ABSTRACT

Title of Dissertation: NATIONAL RENEWABLE ENERGY POLICY IN A GLOBAL WORLD

Minji Jeong, Doctor of Philosophy, 2017

Dissertation directed by: Nathan Hultman, Ph.D., Associate Professor, School of Public Policy, University of Maryland

Increasing trade of renewable energy products has significantly contributed to reducing the costs of renewable energy sources, but at the same time, it has generated protectionist policies, which may negatively affect the trend of the cost reduction. Although a few recent studies examined the rise of renewable energy protectionism and trade disputes, they are limited in addressing the conflict between the original goal of traditional renewable energy policies and the new protectionist policies under the globalized renewable energy industry. To fill this gap, this dissertation explores how the globalized renewable energy industry has changed national renewable energy policies. Through three analyses, three aspects of the globalized renewable energy industry are examined: the rise of multinational corporations, international interactions among actors, and the changes of the global and domestic market conditions. First analysis investigates how multinational renewable energy corporations have affected national policies. A content analysis of the annual reports of 15 solar photovoltaic multinational corporation

shows that solar multinationals have been influenced by national policies and have adapted to the changes rather than having attempted to change national policies. Second analysis examines how diverse actors have framed renewable energy trade issues through a network analysis of the Chinese solar panel issue in the United States. The result shows that the Chinese solar panel issue was framed differently from the traditional environmental frame of renewable energy, being dominated by multinational corporations headquartered in other countries. Third analysis explores what has caused the increasing diversity in national renewable energy policies through the case studies of the U.S. and South Korea. The result reveals that the globalization of solar industry has affected the diversification of solar policies in two countries by generating both challenges, which needed to be addressed by new and additional policies, and opportunities, which strengthened the political power of domestic solar industries. The three analyses show that the globalized renewable energy industry has led to the diversification of national renewable energy policies by increasing international interactions between actors and by introducing both challenges and opportunities to domestic renewable energy industries. This research contributes to the literature on trade and the environment by analyzing a new pattern of the conflicts between traditional environmental policies and "green" protectionist policies. It also contributes to the literature on protectionism by adding an empirical case of green protectionism, one of the forms of "murky" protectionism that has risen after the global financial crisis.

NATIONAL RENEWABLE ENERGY POLICY IN A GLOBAL WORLD

by

Minji Jeong

Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2017

Advisory Committee:
Professor Nathan Hultman, Chair
Professor Anand Patwardhan
Dr. Leon Clarke
Professor Virginia Haufler
Professor Eun-Hee Kim

Dedication

To Jungim Park and Guisoon Kim

Acknowledgements

I am deeply grateful to my dissertation committee. Dr. Nathan Hultman has been a wonderful advisor throughout my graduate school years. I am indebted to him for his great guidance, support, and encouragement during my entire dissertation process. I was very fortunate to have him as my advisor. Dr. Anand Patwardhan's challenges and advice made this research more rigorous. Dr. Virginia Haufler offered insightful comments from a broader political economic perspective. Dr. Leon Clarke's advice led me to polish the research to better communicate with a diverse audience. Dr. Eun-Hee Kim provided thoughtful feedback on how my findings can be seen from business perspective. I thank all for their contributions.

My interviewees in the United States and South Korea deserve special appreciation. They took time out of their busy schedules to speak with me. This research would have not been completed without their willingness to share their experience and perspectives with a student researcher. I also thank the solar people who talked to me and shared their thoughts and knowledge in many conferences, seminars, and workshops.

I would like to thank my family and friends in South Korea, who have faith in me all the time even when I could not believe in myself. Their love and support made me stay strong on the other side of the globe. I am also grateful to my housemates, Lucas Liu and Lu Liu, who distracted me very properly. Haewon McJeon, Sha Yu, Ryna Cui, Gokul Iyer, Naoko Aoki and many other alumni and students at the School of Public Policy provided enormous emotional and intellectual supports. I am also very thankful to Nayoung Jo, Jihyun Kim, Ria Joo and Katie Koo, who went through the final writing stage together. My friends at the Washington Jungto Society shared my tears when I had

the hardest time. Brian Barker read through a draft of this work, and provided me thoughtful feedback. His faith in my successful completion of this project helped me stay calm and strong at the later stages of the dissertation.

I inherited my passion to learn from my mother and grandmother. They were not given the opportunity of higher education, but they have never stopped learning in their lives. My grandmother lifted herself out of illiteracy by self-learning and practiced reading and writing everyday even after she turned ninety years old. My mother, who loves intellectual challenges, is still learning something new. I believe that I was awarded an opportunity to pursue a Ph.D. degree thanks to their efforts to give their children better opportunities in life as well as being great role models. This dissertation is dedicated to these strong and wise women, Jungim Park and Guisoon Kim.

Table of Contents

List of Tables vii

List of Figures viii

Chapter 1. Introduction 1
- Policy problem and research question 1
- Global energy market and renewable energy 8
- International trade and the globalization of renewable energy industry 12
- Rise of diverse corporate actors and diversified interests 17
- Global political economy and renewable energy 19
- Research design 22
- Contributions and policy implication 31
- Organization of the book 32

Chapter 2. Literature review 33
- Trade and the environment 33
- The rise of "murky" protectionism and green protectionism 38
- Institutional theory and institutional change: Theoretical framework for Analysis 1 and Analysis 2 42
- Globalization and policy convergence: Theoretical framework for Analysis 3 54

Chapter 3. Global solar market and multinational corporate actors 60
- Introduction 60
- Data 62
- Method 65
- Findings 69
- Discussion 83

Chapter 4. Politics in the U.S. solar PV field 86
- Introduction 86
- Trade disputes on solar panels between the U.S. and China 89
- Data and method 92
- Findings 96
- Discussion 104

Chapter 5. Solar policies and industry in the United States 108
- Introduction 108
- Data and method 109
- Solar PV and industry in the United States 112
- Federal solar policies 119
- Changes of the solar PV market environment 129
- The reactions of the solar PV industry to the changing environment 142
- Interactions between policies and industry 148
- Summary 150

Chapter 6. Solar policies and industry in South Korea 152
- Introduction 152
- Data and method 154
- Solar PV and industry in South Korea 156
- National solar policies 161

Changes of the solar PV market environment 175
The reactions of the solar PV industry to the changing environment 181
Interactions between policies and industry 185
Summary 187
Chapter 7. The evolution of solar policies 190
Introduction 190
The global solar market and the changes of the domestic solar markets 190
Diversified policies and solar industry 193
Factors for policy divergence 198
Complicated and murky renewable energy policies 201
Limitation 203
Chapter 8. Conclusion 204
Interpretation of the findings of Analysis 1 and Analysis 2 205
Evaluating the propositions 207
Contributions to the literature 208
Policy implications 210
Limitation and future work 212
Appendix A. List of interviews for the U.S. case study 214
Appendix B. List of interviews for the South Korea case study 215
Appendix C. List of observations 216
Appendix D. Interview questions 218
Bibliography 221

List of Tables

Table 1. Selected new types of renewable energy policies. 2
Table 2. International trade disputes on renewable energy policy. 4
Table 3. Top 10 manufacturers in solar PV and wind power, 2015. 16
Table 4. Summary of three analyses. 25
Table 5. Case selection. 28
Table 6. Economics, energy, and solar PV in the U.S. and South Korea. 30
Table 7. Summary of literature and propositions. 59
Table 8. Global top 15 solar module manufacturers, 2013. 65
Table 9. Categories of risks. 68
Table 10. Categories of policy risk. 69
Table 11. Number of samples by newspaper. 93
Table 12. Categories for type of organization. 95
Table 13. Number of statement per actor group by issue category. 97
Table 14. Top 20 frequently used words in the U.S.-China solar panel trade issue 101
Table 15. Selected solar PV plant closure in the U.S in 2011-2014. 118
Table 16. U.S. statute including solar policies. 126
Table 17. U.S. policies mentioned by the interviewed companies. 134
Table 18. Sales and exports by product in 2010. 160
Table 19. The Policies included in the Basic Plan for Technology Development, Application, and Deployment of New and Renewable Energy. 174

List of Figures

Figure 1. Worldwide total primary energy supply by source, 1975-2014. 9
Figure 2. Global average annual growth rate by energy source, 2004-2014. 10
Figure 3. Power generation by source in the Current Policies, New Policies, and 450 Scenarios, 2040. 11
Figure 4. International trade of renewable energy products, 2006-2015. 12
Figure 5. Market prices of solar PV modules, 2009 Q4-2012 Q1. 13
Figure 6. Wind turbine prices in Europe, 2004-2012. 14
Figure 7. Solar PV value chain. 18
Figure 8. WTO disputes between the U.S. and China, 2002-2016. 21
Figure 9. Hypothesized causal chain of policy change. 27
Figure 10. Solar PV module production, cumulative installed capacity, and price, 2004-2012. 64
Figure 11. Risks by source, 2006-2015. 70
Figure 12. Risks from external environment, 2006-2015. 71
Figure 13. Policy risks by source, 2006-2015. 73
Figure 14. Revenue trend of Yingli Green Energy, 2006-2014. 75
Figure 15. Solar module manufacturing capacity of four major solar manufacturers, 2007-2014. 78
Figure 16. Net sales of First Solar by segment, 2008-2014. 82
Figure 17. U.S. import of photosensitive semiconductor devices including PV cells, 1996-2015. 90
Figure 18. U.S. trade balance of solar goods. 90
Figure 19. Actor congruence network 99
Figure 20. Actor congruence network visualized with frames. 102
Figure 21. U.S. electricity generation capacity additions, 2007-2014. 112
Figure 22. U.S. PV installation by segment, 2000-2015. 113
Figure 23. U.S. wafer, cell, module prices. 2010-2015. 114
Figure 24. Member companies of the SEIA by business. 115
Figure 25. Solar PV cell and module production, 2007-2013. 116
Figure 26. Solar PV cell and module production in the U.S., 2007-2013. 116
Figure 27. Location of the headquarters of the U.S. solar cell and module manufacturers, 2015. 117
Figure 28. Solar energy employment by sector, 2010-2015. 119
Figure 29. Federal expenditures for energy development by source, 1950-2010. 120
Figure 30. Energy production in South Korea, 2002-2014. 157
Figure 31. Sales of renewable energy products in South Korea, 2004-2013. 158
Figure 32. Number of Solar PV corporations, sales, and exports, 2004-2013. 158
Figure 33. Number of members of the Korea Photovoltaic Industry Association by business. 159
Figure 34. Additional capacity of solar PV plants receiving feed-in tariff, 2002-2013. 162
Figure 35. Government spending on new and renewable energy, 2004-2013. 163
Figure 36. Solar PV installation, 2003-2014. 169
Figure 37. System marginal price, 2012-2015. 170
Figure 38. The prices of Renewable Energy Certificates, 2012-2016. 171

Figure 39. Interactions between solar industry and policy in the U.S. 195
Figure 40. Interactions between solar industry and policy in South Korea. 196
Figure 41. Causal mechanism of renewable energy policy change. 198

List of Abbreviations

AD	Antidumping
ARRA	American Recovery and Reinvestment Act
CASE	Coalition for Affordable Solar Energy
CASM	Coalition for American Solar Manufacturing
CPP	Clean Power Plan
c-Si	Crystalline Silicon
CVD	Countervailing Duties
EGA	Environmental Goods Agreement
EIA	Energy Information Administration
EKC	Environmental Kuznets Curve
EPC	Engineering, procurement, and construction
FIT	Feed-in Tariff
GATT	General Agreement on Tariffs and Trade
GW	Gigawatts
IEA	International Energy Agency
IPP	Independent Power Producer
IRENA	The International Renewable Energy Agency
IGCC	Integrated Gasification Combination Cycle
ITC	Investment Tax Credit
KEA	Korea Energy Agency
KNREA	Korea New and Renewable Energy Association
KOPIA	Korea Photovoltaic Industry Association

MKE	Ministry of Knowledge Economy
MNCs	Multinational Corporations
MOTIE	Ministry of Trade, Industry, and Energy
MW	Megawatts
NREC	New and Renewable Energy Center at the Korea Energy Agency
OECD	Organization for Economic Co-operation and Development
PACE	Property Assessed Clean Energy
PV	Photovoltaic
RECs	Renewable Energy Certificates
REN21	Renewable Energy Policy Network for the 21st Century
RPS	Renewable Portfolio Standard
SEIA	Solar Energy Industry Association
SEPA	Smart Electric Power Alliance
SMP	System Marginal Price
TPES	Total Primary Energy Supply
WTO	World Trade Organization

Chapter 1. Introduction

Policy problem and research question

Renewable energy has expanded rapidly in recent years. Worldwide renewable power capacity has increased from 1,037 GW in 2006 to 1,985 GW in 2015.[1] New investment in clean energy has expanded from $41 billion in 2004 to $272 billion in 2014.[2] Much of this expansion has been based on governmental support, via policy requirements, subsidies, R&D funding, or other mechanisms. Governments have promoted the use of renewable energy to address various energy and environmental issues they face such as climate change mitigation, energy security, and air pollution. As the costs of renewable energy sources have historically been higher than conventional energy sources, support policies were essential for the promotion of renewable energy. In this vein, the number and the variety of renewable energy policies have sharply increased around the world. For instance, as of early 2015, 145 countries have adopted renewable energy support policies—more than 9 times of that in 2005, which was only 15 countries.[3]

Recently, different types of renewable energy policies from the support policies have been introduced in a number of countries (Table 1). While the support policies serve

---

[1] Whiteman, Adrian, Tobias Rinke, Javier Esparrago and Samah Elsayed. *Renewables Capacity Statistics 2016.* Masdar City: IRENA, 2016. http://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Capacity_Statistics_2016.pdf.

[2] Liebreich, Michael, "Global Trends in Clean Energy Investment", Bloomberg EMEA Summit, London, October 12, 2015.

[3] Renewable Energy Policy Network for the 21st Century, *Renewables 2015: Global Status Report*. Paris: REN21 Secretariat. 2015. http://www.ren21.net/wp-content/uploads/2015/07/REN12-GSR2015_Onlinebook_low1.pdf.

the goal to increase the share of renewable energy in national energy mix, these new policies do not serve this goal. Rather, the purpose of these policies is to protect domestic renewable energy industry. The U.S. and the EU adopted policy measures to address solar panels imported from China since these imported panels injured domestic industry. Domestic content requirement, which requires renewable energy developers to use domestic products, has been adopted by a few countries including Canada and India.

Table 1. Selected new types of renewable energy policies.

	Country	Policy	Timing of implementation
Anti-dumping	U.S.	Tariff on Chinese solar panels	October, 2012
	EU	Minimum price for solar panels from China Limit the total capacity of imports from China	August, 2013
Domestic content requirement	Canada	Guaranteed, long-term pricing for renewable energy from facility that contain domestic content	September, 2009
	India	Requirements for solar power developers to purchase domestic products to enter into power purchase agreement	January 2010
	Italy	Provision of incentive if contents are from within the EU	March, 2011

The rise of these policies has caused international trade disputes. Nine dispute cases have been submitted to the World Trade Organization (WTO) related to renewable energy policies as of October 10, 2016 (Table 2). Among them, five cases are related to domestic content requirement; the complaint countries argued that domestic content requirement of respondent countries were less favorable to imported goods, which was the violation of the WTO rules. Canada had to revise its policy since the WTO concluded that its domestic content requirement violated the WTO rules. China claimed the U.S.

countervailing and anti-dumping measures on Chinese solar panels. As the U.S. government found that Chinese solar panels were dumped by using huge governmental supports, the U.S. imposed tariff on them. China reacted to it by arguing that there was no sufficient evidence of unfair subsidization. On January 16, 2015, the WTO upheld some contentions of the U.S. as well as those of China.

Table 2. International trade disputes on renewable energy policy.

Dispute number	Respondent	Complaint	Request date	At issue	Current status
DS 412	Canada	Japan (USA) (EU)	Sep. 13, 2010 (Sep. 24, 2010) (Sep. 27, 2010)	Domestic content requirements in the feed-in tariff program	Implementation notified by respondent
DS 419	China	USA (EU) (Japan)	Dec. 22, 2010 (Jan. 12, 2011) (Jan. 17, 2011)	Grants to domestic manufacturers of wind power equipment	In consultations
DS 426	Canada	EU	Aug. 11, 2011	Domestic content requirements in the feed-in tariff program	Implementation notified by respondent
DS 452	EU Italy Greece	China (Japan) (Australia) (Argentina)	Nov. 5, 2012 (Nov. 16, 2012) (Nov. 19, 2012) (Nov. 19, 2012)	Domestic content restrictions	In consultations
DS 437	USA	China	May 25, 2012	Imposition of countervailing duty measures by the U.S. on certain products from China	Compliance proceedings ongoing
DS 449	USA	China	Sep. 17, 2012	Countervailing and anti-dumping measures on certain products from China	Report adopted with recommendations
DS 456	India	USA (Japan) (Australia)	Feb. 6, 2013 Feb. 13, 2013 Feb. 21, 2013	Domestic content requirements	Appellate Body report circulated
DS 473	EU	Argentina (Russia) (Indonesia)	Dec. 19, 2013 (Jan. 9, 2014) (Jan. 15, 2014)	Anti-dumping measures	Appellate Body report circulated
DS 510	USA	India	Sep. 9, 2016	Domestic content requirements	In consultations

Source: WTO, "Index of Dispute Issues", https://www.wto.org/english/tratop_e/dispu_e/dispu_subjects_index_e.htm (accessed October 10, 2016).

