



THE FLETCHER
SCHOOL

TUFTS UNIVERSITY

Barriers and incentives for the cross-border transfer of clean technologies

Kelly Sims Gallagher
Associate Professor of Energy and Environmental Policy
The Fletcher School
November 17, 2011

Acknowledgments & Caveat

- Based on forthcoming book, *No Great Wall: The Globalization of Cleaner Energy Technologies*, provisionally accepted by The MIT Press. To be published late 2012/early 2013.
- Book is still in progress! Not final, feedback welcome.
- Research support was provided by The William and Flora Hewlett Foundation, BP Group, The Fletcher School, and Marc Garnick and Bobbi Kates-Garnick.
- Special thanks to Professors Xue Lan and Su Jun at Tsinghua University for hosting me there while I did field research in China, the American Academy of Berlin for hosting me while I did research in Germany, and the American Academy of Arts and Sciences for providing space for me to write the book.

Barriers and Incentives Examined

- In this book, I focus on four main types of barriers and incentives.
- There are two sides to each coin.
- The four barriers/incentives are:
 - Policy factors
 - Cost and finance factors
 - Intellectual property (IP) factors
 - Business practice factors

Mechanisms

| Typology of Mechanisms for the Cross-Border of Technology | |
|---|---|
| Mechanism | Variation(s) |
| Exports or imports of equipment or other physical, embodied technologies | Could include contracts with foreign providers for installation and/or operation of technology |
| Licenses | |
| Purchase of a foreign firm to acquire technology (M&A) | Could be a merger with a foreign firm |
| International strategic alliances or joint ventures | Can be formalized as joint venture |
| Foreign direct investment to invest in or purchase a domestic firm, or to establish a new wholly-owned firm in foreign country | Could be wholly-owned, or a joint venture with contract provisions related to transfer of technology to the JV |
| Migration of people | Could be entrepreneur, financier, consultant, or a formal full-time employee who has worked or been educated in another country |
| Contract with a foreign research entity where IP is to be shared or wholly owned by the investor | Could be a contract with a university lab, a government lab, or a for-profit firm |
| Collaborative R&D | Research partnerships with foreign entities with shared IP arrangements |
| Open sources | Including exhibitions, conferences, books, papers, patent documents |
| Bi- or multi-lateral technology agreements among governments | Could include private participation, may include support for capacity-building or “tied aid” |
| Source: Gallagher, K.S. <i>No Great Wall: The Globalization of Cleaner Energy Technologies</i> , The MIT Press, forthcoming 2012/2013. Sources for table: Mowrey and Oxley 1997; Lanjouw and Mody 1996; Gallagher 2006; Barton 2007; Lewis 2007; Odagiri et al. 2010, Lema and Lema 2010. | |

China as a laboratory

- Fair or not, China is the country currently that industrialized countries are most scared of in terms of IP infringement China has argued it lacks access to key energy technologies
- China has a large quantity of energy firms that have used every conceivable strategy for developing and/or acquiring technology
- Chinese policy for clean energy evolving rapidly
- China is fastest-growing large economy, 2nd in world
- China is fastest-growing major energy consumer, 1st in world
- China is projected by the IEA to be the largest energy market for the next two decades



Four Telling Tales

- Solar PV
- Coal gasification
- Natural gas turbines
- Batteries for advanced vehicles (EV, HEV)



Chinese vs. Foreign Perspectives

| Barriers to the International Transfer of Cleaner Energy Technologies To and From China | | | | | |
|---|---|--------------|---------------------------------|----------|-------------------|
| | | Gas Turbines | Advanced Batteries for Vehicles | Solar PV | Coal Gasification |
| Policy factors | Export controls | C | | | |
| | Import tariffs | | F,C | C | |
| | Restriction of access to domestic market | | F | F | |
| | Weak innovation policy | C | C | C | |
| | Weak industrial policy | C | C* | | C |
| | Weak market-formation policy | C | F,C* | F,C* | C |
| Cost & finance factors | Weak export promotion policy | | F | F | |
| | Access to finance/ability to invest | C | F | F | |
| | Lack of "natural" market | F,C | F,C | F,C | F,C |
| IP factors | High cost of foreign technology | C | C | | C |
| | Export prohibitions in license agreements | C | C | | ? |
| | Defensive, anti-competitive patenting | C | C | | ? |
| | Fear of IP infringement | F | F | F | C |
| | Refusal by foreign firms to license | C | C | C | |
| Business practice factors | Lack of experience in foreign markets | C | | | |
| | Weak IP management | | | | |
| | High risk aversion | F,C | | | |
| | Poor after-sales service | | | | F,C some |

