and the way that China mobilized resources to make them happen is not comparable to civilian projects such as high-speed railways or even NPPs. In China, only in civilian industries can we expect a conflict between long-term national interests and short-term business interests. Therefore, it is necessary to bear in mind the commercial nature of industry sectors when choosing case studies.

Although it is not feasible to go into detail here, a brief review of China's solar PV sector suggests that it lends support to the argument developed in this thesis. As expected in mass-manufacturing industries, indigenous Chinese PV producers became rivals in the fight for market share domestically and internationally, and the situation in solar PV is no less fierce than in the wind power sector. In spite of the weakness in upstream production and the need to import basic stoke, polysilicon, Chinese solar PV firms were able to enter the market through the purchase of production lines and inundate the market with low-cost products through large-scale production. Because of the ready access to technology, they could compete with foreign PV producers not only in China but also in overseas market shortly after start-up. With their strength in downstream production, mainly low value-added assembly, they could make good use of low labor cost and play cost advantages to the full. As a result, China has dominated PV cell and module production since the mid-2000s and its shares of global production capacity of PV cells and modules respectively reached 58% and 65% in 2013 (Ayre 2014). Foreign PV makers could not secure a foothold in the Chinese market throughout the time and were challenged by Chinese firms in their own markets: some even went out of business due to the disadvantage in price. From the anti-dumping tariffs imposed by the US and the EU on Chinese solar products we can see how tense the relationships between Chinese and foreign firms have been in the sector. In the process, Chinese PV producers have been cooperative with the government in carrying out national policy and did bring spectacular growth to the sector, though the "over-embeddedness" of local governments in business also produced a lot of problems.

Aside from the need for more case studies, it is recommended that further research be undertaken in the context of other industrializing countries. Needless to say, future investigation needs to aim for countries pursuing a benevolent developmental trajectory because state-industry coordination is not a prominent feature of predatory states. One could look into current emerging economies such as India or trace back the history of industrialized countries to test the associations between industry characteristics and firm behavior in the same sectors. Nuclear power development in Japan and South Korea is of particular interest because of the techno-nationalist traditions in the two countries and because both purchased reactor designs from international vendors. While Japan had largely established its own domestic nuclear power production capacity within twenty years in its NPP program, South Korea also has developed important capabilities of its own since the 1950s (WNA 2015c; WNA 2015d). Even so, the

Japanese tend to lag internationally and the Koreans still rely on the partnership with Westinghouse, reflecting the difficulty of technology acquisition in the industry (Metzler and Steinfeld 2014). Considering China's experience, it would be interesting to see whether the transnational business partnerships influenced firm behavior and the implementation of national policy in the nuclear energy sector of Japan and South Korea.

Finally, more research may need to be done in order to assess the impact of industry characteristics on state capacity in different industrial sectors. The evaluation of state capacity in the policy process has never been an easy task. Within a single country where the principal-agent relationship is the same, there are many more factors to be taken into consideration. As internal state structure and state-industry ties are inextricably intertwined, it is hard to sort them out in terms of influence. However, it is possible to evaluate whether and how industry characteristics influence other aspects of institutional structures than those examined in the thesis, and to what extent state policy is driven by them. The expectation is that varying types of production across sectors may affect not only government-business interactions but also inter-agency and central-local relationships in specific sectors. And it would be intriguing to know which of these factors plays a greater role in policy-making and implementation than others. In this sense, the investigation of industry characteristics may not necessarily be limited to CoPS and mass-manufacturing but can be carried out along other dimensions. Again taking the example of China's solar PV sector, the major conflict has been between the central government and the symbiosis of local government and business. The decentralization to local governments seems to have greater influence on the national effort of industrial upgrading in solar PV than in wind and nuclear. The nature of solar PV production, particularly low entry barriers in capital and technology, might play a large part. In this sector, small private firms dominate the market and the state-industry relationship at the local level is more significant than it is at the center.

4. Implications for international political economy

The findings of the study have important implications for the wider context of development in international political economy. By linking the characteristics of industrial production and the effectiveness of state intervention, the research indicates that state capacity varies across industry sectors. It is part of a growing body of literature on the diversity of institutional structures in developing countries, particularly in China. Adding to the rising scholarly interest in the internal structure of bureaucracies and business groups of different localities (Segal 2003; Thun 2006), this study stresses diverging institutional patterns in different sectors. In this sense, this thesis is another version of the state as a mosaic of different pieces, not across regions but across sectors. The effectiveness of policy intervention in a particular sector is subject to whether the industry cooperates with the state in that sector. Therefore, in the understanding of sectoral economic outcomes, it is necessary to examine how business interests drive state policy and undermine state capacity in certain sectors but not in others. This is not to argue that industry characteristics are the only determinant of effective state intervention, but rather that they should be taken into the consideration of state-industry relationships, and this should be done along with institutions within the state.