These new types of renewable energy policies conflict with the original goal of renewable energy policies because they increase the cost of renewable energy. For instance, domestic content requirement would increase the cost for renewable energy installation by interrupting developers to use low-priced imported products. Increasing trade of renewable energy products has contributed to reducing the cost of renewable energy, but it led governments to introduce the measures to protect domestic renewable energy industry, which could slow down the increasing trend of renewable energy installation.

Previous studies on renewable energy policy tend to focus on traditional renewable energy policies, which are mostly support policies.[4] Since they investigated how support policies contributed to the growth of renewable energy, these studies barely addressed the recent rise of non-traditional renewable energy policies. Although a few recent studies examined the rise of renewable energy protectionism and trade disputes, they are limited in revealing why new types of renewable energy policies have

---

[4] Bird, Lori, Mark Bolinger, Troy Gagliano, Ryan Wiser, Matthew Brown, and Brian Parsons. "Policies and market factors driving wind power development in the United States," *Energy Policy* 33, no. 11 (2005): 1397-1407; Gan, Lin, Gunnar S. Eskeland, and Hans H. Kolshus. "Green electricity market development: Lessons from Europe and the US." *Energy Policy* 35, no. 1 (2007): 144-155.; Johnson, A., & Jacobsson, S. "Inducement and blocking mechanism in the development of a new industry: the case of renewable energy technology in Sweden" In R. Coombs, G. Ken, A. Richard, & V. Walsh (Eds.), *Technology and the Market: Demand, Users, and Innovation*. (Massachusetts: Edward Elgar Publishing, 2001), 89–111.; Moe, Espen. "Vested interests, energy efficiency and renewables in Japan," *Energy Policy* 40 (2012): 260-273.; Zhao, Zhen-Yu, Jian Zuo, Lei-Lei Fan, and George Zillante. "Impacts of renewable energy regulations on the structure of power generation in China–a critical analysis," *Renewable Energy* 36, no. 1 (2011): 24-30.

increasingly introduced recently despite the conflict between the original goal of traditional renewable energy policies and the new policies.[5]

This research aims to understand why the new types of renewable energy policies have been introduced. Multiple possible reasons of the rise of these non-traditional renewable energy policies can be suggested. First, it can be argued that there is an inherent conflict between renewable energy supports and the global trade regime.[6] The rise of the trade disputes on renewables, however, is a recent trend, although renewable energy supports have been implemented for decades. Second, the rising concern on climate change can be suggested as the cause of renewable energy protectionism. It is, however, natural that the concern on climate change encourages traditional renewable energy policies rather than non-traditional policies. Another possible reason is the global financial crisis in 2007 and 2008. It can be argued that the global financial crisis might increase overall protectionist measures. A number of studies showed that there was no significant increase of protectionist measures after the global financial crisis.[7] However,

---

[5] Caprotti, Federico. "Golden sun, green economy: market security and the US/EU-China 'solar trade war'." *Asian Geographer* 32, no. 2 (2015): 99-115.; Carbaugh, Bob, and M. St Brown. "Industrial policy and renewable energy: Trade conflicts." *Journal of International and Global Economic Studies* 5, no. 1 (2012): 1-16.; Lewis, Joanna I. "The rise of renewable energy protectionism: Emerging trade conflicts and implications for low carbon development." *Global Environmental Politics* (2014); 10-35.; Voituriez, Tancrède, and Xin Wang. "Real challenges behind the EU–China PV trade dispute settlement." *Climate Policy* 15, no. 5 (2015): 670-677.; Dunford, Michael, Kyoung H. Lee, Weidong Liu, and Godfrey Yeung. "Geographical interdependence, international trade and economic dynamics: The Chinese and German solar energy industries." *European Urban and Regional Studies* (2013): 3-13.

[6] Lewis, Joanna I. "The rise of renewable energy protectionism: Emerging trade conflicts and implications for low carbon development." *Global Environmental Politics* (2014); 10-35.

[7] Kee, Hiau Looi, Cristina Neagu, and Alessandro Nicita. "Is protectionism on the rise? Assessing national trade policies during the crisis of 2008." *Review of Economics and Statistics* 95, no. 1 (2013): 342-346.

some argued that “murky” type of protectionist measures have increasingly used by governments.[8] For instance, Aggarwal and Evenett revealed that the countries with more policies discriminating foreign interests tended to use more policies covered by weak or no WTO rule after the global financial crisis.[9] The rise of new types of renewable energy policies can be explained as a part of this trend. However, the rise of murky protectionism does not tell the cause of the increasing new and additional renewable energy policies. To understand the cause, another causal variables need to be considered.

In this context, the globalization of renewable energy industry can be suggested as a reason for the rise of the new types of renewable energy policies. As domestic renewable energy industries have internationally connected through global value chains of renewable energy products, the conditions of domestic renewable energy markets as well as of the global market have significantly changed. These changes of market conditions are expected to generate the necessity of new policies. Moreover, the globalization of renewable energy industry has generated many multinational corporations, which have resources and capabilities to influence policies in multiple countries. This globalization of renewable energy industry is a recent phenomenon. Therefore, it can be considered as a reason of the rise of new types of renewable energy policies, which is also a recent phenomenon. Few studies have been conducted on the connection of the globalization of renewable energy industry and the rise of non-traditional renewable energy policies.

---

[8] Evenett, Simon J., and John Whalley. "18. Resist green protectionism–or pay the price at Copenhagen." The Collapse of Global Trade, Murky Protectionism and the Crisis: Recommendations for the G20 (2009): 93-98.

[9] Aggarwal, Vinod K., and Simon J. Evenett. "Industrial policy choice during the crisis era." *Oxford Review of Economic Policy* 28, no. 2 (2012): 261-283.

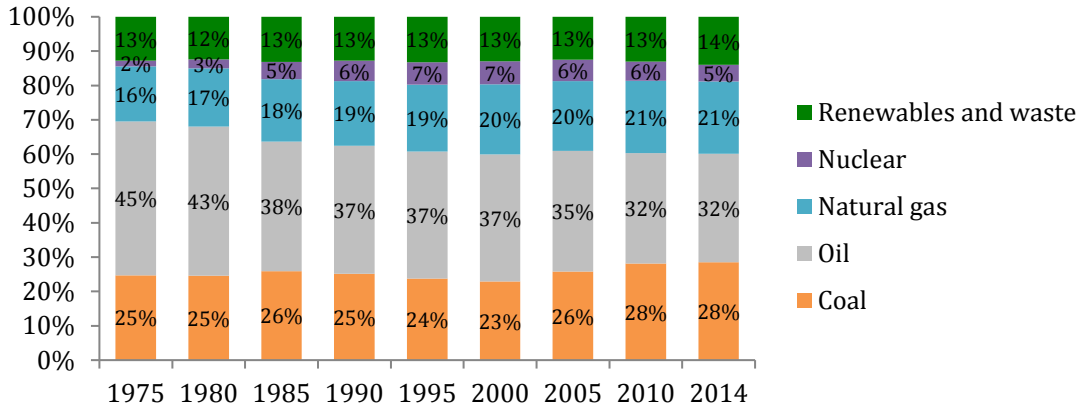
In this sense, the central research question of this research is: *How has the globalized renewable energy industry changed national renewable energy policies?* The globalized renewable energy industry refers to the creation of global value chains of renewable energy products in this research. While previous studies focus either on traditional renewable energy policies or on non-traditional renewable energy policies, this research investigates the change of all the national policies on renewables to find out the mechanism of policy change on renewable energy. In this vein, national renewable energy policies refer to both traditional and non-traditional renewable energy policies in this research.

Global energy market and renewable energy

In recent decades, fossil fuels have been the most dominant energy sources in the global energy market. Although the total share of coal, oil, and natural gas in the global energy supply has decreased to 81% in 2014 from 86% in 1975, they are still dominant energy sources (Figure 1). Natural gas and coal have replaced the decreased share of oil. Renewables has accounted for 12-14% share of the global energy supply.[10] Compared to 1975, the share of renewables has increased only by 1% in 2014.

[10] According to the definition of renewable energy in the IEA's *Renewables Information 2016*, renewable energy is "derived from natural processes that are replenished constantly." Renewable energy includes hydroelectricity, geothermal, solar photovoltaic, solar thermal, tide, wave, ocean, wind, solid biofuels, biogases, liquid biofuels and renewable municipal waste.

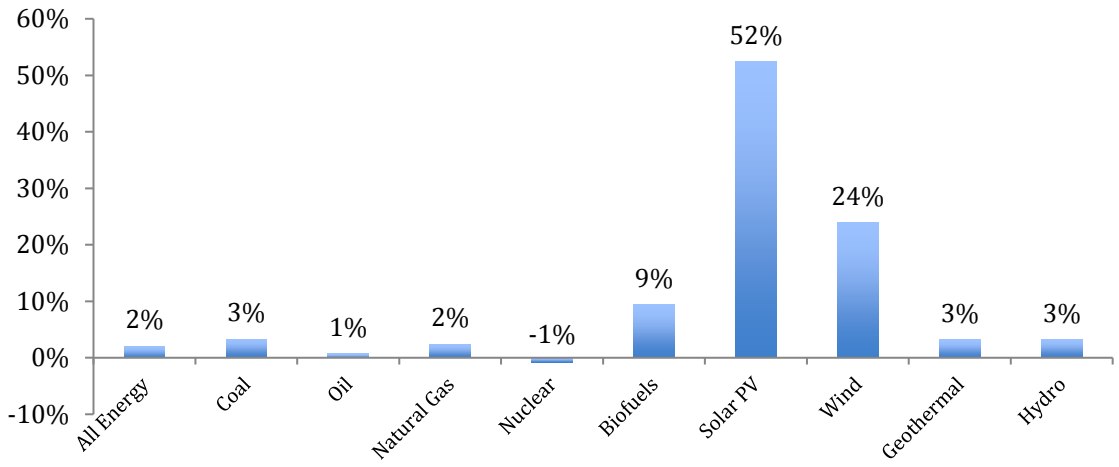
Figure 1. Worldwide total primary energy supply by source, 1975-2014.



Source: IEA Statistics, http://www.iea.org/statistics/

Although the share of renewables has been stable, some renewable energy sources have enormously grown in recent years. While the annual average growth rates of conventional energy sources from 2004 to 2014 are 1-3%, those of biofuels, solar photovoltaic (PV), and wind energy are 9-52% (Figure 2). Natural gas has received much attention as a "bridge fuel" for climate mitigation in recent years due to its least carbon intensity among fossil fuels, but the average annual growth rate is only 2% in recent 10 years.

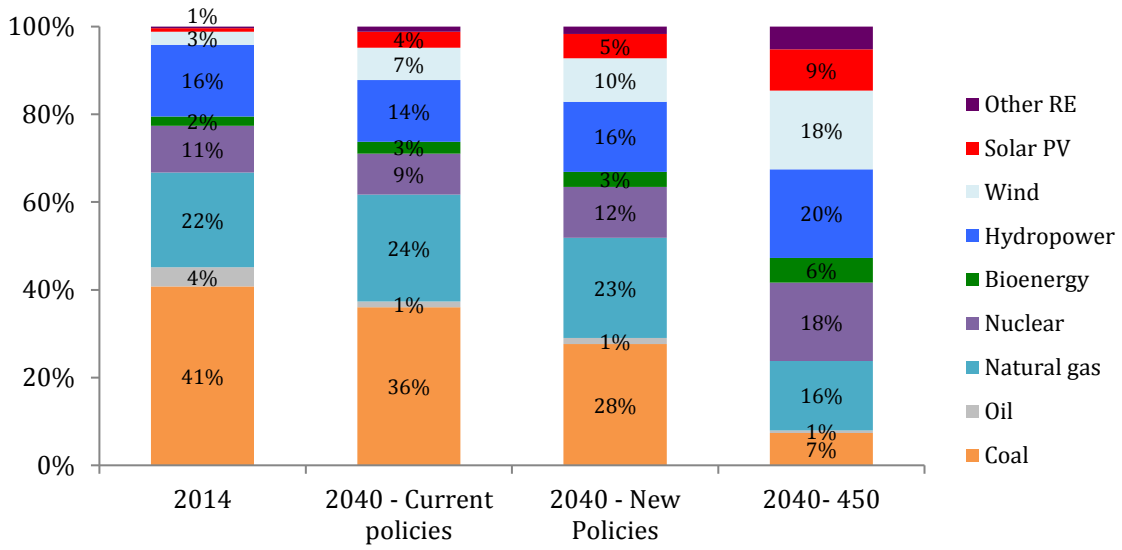
Figure 2. Global average annual growth rate by energy source, 2004-2014.



Note: The rates of all energy, coal, oil, natural gas, and nuclear are based on the total primary energy supply of each energy source. The rates of the other energy sources are based on the electricity generation of each energy source.
Source: IEA Statistics, http://www.iea.org/statistics/

This rapid growth of renewable energy sources is expected to be accelerated. Even without additional policies, renewable energy sources are expected to take the decrease of the share of coal in power generation by 2040. The World Energy Outlook of the International Energy Agency (IEA) projected that the share of solar PV and wind energy in electricity generation would increase to 4% and 7% in 2040 from 1% and 3% in 2014 if current policies are continued (Figure 3). If announced policies, targets, commitments such as climate pledges are implemented as well as current policies, the share of solar PV and wind energy would increase to 5% and 10%, respectively. Under the 450 scenario, which targets average global temperature increase to 2 degrees in 2100, the share of total renewables becomes more than half of the total power generation.

Figure 3. Power generation by source in the Current Policies, New Policies, and 450 Scenarios, 2040.



Source: World Energy Outlook 2016, IEA.

These projections by policy scenarios show that renewable energy installation is significantly influenced by policies. In effect, renewable energy policies have led the rise of renewable energy by driving the cost-down of renewables. For instance, in 2015, the global average capital cost of solar PV has decreased to less than the half of the cost in 2010. According to the IEA, the supports for renewable energy in many countries after 2010 have led this massive cost-down in 5 years, which was expected to take 15 years.[11]

Other than policies, many other factors have influenced the rise of renewable energy. Technology development, accumulated experience of installation, competition and increased scale of deployment have contributed to the cost-down of renewable energy. International trade of renewable energy products has been another driver of renewable energy deployment by driving down costs.

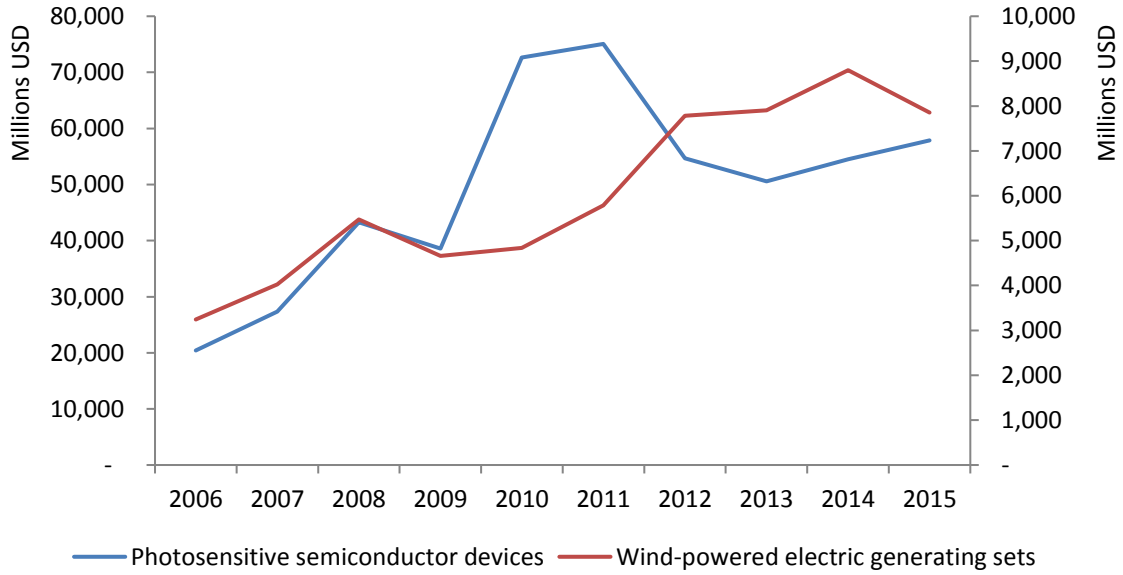
---

[11] International Energy Agency, *World Energy Outlook 2016*, Paris: IEA. 2016. https://www.iea.org/media/publications/weo/WEO2016Chapter1.pdf.