Source: Gallagher, K.S. *No Great Wall: The Globalization of Cleaner Energy Technologies*, The MIT Press, forthcoming 2012/2013.
 Notes: Author analysis, based on case study research. "C" (in yellow) is Chinese point of view. "F" (in blue) is foreign point of view. "F,C" (in green) denotes agreement between foreign and Chinese perspectives. A question mark (?) denotes a lack of data, where as lack of an entry means that the barrier does not clearly apply in this case.
 *Before new policies announced during the 12th Five Year Plan in China

| Incentives for the International Transfer of Cleaner Energy Technologies to and from China | | | | | |
|--|---|--------------|---------------------------------|----------|-------------------|
| | | Gas Turbines | Advanced Batteries for Vehicles | Solar PV | Coal Gasification |
| Policy factors | Clear targets historically, long term policy | | C,F* | C,F* | |
| | Lack of barriers to trade and FDI | | F | C,F | C,F |
| | Strong innovation policy | | C,F | | C,F |
| | Strategic industrial policy | | C,F* | C,F* | |
| | Stable market-formation policy | | C,F* | C,F* | |
| | Strong export promotion policy | | | C,F | |
| | Alignment of all types of policy | | C,F | | |
| | Good access to finance | | C | C,F | ? |
| Cost & finance factors | Natural market exists | n/a | | | C |
| | Ability to buy technology if needed | | C,F | C,F | C,F |
| | Costs of foreign or Chinese technology reasonable | F | F | C,F | F |
| | Strong or improving patent regime domestically | C,F | C,F | C,F | C,F |
| IP factors | Confidence in domestic courts | some F | some C,F | some C,F | some C,F |
| | Willingness of foreign firms to license or cooperate in joint development | some F | some F | C,F | F |
| | Strong domestic technological capabilities | | | | C,F |
| | Knowledge of technology needed/absorptive capacity | C,F | C,F | C,F | C,F |
| | Experience in foreign markets | F | F | F | F |
| Business practice factors | Flexibility, nimbleness of firms | some F | C,F | C | C |
| | Co-location with supply chain | | C | C | C |
| | Global perspective on markets | F | C,F | C,F | C |
| | Good IP management | F | F | C,F | F |
| | Tolerance for risk-taking | some F | some F | C,F | some C,F |
| | Good after-sales service | | ? | C,F | C |

Source: Gallagher, K.S. *No Great Wall: The Globalization of Cleaner Energy Technologies*, The MIT Press, forthcoming 2012/2013.
 Notes: Author analysis, based on case study research. "C" (in yellow) is Chinese point of view. "F" (in blue) is foreign point of view. "F,C" (in green) denotes agreement between foreign and Chinese perspectives. A question mark (?) denotes a lack of data, where as lack of an entry means that the incentive does not clearly apply in this case.
 *Taking into account new policies in the 12th Five Year Plan, but not necessarily historically

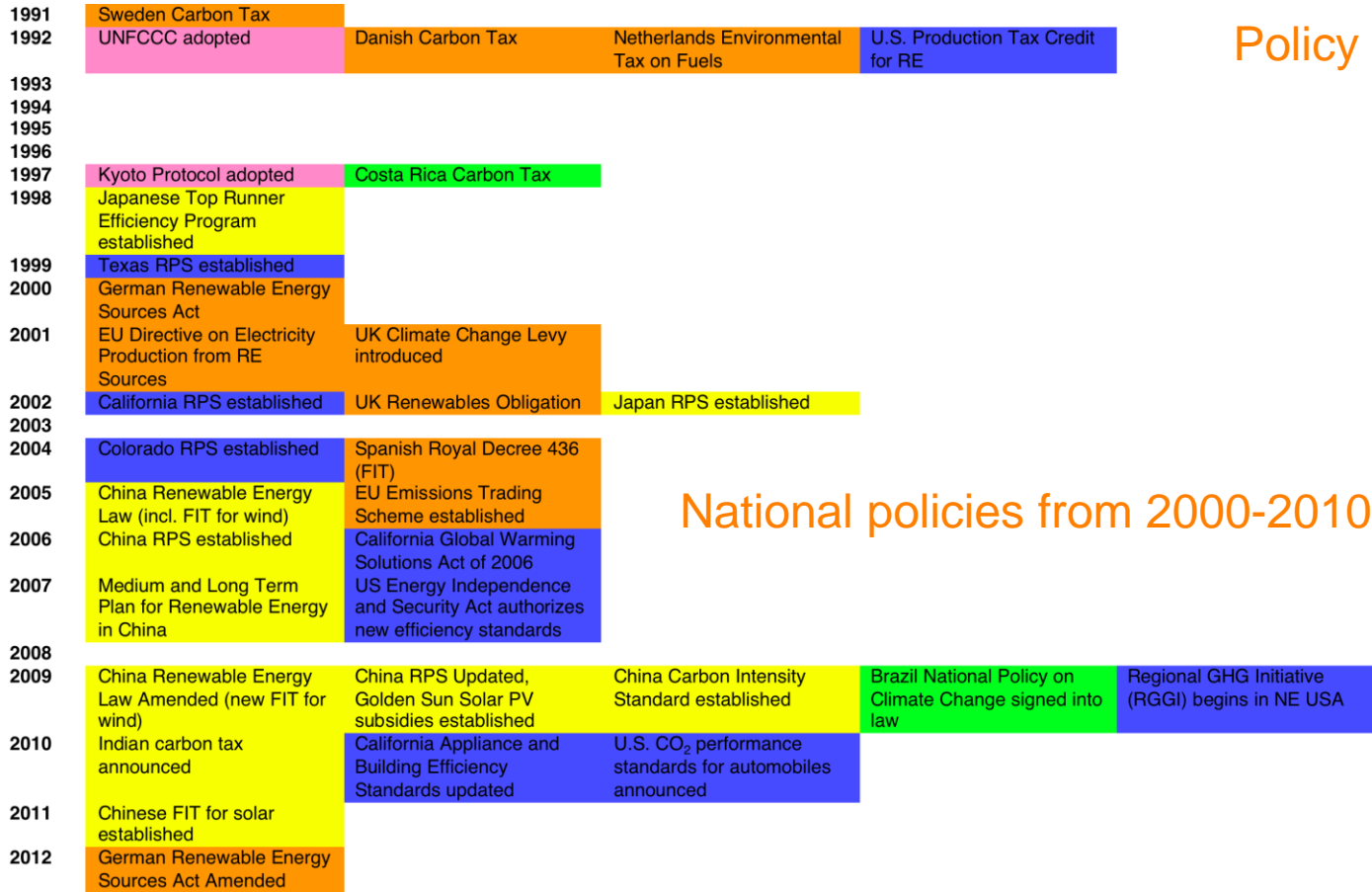
Incentives for Cross-Border Transfer: (Policy)