Relating to the asymmetry in state capacity, this study also suggests that a country labeled as techno-nationalist may not have coherent policies and practices. Even though a country such as China aims to tilt the system in favor of local firms and help them overcome the barriers to development, nationalist initiatives may not bring the desired results. On the one hand, state policy may in large part be driven by business interests, as we can see from Beijing's compromises to the transnational coalitions in NPPs approval. On the other hand, nationalist policies may be ignored or even thwarted by local firms in implementation. This is why in a country where a techno-nationalist ideology is historically rooted, some industry sectors always turn out to be less "nationalist" than others. Contrary to conventional wisdom, the Chinese nuclear energy industry has been more open than many other sectors in terms of dependence on foreign technologies despite the strategic nature and military origin of the sector. The mixture of varying practices in industrial sectors extends the understanding of techno-hybrids or neo-techno-nationalism, a regime reconciling both liberal and mercantile elements in an economy (Keller and Samuels 2003; Suttmeier and Yao 2004; Yamada 2000). With substantial resources going into the economy, China has seen mixed success in technological upgrading across sectors.

An immediate indication of the previous points is that the state effort in industrial upgrading should be sector-specific. As the pattern of production in a particular sector does not change, the patterns of business responses to state-directed industrialization tend to persist through time in much the same way that domestic firms relate to foreign ones. It seems that firm behavior in a sector is destined, completely dictated by the nature of production and technology. If there is a time limit, then it should be until the day when indigenous firms in the catching-up countries become independent in technological innovation, not only production. Just as the nuclear firms in Japan did, they could sever the ties with international vendors after developing the capacity to design and construct reactors by themselves. Because of the fundamental change in associating with foreign firms, the way that local firms relate to the state may no longer be determined by industry characteristics. But before that, states still need to consider industry characteristics and try to find a balance between embeddedness and autonomy in different sectors. There is no one size for all in "getting the institutions right" and building the institutions that promote efficient coordination. Therefore, the state-directed effort of industrial growth and technological upgrading needs to consider the pattern of government-business relations based on the type of production and technology acquisition in a particular sector.

More generally, this thesis offers a new perspective for cross-national economic cooperation, especially between industrializing countries and their economic partners. The notion of sectoral variation in technology acquisition and state-industry interactions helps predict when a certain set of policies dominates a particular sector in a developing country. It is expected that in the sectors that technology is not easily replicable there is hardly any chance for developmental states to break domestic-foreign coalitions, not to mention excluding foreign participation. In a standardized manufacturing sector, industrial policies at the early stage generally focus on promoting the growth of all indigenous firms but later turn to the support of technologically competent ones only. As a result, the discrimination against foreign firms would gradually diminish when market mechanisms are becoming more relevant than protection in building strong national industries. In cooperating with developing countries like China, it is necessary to pay attention to regional and especially sectoral diversity stressed in the thesis. In addition to internal variety, late-industrializers are also constrained in the selection of policy tools by the dramatically different external contexts they face, for instance, their participation in international regimes and regional trade agreements. With the exception of a few key fields in defense production, national resource mobilization in the rest of China's economy is no longer as straightforward as it was for Japan in the post-war era. In the pursuit of industrial and technological upgrading, industrializing countries like China have to incorporate the goals of nurturing domestic industrial capability and opening up to the world economy, which are sometimes complementary but sometimes also conflicting.

Appendix: The list of interviews, 2012-2013

Code	Organizations of the Interviewees	Location	Date
CA200612	Researcher at the National Climate Strategy and International Cooperation Center	Canberra	20 Jun 2012
BJ090812	Researchers at the Institute of World Economics & Politics, Chinese Academy of Social Sciences (CASS)	Beijing	09 Aug 2012
BJ140812	Professors at the Centre for Global New Energy Strategy Studies, Peking University	Beijing	14 Aug 2012
BJ150812	Professors at the Institute of Economic Research, Renmin University	Beijing	15 Aug 2012
BJ160812	Researchers at the Development Research Center of the State Council (DRC)	Beijing	16 Aug 2012
BJ170812	Former researcher at the School of Public Policy & Management, Tsinghua University	Beijing	17 Aug 2012
BJ220812	Researchers at the Chinese Academy of Science and Technology for Development (CASTED), Ministry of Science and Technology	Beijing	22 Aug 2012
BJ280812	Researcher at the Energy Research Institute (ERI), National Development and Reform Committee (NDRC)	Beijing	28 Aug 2012
BJ290812	Researcher at the National Academy of Economic Strategy, Chinese Academy of Social Sciences (CASS)	Beijing	29 Aug 2012
BJ310812	Caixin reporter	Beijing	31 Aug 2012
BJ040912	Former employee of CGNPC	Beijing	04 Sep 2012
BJ070912	Researchers at the Institute of Nuclear and New Energy Technology, Tsinghua University	Beijing	07 Sep 2012
HB120912	Government official at the Science and Technology Department of Hebei Province	Hebei	12 Sep 2012
HB140912	Employee of Huide	Hebei	14 Sep 2012
BJ170912	Employee of Goldwind	Beijing	17 Sep 2012
BJ240912	Professor at the School of International Studies, Peking University	Beijing	24 Sep 2012
BJ111012	Former employee of Sinovel	Beijing	11 Oct 2012
BJ121012	Government official at the National Development and Reform Commission (NDRC)	Beijing	12 Oct 2012
BJ151012	Sinochem Industry Co.,Ltd	Beijing	15 Oct 2012
CA060813	Research fellow at the ANU	Canberra	06 Aug 2013
BJ171013	Former employee of CNNC	Beijing	17 Oct 2013
BJ251113	Manager of the China Wind Power Center	Beijing	25 Nov 2013

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