International trade and the globalization of renewable energy industry

International trade of renewable energy products has sharply increased in recent years (Figure 4). The worldwide exports value of photosensitive semiconductor devices, which include solar photovoltaic cells, has increased to 57,868 million US dollars in 2015 from 20,416 million US dollars in 2006. The value of exports has dropped in 2012 because the export of China has reduced under the policies to restrict flooding of Chinese solar cells in a number of countries. After this drop, the trade value has increased again. The exports of wind energy products have also increased. The worldwide exports of wind-powered electric generating sets has become more than twice in 2015 compared to 2006.

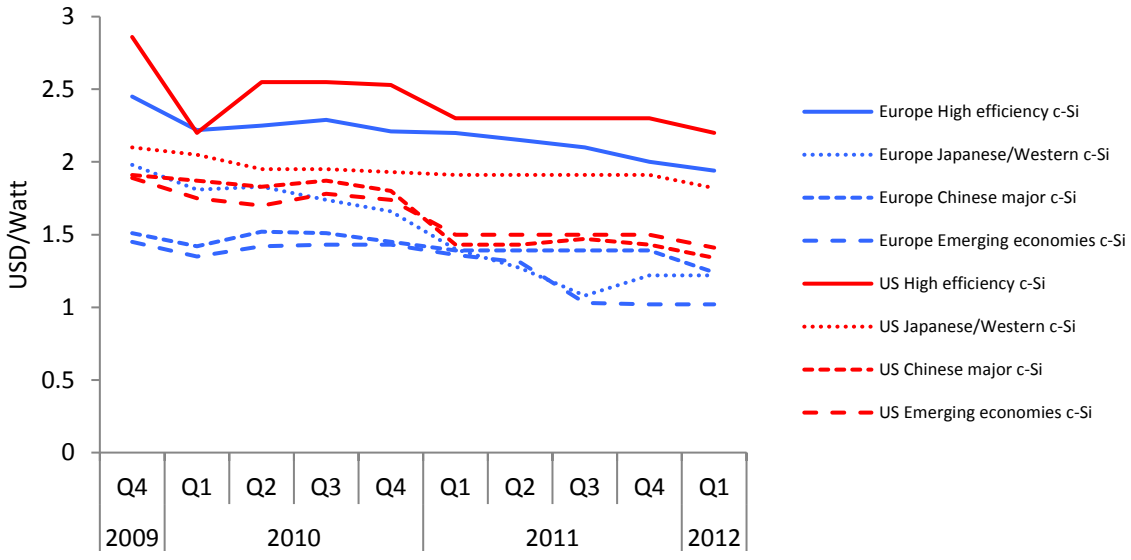
Figure 4. International trade of renewable energy products, 2006-2015.



Source: UN Comtrade, https://comtrade.un.org/data/

Increasing trade of renewable energy products has contributed to reducing the cost of renewable energy by dropping the prices of the products. The overall prices of crystalline silicon solar modules have decreased in recent years. The prices of the modules have declined to 1.0-2.2 USD/watt from 1.5-2.9 USD/watt (Figure 5). The price gap between the modules from Japan and Western countries and those from China and emerging economies shows that the solar modules from China and emerging economies have contributed to dropping the prices of solar modules in the U.S. and Europe. The prices of wind turbine have also decreased since 2009 (Figure 6). Since wind turbine manufacturers from emerging countries including China have expanded production capacity, the competition between manufacturers has led to downward pressure to prices of wind turbines in recent years.[12]

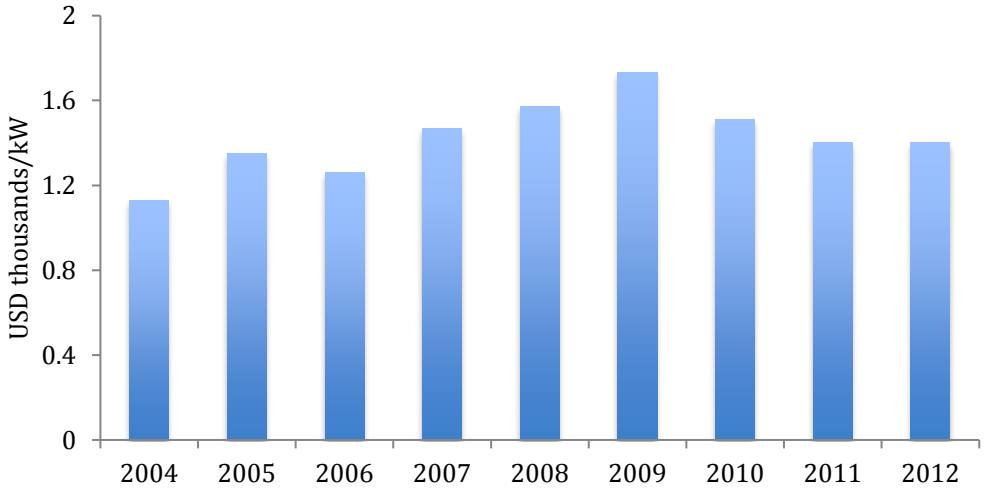
Figure 5. Market prices of solar PV modules, 2009 Q4-2012 Q1.



[12] Taylor, Michael, Kathleen Daniel, Andrei Ilas and Eun Young So. *Renewable Power Generation Cost in 2014*, Masdar City: IRENA, January 2015. https://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Power_Costs_2014_report.pdf.

Source: Renewable Energy Technologies: Cost Analysis Series, Volume 1: Power Sector, Issue 4/5: Solar Photovoltaics, IRENA, June 2012.

Figure 6. Wind turbine prices in Europe, 2004-2012.



Source: Renewable Energy Technologies: Cost Analysis Series, Volume 1: Power Sector, Issue 5/5: Wind Power, IRENA, June 2012.

With the increase of international trade, global value chains have been created for main renewable energy products such as solar modules and wind turbines. The industries of renewable energy products have decoupled from installation. In other words, a country with large renewable energy installation capacity does not necessarily have a large renewable energy industry.

Table 3 shows this decoupling of industry from installation. The share of China in the solar PV capacity is 19%, while the aggregated market share of the five Chinese module manufacturers is 28%. On the other hand, some countries with high solar PV capacity, most of which are European countries, do not have even one of the top 10 solar PV manufacturers. In the case of wind energy, the home countries of the top 10

manufacturers are not exactly the top 10 countries in terms of wind power capacity. For instance, Denmark has Vestas, which has 12% of market share in wind turbine market, but it is not one of the top 10 countries in terms of wind power capacity.

Table 3. Top 10 manufacturers in solar PV and wind power, 2015.

a. Top 10 solar PV module manufacturers and top 10 countries in solar PV capacity

Rank	Solar PV module manufacturer	Global Shipment ratio, %	Home country	Rank	Country	Capacity, GW (%)
1	Trina	7	China	1	China	43.5 (19)
2	JA Solar	7	China	2	Germany	39.7 (17)
3	Hanwha Q-cell	7	South Korea	3	Japan	34.4 (15)
4	Canadian Solar	5	Canada	4	USA	25.6 (11)
5	First Solar	5	USA	5	Italy	18.9 (8)
6	Jinko Solar	5	China	6	UK	9.1 (4)
7	Yingli Green Energy	5	China	7	France	6.6 (3)
8	Motech	4	Taiwan	8	Spain	5.4 (2)
9	NeoSolar	4	Taiwan	9	India	5.2 (2)
10	Suntech	4	China	10	Australia	5.1 (2)
Rest of companies		47		Rest of the world		77 (34)
Total		100		Total		227 (100%)

b. Top 10 wind turbine manufacturers and top 10 countries in wind power capacity

Rank	Wind turbine manufacturer	Market share ,%	Home country	Rank	Country	Capacity, GW (%)
1	Goldwind	13	China	1	China	145 (34)
2	Vestas	12	Denmark	2	USA	74 (17)
3	GE Wind	10	USA	3	Germany	45 (10)
4	Siemens	8	Germany	4	India	25 (6)
5	Gamesa	5	Spain	5	Spain	23 (5)
6	Enercon	5	Germany	6	UK	14 (3)
7	United Power	5	China	7	Canada	11 (3)
8	Mingyang	4	China	8	France	10 (2)
9	Envision	4	China	9	Italy	9 (2)
10	CSIC Haizhuang	3	China	10	Brazil	9 (2)
Rest of companies		31		Rest of the world		68 (16)
Total		100		Total		433 (100)

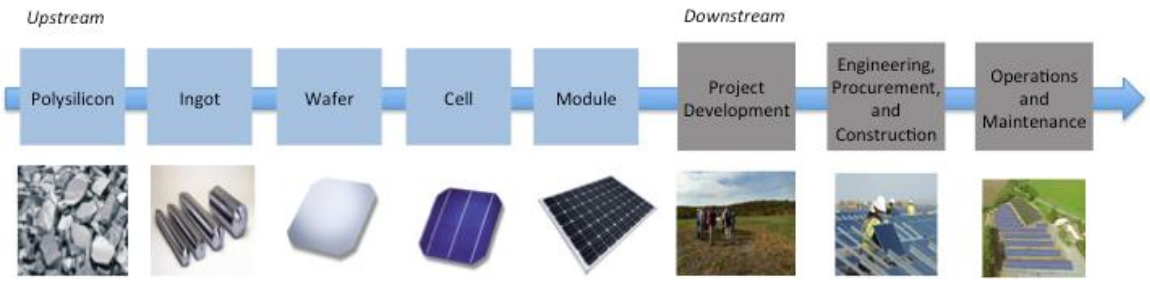
Source: Renewable Energy World, "2015 Top Ten PV Cell Manufacturers", http://www.renewableenergyworld.com/articles/2016/04/2015-top-ten-pv-cell-manufacturers.html; Renewable Energy Policy Network for the 21st century, "Renewables 2016: Global Status Report"

This globalization of renewable energy industry affects global renewable energy development in various ways. It brings the cost-down of renewable energy products since the global corporations could have an economy of scale by increasing manufacturing capacity according to the global demand or can move their manufacturing plants to other countries for cost-down. In terms of the effect on national policies, the global renewable energy corporations may be able to influence the policies in multiple countries. They may do it as an individual actor, or by collaborating with other multinational and domestic actors. Moreover, the rise of the global corporations may change the conditions of domestic renewable energy markets as well as those of the global renewable energy market. These aspects are considered as the aspects of the globalization of renewable energy industry in this research.

Rise of diverse corporate actors and diversified interests

As the renewable energy industry has grown, many actors have entered into the industry. This has created and changed the value chain of renewable energy. Figure 7 shows the solar PV value chain. Since many corporations have entered into the solar PV industry, the value chain has been created and developed. Some corporations are vertically integrated; they conduct most of the businesses in the value chain. For instance, many cell and module manufacturers have expanded to downstream business such as project development and engineering, procurement and construction recently. However, many other smaller corporations are specialized in one or two sectors of the value chain.

Figure 7. Solar PV value chain.



This diversity in solar businesses has led to the differences in perceptions of the external environment among solar corporations. Most notably, the external environment of upstream solar PV corporations is different from that of downstream solar PV corporations. For instance, transmission and interconnection rights, approvals and permits for building power plants are important parts of the external environment of the downstream corporation. However, these are not significant issues for the upstream corporations. In this sense, each corporation has different policy needs based on the type of solar business of it is involved in. Under these circumstances, the solar PV industry has become engaged in more policy issues as the value chain of solar PV has developed and expanded, addressing diversifying policy needs of each corporation.

Due to these diversified interests of solar corporations, some policy issues cause conflicts of interests even within solar PV industry. For instance, the tariff on Chinese solar panels in the U.S. caused debates between upstream and downstream solar PV corporations. Since the tariff would reduce the imports of low-priced Chinese solar panels, the upstream corporations were supportive for the introduction of the tariff. However, the reduction of Chinese solar panels was expected to harm the downstream

corporations by increasing overall cost of solar panels. This difference has caused the conflict of interests in the U.S. solar PV industry.

The development of the solar PV value chain has expanded and diversified solar PV industry's interests and policy needs. Moreover, it also generated the conflicts of interests between corporations within solar PV industry. This has changed the interactions between industry and policies in renewable energy field. These changes of interactions are analyzed throughout this research.

Global political economy and renewable energy

Renewable energy does not exist in a vacuum. In recent years, various international and domestic political factors have affected the development of renewable energy. The global financial crisis was one of the most influential events affecting renewable energy development. Rising exports of Chinese products has been another factor to affect renewable energy development.

In 2009, a year after the global financial crisis, global total final energy consumption was reduced by 1% compared to 2008, which was the first time reduction since 1981.[13] However, this did not last long; it started increasing again in 2010. Moreover, this momentary reduction of energy consumption did not significantly affect the growth of renewable energy. The consumption of renewable energy sources has dramatically increased every year in the most recent ten years including the years of the global financial crisis.

[13] International Energy Agency, "Statistics," http://www.iea.org/statistics/ (accessed March 30, 2017)

Discouraged energy investment caused by the global financial crisis has been a much more critical effect on renewable energy development. In 2009, energy investment dropped in most regions of the world. Many energy projects were slowed, postponed, or cancelled. The investment in renewable energy has slowed in 2008, and the spending for renewable energy in the first quarter of 2009 dropped by 42% compared to the first quarter of 2008.[14] This dramatic drop was caused by the lack of project finances and the reduced economic incentives to invest in renewables due to low fossil fuel prices.[15]

Rising exports of Chinese products introduced increasing international trade conflicts in recent years. In particular, the conflicts between the United States and China became more significant as the U.S. trade deficit with China increased in recent decades. The gap between imports and exports in the U.S. with China has widened to $240 billion in 2009 from $112 billion in 2000.[16] This has led to much debate on the imports from China in the United States. The report of the Peterson Institute for International Economics showed that the number of newspaper articles mentioning the U.S. trade deficit with China has dramatically increased in 2005-2007, and in 2010.[17]

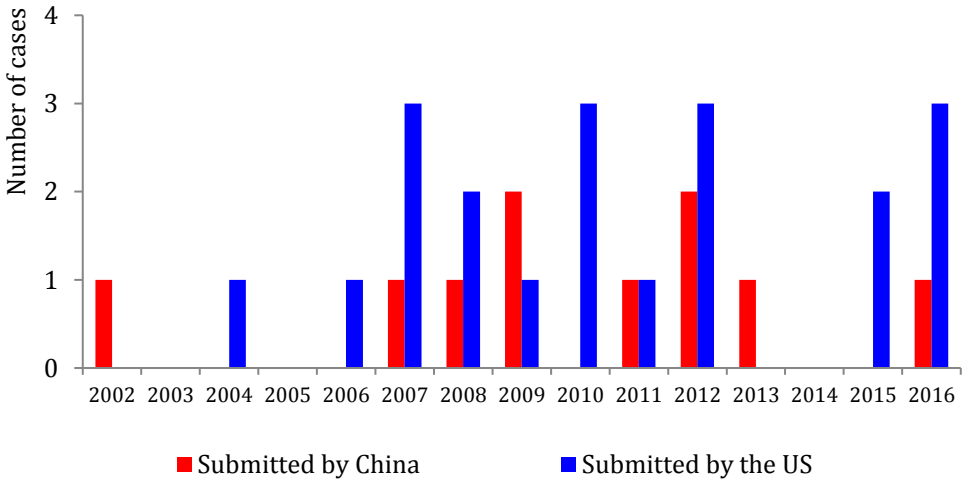
Under these circumstances, the trade disputes between the U.S. and China have risen. By the end of 2016, 10 cases were submitted to the WTO by China with the U.S.,

---

[14] International Energy Agency, *The Impact of the Financial and Economic Crisis on Global Energy Investment*, IEA Background paper for the G8 Energy Ministers' Meeting, May 24-25, 2009.
[15] International Energy Agency, World Energy Outlook 2009, Paris: IEA. 2009. http://www.worldenergyoutlook.org/media/weowebsite/2009/WEO2009.pdf.
[16] Hufbauer, Gary Clyde, and Jared C. Woollacott. *Trade Disputes Between China and the United States: Growing Pains so Far, Worse Ahead?* Peterson Institute for International Economics, Working Paper Series, December 2010.
[17] Ibid., p48.

and 20 cases were submitted by the U.S. with China.[18] The submission of disputes started increasing in 2007 (Figure 8). The U.S. submitted 1-3 disputes with China every year from 2007 to 2012. China also submitted disputes every year since 2007 till 2013 except the year of 2010. One of the drivers of these disputes was the increasing unemployment in the U.S., which has led the U.S. government to attempt to preserve American industry and jobs.

Figure 8. WTO disputes between the U.S. and China, 2002-2016.



Source: World Trade Organization

Renewable energy products were one of the goods that caused trade disputes between the U.S. and China. The dispute on Chinese solar products emerged in 2012, when several other trade disputes were ongoing between China and the U.S. The issue of solar products was discussed with the issues of other goods. Therefore, the overall trade

[18] World Trade Organization, "Disputes by country/territory." https://www.wto.org/english/tratop_e/dispu_e/dispu_by_country_e.htm (accessed March 30, 2017)

conflict between the U.S. and China has affected how solar product trade issue was framed and was solved in both countries.

The global financial crisis and the rise of China in the global economy have changed the external environment of renewable energy development. The effects of the global financial crisis were mostly negative, but the effects of the rise of China were more complicated since the effects were different among actors as well as among countries. These complicated effects are discussed in each analysis of this research.

