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Chinese infrastructure projects in advanced industries: The Atucha 3 nuclear power reactor in Argentina

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Abstract

Chinese participation in Argentina's Atucha 3 nuclear power project highlights substantial issues surrounding growing Chinese involvement in infrastructure and manufacturing projects that require high levels of capability in both advanced technologies and systems integration. Rapid Chinese progress in both areas points to the emergence of a two-tiered market for civilian nuclear power projects, with the Chinese alternative offering "good enough" levels of quality and safety, modest cost advantages compared with offerings from U.S., Japanese or Korean rivals, and, crucially, access to attractive financial terms offered by officially-backed Chinese lenders.

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Among Chinese infrastructure projects in Latin America and the Caribbean, the planned Atucha 3 nuclear power plant (NPP) project to be built in Argentina by the China National Nuclear Corporation (CNNC) presents several interesting features.

NPP construction involves a level of technological and managerial complexity, and a consequent economic and strategic significance, that put it in a class of its own. The NPP business is a complex, multi-technology endeavor that is capital-intensive and long-cycle. Successful design, fabrication and operation of nuclear power plants requires substantial expertise in systems integration, an amalgam of skills that evolve over time and with the accumulation of experience. Systems integration involves bringing together high-technology components, subsystems, software, skills, knowledge, engineers, managers, and technicians to produce complex products and services in competition with other suppliers.[1] The more complex, high technology, and costly the product, the more significant systems integration becomes to the firm's success.

Systems integration capabilities cluster in advanced economies, particularly in private companies (e.g. Toyota, Siemens, Westinghouse, Boeing, General Electric) and in public agencies (NASA) that specialize in extremely complex design and production processes. China and other "follower nations" typically have limited capacity in this area. Latecomer suppliers of complex capital goods face multiple barriers: poorly developed national systems of innovation, dislocation from international networks of suppliers and users, underdeveloped local supply chains, lack of experience in coordinating networks of suppliers, and lack of trust among industry actors.[2] Plan-era legacies represent a further potential obstacle. Brooks (2005) links Soviet decline to failures of systems integration: "design bureaus were poorly integrated with manufacturing plants, so they rarely considered the challenges of actually building their high-end products, and the rigidity of the plan often prevented simple substitution of components or materials…with equivalents (or even better inputs) from another domestic supplier."[3] China's planned economy displayed

[1] Hobday, M., Davies, A. & Prencipe, A. (2005). Systems integration: a core capability of the modern corporation. *Industrial and Corporate Change*, 14(6), 1109–1143.
[2] Kiamehr, M., Hobday, M., & Kermanshah, A. (2014). Latecomer systems integration capability in complex capital goods: the case of Iran's electricity generation systems. *Industrial and Corporate Change* 23(3): 689–716.
[3] Brooks, S. G. (2005). *Producing Security: Multinational Corporations, Globalization, and the Changing Calculus of Conflict*, Princeton University Press. Cited on p. 634 in Gholz, E. (2007). Globalization, Systems Integration, and the Future of Great Power War. *Security Studies*, *16*(4), 615–636.

similar shortcomings; Chinese experts continue to criticize the tendency of manufacturers to put quantity, speed and cost considerations ahead of quality control – an unfortunate legacy of the socialist past. Political rivalry and bureaucratic infighting among the (state-owned) firms and official agencies responsible for nuclear operations, as well as reports of capability gaps in IT, instrumentation and controls indicate that Chinese nuclear efforts may encounter similar difficulties.

With its growing mastery of complex products and rapid expansion of both domestic and transnational supply chains, however, China's recent development may have ameliorated these disadvantages. Since domestic demand is a key driver of capability creation,[4] China's prospects for developing expertise in systems integration seem unusually bright.

Overseas construction of NPPs is a relatively new activity for Chinese enterprises. China sees nuclear power as "a nexus of clean energy, economic incentives, and international prestige."[5] In 2014, the National Energy Administration director Wu Xinxiong outlined the Chinese goal of becoming a world leader in nuclear power[6]. This ambition has propelled a strong push to enter the world civil nuclear market. China's nuclear advance builds on an already strong international presence in conventional power systems and equipment. China's emergence as the world's largest producer and consumer of electric power and of power-related equipment, coupled with Beijing's "Go Outward" and "One Belt One Road" campaigns promoting overseas direct investment on the part of (especially state-controlled) Chinese companies, has prompted rapid expansion into global markets related to conventional electricity. Chinese engineering firms have become a major force in global markets. Annual exports of steam generating boilers, for example, exceeded US$1.5 billion throughout 2009-2013, years in which no other country's exports reached that figure; indeed, only South Korea's annual exports reached US$1 billion, and then only in 2011 and 2012.[7] Sinohydro has become "the world's dominant dam builder," apparently controlling "50 percent of the global market for hydropower contracts."[8] State Grid Corporation has major investments in Australia, Brazil, the Philippines and Portugal.

