Submission: 16754

Title:

Tensions Between Government, Industrial Innovation, and Energy Efficiency in China

Chair:

John Paul Helveston, Carnegie Mellon University

Presenters:

Valerie J. Karplus, Massachusetts Institute of Technology

Cao Jing, Tsinghua University

Michael Murphree, Georgia Institute of Technology

Dan Breznitz, University of Toronto

Jonas Nahm, Massachusetts Institute of Technology

John Paul Helveston, Carnegie Mellon University

Yimin Liu, Ford Motor Company

Elea McDonnell Feit, University of Pennsylvania

Erica R.H. Fuchs, Carnegie Mellon University

Erica Klampfl, Ford Motor Company

Jeremy Michalek, Carnegie Mellon University

Discussant:

Gary Herrigel, University of Chicago

Potential Sponsors:

IM: International Management
TIM: Technology & Innovation Management
BPS: Business Policy & Strategy

In recent years, the Chinese government, motivated by rapidly increasing energy demand and limited oil and natural gas reserves, has promoted policies for energy efficiency and research investments in new energy-saving technologies. At the same time, China has also become home to distinct forms of industrial innovation, which often occur downstream in technology commercialization and redefinition (Brandt & Thun, 2010; Breznitz & Murphee, 2011; Ernst & Naughton, 2008). Some evidence suggests that these two themes could be synergistic; that is, despite having less stringent requirements in WTO negotiations (WTO, 1979), developing nations like China that receive large amounts of foreign investment may be able to successfully reduce pollution while contributing to industrial innovation (Wheeler, 2001). Given this context, what are the implications of China's regulatory environment for local and multinational firms and their technology and innovation decisions? This symposium unpacks the tensions between China's governmental structure and policies, opportunities for industrial innovation by local and multinational firms, and the implications for energy efficiency and the environment.

Over the past three decades, China has emerged not only as an extraordinary global manufacturing powerhouse, but also as one of the world's largest consumers across many industries. In the automobile industry, for example, China leads the world in both vehicle manufacturing, with approximately one quarter of 2012 global production (OICA, 2013a), and new vehicle sales, a title held since surpassing U.S. sales in 2009 (OICA, 2013b). Such growth in demand and production is associated with unique forms of industrial innovation in China and concerns over energy consumption. Examining the role of the Chinese government in relation to both industrial innovation and energy efficiency reveals insights into the effectiveness of policies as well as the abilities of firms to innovate and meet both market and government goals. In addition, since China's economy is the largest and arguably the most open of any large

developing country (Branstettar & Lardy, 2006), incentives for innovation and energy efficiency in China are likely to influence global innovation incentives and trajectories.

The first two papers highlight differences in state and non-state entities in China and their implications for innovation and achieving energy savings. In the first paper, "Firm-level energy efficiency gains within China's industries: The role of ownership," Valerie Karplus and Cao Jing examine the understudied links between elements of reform in China (such as "gaizhi," or "transforming the system") and energy intensity reduction. By investigating the relationship between firm ownership and the determinants of electricity demand in China's industrial firms, the authors conclude that state and non-state firms are influenced by different mechanisms, (specifically price vs. non-price drivers) in achieving energy savings. In the second paper, "State and Market: Institutions of Technology Standardization in China," Michael Murphree and Dan Breznitz shed light on China's hybrid technology standardization system which combines the two major paths to standardization: a state-led approach emphasizing technology development in universities and government research and a market-led approach where standardization is largely carried out by R&D conducting enterprises. The authors use a brief case study of China's home networking standard to argue that this hybrid system is responsible for changing performance of Chinese attempts to develop new globally competitive technologies in high-risk, capital-intensive industries.

Whereas the first two papers examine tensions between state and non-state entities, the third paper focuses on tensions within the state itself, building on the literature of divergent policy objectives between China's central and local governments. In his paper, "Contradictory or complementary? Indigenous innovation and manufacturing policy in China's wind and solar sectors," Jonas Nahm argues that while central and local governments have had divergent goals

for renewable energy industries, they have actually been synergistic in the establishment of innovative capabilities in Chinese wind and solar firms. Based on 107 interviews in 43 Chinese wind and solar firms, the authors show how rather than preventing the establishment of innovative capabilities, local government policies have actually served to strengthen some of the weaknesses inherent in China's indigenous innovation policy framework. Chinese wind and solar firms have used local manufacturing resources to establish innovative manufacturing capabilities and follow global trends toward niche specialization and collaboration in product development. Interestingly, the success in these industries has also enabled firms to meet the central government goals for renewable energy production.