Research design

Among renewable energy sources, this research focuses on solar PV. Solar PV is the most substantially growing field in renewable energy in recent years. With this growth, a global value chain was created since many solar PV corporations have expanded their business overseas. This led solar PV industry to be more globalized compared to the other renewable energy industries. To examine the case of the most globalized renewable energy industry enables to understand what will happen for the other renewable energy sources as the industries of them become globalized.

This research consists of three separate analyses (Table 4). Each analysis focuses on a different aspect of the globalization of renewable energy industry. Analysis 1 and Analysis 2 focuses on the effects of multinational renewable energy corporations on national policies as actors. Analysis 1 examines the behavior of multinational solar PV corporations to change national policies. Since multinational corporations have resources and capabilities to affect policies beyond their national boundaries, it is expected that they can be critical actors to affect national policies. Analysis 2 focuses on the political

interactions among multinational and domestic actors. While the first analysis examines the behavior of an actor, the second analysis investigates the interplay of actors to change a policy. Finally, Analysis 3 focuses on the change of market conditions by the globalization of renewable energy industry. It investigates how national renewable energy policies have actually changed under the changes of the global renewable energy market.

Analysis 1 answers: *How have multinational renewable energy corporations affected national policies?* The proposition is that multinational renewable energy corporations are more likely to engage in policymaking for favorable policies under the challenges of the global market. This proposition was developed based on the institutional theory, which will be reviewed in the Chapter 2. To answer this question, a content analysis of the 125 annual reports of the top 15 solar PV multinational corporations was conducted.

The research question of Analysis 2 is: *How have diverse actors framed renewable energy trade issues?* The proposition, which was also developed grounded in the institutional theory, is that the central domestic actors of a renewable energy field have framed renewable energy trade issues with a traditional environmental frame. The research method is a discourse network analysis. The articles from the seven U.S. newspapers on the U.S.-China solar panel trade were used as data.

Finally, Analysis 3 answers: *What has caused the increasing divesity in national renewable energy policies?* The proposition is that the growth of domestic renewable energy industries has caused the diversification of national renewable energy policies as renewable energy industries have become globalized. This is grounded in the theory of

policy convergence, which will be reviewed in Chapter 2. The research method is a case study of the U.S. and South Korea.

Table 4. Summary of three analyses.

	Level (Aspect of globalization)	Research question	Proposition	Method	Data	Chapter
Analysis 1	Firm (Rise of multinational corporations)	How have multinational renewable energy corporations affected national policies?	Multinational renewable energy corporations are more likely to engage in policymaking for favorable policies under the challenges of the global market	Content analysis	Annual reports of the top 15 solar PV multinational corporations	Ch. 3
Analysis 2	Field (Increasing international interactions)	How have diverse actors framed renewable energy trade issues?	The central domestic actors of a renewable energy field have framed renewable energy trade issues with a traditional environmental frame	Discourse network analysis	Newspaper articles on the US-China solar panel trade	Ch. 4
Analysis 3	Country (Change of market conditions)	What has caused the increasing diversity in national renewable energy policies?	The growth of domestic renewable energy industries has caused the diversification of national renewable energy policies as renewable energy industries have become globalized	Case study	Qualitative interviews, observations, archival data	Ch. 5-7

Case Study Method

The details of the methods of Analysis 1 and Analysis 2 are described in Chapter 3 and Chapter 4, respectively. Since the results of the Analysis 3 are described from Chapter 5 to Chapter 7, the overview of the case study method is illustrated in this section.

The independent variable of the case study is the growth of solar PV industry and the dependent variable is the change of national solar PV policies. The study identifies a causal chain that links the independent variable with the dependent variable. National solar PV policies include all the national level policies related to solar PV such as tariffs and industrial policies as well as the traditional support and market-based renewable energy policies. Globalization of solar PV industry is an intervening variable governing the mechanism of interactions between solar PV industry and the policies.

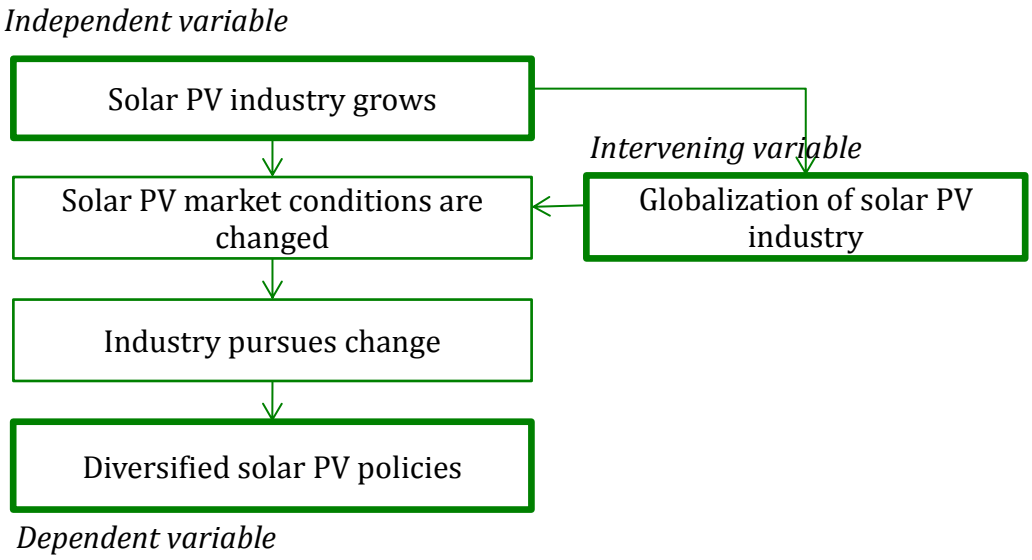
To reveal the causal chain between solar PV industry and policies, process-tracing method is used. The process-tracing method is to "identify the intervening causal process—the causal chain and causal mechanism—between an independent variable and the outcome of the dependent variable".[19] Process-tracing can identify whether a potential causal variable can be ruled out in non-perfectly matched cases. Since this research investigates countries, which cannot be perfectly matched cases due to each country's specific political, economic, and social contexts, the method of controlled comparison, which requires the cases similar in every aspect but one, cannot be used. Moreover, by examining causal paths, it enables researchers to address the issue of equifinality, which

[19] George, Alexander L., and Andrew Bennett. *Case Studies and Theory Development in the Social Sciences*. (Massachusetts: MIT Press, 2005), 206.

means different causal paths that lead to a similar outcome. As this research deals with complicated relations between industry and policy within political and economic contexts, process-tracing can help to reduce the threats to internal validity.

Explanation building of cases by using process-tracing requires hypothesized intervening steps. Figure 9 shows the hypothesized causal chain. This hypothesized causal chain is modified repetitively during the research process to better explain cases.

Figure 9. Hypothesized causal chain of policy change.



Two countries are selected as cases: the United States and South Korea. It is hard for a single case study to be compelling because each country exists in its unique contexts. Therefore, two-case studies are chosen for this research. The pool of cases was limited to the Organization for Economic Co-operation and Development (OECD) member countries to control the effects of the lack of institutional infrastructure. Among these 33 countries, six countries that have multinational solar manufacturers were

selected (Table 5). Having multinational solar manufacturers means that the countries have developed solar PV industry. Since the independent variable of this research is the growth of solar PV industry, the cases were limited in the countries with developed solar PV industry. Those countries were divided into two groups: the countries with a big domestic market and the countries with a small domestic market. The U.S., Japan, and Germany are in the big domestic market group since each country is one of the top 10 countries in terms of solar capacity.[20] South Korea, Norway, and Canada are in the small domestic market group. One country was selected from each group. The size of domestic market was used as a criterion since it is expected to influence the degree of effect of globalization of solar PV industry. For the country with a small domestic market, globalization of the industry would more significantly influence the domestic industry and policies compared to the country with a large domestic market. Finally, the U.S. and South Korea were selected as cases considering the feasibility of data collection.

Table 5. Case selection.

		Multinational solar manufacturer	
		Yes	No
Size of domestic market	Big	**U.S.**, Germany, Japan	Australia, France, Italy, Spain, UK
	Small	**South Korea**, Norway, Canada	Austria, Chile, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Iceland, Israel, Luxemburg, Mexico, Netherland, Poland, Portugal, Slovak Republic, Slovenia, Sweden, Switzerland, Turkey

[20] IEA, *2014 Snapshot of Global PV Markets*. IEA PVPS T1-26:2015. http://www.iea-pvps.org/fileadmin/dam/public/report/technical/PVPS_report_-_A_Snapshot_of_Global_PV_-_1992-2014.pdf.

Table 6 shows the differences between the U.S. and South Korea. In terms of the size of economy, the U.S. economy is more than ten times of that of South Korea, but the size of high-technology exports is similar. This shows that the economy of South Korea is more export-driven. Renewable energy is more developed in the U.S. than South Korea; the share of renewables in primary energy is 6.9% in the U.S, and 1.5% in South Korea. The investments in renewables of South Korea are only about 2% of the investments of the U.S.

The technical potential of solar PV is much higher in the U.S. than in South Korea. This shows that the potential growth of domestic market would be much bigger in the U.S. In South Korea, insufficient potential of solar PV has been pointed out as one of the barriers of solar PV development. Under these circumstances, the solar PV industry in South Korea has focused on manufacturing and exporting of solar PV products such as polysilicon, cell, module, components and equipment. As a result, in South Korea, 61% of the solar PV corporations are manufacturers, while it is only 21% in the U.S. Small domestic market and advanced manufacturing have driven Korean solar PV industry to export most of their products. In 2014, South Korea exported $2.3 billion, which was similar size of the solar PV exports of the U.S. Given that the electricity generation from solar PV in South Korea is only 12% of that in the U.S., the statistics of export shows that Korean solar PV industry is much more export-driven than the U.S.

Table 6. Economics, energy, and solar PV in the U.S. and South Korea.

		United States	South Korea
Economics [a]	GDP (billion USD, 2015)	17,947	1,378
	GDP per capita (USD, 2015)	55,837	27,222
	Export of goods and services (% of GDP, 2015)	12.6	45.9
	High-technology exports (billion USD, 2014)	155	133
	R&D Expenditure (% of GDP, 2013)	2.73	4.15
Energy	Total primary energy supply (Mtoe, 2014) [b]	2,216	268
	Share of renewables (% in TPES, 2014) [b]	6.9	1.5
	Investment in renewable energy (billion USD, 2014) [c]	37	7.7
Solar PV	Electricity Production from Solar PV (GWh, 2014) [b]	21,915	2,557
	The Share of Solar PV in Electricity Generation (%) [b]	4	18
	Technical Potential (TWh) [d]	283,600	2,341
Solar PV Industry	Multinational PV module manufacturer	Yes	Yes
	The share of manufacturers in solar PV companies (%)[e]	21%	61%
	Solar PV Exports (billion USD, 2014) [f]	2.2	2.3
Main Solar Policies	Renewable Energy Policy	Investment Tax Credits (2005-)	Feed-in-Tariff (2002-2011) Renewable Portfolio Standard (2012-)
	Others	Imposition of tariffs on Chinese solar panels (2013)	Promotion of renewable energy industry and exports

[a] Source: The World Bank, "World Bank Open Data", http://data.worldbank.org
[b] Source: IEA, 2016 Renewables Information
[c] Source: REN21, Renewables 2016: Global Status Report; New and Renewable Energy Korea, https://www.renewableenergy.or.kr/main.do
[d] Source: White Paper on New and Renewable Energy, 2012; Lopez et al. (2012).
[e] Membership data of the U.S. Solar Energy Industries Association and Korea Photovoltaic Industry Association
[f] The USITC Interactive Tariff and Trade DataWeb; New and Renewable Energy Korea, https://www.renewableenergy.or.kr/main.do

Contributions and policy implication

This research contributes to the literature on trade and the environment by analyzing a new phenomenon, the recent rise of trade and industrial policies on renewable energy, which conflict with the original goal of traditional renewable energy policies. Previous research provides good understanding of current growth of renewable energy installation and expanding traditional renewable energy policies in many countries, but it is limited in explaining countries' increasing adoption of protectionist measures on renewable energy. The research also contributes to the literature on protectionism. Despite the concern on the rise of murky type of protectionism after the global financial crisis, its contexts have been less understood. This research complements the literature by analyzing a case of one of the forms of murky protectionism.

Other than these contributions, each analysis of this research makes additional contributions. Analysis 1 and Analysis 2 provide better understanding to the literature on institutional change by showing the interactions between multinational corporations and national policies, and by studying collaborative actions of multinational actors in an issue field. Analysis 3 suggests a model on the diversification of national policies under a globalized industry, which provides implications on the theory of policy convergence.

The findings of this research provide implications to the policymakers who design renewable energy policies. Unlike the past, it is difficult to predict the result of a renewable energy policy because diverse domestic and international factors affect the policy. Understanding these factors will be the first step to design an effective renewable energy policy. The findings of this work would be beneficial from this perspective.

Moreover, based on the understanding of the contexts of globalized renewable energy industry, the research contributes to suggestions about the direction of national or international renewable energy policy.

Organization of the book

Chapter 2 reviews the literature on trade and the environment and the theories used for each analysis. Chapter 3 describes the findings of Analysis 1, which examines how solar PV multinational corporations have affected national policies. In Chapter 4, the result of Analysis 2, which investigates the political interactions regarding solar PV trade issue, is presented. Chapter 5 through Chapter 7 describes the result of Analysis 3. Chapter 5 explores the policy changes in the U.S, and Chapter 6 describes the changes in South Korea. Chapter 7 analyzes the mechanism of policy change by synthesizing two cases. Chapter 8 evaluates the propositions, and concludes with contributions and policy recommendations.

Chapter 2. Literature review

This chapter reviews the literature on trade and the environment, and the theories used for the three analyses of this research. Overall, this research aims to provide better understanding to the literature of trade and the environment, but each analysis uses different theories to answer the question of each analysis. Analysis 1 and 2 are grounded in institutional theory; Analysis 1 is based on the literature of multinational corporations' co-evolution with institutions, and Analysis 2 is based on the concept of an issue field. Analysis 3 is based on the literature on globalization and policy convergence.

Trade and the environment

The relations between trade and the environment have been an interest of many scholars. Many hypotheses have developed to explain the relations, and empirical studies have conducted to test them. There is no consistency on the effect of trade on the environment among these studies. Some studies showed positive effects of international trade, but the others revealed negative effects.

One of the most well-known hypothesis suggesting positive effects of trade on the environment is environmental Kuznets curve (EKC) hypothesis. Grossman and Kreuger found that economic growth eventually brought an improvement of environmental quality after an initial phase of environmental degradation.[21] They suggested three effects of economic growth on the environment: *the scale effect, the technique effect, and the*

[21] Grossman, Gene M., and Alan B. Krueger. *Environmental Impacts of a North American Free Trade Agreement*. No. w3914. National Bureau of Economic Research, 1991.

composition effect. The scale effect is the increase of pollutants by the growing economic activities. The technique effect is the changes of technologies for production. Trade liberalization generates the technique effect by boosting the introduction of new technologies from foreign producers and by encouraging stricter environmental regulations under increased income level. Finally, the composition effect refers to the changes of composition of the economy as countries specialize in certain activities under trade liberalization. Grossman and Kreuger suggested that lowered trade barrier influence the environment by increasing these three effects. In the initial period, the scale effect outweighs the other two effects, but over time, the other two effects offset the scale effect.

The technique effect has been pointed out as a critical factor to offset the scale effect. Stern found that technical change was one of the main factors offsetting the scale effect through developing a decomposition model using sulfur emissions data.[22] Copeland and Taylor showed that the technique effect could reduce pollutants by more than the increase of pollutants by the scale effect.[23] Based on these results, they suggest that economic growth with environmentally friendly technologies could even improve the environment. Bruvolle and Medin also showed that technologies played a significant role to reduce the increase of emissions caused by the scale effect.[24]

---

[22] Stern, David I. "Explaining changes in global sulfur emissions: an econometric decomposition approach." *Ecological Economics* 42, no. 1 (2002): 201-220.
[23] Copeland, Brian R., and M. Scott Taylor. *Trade and the environment: Theory and evidence*. Princeton University Press, 2003.
[24] Bruvoll, Annegrete, and Hege Medin. "Factors behind the environmental Kuznets curve. A decomposition of the changes in air pollution." *Environmental and Resource Economics* 24, no. 1 (2003): 27-48.

Openness to international trade drives faster technology diffusion.[25] Frankel and Rose suggested the gains-from-trade hypothesis, which refers to the positive effect of the openness to trade.[26] They proposed three possible effects. First, trade can trigger technological innovations. Trade speed up the adoption of advanced technologies and best practices.[27] Second, as the public awareness of environmental issues increase, the environmental standards go higher. Third, multinational corporations diffuse clean technologies from advanced countries.

Empirical studies on the composition effect have mixed results, while a majority of the studies on the technique effect showed positive effects of it. The composition effect is generated since the industrialized countries tend to move to light manufacturing from heavy manufacturing, while industrializing countries focus on heavy manufacturing. Suri and Chapman examined these changes by modeling the imports and the exports of manufactured goods with the EKC model. They found that the exports were positively associated with energy use, while the imports were negatively associated.[28] This composition effect was criticized by the claim that manufacturing activities may be shifted to South from North.[29] In this case, the composition effect has not contributed to the improvement of the environment.