Following a lengthy period in which China's involvement in overseas nuclear operations was limited to Pakistan, China's nuclear export ambitions received a major boost from a flurry of activity in 2014. Multiple successes involving two of

[4] Kiamehr, Hobday & Kermanshah, 2014, *ibid*.
[5] The Diplomat, Oct 8, 2014. Why China will go all-in on Nuclear Power. http://thediplomat.com/2014/10/why-china-will-go-all-in-on-nuclear-power/ last accessed September 12, 2016
[6] South China Morning Post, Sept 14, 2014. China plans to be world leader in nuclear power by 2020. http://www.scmp.com/news/china/article/1591984/china-plans-be-world-leader-nuclear-power-2020 last accessed September 12, 2016
[7] Ueno, T., Yanagi, M. and Nakano, J. (2014). Quantifying Chinese public financing for foreign coal power plants. University of Tokyo Graduate School of Public Policy Discussion Paper GraSPP-DP-E-14-003, Figure 1
[8] Brosshard, P. (2014). China's global dam builder at a crossroads. The Asia-Pacific Journal: Japan Focus. 12.3, December 29. Accessed September 12, 2016.

China's three big nuclear operators represent a major breakthrough for China's efforts to penetrate global nuclear markets. Chinese participation in the U.K.'s Hinkley Point project is particularly important as an endorsement of Chinese nuclear capability. Contracts and ongoing negotiations in Argentina, Romania and Turkey constitute further evidence of global penetration. Ongoing discussions and cooperation agreements elsewhere, particularly South Africa, may lead to further international project agreements in the near future.

As these new agreements unfold, two developments on the home front promise to further expand China's international nuclear opportunities. Announcement of official certification for the Hualong (Dragon) 1 design jointly developed by China National Nuclear Corporation (CNNC) and rival firm China General Nuclear (CGN) creates a standardized technology platform that can now be offered to potential customers both within and beyond China's borders. At the same time, a unique joint venture seems likely to accelerate the rate at which components of China's domestic nuclear supply chain enter overseas markets. SNPTC-Westinghouse Nuclear Power Technical Services (Beijing) Company (SWSC), a joint venture between Westinghouse Electric and China's State Nuclear Power Technology Corporation, seeks to help Chinese nuclear suppliers obtain certification as international nuclear vendors serving Westinghouse and other international nuclear firms. This operation has the potential to generate multiple benefits. For Westinghouse, upgrading its domestic Chinese suppliers will improve the outcome of its China-based projects, and thus expand worldwide sales prospects for its AP1000 technology. Adding Chinese firms, which typically achieve low production costs, to its roster of qualified international suppliers will expand Westinghouse's procurement base while pressuring overseas suppliers to reduce costs.

China's recent economic slowdown, which has created massive excess capacity throughout China's energy sector, provides Chinese nuclear suppliers with powerful incentives to push into global markets. The presence of SWSC – a company explicitly designed to assist such efforts – coupled with the potential costs of failing to match efforts by close rivals to penetrate overseas markets – seems likely to push domestic nuclear suppliers to satisfy international requirements for quality and safety certification – the best possible outcome for assuring a supply of high-quality equipment to both domestic and overseas nuclear projects.

We see Chinese entry as a disruptive force in the global civil nuclear market. Taking advantage of lower costs and potential scale economies, China's entry might appear to be a low-end disruption from the viewpoints of the industry's incumbents. However, given the inherent complexity and global footprint of the nuclear supply chain, as well as rising wages and high internal transport costs, there may be limits to how much China can undercut incumbents. China's most potent business weapon might well be its ability to provide vendor financing to customer nations that might otherwise be unable to afford a nuclear power plant. Another factor will be political, i.e., a greater willingness to deal with nations that might have a difficult time getting U.S., French or Japanese authorities to allow their firms to acquire sensitive dual-use technologies. In combination, deep pockets and regulatory flexibility may well work to make China's reactors appealing to prior non-consumers such as emerging nations in Asia, Africa and South America.

For technologically complex and potentially dangerous products like large-scale passenger aircraft and nuclear power plants, we anticipate exceptionally narrow windows located at the upper extremity of the quality space.[9] Historically, the global market for nuclear power has behaved in this exact fashion. After absorbing and then developing their own adaptations of technology originally imported from the United States, French, Japanese and Korean firms have emerged as full-fledged global competitors, but only after lengthy periods of maturation during which their firms' skill and experience gradually came to match that of Westinghouse and other original innovators.

China's recent success in capturing overseas contracts, its accumulation of experience in erecting and operating the AP-1000 reactors that currently occupy the leading edge Generation III nuclear technology, and its growing capacity in nuclear design and equipment manufacture point to a surprising outcome: the emergence of a two-tiered market for nuclear power plants, with American, French and South Korean firms occupying the upper and Chinese (and possibly Russian) rivals populating the lower tier of a global price-quality ladder.