- Widespread agreement that **national-level policies** are the most important incentive based on historical evidence
 - Specifically, these types of policies matter the most: clear targets over time, lack of significant barriers to trade and FDI, stable market-formation policy, consistent technology/innovation policy, strong export promotion policy, and *alignment* of all the above.
 - None applied in gas turbine case, and fewer in coal gasification. Market-formation policy critical for solar PV and batteries. Foreign perception of Chinese market-formation policy is very positive (more so than Chinese perception). Longer-term view in China is noted.

Policies that matter

- So far, primarily national and sub-national-level government policies have incentivized the most tech transfer. International climate policy has not been a factor in these cases (but WTO/TRIPS are significant).
- National and sub-national policies are already incentivizing technology transfer. It is in the power of national and local governments to effect change.
- The policies that matter most in these cases (in approx. order of importance):
 - **Market-formation policy**
 - **Industrial/manufacturing policy**, including access to capital
 - **Technology/innovation policy** (RD&D, coordinated with D)
 - **Export promotion policy**
 - **IP regime policy** (more ambiguous)

Timeline of Major Clean Energy Policies



Policy forerunners

National policies from 2000-2010

Legend



Incentives for Cross-Border Transfer: (Cost and Finance)

- Cost and financing factors present different barriers for Chinese versus foreign firms:
 - Chinese firms have good access to capital in both solar PV and battery industries, but foreign firms cite this factor as a major barrier at home.
 - No barriers to license technology or acquire firms in either direction except in the case of gas turbines
 - Chinese think cost of foreign technology is too high at times, and this is still a significant factor for gas turbines and batteries. Was a factor for coal gasification, does not appear to have been a serious factor for solar PV. High costs motivated the Chinese to develop their own technology in coal gasification and advanced vehicles/batteries.
 - Foreign firms view costs as legitimate given investments into innovation.
 - All agree that Chinese firms have helped to bring down global costs of solar PV and coal gasification.

Incentives for Cross-Border Transfer: (IP factors)

- Clear agreement from Chinese and foreign firms that IP environment is already strong or improving in China.
- Confidence in Chinese courts is cautiously growing: no court cases identified.
 - Some foreign firms believe courts are pretty fair, a source of potential remedy, and worth utilizing, others more suspicious. Chinese most suspicious in cases of Chinese suing other Chinese.
- Chinese firms unambiguously have access to cleaner foreign technology in all cases. At least one firm is willing to license or sell final product to China, with possible exception of hybrid-vehicle control technology. But, costs can be high.
- There is evidence that some foreign firms do refuse to sell or license certain cleaner technologies to China, but Chinese have been clever at finding second options.
- Chinese have very good knowledge of what technologies they need to acquire, and reasonably good absorptive capacities. Excellent project execution and manufacturing capabilities in all cases. Design capabilities remain weak except for in coal gasification.

Incentives for Cross-Border Transfer: (Business Practice)

- Business practices (both foreign and Chinese) make a HUGE difference
 - World is your oyster. Global perspective on foreign markets and foreign technology is essential. Know what/where/how to buy, what/where/how to sell.
 - Can come from work experience or education abroad.
 - Experience with foreign markets greatly facilitates tech transfer. Less suspicion, greater trust, more sense of opportunity, more risk-taking.
 - Flexibility and nimbleness – Chinese firms are exemplary in solar PV, batteries, and coal gasification, but not gas turbines.
 - Responses to changes in market, industrial clustering
 - Good IP management
 - Risk taking to learn from foreign market, and innovate
 - Creation of partnerships, strategic alliances, collaboration
 - Protecting “secret sauce” as necessary

Barriers for Cross-Border Transfer: (Policy)

- There is little agreement between Chinese and foreigners on policy barriers.
 - Foreign firms identify a lack of access to the Chinese market as the key barrier in both advanced batteries and solar PV technologies.
 - Formal and informal barriers
 - Chinese experts believe that Chinese innovation, industrial, or market-formation policy has been inadequate in all cases except for in the solar PV industry (note the Chinese solar firms benefited much more from local or provincial policy than central government).

Barriers for Cross-Border Transfer: (Cost and finance)

- Everyone agrees that governments must correct for market-distortions to better enable cleaner technologies to compete against incumbents.
 - Marketplace does not typically value the benefits of reducing GHG emissions, improving energy security, protecting public health and so forth.
- Lack of “natural” market for all four technologies in the Chinese context is a big problem. Gas turbines have natural market elsewhere.
- Non-Chinese firms have major problems accessing capital at home for expansionary or export activities, but Chinese firms do not have this problem.
- Chinese firms/gov’t believe that foreign technology is generally too expensive (except for in solar). Yet, they usually pay for it, and sometimes they are motivated by high foreign costs to develop their own technology.