---

[25] Reppelin-Hill, Valerie. "Trade and environment: An empirical analysis of the technology effect in the steel industry." *Journal of Environmental Economics and Management* 38, no. 3 (1999): 283-301.
[26] Frankel, Jeffrey A., and Andrew K. Rose. "Is trade good or bad for the environment? Sorting out the causality." *Review of Economics and Statistics* 87, no. 1 (2005): 85-91.
[27] Frankel, Jeffrey A. "Environmental Effects of International Trade." HKS Faculty Research Working Paper Series RWP09-006 (2009).
[28] Suri, Vivek, and Duane Chapman. "Economic growth, trade and energy: implications for the environmental Kuznets curve." *Ecological Economics* 25, no. 2 (1998): 195-208.
[29] Stern, David I. "Progress on the environmental Kuznets curve?." *Environment and Development Economics* 3, no. 02 (1998): 173-196.

Pollution haven hypothesis is connected to the criticism to the composition effect. It states that the differences of environmental regulations between countries lead the shift of pollution-intensive manufacturing from developed to developing countries.[30] Since Pethig modeled that the country with weak environmental policy would export polluting goods, many studies examined if pollution haven exists.[31] The results of these studies are not consistent. Some empirical studies found an evidence of pollution haven, while many other studies did not find any evidence or found counter evidence.[32]

Pollution haven hypothesis infers race to the bottom theory, which refers to the downward pressure of the stringency of environmental regulations to attract foreign investments. On the other hand, there is a hypothesis of the opposite direction, which is called the race to the top. Regulatory competition tends to lead more stringent environmental regulations rather than weaker regulations. Vogel suggested that trade may generate upward pressure of regulations when countries' export markets have stringent

30 Cole, Matthew A. "Trade, the pollution haven hypothesis and the environmental Kuznets curve: examining the linkages." *Ecological Economics* 48, no. 1 (2004): 71-81.
31 Pethig, Rüdiger. "Pollution, welfare, and environmental policy in the theory of comparative advantage." *Journal of Environmental Economics and Management* 2, no. 3 (1976): 160-169.
32 Eskeland, Gunnar S., and Ann E. Harrison. "Moving to greener pastures? Multinationals and the pollution haven hypothesis." *Journal of Development Economics* 70, no. 1 (2003): 1-23.; Cole, Matthew A. "Trade, the pollution haven hypothesis and the environmental Kuznets curve: examining the linkages." Ecological economics 48, no. 1 (2004): 71-81.; Millimet, Daniel L., and Jayjit Roy. "Empirical tests of the pollution haven hypothesis when environmental regulation is endogenous." Journal of Applied Econometrics (2015).; Dong, Baomin, Jiong Gong, and Xin Zhao. "FDI and environmental regulation: pollution haven or a race to the top?." *Journal of Regulatory Economics* 41, no. 2 (2012): 216-237.; Kearsley, Aaron, and Mary Riddel. "A further inquiry into the Pollution Haven Hypothesis and the Environmental Kuznets Curve." *Ecological Economics* 69, no. 4 (2010): 905-919.

regulations.[33] Empirical studies show little evidence of the race to the bottom.[34] Rather, their result supported the pressure for the race to the top.[35]

Previous literature on trade and the environment do not agree on any specific direction of effect of international trade on the environment. Trade can improve the environment by driving technology innovation and the change of industrial structure, and by ratcheting up the stringency of environmental regulations. On the other hand, trade can harm the environment by increasing the scale of pollution, transferring polluting industry from developed to developing countries, and driving downward pressure of environmental regulations.

The rise of renewable energy suggests the positive side of international trade. Increasing international trade of renewable energy products have generated technology innovations, which enabled dramatic cost-down of some products. Moreover, increasing number of countries adopting renewable energy policies support the race to the top rather than the race to the bottom. However, the other side of renewable energy trade, the rise of protectionist policies, needs different perspective since it is not well understood by trade and the environment literature.

---

[33] Vogel, David. *Trading up: Consumer and environmental regulation in a global economy*. Harvard University Press, 2009.
[34] Potoski, Matthew. "Clean air federalism: Do states race to the bottom?." *Public Administration Review* 61, no. 3 (2001): 335-343.; Konisky, David M. "Regulatory competition and environmental enforcement: Is there a race to the bottom?." *American Journal of Political Science* 51, no. 4 (2007): 853-872.; Prakash, Aseem, and Matthew Potoski. "Racing to the bottom? Trade, environmental governance, and ISO 14001." *American Journal of Political Science* 50, no. 2 (2006): 350-364.
[35] Prakash, Aseem, and Matthew Potoski. "Racing to the bottom? Trade, environmental governance, and ISO 14001." *American Journal of Political Science* 50, no. 2 (2006): 350-364.

Esty pointed out that domestic environmental regulations could act as nontariff barriers by using an example of the tuna-dolphin case.[36] The U.S. banned tuna imports from Mexico since the fishing methods in Mexico did not meet the standards to protect dolphins. In 1991, General Agreement on Tariffs and Trade (GATT) declared that the U.S. violated GATT rules for imposing the ban. He suggested that new issues like climate change would increase the conflicts between domestic regulations and trade rules.

Renewable energy protectionism seems similar with the tuna-dolphin case, but it is different in that domestic trade and industrial policies conflict with the trade of environmental goods. In other words, the conflict in the past was environmental regulation versus trade policy, but the current conflict is trade/industrial policy versus the trade of environmental goods. The current phenomenon is less transparent and more complicated compared to the past conflicts between domestic regulations and trade.

The rise of "murky" protectionism and green protectionism

Although the global financial crisis in 2007 has generated much concern on the rise of protectionism, no significant increase of protectionist measures was observed in recent years.[37] Countries attempted to use trade policies to address the crisis but it was not very substantial compared to the degree before the crisis. The opposite direction of actions was also observed. Many countries reduced the degree of protection selectively

[36] Esty, Daniel C. "Bridging the trade-environment divide." *The Journal of Economic Perspectives* 15, no. 3 (2001): 113-130.
[37] Kee, Hiau Looi, Cristina Neagu, and Alessandro Nicita. "Is protectionism on the rise? Assessing national trade policies during the crisis of 2008." *Review of Economics and Statistics* 95, no. 1 (2013): 342-346.

for some products. Governments' use of trade policies has become heterogeneous since they use both restricting and liberalizing trade policies in recent years.[38]

Some argued that governments used more "murky" form of protectionist measures to fight against the crisis, while they did not use more traditional trade policies. Murky form of protectionism refers to "abuses of legitimate discretion which are used to discriminate against foreign goods, companies, workers and investors."[39] This is murky since it is not clearly against the WTO rules. Environmental and health regulations, stimulus package, or license requirements can be used as this murky protectionist measures by providing favor to domestic products.

A few empirical studies show the evidence of murky protectionism. According to the analysis of the Global Trade Alert, less than half of the protectionist measures were the traditional instruments such as tariffs and anti-dumping measures after the global financial crisis.[40] A majority of the other protectionist measures were less transparent instruments. Aggawal and Evenett found that the countries with more policies discriminating foreign interests tended to use more policies covered by weak or no WTO rule by investigating all state intervention in seven major economies for three years after

---

[38] Bollen, Yelter, Ferdi De Ville, and Jan Orbie. "EU trade policy: persistent liberalisation, contentious protectionism." *Journal of European Integration* 38, no. 3 (2016): 279-294.

[39] Evenett, Simon J., and John Whalley. "18. Resist green protectionism–or pay the price at Copenhagen." The Collapse of Global Trade, Murky Protectionism and the Crisis: Recommendations for the G20 (2009): 93-98.

[40] Aggarwal, Vinod K., and Simon J. Evenett. "A fragmenting global economy: A weakened WTO, mega FTAs, and murky protectionism." *Swiss Political Science Review* 19, no. 4 (2013): 550-557.

the global financial crisis.[41] This suggests that WTO rules are hard to constrain governments' use of protectionist measures.

Green protectionism is one of the forms of murky protectionism. It refers to the cases of governments to justify the protectionist measures by using environmental concerns. These policies seem like environmental policies but are driven by the desire to promote domestic industry against foreign competitors. As an example of green protectionism, Evenett and Walley took national stimulus packages on "green" spending.[42] The U.S. stimulus legislation included funding for advanced battery systems, which can benefit only the U.S. manufacturers. Government procurement of environmental goods from domestic providers can be argued as an example of green protectionism. Erixon suggested that new sustainability criteria for biofuel production would be used to protect local producers from foreign competitors in Europe, which would be one of the forms of green protectionism.[43]

As for renewable energy, both the traditional protectionist measures and murky protectionist measures have observed in recent years. China's industrial policies to promote renewable energy have led trade frictions with the U.S. and Europe.[44] The U.S. imposed tariffs on the solar modules from China, and the EU implemented minimum price and a quota policy to protect domestic industry from China's "unfair" trade

---

41 Aggarwal, Vinod K., and Simon J. Evenett. "Industrial policy choice during the crisis era." *Oxford Review of Economic Policy* 28, no. 2 (2012): 261-283.
42 Evenett, Simon J., and John Whalley. "18. Resist green protectionism–or pay the price at Copenhagen." The Collapse of Global Trade, Murky Protectionism and the Crisis: Recommendations for the G20 (2009): 93-98.
43 Erixon, Fredrik. "The rising trend of green protectionism: Biofuels and the European Union." ECIPE Occasional Paper 2 (2012).
44 Carbaugh, Robert J., and Max St Brown. "Industrial policy and renewable energy: Trade conflicts." *Journal of International and Global Economic Studies* (2012): 1-16.

practices. A number of countries have introduced domestic content requirements, which require renewable energy developers to use domestically-produced facilities.

Lewis argues that renewable energy protectionism has caused by inherent conflicts between renewable energy support and the global trade regime.[45] Since economic rationale was necessary to have political supports for renewable energy policies, especially after the global financial crisis, countries use protectionist measures to promote domestic renewable energy manufacturing. The environmental rational of these industrial policies was not enough to be justified under the global trade rules. Therefore, the policies have led conflicts with international trade rules.

Previous research showed that green protectionism has risen after the global financial crisis. However, it is less understood why green protectionism has increased in recent years although environmental policies and renewable energy policies have been implemented in several decades. Lewis suggested fundamental conflicts between renewable policies and trade rules, but many traditional renewable energy policies have been implemented to create demand of renewable energy sources rather than to directly support industry. The increase of protectionist policies is a recent trend. The cause of this current trend needs to be investigated to better understand the mechanism of green protectionism.

---

[45] Lewis, Joanna I. "The Rise of Renewable Energy Protectionism: Emerging Trade Conflicts and Implications for Low Carbon Development." *Global Environmental Politics* (2014):10-35.

Institutional theory and institutional change: Theoretical framework for Analysis 1 and Analysis 2

Institutional theory suggests that organizational actions are the choices among limited options, which are determined by specific environmental conditions rather than a pure rational choice of the organization. In other words, organizational choices are shaped by institutional environments around an organization, which is called an organizational field. An organizational field is defined as "organizations in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar service or products".[46] Organizational fields are the areas for institutional life; organizations "gather and frame their actions vis-a-vis one another".[47]

Central to institutional theory is the preference for certainty of organizations.[48] Organizations attempt to avoid uncertainty for their survival, which is the goal of their organizational actions.[49] As the goal is survival rather than profit maximization, internal elements of organizations are legitimated by external factors than in terms of efficiency.[50] For organizations, one of the ways to avoid uncertainty is to imitate other organizations

---

[46] DiMaggio, Paul, and Walter W. Powell. "The iron cage revisited: Collective rationality and institutional isomorphism in organizational fields." *American Sociological Review* 48, no. 2 (1983): 147-160.
[47] Fligstein, Neil. "Social skill and the theory of fields." *Sociological Theory* 19, no. 2 (2001): 105-125.
[48] DiMaggio, P. J. "Interest and Agency in Institutional Theory", in *Institutional Patterns and Organizations: Culture and Environment*, ed. Lynne G Zucker (MA: Ballinger, 1988). 3-22.
[49] Fligstein, Neil. "Markets as politics: A political-cultural approach to market institutions." *American Sociological Review* (1996): 656-673.
[50] Meyer, John W., and Brian Rowan. "Institutionalized organizations: Formal structure as myth and ceremony." *American Journal of Sociology* (1977): 340-363.

that are successful or legitimate. For this reason, the greater the uncertainty of a field, the greater institutional isomorphism among organizations.

The notion of isomorphism in institutional theory is criticized due to its failure to explain institutional change.[51] Although most firms imitate successful firms' behaviors, some firms behave differently from other firms, or they attempt to change existing institutions. Lack of explanations for endogenous institutional changes have been regarded as core weakness of institutional theory.

"Old" institutionalism was reintroduced for some research to address this gap.[52] Old institutionalism focuses on conflicts of interests, institutional changes, and focal organizations, while "new" institutionalism is interested in homogeneity, persistence, and fields. Hoffman showed how organizational fields and institutions "coevolve" by using the concept of change in old institutionalism; although the options of individual actions are limited by organizational fields, these options evolve with the fields.[53] Greenwood and Hinings examined the responses of organizations to institutional pressures as a

---

[51] Hirsch, Paul M., and Michael Lounsbury. "Ending the family quarrel toward a reconciliation of "old" and "new" institutionalisms." *American Behavioral Scientist* 40, no. 4 (1997): 406-418. Oliver, Christine. "Strategic responses to institutional processes." *Academy of Management Review* 16, no. 1 (1991): 145-179.

[52] Greenwood, Royston, and Christopher R. Hinings. "Understanding radical organizational change: Bringing together the old and the new institutionalism." *Academy of Management Review* 21, no. 4 (1996): 1022-1054.; Hoffman, Andrew J. "Institutional evolution and change: Environmentalism and the US chemical industry." *Academy of Management Journal* 42, no. 4 (1999): 351-371.

[53] Hoffman, Andrew J. "Institutional evolution and change: Environmentalism and the US chemical industry." *Academy of Management Journal* 42, no. 4 (1999): 351-371.

function of internal dynamics of organizations including interests, values, power dependencies and capacities.[54]

A line of studies focuses on the concept of "institutional entrepreneurship" to address institutional change. Institutional entrepreneurs are actors who envision new institutions or transform existing institutions.[55] As the concept focuses on the actors, it easily overemphasizes the heroic behaviors of specific actors, which result in ignoring institutional pressures on those actors. To address this weakness, Battilana, Leca, and Boxenbaum suggested two enabling conditions for institutional entrepreneurship: field characteristics, and actor's social position.[56] Field characteristics include jolts and crises, heterogeneity of institutional arrangements, and the degree of institutionalization. Jolts and crises such as regulatory change, economic and political crises, and social upheaval encourage the introduction of new ideas by disturbing field-level consensus.[57] Heterogeneity could be enabling conditions, since they are likely to increase internal conflicts. Seo and Creed also suggested that institutional contradictions such as efficiency gaps, nonadaptability, interinstitutional incompatibility, and misaligned interests increase

---

54 Greenwood, Royston, and Christopher R. Hinings. "Understanding radical organizational change: Bringing together the old and the new institutionalism." *Academy of Management Review* 21, no. 4 (1996): 1022-1054.

55 DiMaggio, P. J. "Interest and Agency in Institutional Theory", in *Institutional Patterns and Organizations: Culture and Environment*, ed. Lynne G Zucker (MA: Ballinger, 1988). 3-22.

56 Battilana, Julie, Bernard Leca, and Eva Boxenbaum. "2 how actors change institutions: towards a theory of institutional entrepreneurship." *The Academy of Management Annals* 3, no. 1 (2009): 65-107.

57 Fligstein, Neil. "Social skill and institutional theory." *American Behavioral Scientist* 40, no. 4 (1997): 397-405.; Greenwood, Royston, Roy Suddaby, and Christopher R. Hinings. "Theorizing change: The role of professional associations in the transformation of institutionalized fields." *Academy of Management Journal* 45, no. 1 (2002): 58-80.

the likelihood of human praxis for institutional change.[58] Lower level of institutionalization encourages the actions of institutional entrepreneurs since it increases uncertainty. Under increasing uncertainty, firms tend to find institutional solution since they are not able to solve problems under existing conditions.[59]

Under these enabling conditions, institutional entrepreneurs initiate divergent institutional changes. The activities of institutional entrepreneurs can be divided into two categories of creating a vision for change, and mobilizing actors.[60] First, institutional entrepreneurs develop and provide a vision for change to appeal audience. Greenwood and colleagues suggested "theorization" as a key stage of institutional change, which include framing current problems and justifying solutions.[61] Maguire and colleagues found empirical evidence of theorization in emerging fields; they showed that institutional entrepreneurs theorize new practices by organizing diverse arguments that address different interests in the fields.[62] A new logic that best suit actors' interests can be a powerful tool of institutional change for institutional entrepreneurs.[63]

---

58 Seo, Myeong-Gu, and WE Douglas Creed. "Institutional contradictions, praxis, and institutional change: A dialectical perspective." *Academy of Management Review* 27, no. 2 (2002): 222-247.