Finally, the fourth paper discusses tensions between China's national regulatory environment, local consumer preferences, and global innovation trajectories, with implications locally and globally for energy security and the environment. In their paper, "Will Subsidies Drive Electric Vehicle Adoption? Measuring Consumer Preferences in the U.S. and China," John Helveston et al. illustrate that while U.S. and Chinese subsidies for plug-in vehicles have similar structures, differences in consumer preferences lead to different technology adoption outcomes. Chinese consumers are willing to adopt battery electric vehicles (BEVs) at higher rates than low-range plug-in hybrid vehicles (PHEVs) relative to their respective gasoline counterparts, whereas American consumers prefer low-range PHEVs despite the subsidies. With the higher emissions associated with electricity generation in China, a transition to BEVs over PHEVs may reduce oil consumption at the expense of increased air pollution and greenhouse gas emissions (Ji et al., 2011). Thus, China's subsidy policies for plug-in vehicles are central in the tension between strategies for national oil security and global environmental damage. In addition, given the size

of China's vehicle market, demand from China could also increase global incentives for electric vehicle technology development, impacting innovation trajectories worldwide.

Combined, these four papers emphasize the importance of both state and market forces in influencing China's role in the global economy in terms of production, consumption, innovation, and the environment. While the papers individually highlight different issues, together they shed light on important mechanisms by which firms and government interact to spur innovation while seeking energy efficiency. In addition, the papers also illustrate how general goals, such as adopting energy-saving technologies, can be achieved despite seemingly conflicting government and market goals and incentives. Nonetheless, as the global distribution of manufacturing activities continues to shift to China, these tensions between government, innovation, and the environment are likely to also grow. For example, recent work in engineering has shown that moving the locus of manufacturing overseas, and in particular to developing countries, may result in a disincentive to local and global innovation, at least in the short- to medium- term (Fuchs et al., 2011; Fuchs & Kirchain, 2010). Leveraging his extensive background in in comparative political economy and alternative forms of governance in economic process and regulation throughout the developed and developing world, Gary Herrigel will discuss the four papers.

**References**

Brandt, L., & Thun, E. (2010). The Fight for the Middle: Upgrading, Competition, and Industrial Development in China. *World Development*, *38*(11), 1555–1574. doi:10.1016/j.worlddev.2010.05.003

Branstettar, L., & Lardy, N. (2006). China's Embrace of Globalization.

Breznitz, D., & Murphee, M. (2011). *Run of the red queen: Government, innovation, globalization and economic growth in China.* New Haven, CT: Yale University Press.

Ernst, D., & Naughton, B. (2008). China's emerging industrial economy: Insights from the IT industry. In C. A. McNally (Ed.), *China's emergent political economy*. New York, NY: Routledge.

Fuchs, E. R. H., Field, F. R., Roth, R., & Kirchain, R. E. (2011). Plastic cars in China? The significance of production location over markets for technology competitiveness in the United States versus the People's Republic of China. *International Journal of Production Economics*, *132*(1), 79–92. doi:10.1016/j.ijpe.2011.03.008

Fuchs, E. R. H., & Kirchain, R. E. (2010). Design for Location? The Impact of Manufacturing Offshore on Technology Competitiveness in the Optoelectronics Industry. *Management Science*, *56*(12), 2323–2349. doi:10.1287/mnsc.1100.1227

Huang, Y. (2008). *Capitalism with Chinese Characteristics: Entrepreneurship and the State*. New York, NY: Cambridge University Press.

Ji, S., Cherry, C. R., Bechle, M. J., Wu, Y., & Marshall, J. D. (2011). Electric vehicles in China: emissions and health impacts. *Environmental science & technology*, *46*(4), 2018–24. doi:10.1021/es202347q

OICA. (2013a). *World Motor Vehicle Production by Country and Type*. Retrieved from http://www.oica.net/category/production-statistics/

OICA. (2013b). *World Passenger Car Sales by Country*. Retrieved from http://oica.net/category/sales-statistics/

The World Bank. (2013). *Manufacturing value added (current US$) World Bank National Accounts Data and OECD National Accounts data files*. Retrieved from http://data.worldbank.org/indicator/NV.IND.MANF.CD?page=4

Wheeler, D. (2001). Racing to the Bottom? Foreign Investment and Air Pollution in Developing Countries. *Journal of Environment & Development*, *10*(3), 225 – 245.

WTO. Differential and more favourable treatment reciprocity and fuller participation of developing countries (1979). Retrieved from http://www.wto.org/english/docs_e/legal_e/enabling_e.pdf

**Explanation of why this symposium should be of interest to each of the specified sponsors**

International Management

This symposium unpacks the tensions between China's governmental structure and policies, opportunities for industrial innovation by local and multinational firms, and the implications for energy efficiency and the environment. As China continues to liberalize it's economy while seeking energy efficiency, these tensions will become increasingly prevalent for both local and multinational firms in China. In addition, as the leading receiver of foreign direct investment (FDI) among developing nations, the tensions examined in this symposium will likely have consequences for firms worldwide.