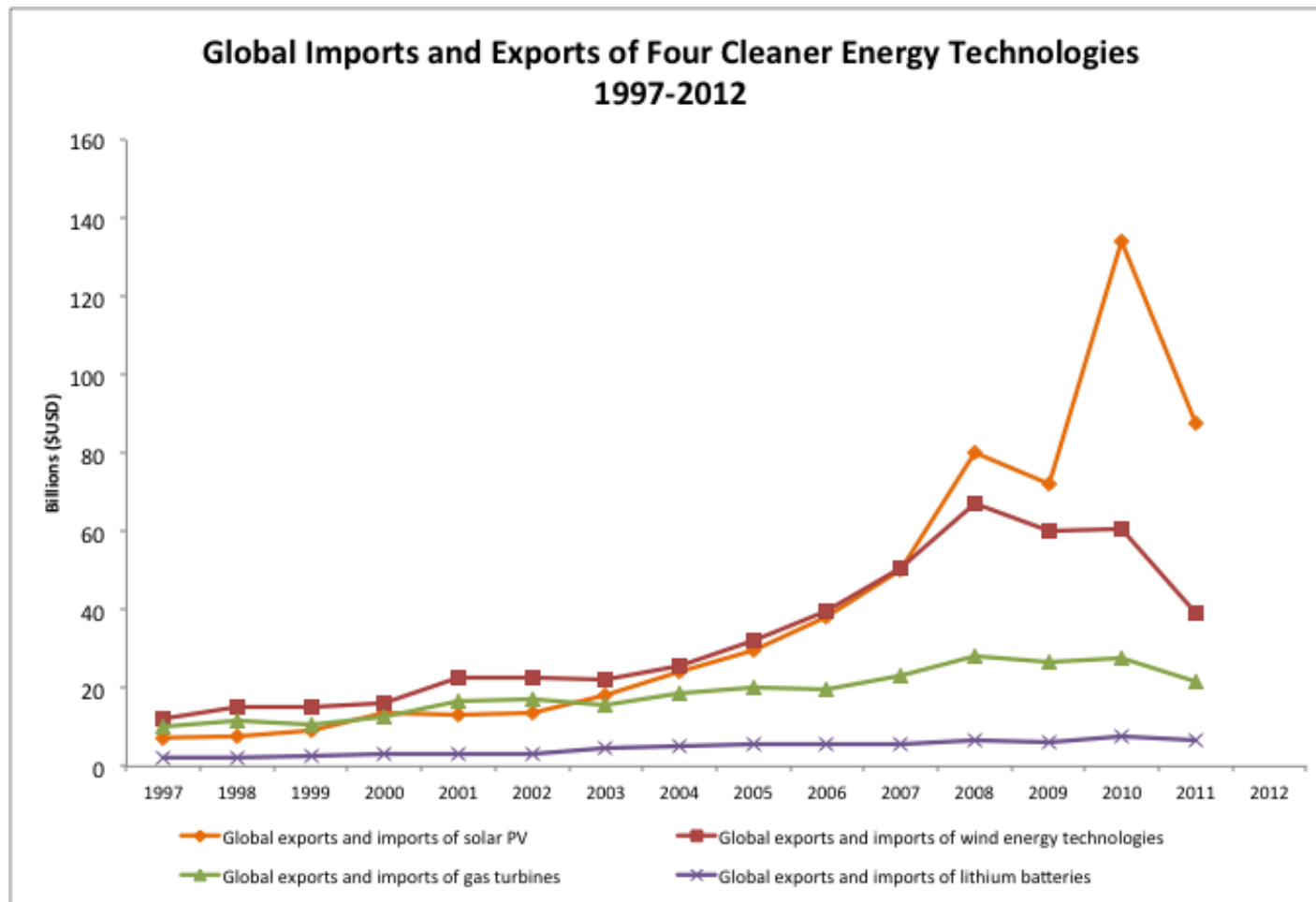
Barriers for Cross-Border Transfer: (Intellectual Property)

- Surprisingly, not a major barrier.
- No major cases of infringement in clean energy technologies in China (except current dispute between Sinovel and AMSC in wind).
- Some evidence of “mild” infringement, usually rogue employees trying to make a buck, not life-threatening to foreign firms due to good business practice
- Chinese have generally been able to acquire all technologies they want through licenses except for latest gas turbines and HEV control technologies. Have access to final product in all cases.
- Chinese have experienced export prohibitions in license agreements, defense patenting, and plain refusals to license.
- For foreign firms, the barrier is mainly fear itself. Lack of experience.