Although this differentiated (i.e., two-tiered) market remains in its infancy, the characteristics of the second, lower tier are already visible. They include (1) "good enough" levels of quality, longevity and durability, (2) low cost and (3) Chinese project financing. Chinese success in winning nuclear business (the UK Hinkley project) and in obtaining certification (AP-1000 start-up data accepted by the U.S. Nuclear Regulatory Commission; SWSC clients qualifying for international project participation) from national authorities in advanced countries with stringent safety requirements is crucial to China's overseas nuclear ambitions. For it is these accomplishments that will persuade decision-makers in countries like South Africa that China's nuclear companies can be trusted to build (and in some cases operate) nuclear installations with adequate levels of reliability.

Nuclear facilities embody multiple layers of safety systems – for example protection against a direct hit from a large-scale passenger aircraft – that are hugely expensive. If Chinese alternatives are perceived as safe and reliable, potential buyers, especially in low and middle-income countries, will enthusiastically welcome the cost advantages available from Chinese equipment-makers and construction specialists. Potential cost savings are substantial: equipment typically occupies 50 percent of nuclear project budgets.[10] A Chinese nuclear specialist indicated that, with the exception of materials-intensive devices, Chinese firms can typically undercut the

[9] Sutton, J. 1998. *Technology and market structure: theory and history.* Cambridge MA: MIT Press.
[10] http://www.shhdb.gov.cn/shhxw/654085.htm (in Chinese), last accessed Sept 12, 2016.

costs of international vendors of nuclear-related equipment by approximately one-third.[11]

Argentina is not a newcomer to NPPs, with three reactors operating since 1974, 1983 and 2014, as well as a local nuclear supply chain and a degree of local design expertise. About 1/10th of Argentina's electricity is generated from nuclear sources, but government plans call for boosting this to15-18%. Argentina's *Comisión Nacional de Energia Atomica* (CNEA) was established in 1950, although nuclear power efforts were launched only in 1964. A firm policy preference for natural uranium fuel (to save on uranium enrichment) predisposed Argentina to heavy water reactors, leading to the construction of German and Canadian reactors (Siemens and Candu designs, respectively). Argentine capability in this sector is evidenced by the following facts, among others.

- Candu Energy agreed to a technology transfer agreement, which has led to significant local capability.
- For the Siemens reactor Atucha 2, which was connected to the grid in 2014, local content is reported to be 90%.
- A local supply chain for Pressurized Heavy Water Reactors exists.
- A locally designed reactor prototype, CAREM-25, is under construction.

***China's role in the Atucha 3 project is primarily as a financier and supplier of equipment and services, with technology coming from Candu Energy (Canada) and with Nucleoelectrica Argentina SA (NASA) as the designer, architect-engineer, builder and operator*.** The daunting cost of nuclear facilities creates problems even for buyers in advanced countries. This gives a big advantage to vendors whose tenders incorporate offers of financial backing from their home governments. China's "Go Outward" and "One Belt One Road" policies include generous financial support for large-scale overseas infrastructure projects,[12] and also provide full payment for training and preliminary cooperative efforts that increase the prospects for future reactor sales. Financing can be crucial to buyer decisions: Japanese nuclear firms have warned Japan's government that their industry's viability is critically dependent upon Tokyo's willingness to finance overseas nuclear projects.[13]

A framework agreement provides for a second reactor (at Atucha or elsewhere), which may use the Hualong One design. A prior technology transfer agreement suggested that Argentina could act as a technology platform for Chinese nuclear design, supplying other Latin American nations with nuclear technology and services built around the Chinese design. In such a scenario, the Chinese NPP company model is seen as drawing closer to that of the system integrator and technology

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[11] Interview, May 2014. Interviews with western nuclear executives indicate that Chinese firms' limited capacity to "get it right the first time" may undercut this cost advantage**.**

[12] Ueno, Yanagi and Nakano (2014) discuss Chinese financing for exports of conventional power equipment.

[13] Interview with Japanese executive, May 2014.

licensor model more commonly associated with Western companies (e.g., Westinghouse).

Conclusion. Thus, Atucha 3 represents a radical departure from the Chinese default model of vertically integrated infrastructure projects with minimal local content (i.e., maximal Chinese content). Plans for Atucha 3 call for local content of 70%. A second reactor may employ a Chinese design (Hualong One), but will have 50-70% local content; in addition, 100% of the civil works will be Argentine. While such "industrial offsets" are not unusual in advanced industries like NPPs and aircraft, the managerial model of embracing and incorporating local content is new to Chinese export projects.[14] Successful implementation of this project, with its emphasis on integrating major contributions by both partners, may strengthen China's capacity to compete for overseas infrastructure business in a growing array of industries and venues.

[14] Metzler, F., & Steinfeld, E. S. (2013). Sustaining Global Competitiveness in the Provision of Complex Products and Systems. MIT Department of Political Science Working Paper.