Technology & Innovation Management

Today, China's Manufacturing Value Added approximately matches that of the U.S., both in absolute and in percentage terms (The World Bank, 2013). In addition, as the largest and most open economy of any large developing country, the incentives for innovation and energy efficiency in China are likely to influence global innovation incentives and trajectories. In this environment, both state and non-state actors exert significant influence in firm and individual technology adoption decisions. This symposium unpacks multiple dimensions of tension surrounding technology and innovation decisions in China, including state versus non-state forces, central versus local government forces, and goals for national security versus environment protection.

## Business Policy & Strategy

Over the past few decades, China's economic strategy has transformed from primarily state-owned and managed industry to private ownership and financial liberalization (Huang, 2008). As a result, China has emerged as a major global producer, consumer, and center for unique, downstream industrial innovation. Today, given China's position in the world as the largest and most open economy of any large developing country, the incentives for innovation and energy efficiency in China are likely to influence global innovation incentives and trajectories. In this environment, both state and non-state actors exert significant influence in firm and individual technology adoption decisions. This symposium unpacks multiple tensions that arise in the modern Chinese political environment surrounding technology and innovation decisions in China, including state versus non-state forces, central versus local government forces, and goals for national security versus environment protection.

**Firm-level energy efficiency gains within China's industries: The role of ownership**

Valerie J. Karplus
Massachusetts Institute of Technology, Sloan School of Management,
and MIT Joint Program on the Science and Policy of Global Change

Cao Jing
Tsinghua University, School of Economics and Management

China's energy demand and emissions of carbon dioxide ($CO_2$) are the highest in the world, with industrial activity responsible for over 70% of national totals. Firms in China's industrial sector rely heavily on coal-fired electric power and direct coal use, with severe adverse impacts on the environment and human health (World Bank and China SEPA, 2007; Matus et al., 2012). Many industries in China have high energy intensities relative to their counterparts abroad, consistent with observations of a broader productivity gap (Hsieh and Klenow, 2009). Raising efficiency and curbing emissions increases—across the economy as a whole and in the industrial sector in particular—rank among the nation's top energy policy priorities. Electricity price liberalization and emissions pricing are widely viewed as potentially effective policy approaches. There is a need to understand better the responses that price and policy changes galvanize within firms, how these responses in turn shape forthcoming policy decisions, and the broader consequences for economic development, competitiveness, and sustainability. This paper focuses on the first of these tasks, focusing on the role of firm ownership.

This inquiry is important given that the ownership structure of China's industrial enterprises has been in a state of transformation since the late 1970s. Reforms changed the country's formerly ubiquitous state-owned enterprises through a combination of public offerings, internal restructuring, bankruptcy and reorganization, and other means, a process often referred to as *gaizhi* (改制 or "transforming the system"). Today's economic landscape is comprised of a

mix of firm types that vary in form and relationship to the state. The extent to which the *gaizhi* process resulted in productivity gains is a topic of active investigation. Shleifer and Vishny (1994) point out that such large-scale transformation is shaped as much by political priorities as by economic ones. Oi (2005) discusses the dynamics of this process in China, providing evidence it has been shaped by a desire to maintain employment, minimize government losses, and otherwise preserve social stability.

In parallel with ongoing reforms and the process of *gaizhi*, energy intensity in China has consistently fallen since the beginning of the reform period in 1978, with the exception of a short-lived increase in the mid-2000s.[1] China's national policy targets reductions in energy intensity to manage rising fossil energy use and its adverse environmental impacts. A large body of scholarship has focused on explaining the reductions in national energy intensity over different periods since 1978 (Lin and Polenske, 1995; Garbaccio et al., 1999; Fisher-Vanden et al., 2004; Fisher-Vanden et al., 2006; Crompton and Wu, 2005; Liao et al., 2007; Ma and Stern, 2008; Ma et al., 2009). Energy intensity masks the influences of economic structural change and underlying energy efficiency, effects that scholars have tried to disentangle (see for example Sinton and Levine, 1994; Zhang, 2003). Inefficient use of energy and other inputs has been well documented during the existence of the Soviet Union and other centrally-planned economies (Cooper and Schipper, 1992; Cornillie and Fankhauser, 2004). Post-transition economies realized reductions in energy intensity in parallel with changes in the structure of their economies. While the decline in China's energy intensity since 1978 no doubt mirrors a similar process underway in China, the link between elements of reforms and energy intensity reduction has been less well studied.

[1] Energy intensity at the national level is calculated as the sum of all energy used by firms and households divided by the value of real economic output.