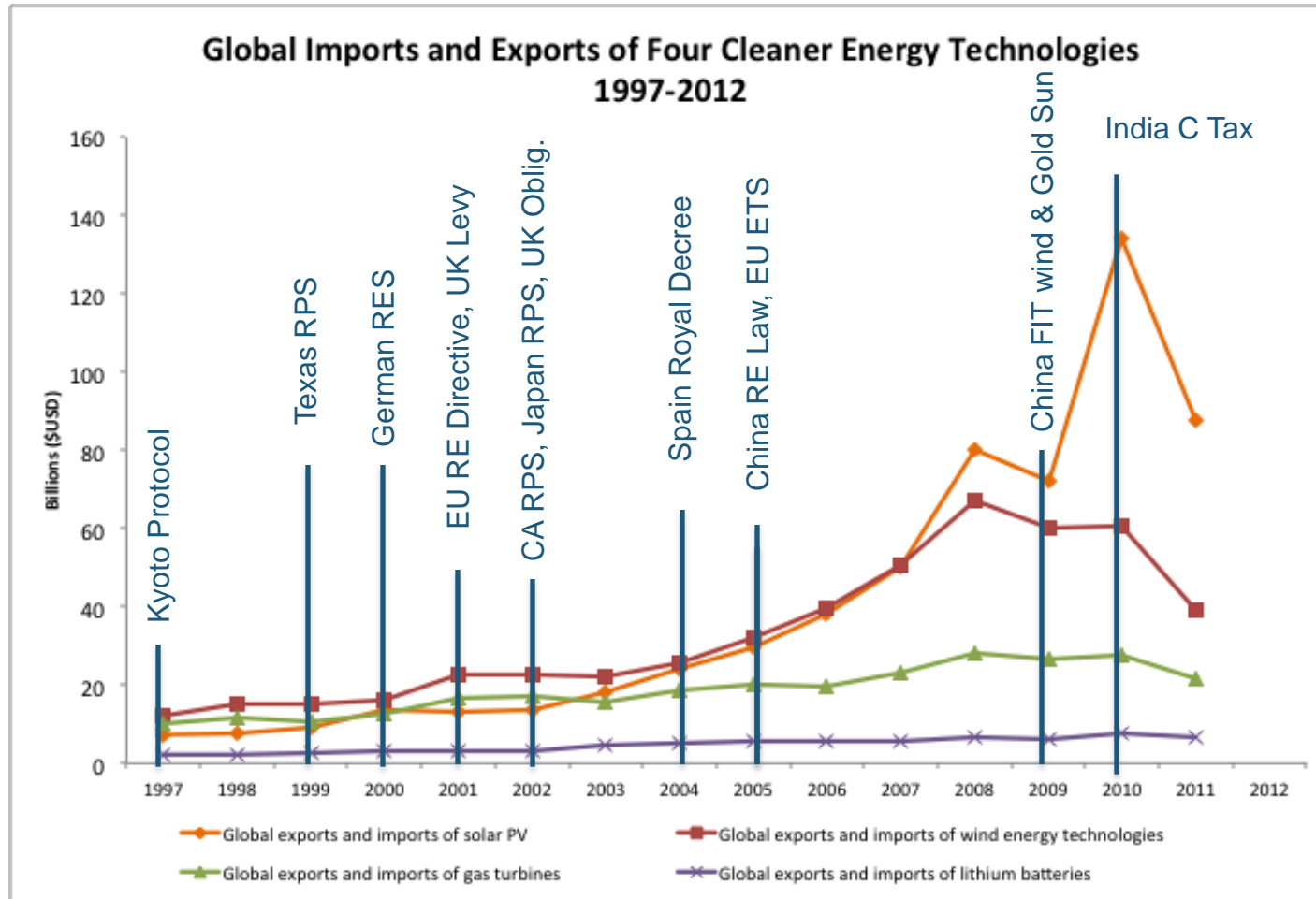
Barriers for Cross-Border Transfer: (Business Practice)

- Lack of experience is the main barrier.
- High risk aversion is present in the case of gas turbines.
- Poor after-sales service was a big factor in the coal gasification case.