59 Fligstein, Neil. *The Architecture of Markets: An Economic Sociology of Twenty-first-century Capitalist Societies*. Princeton: Princeton University Press, 2002.

60 Battilana, Julie, Bernard Leca, and Eva Boxenbaum. "2 how actors change institutions: towards a theory of institutional entrepreneurship." *The Academy of Management Annals* 3, no. 1 (2009): 65-107.

61 Greenwood, Royston, Roy Suddaby, and Christopher R. Hinings. "Theorizing change: The role of professional associations in the transformation of institutionalized fields." *Academy of Management Journal* 45, no. 1 (2002): 58-80.

62 Maguire, Steve, Cynthia Hardy, and Thomas B. Lawrence. "Institutional entrepreneurship in emerging fields: HIV/AIDS treatment advocacy in Canada." *Academy of Management Journal* 47, no. 5 (2004): 657-679.

63 Lounsbury, Michael, Heather Geraci, and Ronit Waismel-Manor, "Policy Discourse, Logics, and Practice Standards: Centralizing the Solid-Waste Management Field," in

Institutional entrepreneurs motivate cooperation and mobilize alliance by using political tactics and strategies. Fields are alignments of forces, and the tensions between them provide rooms for strategic agency.[64] From this perspective, institutional entrepreneurs are strategic actors rather than dominant actors with much resource. Lawrence, Hardy, and Phillips suggested interorganizational collaboration can initiate institutional changes even with a lack of resources and power.[65] Institutional entrepreneurs are embedded in fields; thus, their strategies are influenced by field characteristics and other actors.

The studies on institutional change have focused on the interactions between institutions and actors. Regulatory capture theory has more focused on the effect of private interests on regulations rather than interactions between them. Since the interest of this research is the effect of industry on national policies, it would be benefitted from reviewing the literature on regulatory capture.

Regulatory capture

Broadly, regulatory capture is the process that special interests influence state intervention.[66] Regulatory capture is possible because special interests, especially firms, have private information that is not shared with political representatives and citizens. The

---

Organizations, Policy, and the Natural Environment, ed. Andrew Hoffman and Marc Ventresca (California: Stanford University Press, 2002): 327-342.

[64] Levy, David, and Maureen Scully. "The institutional entrepreneur as modern prince: The strategic face of power in contested fields." *Organization Studies* 28, no. 7 (2007): 971-991.

[65] Lawrence, Thomas B., Cynthia Hardy, and Nelson Phillips. "Institutional effects of interorganizational collaboration: The emergence of proto-institutions." *Academy of Management Journal 45*, no. 1 (2002): 281-290.

[66] Dal Bó, Ernesto. "Regulatory capture: a review." *Oxford Review of Economic Policy* 22, no. 2 (2006): 203-225.

type of regulation capture can be various including a direct subsidy, controlling over entry by new rivals, controlling substitutes and complements, and price-fixing.[67] This can be costly to society. For instance, the costs of the rents caused by "political" firms ranged from 0.3 to 1.9 of the GDP in Pakistan.[68]

Stigler showed that regulation is acquired by an industry and is operated for its benefits by using several cases.[69] The statistical analysis of the pattern of weight limits on trucks has influenced by the agricultural interests, railroads, and the public concerns. He also showed that the licensed occupations have higher incomes and the membership of the licensed occupation is more stable.

To explain interest group politics, Laffont and Tirole suggested a three-tier hierarchy model with firm, agency, and the Congress.[70] The model showed that the agency's discretion to determine the level of regulation was reduced when interest groups were better organized. The characteristic of regulations has an effect on the political power of interest groups. An interest group has more political power if its interest is in inefficient rather than efficient regulation, since the agency's discretion is for hiding information from Congress, and this asymmetry makes regulation less efficient.

Regulatory capture happens in multiple ways. Etzioni categorized the types of regulatory capture and showed the evidence of each type of regulatory capture in the real

---

67 Stigler, George J. "The theory of economic regulation." *The Bell Journal of Economics and Management Science* (1971): 3-21.
68 Khwaja, Asim Ijaz, and Atif Mian. "Do lenders favor politically connected firms? Rent provision in an emerging financial market." *The Quarterly Journal of Economics* (2005): 1371-1411.
69 Stigler, George J. "The theory of economic regulation." *The Bell Journal of Economics and Management Science* (1971): 3-21.
70 Laffont, Jean-Jacques, and Jean Tirole. "The politics of government decision-making: A theory of regulatory capture." *The Quarterly Journal of Economics* (1991): 1089-1127.

world.[71] Special interests involve in drafting legislation, but even if a regulation has already drafted, special interests still dilute and weaken the regulation. They are also able to weaken the enforcement of a regulation without changing the regulation. With the decreasing public concern, special interests can affect repealing a regulation. Sometimes, they switch regulators if they could not affect existing regulations. Special interests also involve in setting rates and prices, which are higher than the market sets. To prevent these engagements, Etzioni suggests restricting the role of private money in public life. According to him, legislators are dependent on special interests due to funds. Thus, reforming campaign-finance law would be helpful to reduce regulatory capture.

Previous studies on regulatory capture focused on the relationship between the regulatory authority and interest groups. They tend to focus on the game between government and firms. Although the theory of regulatory capture well explains the effects of interest groups on governmental policy, it is limited in showing the political contexts of policymaking. In this sense, Spiller and Tommasi pointed out the importance of institutional environment for the behaviors of actors in policymakings.[72] They suggested several conditions for cooperation for a stable and flexible policy. The conditions include small number of key actors, strong intertemporal linkage between the actors, observable political moves. This shows that regulations are difficult to be understood as a pure game of government and firm.

---

[71] Etzioni, Amitai. "The capture theory of regulations—Revisited." Society 46, no. 4 (2009): 319-323.
[72] Spiller, Pablo T., and Mariano Tommasi. "The institutions of regulation: An application to public utilities." in *Handbook of New Institutional Economics*, ed. Claude Menard and Mary M. Shirley (Springer, 2005). 515-543.

Embeddedness of multinational corporations

Current globalization of industries is raising doubts on the concept of an organizational field. A number of studies have suggested that an organizational field operates in different ways for multinational corporations (MNCs). Although neoinstitutional models consider endogenous changes by adopting the institutional entrepreneurship, they still focus on external institutional pressures, which come from fields. As MNCs operate across diverse national institutions and are consist of multiple subsidiary units, organizational fields of MNCs are hard to be defined. In other words, the institutional environments of them are multiple, fragmented, and conflicting each other rather than granted and static fields.[73] Therefore, institutional pressures for MNCs are weak and diverse. Under multiple institutional environments, MNCs select to what extent they will be embedded in the environments in which they operate.[74]

In this sense, for MNCs, social environments are evolving rule system, which are "products of a continuous process of sensemaking, enactment, and negotiated political interactions".[75] Legitimacy is constructed by political processes, and power plays an important role in the dynamics of institutions. Powerful business and financial organizations can change the relationship between institutions and organizations. These organizations can "reverse-legitimate" institutions like institutions legitimate

---

[73] Kostova, Tatiana, Kendall Roth, and M. Tina Dacin. "Institutional theory in the study of multinational corporations: A critique and new directions." *Academy of Management Review* 33, no. 4 (2008): 994-1006.
[74] Heidenreich, Martin. "The social embeddedness of multinational companies: a literature review." *Socio-Economic Review* (2012): 549-579.
[75] Kostova, Tatiana, Kendall Roth, and M. Tina Dacin. "Institutional theory in the study of multinational corporations: A critique and new directions." *Academy of Management Review* 33, no. 4 (2008): 994-1006.

organizations.[76] In this vein, isomorphism does not help MNCs to be legitimate. MNCs become less homogeneous under the activities for legitimacy.

Focusing on the active agency of MNCs, Cantwell, Dunning, and Lundan suggest a framework for the co-evolution of MNCs and institutions.[77] They argue that new institutions are necessary to reduce the rising importance of "non-ergodic" uncertainty. According to North, the newly created institutions for reducing uncertainty of physical environment have generated a new set of uncertainties in human environment, although they reduce uncertainty of physical environment.[78] For instance, the development of technologies has enhanced the well-being in many countries, it has generated different types of uncertainty by global interconnectedness. Under this new set of uncertainties, it is not possible to predict future based on the past. In this vein, optimal institutions are difficult to be lasted as environmental changes over time make those institutions be far from optimal. Therefore, the uncertainties that firms face now are different from those they faced in the past

According to Cantwell and colleagues, firms' response can be categorized into three: *institutional avoidance, institutional adaptation, and institutional co-evolution. Institutional avoidance* is that MNCs select between given institutional environments. For instance, under weak institutions and poor regulations, a firm can decide to exit. The second type, *institutional adaptation*, is to adjust the MNCs' structure to fit with

---

[76] Riaz, Suhaib. "The global financial crisis: an institutional theory analysis." *Critical Perspectives on International Business* 5, no. 1/2 (2009): 26-35.
[77] Cantwell, J., Dunning, J. H., & Lundan, S. M. "An evolutionary approach to understanding international business activity: The co-evolution of MNEs and the institutional environment." *Journal of International Business Studies*, 41 (2010), 567–586.
[78] North, Douglass C. *Understanding the process of economic change*. (New Delhi: Academic Foundation, 2006).

institutional environments. In the third type of *institutional co-evolution*, firms affect institutional environments. Co-evolution includes various efforts of firms such as transmission of home-country practices into other subsidiaries, and affecting institutional changes at the national, and supra-national levels. Under non-ergodic uncertainty, co-evolution is more likely than adaptation or avoidance. As it is impossible to predict future based on the past trends, diverse experimentation is the way to address the uncertainty that firms face. In this sense, Cantwell and colleagues suggest that MNCs evolve more locally responsive, yet internationally connected governance structures.

Although co-evolution is a promising concept to explain the mechanism of institutional change by MNCs, the concept needs to be elaborated, as there are many unanswered questions such as which institutional environments MNCs change. In this sense, an empirical study showing the pattern of co-evolution is expected to contribute to elaborate it. Among the unanswered questions on co-evolution, this research focuses on the MNCs' effect on national policies. In line with the literature on co-evolution, Proposition 1 is suggested:

Proposition 1. Multinational renewable energy corporations are more likely to engage in policymaking for favorable policies under the challenges of the global market.

Issue fields for change

Since the concept of an organizational field has not been very clear, a recent study suggested a systematic classification of organizational fields.[79] They recommended using two different types of fields: *exchange field* and *issue field*. Exchange fields refer to the fields including a class of actors, which are alike in some respect, and their exchange partners. It is consistent with the traditional concept of an organizational field. Issue fields comprise of actors from multiple exchange fields, which participate in the fields to affect a specific issue. Zietsma and colleagues suggested the necessity of considering issue fields differently from exchange fields because the effects of issue fields on institutional process are different from those of exchange fields.

Hoffman suggested the initial idea of issue fields by arguing that organizational fields form around a central issue rather than a technology or market.[80] His study empirically showed that issue field is "the center of common channels of dialogue," where organizations interpret and negotiate issue. O'Sullivan and O'Dwyer advanced Hoffman's concept of issue field and suggested a theory of issue field structuration.[81] Through the case analysis of commercial banks' environmental and social risk management guidelines, they suggested that issue fields evolve based on the infrastructure of matured exchange fields that the actors of issue fields are in. Their model consists of three phases. First, the central actors of existing field enlist the logic of the field relevant the issue and reconstruct it to serve the logic of challengers. Second, the

---

79 Zietsma, Charlene, Peter Groenewegen, Danielle Logue, and Cr Hinings. "Field or fields? Building the scaffolding for cumulation of research on institutional fields." *Academy of Management Annals* (2016).

80 Hoffman, Andrew J. "Institutional evolution and change: Environmentalism and the US chemical industry." *Academy of Management Journal* 42, no. 4 (1999): 351-371.

81 O'Sullivan, Niamh, and Brendan O'Dwyer. "The structuration of issue-based fields: Social accountability, social movements and the Equator Principles issue-based field." *Accounting, Organizations and Society* 43 (2015): 33-55.

central actors use their networks and channels to diffuse the reconstructed logic. Finally, issue field is shaped clearly with more participants and interactions between them.

The model of O'Sullivan and O'Dwyer emphasized the role of central actors from existing exchange fields. On the other hand, Van Wijk and colleagues suggested that collaboration between incumbents and independent activists change organizational fields under challenge.[82] Through the case study of sustainable tourism, they contended that the multiple actors shape social structure that they can co-create, and this "confluence of cultural and relational structuration" generates a tipping point for change. The actors' agency for field changes has showed inconsistent results even in the studies of exchange fields. Some studies suggested that changes are initiated by low status organizations, while other studies found that high-status organizations initiated institutional changes.[83]

In an issue field, the other difficulty to find out who leads field change is that it is not clear who are central actors since actors are from multiple fields. Moreover, the competition in an issue field can influence the hierarchies of related exchange fields. In this case, the hierarchies of exchange fields become less clear. Thus, it is harder to find out the power relations in an issue field as well as exchange fields.

---

82 Van Wijk, Jakomijn, Wouter Stam, Tom Elfring, Charlene Zietsma, and Frank Den Hond. "Activists and incumbents structuring change: The interplay of agency, culture, and networks in field evolution." *Academy of Management Journal* 56, no. 2 (2013): 358-386.

83 Garud, Raghu, Sanjay Jain, and Arun Kumaraswamy. "Institutional entrepreneurship in the sponsorship of common technological standards: The case of Sun Microsystems and Java." *Academy of Management Journal* 45, no. 1 (2002): 196-214.; Greenwood, Royston, and Roy Suddaby. "Institutional entrepreneurship in mature fields: The big five accounting firms." *Academy of Management Journal* 49, no. 1 (2006): 27-48.; Haveman, Heather A., and Hayagreeva Rao. "Structuring a theory of moral sentiments: institutional and organizational coevolution in the early thrift industry 1." *American Journal of Sociology* 102, no. 6 (1997): 1606-1651.; Maguire, Steve, Cynthia Hardy, and Thomas B. Lawrence. "Institutional entrepreneurship in emerging fields: HIV/AIDS treatment advocacy in Canada." *Academy of Management Journal* 47, no. 5 (2004): 657-679.

The review of literature on issue fields shows that the relations of actors to change an issue field are not well understood. Using a network analysis can provide better understanding to power relations of the actors in an issue field by showing both competition and collaboration between actors in a quantitative way. By conducting a network analysis, Analysis 2 evaluates Proposition 2, which is suggested in line with O'Sullivan and O'Dwyer's model.

Proposition 2. The central domestic actors of a renewable energy field have framed renewable energy trade issues with a traditional environmental frame.

Globalization and policy convergence: Theoretical framework for Analysis 3

Policy convergence refers to "the tendency of policies to grow more alike, in the form of increasing similarity in structures, processes, and performances"[84] Many scholars have studied if and how globalization leads the convergence of national policies in diverse policy areas. These studies show inconsistent results depending on the studied regions, periods, and policy areas.[85]

Jänicke was one of the early scholars suggesting the effect of international interdependence on policy convergence.[86] The role of international mechanism such as the United Nations and European Community has been pointed out in expanding the

84 Drezner, Daniel W. "Globalization and policy convergence." International studies review 3, no. 1 (2001): 53-78.
85 Heichel, Stephan, Jessica Pape, and Thomas Sommerer. "Is there convergence in convergence research? An overview of empirical studies on policy convergence." *Journal of European public policy* 12, no. 5 (2005): 817-840.
86 Jänicke, Martin. "Conditions for environmental policy success: an international comparison." *Environmentalist* 12, no. 1 (1992): 47-58.

implementation of environmental protection policies. Through the case studies of five environmental policy innovations, Kern and colleagues tried to find the mechanism of cross-national policy convergence.[87] They identified a number of explanatory factors for policy diffusion including national factors and international dynamics. According to their study, increasing number of international organizations and transnational networks were important for policy diffusion.

Busch and Jorgens broadened these studies by suggesting three mechanisms of cross-country policy convergence.[88] First, countries may modify their policies to comply international agreements or laws. The other mechanism is to be coerced by other nations to implement a specific policy. Finally, countries voluntarily adopt a policy by communicating through international system. These three mechanisms simultaneously influence the process of policy convergence. They suggested that a holistic view on policy change was necessary rather than selecting one particular cause of policy convergence.

Many studies suggested that domestic factors have affected policy change as well as international factors. Domestic factors work as "filters" of globalization pressure.[89] Kern and colleagues suggested that national capacity for action is important for policy

---

[87] Kern, Kristine, Helge Jörgens, and Martin Jänicke. "The diffusion of environmental policy innovations: a contribution to the globalisation of environmental policy." WZB Discussion Paper, No. FS II 01-302 (2001).

[88] Busch, Per-Olof, and Helge Jörgens. "International patterns of environmental policy change and convergence." *Environmental Policy and Governance* 15, no. 2 (2005): 80-101.