Against this backdrop, this analysis investigates the relationship between ownership—and the roles, pressures, and opportunities it implies—and the determinants of electricity demand in China's industrial firms. Using a new data set representing a cross section of industries in mainland China during a period of intensified pressure to reduce energy intensity (the Eleventh Five-Year Plan, 2006 to 2010) this analysis asks whether the dynamics of firm-level electricity demand differ systematically in state and non-state firms. The focus is on distinguishing the relative contribution of two channels that lead to energy savings: price and non-price drivers (e.g. mandates, technology, or other influences). Multiple specifications of an input demand function for electricity are estimated to quantify the impacts of prices of electricity, capital, and labor, the scale of output, firm ownership, and exogenous (non-price mediated) technological changes. Electricity price responses are found to differ significantly across ownership types. We find evidence that electricity use in private, stock-limited, and joint venture firms strongly responds to prices, while efficiency in state firms seems to be mediated instead through non-price channels, consistent with a stronger influence of regulatory mandates, state subsides, and performance evaluations. We test the robustness of this result by comparing firms of different ownership within the same or similar industries. Qualitative survey results help to contextualize observed firm behavior. Interestingly, in addition to privately-owned firms—which might be expected to be most market responsive—firms belonging to the stock-limited category (many of which were formerly part of state-owned enterprises) show a significantly larger price response than state-owned firms. Understanding the origins of this inefficiency is critical to identifying correctly the targets and potential impacts of future reform and energy policy initiatives.

**References:**


Cooper, R.C. and Schipper, L. (1992). The efficiency of energy use in the USSR —an international perspective. *Energy*. *17*(1), 1-24.

Cornillie, J. and Fankhauser, S. (2004). The energy intensity of transition countries. *Energy Economics*, *26,* 283-295.

*Crompton, P.* and *Wu,* Y. (*2005).* Energy Consumption in China: Past Trends and Future Directions, Energy Economics *27*(1), 195-208.

Hsieh, C.-T. and Klenow, P.J. (2009). Misallocation and manufacturing TFP in China and India. *The Quarterly Journal of Economics*, *124*(4), 1403-1448.

Liao, H., Fan, Y., and Wei, Y.-M. (2007). What induced China's energy intensity to fluctuate: 1997–2006? *Energy Policy*, *35*, 4640-4649.

*Lin,* X. and Polenske, K.R. *1995.* Input-Output Anatomy of China's Energy-Use. Changes in the 1980s. *Economic Systems Research*, *7* (1): 67-84.

Garbaccio, R.F., Ho, M.S., and Jorgenson, D.W., (1999). Why has the energy-output ratio fallen in China? *Energy Journal*, *20*(3), 63-91.

Fisher-Vanden, K., Jefferson, G.H., Liu, H., and Tao, Q. (2004). What is driving China's decline in energy intensity? *Resource and Energy Economics. 26*(1), 77-97.

Fisher-Vanden, K., Jefferson, G.H., Ma, J., and Xu, J. (2006). Technology development and energy productivity in China. *Energy Economics*, *28*(5-6), 690-705.

Ma, C. and Stern, D.I., (2008). China's changing energy intensity trend: a decomposition analysis. *Energy Economics*, *30*, 1037-1053.

Ma, H., Oxley, L., and Gibson, J., (2009). Substitution possibilities and determinants of energy intensity for China, *Energy Policy*, *37*, 1793-1804.

Matus, K., Nam, K. M., Selin, N. E., Lamsal, L. N., Reilly, J. M., and Paltsev, S. (2012). Health damages from air pollution in China. *Global Environmental Change: Human and Policy Dimensions*, *22*(1), 55-66.

Oi, J. 2005. Patterns of Corporate Restructuring in China: Political Constraints on Privatization. *The China Journal*, *53*, 115-137.

Schleifer, A. and Vishny, R.W. (1994). Politicians and firms. *The Quarterly Journal of Economics*, *109*(4), 995-1025.

Sinton, J.E. and Levine, M.D., (1994). Changing energy intensity in Chinese industry. *Energy Policy*. *17*, 239-255.

World Bank and China SEPA (State Environmental Protection Administration of China). (2007). Cost of pollution in China: Economic estimates of physical damages. Washington, DC: The World Bank.

Zhang, Z.X. (2003). Why did the energy intensity fall in China's industrial sector in the 1990s? The relative importance of structural change and intensity change. *Energy Economics*. 25(6), 625-638.