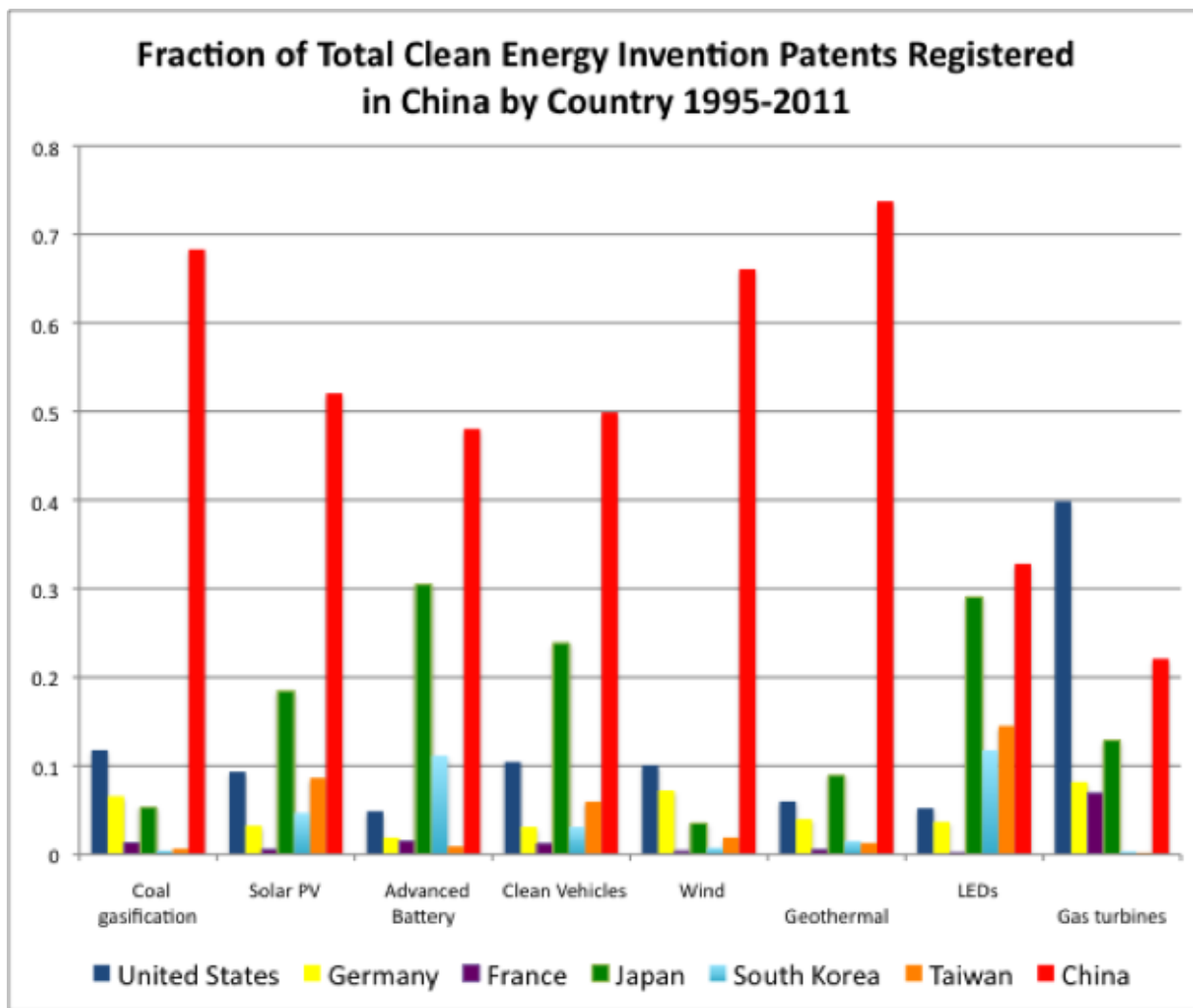
Evidence of a Globalization of Cleaner Energy Technologies



Evidence of a Globalization of Cleaner Energy Technologies



Annual Share of Foreign Patents: My Case Studies



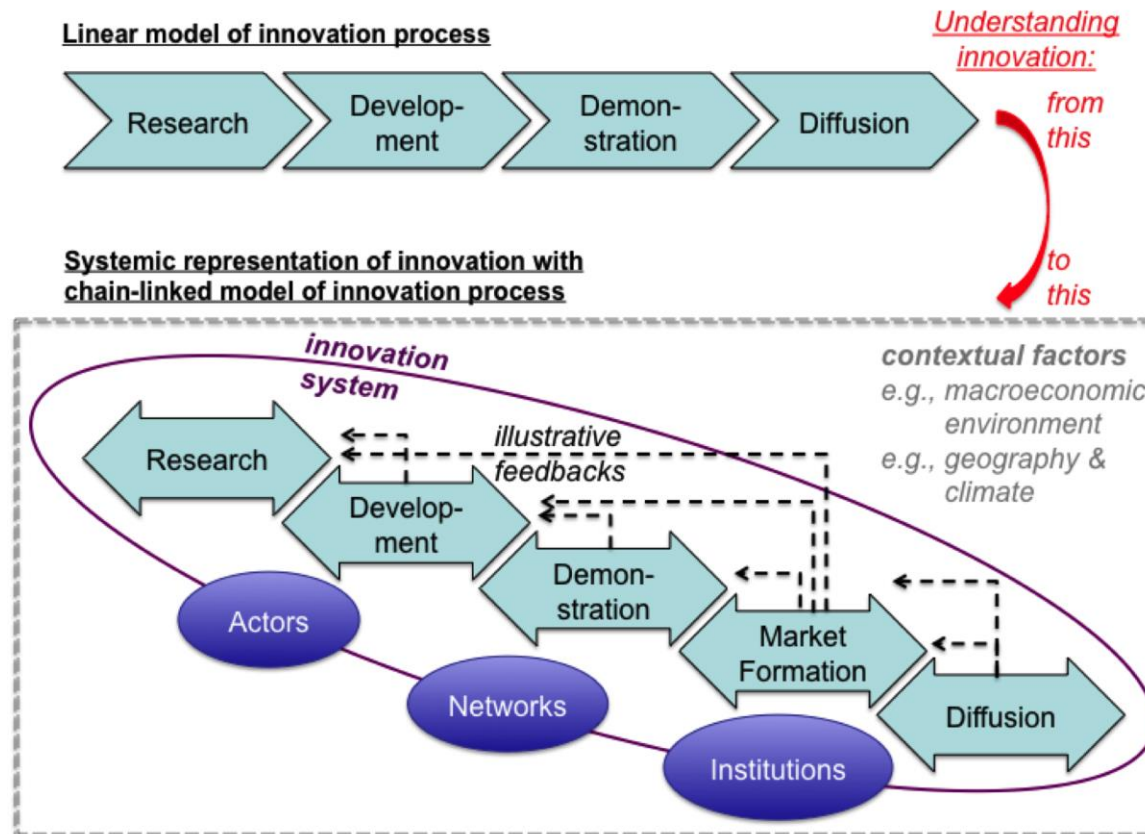
Gallagher, K.S. and A. Irwin, The Fletcher School, *submitted to Energy Policy*, 2012. Raw data from the State Intellectual Property Organization, China – accessed 2012.