[89] Heichel, Stephan, Jessica Pape, and Thomas Sommerer. "Is there convergence in convergence research? An overview of empirical studies on policy convergence." *Journal of European Public Policy* 12, no. 5 (2005): 817-840.

diffusion.[90] In this reason, advanced industrialized countries tend to be the front-runner countries in policy innovation. The demand for policy innovation was another national factor affecting policy diffusion. Their case studies showed that this was an important factor for diverse environmental policies in Europe. Some studies show that national factors caused a lack of convergence. Howlett did not find any evidence of convergence in environmental policies in Canada and the U.S., and suggested that this was because the difference of institutional and constitutional structure.[91] Harrison argued that competing domestic interests and institutional contexts can lead policy "divergence" through the study of policy responses to dioxin effluents in Canada, the U.S., and Sweden.[92]

Through the review of literature on policy convergence, Holzinger and colleagues suggested five central factors of policy convergence.[93] First, independent responses of different countries under the parallel environmental problems result in policy convergence. Although countries respond to the problems independently, similar environmental problems cause similar policies. Second, complying with international rules cause similar policies among countries. Third, when countries or international organizations force other countries to implement a policy, it causes policy convergence. Fourth, increasing economic integration leads regulatory competition, which drives

---

[90] Kern, Kristine, Helge Jörgens, and Martin Jänicke. "The diffusion of environmental policy innovations: a contribution to the globalisation of environmental policy." WZB Discussion Paper, No. FS II 01-302 (2001).

[91] Howlett, Michael. "The judicialization of Canadian environmental policy, 1980–1990: A test of the Canada-United States convergence thesis." *Canadian Journal of Political Science* 27, no. 01 (1994): 99-127.

[92] Harrison, Kathryn. "Ideas and environmental standard‐setting: a comparative study of regulation of the pulp and paper Industry." *Governance* 15, no. 1 (2002): 65-96.

[93] Holzinger, Katharina, Christoph Knill, and Bas Arts. *Environmental Policy Convergence in Europe: The impact of international institutions and trade*. (Cambridge: Cambridge University Press, 2008).

adjustment of policies across countries. Finally, transnational communication among countries increases policy similarity. Among these factors, they found that complying with international rules and communicating through transnational network have affected policy convergence through empirical study of the member states of the EU. Legally binding policies at the level of the EU drove policy similarities. Moreover, policy discussions and exchange of information among countries also affected policy convergence. On the other hand, regulatory competition among countries was not a significant factor.

Jacobs tested the causal mechanisms of Holzinger and colleagues through studying feed-in tariff in Germany, France and Spain, and suggested the necessity of elaborating the theory.[94] The study found that regulatory competition has led the countries to improve the framework of the feed-in tariff, although there was no evidence of "race to the top" in feed-in tariff. Moreover, it was found that the feed-in tariffs were driven more from opportunities than from problems. Although the theory of Holzinger and colleagues suggested that individual problem solving was driven by a similar problem, the study of the feed-in tariff showed that individual problem solving can be driven by technological advances.

While the increasing number of countries adopting renewable energy policies infers the tendency of cross-national policy convergence, the rise of different type of policies such as industrial policies and trade policies on renewables is not consistent with the literature on policy convergence. As the globalization of renewable energy industry introduced some challenges in countries, it may lead countries to adopt policies to

---

[94] Jacobs, David. *Renewable energy policy convergence in the EU: the evolution of feed-in tariffs in Germany, Spain and France*. (New York: Routledge, 2016).

address the challenges. According to the causal mechanism suggested by Holzinger and colleagues, independent problem solving of countries can lead policy convergence among countries. Jacobs also showed that the countries' chasing of opportunities has led the convergence of feed-in tariff. In the case of renewable energy, since countries' problem solving resulted in more differences in policies among countries, domestic factors may affect policy change.

Previous research suggested a number of domestic factors affecting policy change including national capacity, demand for policy, institutional contexts, and domestic interests. Among these domestic factors, this research focuses on domestic interests since the huge growth of industry was the most notable change in renewable energy field in recent years. Although the focus is the industry, the other domestic factors are also considered through building explanations for the rise of new policies. Moreover, the international factor is also considered as an intervening factor in the policy change. In this sense, Proposition 3 for Analysis 3 is suggested. The purpose of the research is to elaborate the causal mechanism of policy change rather than evaluating this proposition.

Proposition 3. The growth of domestic renewable energy industries has caused the diversification of national renewable energy policies as renewable energy industries have become globalized.

This chapter reviews the literature for the three analyses of this research. Three analyses were designed to contribute to the literature on trade and the environment, but

each analysis is based on different literature. Table 7 summarizes the theoretical frameworks and propositions.

Table 7. Summary of literature and propositions.

	Theoretical framework	Proposition
Analysis 1	Institutional theory: co-evolution of multinational corporations	Proposition 1. Multinational renewable energy corporation are more likely to engage in policymaking for favorable policies under the challenges of the global market.
Analysis 2	Institutional theory: issue fields	Proposition 2. The central domestic actors of a renewable energy field have framed renewable energy trade issues with a traditional environmental frame.
Analysis 3	Theory of policy convergence	Proposition 3: The growth of domestic renewable energy industries has caused the diversification of national renewable energy policies as renewable energy industries have become globalized.

Chapter 3. Global solar market and multinational corporate actors

Introduction

The global solar PV market has rapidly grown in recent years. Global solar PV installation capacity, which was less than 1GW in 1994, reached 177GW in 2014.[95] Although the solar PV installation has continuously grown during this period, the global solar market has experienced ups and downs, which have been caused by diverse national and international factors. The global financial crisis in late 2000s has negatively affected the governmental support for solar power as well as discouraged investors to finance for solar projects. Meanwhile, the global oversupply of solar products had led many solar PV corporations out of the business in recent years. Despite these challenges, a number of solar PV corporations have substantially grown into large multinational corporations during this period.

This chapter explores the dynamics of these recent changes in the global solar PV market and the reactions of multinational corporations to the changes. To answer the central question of this research, this chapter focuses on the rise of multinational corporations, one of the aspects of the globalization of industry. The question of this chapter is: *How have multinational renewable energy corporations affected national policies?*

---

[95] IEA, *IEA-PVPS Trends 2015: In Photovoltaic Applications Executive Summary*. IEA-PVPS T1-27:2015. http://www.iea-pvps.org/fileadmin/dam/public/report/national/IEA-PVPS_-_Trends_2015_-_Executive_Summary_-_Final.pdf.

Previous literature suggests that multinational corporations "co-evolve" with their external environment, since social environments are "evolving rule systems" for them.[96] According to Canwell and colleagues, under uncertain environments, multinational corporations are likely to co-evolve with the environment rather than just adapting to the environment. The ups and downs of global solar market in recent years infer more uncertainty in the market; thus, it is predicted that co-evolution might happen. The effect of uncertainty on co-evolution is not the only theoretical prediction. The contradictions between institutions have been pointed out as one of the enabling factors for the firms to initiate changes of their external environment.[97] Based on these theoretical predictions, this chapter assesses if co-evolution of multinational corporations with the external environment has happened in the global solar market focusing on the effect of them on national policies. The proposition is that *multinational renewable energy corporations are more likely to engage in policymaking for favorable policies under the challenges of the global market.*

To investigate the interactions between multinational solar corporations and the external environment, a content analysis of the annual reports of the global top 15 solar module manufacturers was conducted. A solar module, an assembly of solar cells, is a

---

96 Cantwell, J., Dunning, J. H., & Lundan, S. M. "An evolutionary approach to understanding international business activity: The co-evolution of MNEs and the institutional environment." *Journal of International Business Studies*, 41 (2010), 567–586.; Kostova, Tatiana, Kendall Roth, and M. Tina Dacin. "Institutional theory in the study of multinational corporations: A critique and new directions." *Academy of Management Review* 33, no. 4 (2008): 994-1006.

97 Battilana, Julie, Bernard Leca, and Eva Boxenbaum. "2 how actors change institutions: towards a theory of institutional entrepreneurship." *The Academy of Management Annals* 3, no. 1 (2009): 65-107.; Seo, Myeong-Gu, and WE Douglas Creed. "Institutional contradictions, praxis, and institutional change: A dialectical perspective." *Academy of Management Review* 27, no. 2 (2002): 222-247.

core product for solar power generation. Solar module manufacturing has rapidly grown and globalized in recent years; currently, the top 15 solar module manufacturers account for 59% of the global market share.[98] The selection of global top manufacturers is natural given the significant influence of these firms on the global solar market. The content analysis of the annual reports of the firms enabled to explore and explain the changes of the global solar market and multinational corporations' reactions to the changes.

Data

Annual reports have been used by many scholars for content analysis due to their vast amount of information.[99] The reports include both quantitative and qualitative data such as a CEO's statement, financial status, strategies, market risks, and governance. As annual reports are one of the most important corporate tools for communicating with their environments, substantial efforts of top-level management are involved.[100] In this sense, although an annual report is written by public relations department, it can be said that it represents the position of a corporation.

---

98 IHS, "Leading Solar Module Suppliers Extend Dominance in 2013; Chinese Still on Top," http://press.ihs.com/press-release/design-supply-chain-media/leading-solar-module-suppliers-extend-dominance-2013-chinese (April 30, 2014).

99 Brennan, Niamh. "Reporting intellectual capital in annual reports: evidence from Ireland." *Accounting, Auditing & Accountability Journal* 14, no. 4 (2001): 423-436.; Lajili, Kaouthar, and Daniel Zéghal. "A content analysis of risk management disclosures in Canadian annual reports." *Canadian Journal of Administrative Sciences/Revue Canadienne des Sciences de l'Administration* 22, no. 2 (2005): 125-142.; Mio, Chiara, and Andrea Venturelli. "Non-financial Information About Sustainable Development and Environmental Policy in the Annual Reports of Listed Companies: Evidence from Italy and the UK." *Corporate Social Responsibility and Environmental Management* 20, no. 6 (2013): 340-358.; Niskala, Mikael, and Michael Pretes. "Environmental reporting in Finland: A note on the use of annual reports." *Accounting, Organizations and Society* 20, no. 6 (1995): 457-466.

100 Bowman, Edward H. "Content analysis of annual reports for corporate strategy and risk." *Interfaces* 14, no. 1 (1984): 61-71.

Unlike surveys or qualitative interviews, annual reports are not designed for research. Therefore, there are risks that necessary data for this research may not be included in annual reports. However, most annual reports address the risks and the business of their organizations, since those are one of main interests of the readers of annual reports, their shareholders. Moreover, as detailed description of risks and their business are required for publicly traded companies in the United States, the annual reports of those companies include decent quality data. The U.S. Securities and Exchange Commission requires publicly traded companies to submit annual reports, which include very detailed information on financial status. Domestic public firms use form 10-K, and foreign private issuers use form 20-F.[101] These forms include a detailed description of risks, an overview of the firm's business, audited financial statements, and details of governance.

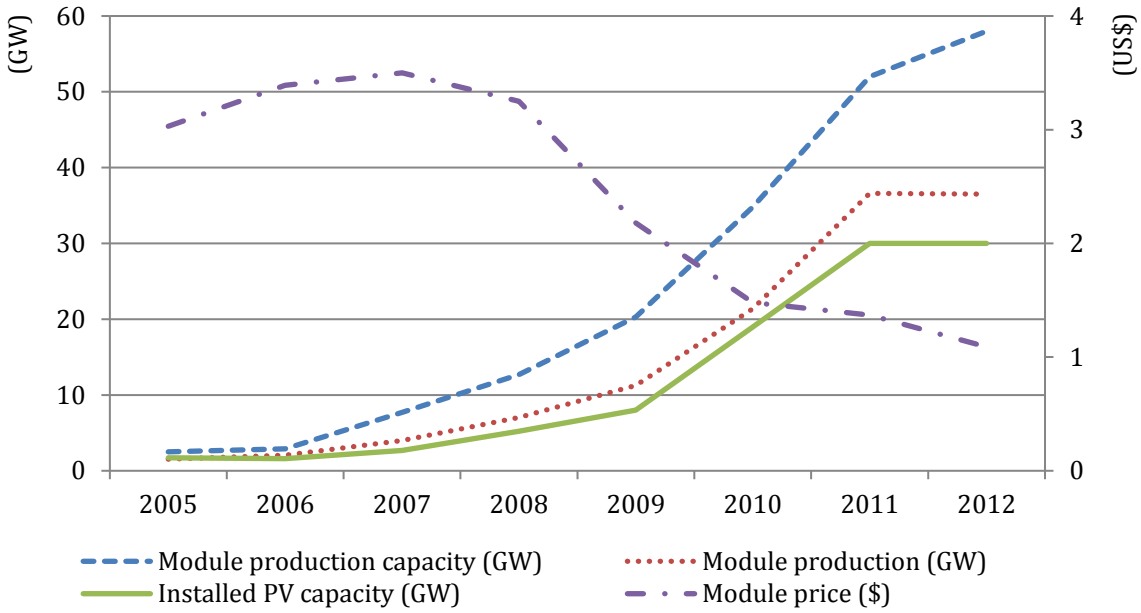
The time frame of the study is the recent ten years from 2005-2014.[102] The solar PV market has experienced many changes during this period. Since 2005, solar module capacity has rapidly increased until 2011. The oversupply of products became a serious issue in the global solar PV market since 2011. Figure 10 shows the degree of oversupply of solar PV module has started increasing in 2006, and sharply increased in 2011. In 2012, the module production capacity is about twice of installed PV capacity. This oversupply caused a sharp drop of module prices, which made many solar PV corporations go out of business or file for bankruptcy. Under these circumstances, the

---

[101] Although foreign companies publish annual reports under the U.S. rules, they write the reports as a whole company rather than as a subsidiary in the U.S. Therefore, the annual reports written by using form 20-F can be used as data for this study.
[102] The U.S. Securities and Exchange Commission amended the rule on 20-F on December 7, 2007. As this amendment was related to financial statements, this amendment does not affect the validity of the data.

solar module price has rapidly decreased since 2008. This significant change of the global solar market shows that the analysis of the recent ten years enables to understand the change of the external environment and the reactions of the actors in the market.

Figure 10. Solar PV module production, cumulative installed capacity, and price, 2004-2012.



Source: Trends 2013 in Photovoltaic Application: Survey Report of Selected IEA Countries between 1992 and 2012, IEA; Renewable Energy Focus magazine, http://www.renewableenergyfocus.com.

The top 15 solar module manufacturers were selected based on the 2013 global ranking from IHS technology (Table 8). The annual reports of these manufacturers are publicly available except Q-cell. Since Q-cell was acquired by HanwhaSolarOne in 2015, its annual reports were not publicly available except 2015. Suntech has published its annual reports until 2012 because it was out of business in 2013. As a result, 125 annual reports are used as data.

Table 8. Global top 15 solar module manufacturers, 2013.

Rank	Manufacturer	Location of Headquarters	Founded year	Annual Report (Form)	Number of Samples[a]
1	Yingli Green Energy	China	1998	2007-2015 (20-F)	9
2	Trina Solar	China	1997	2006-2015 (20-F)	10
3	Canadian Solar	Canada	2001	2006-2015 (20-F)	10
4	Sharp	Japan	1912	2006-2015 (other)	10
5	Jinko Solar	China	2006	2010-2015 (20-F)	6
6	First Solar	USA	1990	2006-2015 (10-K)	10
7	ReneSola	China	2005	2006-2015 (20-F)	10
8	Kyocera	Japan	1959	2006-2015 (20-F)	10
9	JA Solar	China	2005	2006-2015 (20-F)	10
10	Hanwha SolarOne	South Korea	1997	2007-2014 (20-F)	8
11	Sunpower	USA	1985	2006-2015 (10-K)	10
12	Suntech	China	2001	2006-2012 (20-K)	7
13	Solar Frontier	Japan	2006	2009-2015 (other)	6
14	REC Group	Norway	1996	2006-2014 (other)	8
15	(Hanwha) Q-cell	Germany (South Korea)	1999 (2015)	2015 (20-F)	1
Total		-	-	-	125

Note: Because an annual report describes the corporation's status in the previous year, the period of 2006-2015 corresponds with the time frame of this study, which is 2005-2014.

Method

Content analysis is defined as a technique for making inferences from texts based on systematic coding.[103] It has been used for many organizational studies since it enables exploring difficult-to-study issues in management fields.[104] It enables researchers to

[103] Stemler, Steve. "An overview of content analysis." *Practical Assessment, Research & Evaluation* 7, no. 17 (2001): 137-146.

[104] Levihn, Fabian, Cali Nuur, and Henrik Blomgren. "Corporate response to climate change mitigation: What can we learn from annual reports of European industries?" *International Journal of Industrial Engineering and Management* 2, no. 3 (2011): 77-86.; Waller, David S., and Roman Lanis. "Corporate social responsibility (CSR) disclosure of advertising agencies: an exploratory analysis of six holding companies' annual reports." *Journal of Advertising* 38, no. 1 (2009): 109-122.

access individual and collective values, intentions, cognitions and attitudes.[105] Content analysis can be used in a flexible way by taking quantitative or interpretive approaches. Frequency count of codes has commonly been used in many studies, and some studies have analyzed qualitative terms and themes emerged from their investigation.