**State and Market: Institutions of Technology Standardization in China**

Michael Murphree
Georgia Institute of Technology

Dan Breznitz
University of Toronto

Technology standards have become a central pillar of China's technology innovation and economic upgrading strategy. Since at least the mid-1990s, the Ministry of Industry and Information Technology (MIIT), and the Ministry of Science and Technology (MoST) have been active in their promotion of unique, indigenously developed standards. The hope is to develop globally competitive alternatives to foreign-developed technologies or at a minimum to improve the innovation capabilities and profitability of Chinese firms through reduced payments of licensing fees for proprietary technologies embedded in existing standards.

China's technology standardization drive has led to the creation of hundreds of thousands of standards since the 1990s. As in most countries, a significant portion of the standards are essentially or entirely identical to established international or foreign-developed standards. Indeed the vast majority of standards adopted and implemented in China are non-controversial. However, a special subset of technology standards – those for information technology hardware and electronics – has raised concerns and international interest over the last two decades. In these industries – where China's production and innovation capabilities are arguably the greatest, China has attempted to establish new, unique alternatives to internationally established technologies. This research symposium paper briefly explores one of these standards: the IGRS home networking standard. IGRS has been strongly promoted by the government, specifically MIIT, yet its development has differed from the heavily state-led path of earlier and more well-

known standards such as TD-SCDMA and WAPI. IGRS suggests the hybrid path likely for future standardization in China.

China's technology standards system has become a hybrid of the two traditional approaches to standardization. Research since the 1980s typically argues that standards are developed either through state-led or market-led processes (Besen and Johnson 1986). In the state-led option, typified by the approach common in Europe – and France in particular – a government ministry or ministries decides upon which industrial sectors needs standardization, selects the likely technology to use and through state power ensures that other government units and private industry support the standardization effort (Besen 1990; Brenton 1990). This approach can be highly efficient and coordinated, as was the case in the French development of the SECAM color television standard, but is also susceptible to being backward-looking and technologically inferior as ministry bureaucrats are often ill-prepared to select cutting-edge technologies (Crane 1979). The state-led approach also needs an unequivocal commitment from the government to support the standard, to the exclusion of alternatives, in order to ensure industry support. The market-led approach, by contrast, is led by private industry actors – usually firms – rather than state bodies (Russel 2009). Here firms either independently or in ad hoc consortia develop technologies and assert them as potential standards. By market processes, alternative technologies are pushed out and a standard is established, frequently earning monopoly rents for the developing firm(s).

The Chinese standardization system blends these two approaches. Legally, China's technology standards are state-led (Wang, Wang et al. 2009). The 1989 Standardization Law, which remains the legal basis for standardization activities of all types including technology standards, mandates that only a body under the State Council (China's equivalent of a cabinet of

ministers) has the authority to lead standardization, or to create standards (NPCPRC 1989). At the same time, the law also recognizes four distinct tiers of standardization: national, industry, regional and enterprise. Where there is conflict between standards, the higher standard (industry over regional for example) will supplant the lower standard. At all levels except for enterprise, however, the government – whether the State Council body (for national standards) an industrial ministry (for industry standards) or a provincial or city government (for regional standards) is responsible for the initiation, funding, and approval of standards. This system heavily draws on the heritage of the planned economy where government dictate determined the direction of industrial activities including new technology development, implementation and adoption (Breznitz and Murphree 2013).

Over the past thirty years, however, China's economy has become increasingly market-based. As in the US system, large firms have gained increasing power and influence, and are less inclined to support state-direction, particularly in technology development where firms increasingly feely the state selects uncompetitive or politically motivated technologies, as opposed to those mostly likely to yield economic success for firms. To that end, firms have increasingly sought alternatives to the state-led approach to standardization. This has manifested itself in Chinese firms' increasing participation in international standards bodies such as those under the IEEE and W3P, as well as in attempts to create industry consortia which develop technologies. These efforts within China, however, remain constrained by the legal need for official state leadership and sanction for standardization to take place.

This hybrid system determines how Chinese standards are developed and their relative ability to then succeed in domestic and global markets. The ever present influence of the state means that firms still seek state approval and sanction for standards efforts. In most cases, firms

will not begin standards development unless the state has first indicated that it supports standardization in a given industrial sector. Interviewees in China noted that unless a government effort encourages a given standardization activity, most firms will not take the initiative to develop a standard, even where it may make industrial or technological sense to do so. However, even where the state has indicated that standardization is desired, there is never an unequivocal move to support the standard to the exclusion of alternatives. As a result, firms' participation in standardization is often tepid. A few leading firms assume responsibility for the development of the standard, thus limiting the potential benefits from more broad-based participation. The impact of this hybrid system can be briefly illustrated in the IGRS home networking standard.