Summary

- No Great Wall – no insurmountable hurdles to transferring cleaner energy technologies
- Highly globalized process of technology acquisition and sales
- No longer a north to south phenomenon
- Policy is very important
 - Market formation in domestic markets as a basic incentive
 - Reducing financial risk or capital costs through favorable financing
 - IP protections and remedies – enough but not too much
- Business practices strongly affect the process. There are best practices, and in general, large multinationals know how to do this but small and medium-sized firms are more vulnerable

Back Up Slides

The Energy Innovation System



Grubler, A., et al , “Innovation” in *Global Energy Assessment*, forthcoming 2012.

Investments in ERD&D

Gallagher, K.S., Anadon, L.D., Kempener, R. and C. Wilson, “Trends in Investments in Global Energy RD&D,” WIRES: Climate Change, Vol. 2, May/June, 2011.

TABLE 3 | Snapshot of Direct Government Support and Related Other Sources of Funding for Energy RD&D in the BRIMCS in Latest Year Available⁴¹

| <i>In Million 2008 PPP \$Int¹</i> | Fossil (incl. CCS) | Nuclear (incl. fusion) | Electricity, transmission, distribution, & storage | Renewable energy sources | Energy Efficiency | Energy technologies (not specified) | Total |
|--|-----------------------|---------------------------|---|--------------------------------|----------------------|---|---------|
| United States—Government | 659 | 770 | 319 | 699 | 525 | 1160 | 4132 |
| United States—Other | 1162 | 34 | No data | No data | No data | 1350 | 2545 |
| Brazil—Government | 79 | 8 | 122 | 46 | 46 | 12 | 313 |
| Brazil—Other | 1167 | No data | No data | No data | No data | 184 | 1351 |
| Russia—Government | 20 | No data | 22 | 14 | 25 | 45 | 126 |
| Russia—Other | 411 | No data | No data | No data | No data | 508 | 918 |
| India—Government | 106 | 965 | 35 | 57 | No data | No data | 1163 |
| India—Other | 694 | No data | No data | No data | No data | No data | 694 |
| Mexico—Government | 140 | 32 | 79 | No data | No data | No data | 252 |
| Mexico—Other | 0.1 ² | No data | No data | No data | 263 ³ | 19 ⁴ | 282 |
| China—Government | 6755 | 12 | No data | No data | 136 | 4900 | 11,803 |
| China—Other | 289 | 7 | No data | No data | 26 | 985 | 1307 |
| South Africa—Government | No data | 133 | No data | No data | No data | 9 | 142 |
| South Africa—Other | 164 | 31 ⁵ | 26 | 7 | No data | No data | 229 |
| BRIMCS—Government | 7100 | 1149 | >259 | >117 | >208 | >4966 | >13,799 |
| BRIMCS—Other | 2724 | »38 | »26 | »7 | »289 | >1696 | >4781 |
| BRIMCS—GRAND TOTAL | 9824 | >1187 | >285 | >124 | >497 | >6662 | >18,580 |

¹Data based on Kempener et al.⁴¹: Data from United States, Brazil, Russia, India, China, and South Africa based on 2008, Mexico on 2007. ‘Other’ includes (whenever available) funding from state and local governments, partially state-owned enterprises, NGOs, and industry. US data on industry expenditure is from 2004.⁴⁴ > These cumulative values are based on data from only three to four BRIMCS countries, so actual expenditures are likely to be higher. >> These cumulative values are based on data from two BRIMCS countries or less, so actual expenditures are expected to be much higher.

²On the basis of PEMEX’s fund for Scientific and Technological Research on Energy⁴⁴.

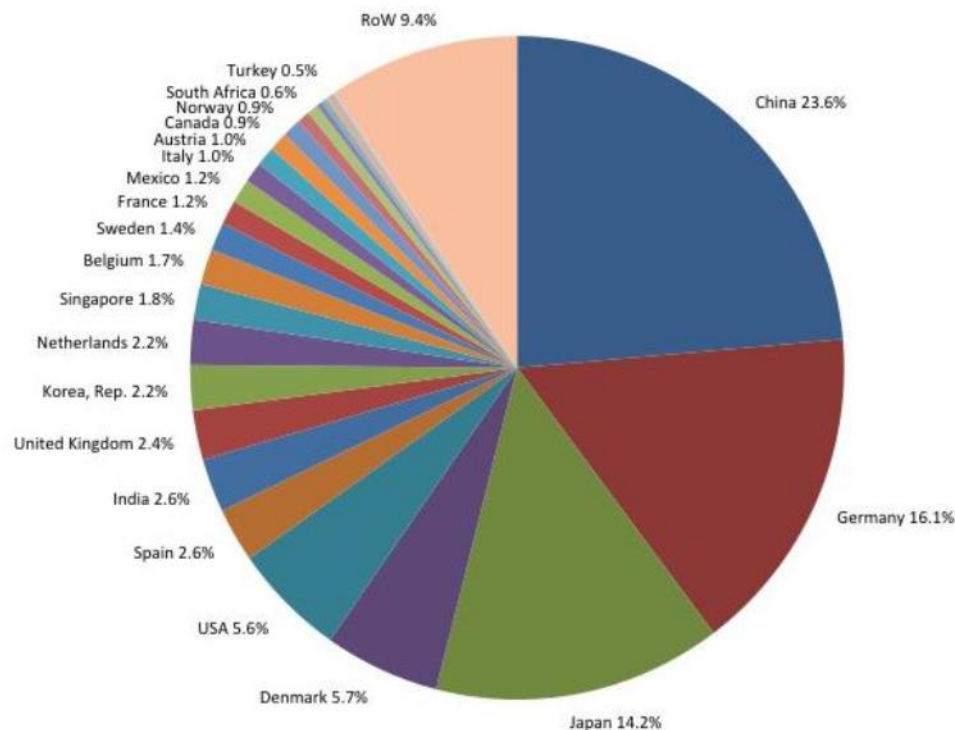
³On the basis of 2005 R&D expenditure in car manufacturing industry⁴⁷.