Development of the home networking standard, IGRS, began in the early 2000s. Unlike other standardization efforts in China, the initial impetus came from industry – specifically China's largest information technology hardware companies including Lenovo. The initial group's leadership was drawn heavily from Lenovo and many firms saw the IGRS development project as effectively a Lenovo initiative. Fear of collaborating with a competitor discouraged participation. In 2003, in accordance with China's legally statist standardization system, the alliance received a formal working group designation from the central government, specifically from MIIT. While state endorsement and creation of a legal non-corporate development entity should have facilitated development, China's hybrid system posed a problem for the standard. The government-sponsored working group required all prospective participants to sign a full technology disclosure agreement. As Lenovo still dominated the alliance, many firms balked at disclosing their technology to a competitor. Rather than seek a state solution to the impasse – which would likely have driven even more firms from active participation (as happened in the TD-SCDMA mobile telephony standard), however, IGRS decided to self-incorporate and thus

fully separate itself from Lenovo's legal corporate structure. In accordance with China's standardization system, the working group remains formally under the supervision of MIIT but the independent IGRS corporate entity is responsible for commercialization and popularization of the standard. Since splitting off from Lenovo, membership in IGRS increased from 60 to 170 members. In this way, the group has become better able to attract broader support. The group continues to operate within China's legal system by remaining a working group under a government ministry but its internal direction is determined by a Core Committee made up of leaving technology contributors – all firms. This makes IGRS very different from other working groups in China which are usually dominated by university and government research institutions.

China's hybrid system today makes it possible to capitalize on the strengths of both the market-led and state-led standardization systems. Neither system is perfect. Both have lists of successes and failures worldwide. In China, the developing standards system seeks to maximize the leadership and stability benefits of state leadership while also harnessing the dynamism and market rationality of standards development by firms. Future development of technology standards and their potential success will hinge on whether or not the hybrid system is able to achieve these simultaneous advantages.

**References:**

Besen, S. M. (1990). "The European Telecommunication Standards Institute: A Preliminary Analysis." Telecommunications Policy 14(4): 521-530.

Besen, S. M. and L. L. Johnson (1986). Compatibility Standards, Competition, and Innovation in the Broadcasting Industry. Santa Monica, CA, RAND Publishing.

Brenton, M. E. (1990). The Role of ETSI in IT Standardization. An Analysis of the Information Technology Standardization Process. J. L. Berg and H. Schummy. New York, Elsevier Science Publishing Company: 49-52.

Breznitz, D. and M. Murphree (2013). The Rise of China in Technology Standards: New Norms in Old Institutions. Washington, DC, US-China Economic and Security Review Commission.

Crane, R. J. (1979). The Politics of International Standards: France and the Color TV War. Norwood, NJ, ABLEX Publishing Corporation.

NPCPRC (1989). Standardization Law of the People's Republic of China. National People's Congress. Beijing.

Russel, A. L. (2009). "Industrial Legislatures: Consensus Standardization in the Second and Third Industrial Revolutions." Enterprise and Society 10(4): 661-674.

Wang, P., Y. Wang, et al. (2009). Zhongguo De Biaozhun Zhanlue - Chengjiu Yu Tiaozhan. CS09, National Bureau of Asian Research.

**Contradictory or complementary? Indigenous innovation and manufacturing policy in China's wind and solar sectors**

Jonas Nahm
Massachusetts Institute of Technology

Literatures on Chinese politics have long documented divergent policy objectives between China's central and local governments, for instance in the implementation of labor laws and environmental regulation (Lee 2007; Mertha 2008; O'Brien and Li 2006), but also in the area of industrial policy (Heilmann et al. 2013; Huang 2002; Kostka and Hobbs 2012; Thun 2006). Such center-local divergence has frequently led to policy inefficacy, most commonly when local governments have failed to enforce central-level legislation.

In the support of renewable energy industries, central and local governments have pursued similarly divergent goals, as central government policies have encouraged industrial upgrading through 'indigenous innovation' (Liu and Cheng 2011; OECD 2008), while local governments have continued to provide incentives and policy support for traditional manufacturing activities (Bradsher 2010; Haley and Haley 2013). In this environment, China's wind and solar firms have often shunned central government requirements for autonomous technology development, drawing instead on local government resources for mass production. To date, China's wind and solar firms continue to rely on global partners in the development of renewable energy products, even as China has become an important location for the commercialization of new wind turbine and solar panel technologies (Nahm and Steinfeld 2014). Has local government support for the manufacturing economy undermined the central government's indigenous innovation strategy for renewable energy sectors?

This paper argues that local manufacturing policies have not prevented the establishment of innovative capabilities in Chinese wind and solar firms. Rather, local government policies

have provided an important corrective to some of the weaknesses inherent in China's indigenous innovation policy framework, most importantly its inattention to the collaborative nature of innovation in contemporary supply chains and the importance of innovative manufacturing capabilities in product development. Based on 107 interviews in 43 Chinese wind and solar firms, I find that China's wind and solar firms have build on local government resources for manufacturing to establish highly innovative capabilities in mass production. I show that the globalization of production over the past two decades has dispersed innovative capabilities required to bring a product to market across a wide range of firms in global supply chains, including manufacturing firms in middle-income economies such as China. Few firms now possess all the capabilities necessary for product development and commercialization, relying instead on collaboration with others. By utilizing local manufacturing resources to establish innovative manufacturing capabilities, Chinese wind and solar firms have not defied upgrading and innovation, but have followed global trends toward niche specialization and collaboration in product development.

These findings suggest that local government policies to support the manufacturing economy are not in conflict with central government goals for upgrading and innovation. Resources for manufacturing firms provided by local governments have enabled new options for the establishment of innovative capabilities in manufacturing itself -- options which have been neglected by the narrow conceptualization of innovation underlying the central government's indigenous innovation framework.

**References:**


Bradsher, K. (2010). On Clean Energy, China Skirts Rules, New York Times, September 8.

Haley, U. and G. Haley (2013). Subsidies to Chinese Industry: State Capitalism, Business Strategy, and Trade Policy. Oxford, Oxford University Press.

Heilmann, S., et al. (2013). "National Planning and Local Technology Zones: Experimental Governance in China's Torch Programme." The China Quarterly 216: 896-919.

Huang, Y. (2002). "Between two coordination failures: automotive industrial policy in China with a comparison to Korea." Review of International Political Economy 9(3): 538-573.

Kostka, G. and W. Hobbs (2012). "Local Energy Efficiency Policy Implementation in China: Bridging the Gap between National Priorities and Local Interests." The China Quarterly 211: 765-785.

Lee, C. K. (2007). Against the law: labor protests in China's rustbelt and sunbelt. Berkeley CA, University of California Press.

Liu, X. and P. Cheng (2011). Is China's Indigenous Innovation Strategy Compatible with Globalization? Policy Studies. Honululu, East-West Center. 61.

Mertha, A. C. (2008). China's Water Warriors: Citizen Action and Policy Change. Ithaca NY, Cornell University Press.

Nahm, J. and E. S. Steinfeld (2014). "Scale-up Nation: China's Specialization in Innovative Manufacturing." World Development 54(0): 288-300.

O'Brien, K. J. and L. Li (2006). Rightful Resistance in Rural China. Cambridge Cambridge University Press.

OECD (2008). OECD Reviews of Innovation Policy: China. Paris, OECD Publications.

Thun, E. (2006). Changing Lanes in China - Foreign Direct Investment, Local Governments, and Auto Sector Development. Cambridge, Cambridge University Press.

**Will Subsidies Drive Electric Vehicle Adoption?**
**Measuring Consumer Preferences in the U.S. and China**

*John Paul Helveston[a], Yimin Liu[b], Elea McDonnell Feit[c], Erica Fuchs[a], Erica Klampfl[b], Jeremy Michalek[a,d]*

*a) Department of Engineering and Public Policy, Carnegie Mellon University*
*b) Ford Motor Company*
*c) Wharton Customer Analytics Initiative, The Wharton School, University of Pennsylvania*
*d) Department of Mechanical Engineering*

Motor vehicles consume one third of all oil used globally, two thirds of oil used in the U.S., and half of oil used in China (Davis et al., 2013), (Ma et al., 2012). Together, China and the U.S. consume approximately one third of all oil consumed globally each year (U.S. EIA, 2012). Passenger cars in both countries are also responsible for large portions of annual greenhouse gas (GHG) emissions as well as other harmful pollutants such as CO, NOx, and VOCs (U.S. EIA, 2011), (Lang et al., 2013). In addition, while vehicle ownership rates within developed countries are nearly static, China's has grown at an average annual growth rate of 29% over the past two and a half decades (CATARC, 2009). This growth path should not be expected to stop soon. Currently, with 20% of the world's population, China has just 60 vehicles per thousand people, compared to 800 vehicles per thousand people in the U.S. (National Bureau of Statistics of China, 2012) (U.S. FHWA, 2012).