⁴On the basis of 2005 R&D expenditure in utilities sector⁴⁷.

⁵On the basis of total non governmental investments into PBMR Ltd.⁴⁵

U.S. Competitiveness in CET Exports

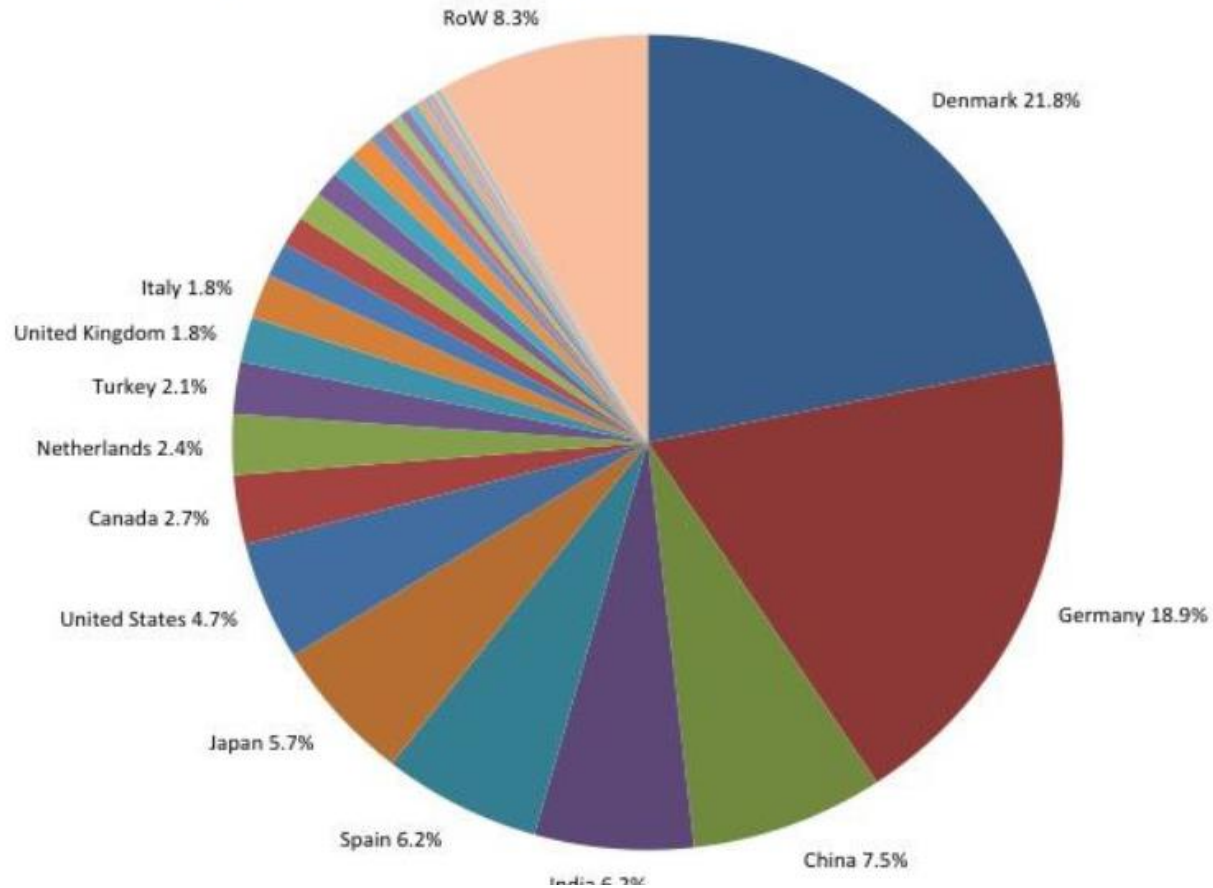
Chart 5 - Share of world exports of wind & solar PV components (countries 0.5% and above), 2007-2009



Liebert, Tilmann, "Competitiveness of Renewable Energies in Climate Change Policy: Explaining Post-Kyoto Emission Reduction Commitments," Unpublished master's thesis, The Fletcher School, Tufts University, 2011. Data from COMTRADE (UN Statistics Div. 2010).

Global Exports of Wind

Chart 3 - Share of world exports of wind energy components (countries above 1.5%), 2007-2009



Liebert, Tilmann, "Competitiveness of Renewable Energies in Climate Change Policy: Explaining Post-Kyoto Emission Reduction Commitments," Unpublished master's thesis, The Fletcher School, Tufts University, 2011. Data from COMTRADE (UN Statistics Div. 2010).

Global Exports of Solar

Chart 4 - Share of world exports of solar PV components (countries above 1.5%), 2007-2009