In an effort to reduce some of the harmful impacts from passenger cars, both the U.S. and Chinese governments have promoted the use of energy-efficient and alternative-energy vehicles. In particular, both offer federal subsidies for plug-in electric vehicles, which increase proportionally with the vehicle's battery capacity from a baseline up to a maximum of $7,500 in the U.S. and $9,400 in China (Congress, 2009), (Scott, 2010). In this study, we model consumer preferences for conventional, hybrid electric (HEV), plug-in hybrid electric (PHEV), and battery

electric (BEV) vehicle technologies in China and the U.S. leveraging survey data from simulated market choice scenarios (stated preference data) and actual market purchase data (revealed preference data). Since data in China is traditionally poor (Huang, 2008), we collected the stated preference data ourselves by applying choice-based conjoint analysis to design and field equivalent controlled survey experiments in China and the U.S. during the summer of 2012 and spring of 2013. We supplement this unique dataset with actual sales data on the individual-level in the U.S. and at the aggregate level in China. The individual-level U.S. data is from a large, nation-wide survey of new car buyers collected by Maritz that includes detailed information on consumers, the vehicles they purchased, and the vehicles they were considering purchasing. The aggregate data in both China and the U.S. comes from Polk. We use the combination of these datasets to estimate several random utility discrete choice models (Train, 2009), building on previous methods (Feit, Beltramo, & Feinberg, 2010).

Using the two data sources allows us to gain the advantages of both while mitigating their individual limitations. In addition,. The past purchase data has the advantage of measuring actual purchases in real market conditions; however, such data lacks information about responses to vehicle profiles not yet on the market, the modeler lacks information about many of the factors that affected the choice but were not recorded as data, and model estimation requires a number of assumptions that are difficult to validate. Using simulated choice sets in a conjoint survey has many advantages: hypothetical new products can be included, multiple observations can be made for each respondent, the set of alternatives under consideration and their attributes are fully known, and multicolinearities can be avoided . The main disadvantage of simulated choice is that people may choose differently in a hypothetical, rather than an actual vehicle purchase scenario.

We use both methods to compare, to mitigate the limitations of each approach, and to assess uncertainty.

We find that with the combined bundle of attributes offered by vehicles available today, mainstream consumers prefer gasoline models over their plug-in counterparts. In the U.S., low-range PHEVs compete more strongly than BEVs against their respective gasoline counterparts, whereas in China they are comparable. Notably, American respondents have significantly lower relative willingness to pay for BEV technology than Chinese respondents. While U.S. and Chinese subsidies are similar, favoring vehicles with larger battery packs, differences in consumer preferences lead to different outcomes: Our results suggest that with subsidies in place, Chinese consumers are willing to adopt BEVs at higher rates than low-range PHEVs relative to their respective gasoline counterparts, whereas American consumers prefer low-range PHEVs despite the subsidies. This implies potential for earlier BEV adoption in China, given adequate supply.

These results highlight tensions between China's national regulatory environment, local consumer preferences, and global innovation trajectories, with implications locally and globally for energy security and the environment. With the higher emissions associated with electricity generation in China, a transition to BEVs may reduce oil consumption at the expense of increased air pollution and greenhouse gas emissions. In addition, given the size of China's vehicle market, demand from China could also increase global incentives for electric vehicle technology development, impacting innovation trajectories worldwide.

**References:**


CATARC. (2009). China Automotive Technology and Research Center (CATARC) Automotive Industry Yearbook.

Congress, U. S. American Recovery and Reinvestment Act of 2009 (2009).

Davis, S. C., Diegel, S. W., & Boundy, R. G. (2013). Transportation Energy Data Book (32nd ed.). Oak Ridge National Laboratory.

Feit, E. M., Beltramo, M. A., & Feinberg, F. M. (2010). Reality Check: Combining Choice Experiments with Market Data to Estimate the Importance of Product Attributes. Management Science, 56(5), 785–800. doi:10.1287/mnsc.1090.1136

Huang, Y. (2008). Capitalism with Chinese Characteristics: Entrepreneurship and the State. New York, NY: Cambridge University Press.

Lang, J., Cheng, S., Zhou, Y., Zhao, B., Wang, H., & Zhang, S. (2013). Energy and Environmental Implications of Hybrid and Electric Vehicles in China. Energies, 6(5), 2663–2685. doi:10.3390/en6052663

Ma, L., Fu, F., Li, Z., & Liu, P. (2012). Oil development in China: Current status and future trends. Energy Policy, 45, 43–53. doi:10.1016/j.enpol.2012.01.023

National Bureau of Statistics of China. (2012). China Statistical Yearbook 2012. Beijing, China: China Statistics Press.

Scott, D. (2010, June 1). China Announces Plan to Subsidize EVs and Plug-in Hybrids in Five Major Cities. Edmunds.

Train, K. E. (2009). Discrete Choice Methods with Simulation (2nd ed.). Cambridge University Press.

U.S. EIA. (2011). Annual Energy Review 2011. Washington, D.C.

U.S. EIA. (2012). U.S. Energy Information Administration, International Energy Statistics. Retrieved from http://www.eia.gov/countries/data.cfm

U.S. FHWA. (2012). Licensed Drivers, Vehicle Registrations, and Resident Population.