Both quantitative and qualitative approaches were taken to analyze the changes in the external environment of the solar module manufacturers and their reactions to it. First, a structured content analysis with pre-determined codes was conducted to classify the risks faced by the firms in recent ten years. Second, a qualitative approach was taken for developing a description of the reactions of the firms to the changing environments.

For the structured content analysis, each risk factor in every annual report was assessed and classified according to the pre-determined codes. The annual reports on Form 10-K and 20-F include a specified format describing risks, which provides detailed descriptions of each risk factor. The description of each risk factor consists of a main statement and detailed explanation. Both the main description and the details of the risk factor were classified as one unit, which was the unit of analysis in this study. As a result, the unit of risk factor consists of a few paragraphs. Although the annual reports written in their own forms provide less standardized descriptions of risk factors, they also provide separate sections of risks. This enabled coding of each risk factor. The analysis was restricted to the risk section of each annual report and every text of the risk section was coded.

---

[105] Duriau, Vincent J., Rhonda K. Reger, and Michael D. Pfarrer. "A content analysis of the content analysis literature in organization studies: Research themes, data sources, and methodological refinements." *Organizational Research Methods* 10, no. 1 (2007): 5-34.

The codes for risks were pre-determined based on literature initially, and were revised during the research process. To reduce rater bias, the Weber protocol for coding, which has been widely referenced in the content analysis studies, was adopted.[106] The coding categories were defined, and were tested with samples, which were 10% of the data. The results of the testing showed that the codes were not exhaustive and some codes were not accurate enough. The codes were revised based on these testing results, and they were tested again with the same 10% of the samples. All the data was coded with these revised codes. After completing coding, the reliability and accuracy were assessed again. Since no issue was found, the coding was completed.

The risks are classified according to the source of risks: *internal environment*, and *external environment* (Table 9). The risks from external environments are classified again into seven categories: *competition, demand, policy*, *resource*, *supplier, technology*, and *other*. The categories for the risks from external environment were initially determined based on the study of Meijer, Hekkert, and Koppenjan, and they were revised after testing the codes.[107]

---

[106] Duriau, Vincent J., Rhonda K. Reger, and Michael D. Pfarrer. "A content analysis of the content analysis literature in organization studies: Research themes, data sources, and methodological refinements." *Organizational Research Methods* 10, no. 1 (2007): 5-34.;Weber, Robert Philip. *Basic content analysis*. (London: Sage, 1990).

[107] Meijer, Ineke SM, Marko P. Hekkert, and Joop FM Koppenjan. "How perceived uncertainties influence transitions; the case of micro-CHP in the Netherlands." *Technological Forecasting and Social Change* 74, no. 4 (2007): 519-537.

Table 9. Categories of risks.

Source		Description
Internal environment		Risks caused by internal factors such as internal resource and capability
External environment	Competition	Risks caused by competition
	Demand	Risks caused by demand or consumers
	Policy	Risks caused by policy or political factors
	Resource	Risks caused by availability of raw materials and other resources
	Supplier	Risks caused by suppliers
	Technology	Risks caused by new technology, the relations between the technology and the infrastructure, and the possibility of choosing alternative technological options
	Other	Risks caused by other factors

The codes of policy risks were separated and were coded again based on the pre-determined categories: *uncertainty* and *contradiction* (Table 10). A policy risk component was coded as uncertainty if a firm could not predict the direction or the effect of policy on the firm. If a firm predicts the effect of a policy risk component on the firm, the policy risk was coded as contradiction. The four categories of contradiction were developed based on the study of Seo and Creed.[108]

[108] Seo, Myeong-Gu, and WE Douglas Creed. "Institutional contradictions, praxis, and institutional change: A dialectical perspective." *Academy of Management Review* 27, no. 2 (2002): 222-247.

Table 10. Categories of policy risk.

Source		Description
Uncertainty		The direction of a policy or its effect on the firm is not known
Contradiction	Inefficiency	A policy causes inefficiency of business
	Unresponsiveness	A policy is unresponsive to the external environment
	Incompatibility	Policies are inconsistent between them
	Conflicts of interest	A policy cannot serve diverse interests

For the qualitative content analysis of the firms' reactions to the environment, the author read each annual report and extracted themes. Since only a few annual reports provide a standardized strategy section, the author looked for the descriptions of actions or planned actions of the firms in the whole annual report. The extracted themes were analyzed, and an explanation for firms' reactions to the external environment was developed.

Findings

Changes of the external environment of multinational solar corporations

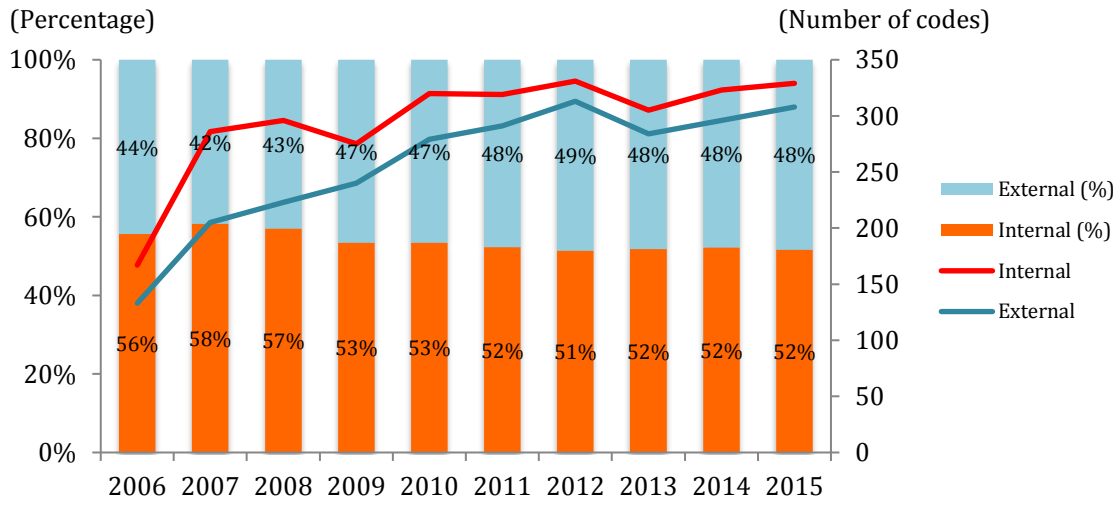
The results of the structured content analysis show two trends. First, the reporting on risk factors that solar multinationals face have continuously increased. Second, the corporations have identified more risk factors from policies over time.

Increasing risks

The analysis of the annual reports indicates that the risks of the global solar manufacturers had grown over time. The number of risk factors reported from the internal environment has almost doubled, and that of risk factors from the external environment

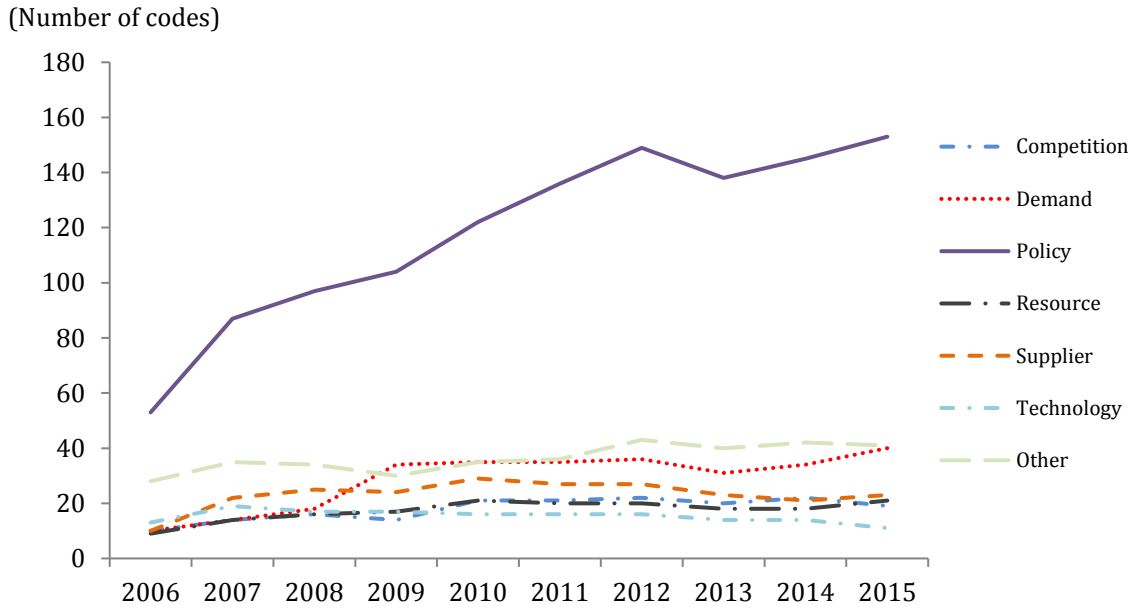
have more than doubled in recent ten years (Figure 11). The risk factors from the external environment have grown more sharply compared to the risk components from internal environment. As a result, in 2015, the number of the risk factors from external environment accounts for almost half of the total number of the risk factors.

Figure 11. Risks by source, 2006-2015.



A major portion of the increasing risk factors from the external environment is caused by policy. Compared to the other risk components, the risks caused by policy have more sharply increased in recent ten years (Figure 12). The number of policy risk components has increased to 153 in 2015 from 52 in 2006. Another noteworthy trend is that the number of risk factors from demand has doubled in 2009.

Figure 12. Risks from external environment, 2006-2015.



The number of risk factors from demand has doubled in 2009 largely because of the global financial crisis in 2007 and 2008. Many global module manufacturers have described the slowdown in the market demand after the crisis in their annual reports. The reduced energy demand caused by economic contraction discouraged the investments in solar PV projects. The 2009 report of Hanwha SolarOne explains: "The current credit crises, weak consumer confidence and diminished consumer and business spending have contributed to a significant slowdown in the market demand for PV products due to decreased energy requirements."

More direct effect of the global financial crisis on the demand was from third party financing. Solar project developers, the consumers or the end-users of solar modules, depend on third party financing to fund their projects, which require significant initial capital expenditures. Due to the crisis, they had much difficulty in acquiring sufficient financing. Even if the developers obtain financing, the costs of financing had

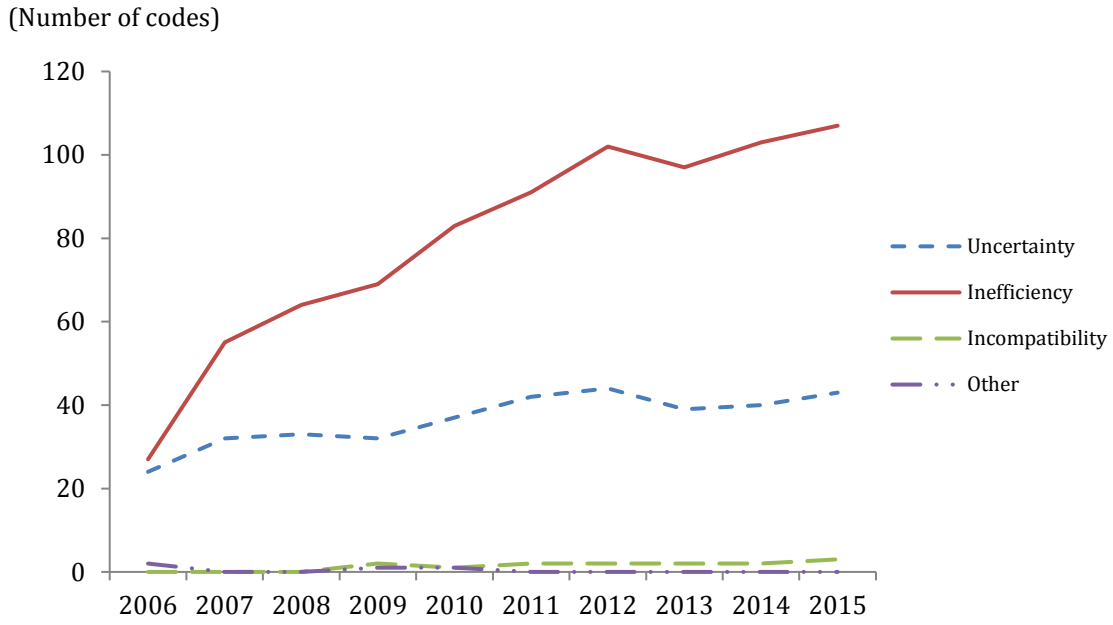
higher than the costs before the crisis. This has lowered the returns from solar projects, so the developers changed their investment plans or delayed the projects. As a result, the demand for solar products has decreased.

The declining demand became a more serious risk when it combined with the oversupply of solar products. The 2012 report of JA Solar pointed out: "Combined with other factors such as the European sovereign debt crisis, lack of available financing to solar power projects and an oversupply of solar power products, the average selling prices of solar power products have declined significantly." The supply of solar products started growing with an increase of polysilicon supply in 2008. The limited supply of polysilicon, which was the core raw material of solar modules, had been one of the biggest entry barriers. Since this barrier became less significant after 2008, the manufacturing capacity of solar products has sharply grown with the entry of new manufacturers, and this caused the oversupply of the market. The decreasing demand has been a more serious risk under this flood of solar products.

Rise of "inefficient" policies

While the demand risk increased sharply only in 2009 and has stabilized, the policy risk has continuously increased over time. The increasing trend of policy risks is largely caused by the increasing number of policies causing inefficiency of the business of the corporations. Figure 13 shows the result of coding of the policy risk factors by source. The number of policy risk factors causing inefficiency in 2015 is almost four times of that in 2006.

Figure 13. Policy risks by source, 2006-2015.



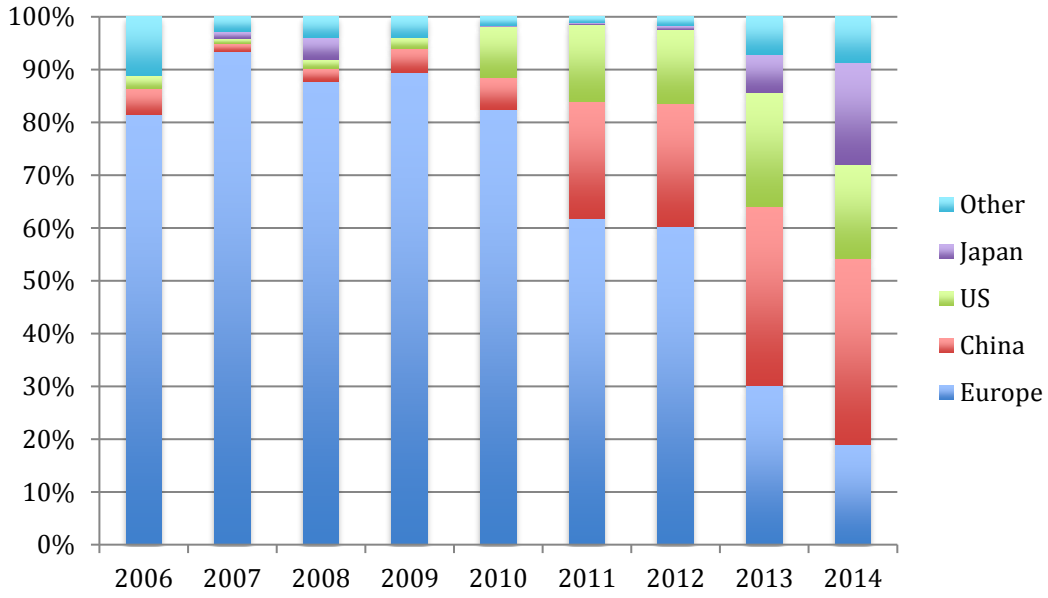
Solar module manufacturers have perceived that more policies have acted as a barrier to conduct their business in an efficient manner. Mainly, two factors have affected this increasing trend of inefficiency of policies: the trade protectionist actions of governments and the solar module manufacturers' expansion to project development business.

Under the struggling solar market after the global financial crisis, governments have introduced measures to protect domestic solar PV industry. The solar module imported from China was one of the main issues. On October 19, 2011, the U.S. solar module manufacturers filed a petition against Chinese solar module producers of selling their products less than the fair value with the U.S. Department of Commerce. This resulted in the issuance of the antidumping duty order and countervailing duty order in 2012. In December 2013, the Council of European Union decided imposing antidumping

and anti-subsidy duties on imported Chinese cells and modules after a one-year investigation. In 2012, India has started antidumping investigations on solar cells from China, the U.S., Malaysia, and Taiwan.

China-based solar module manufacturers have showed much concern on the negative impact of the anti-dumping measures since a significant portion of their revenue is generated from outside of China. For instance, Yingli Green Energy, one of the China-based manufacturers, had acquired more than 80% of its revenue from European market until 2010 (Figure 14). One of the other Chinese manufacturers, Suntech, said in its 2012 annual report: "Any determination of duties and tariffs against importation of our modules into the United States and Europe could render us unable to sell modules in these countries that could impact our sales, business operations, competitiveness, and profitability." Since the measures are decided by each government, the module manufacturers could not make sure if they will not be negatively impacted by the measures even if they believe that they did not violate any trade rules. Trina Solar said in its 2014 report: "Although our policy requires that all of our export sales comply with international trade practices, we cannot guarantee that the government agencies in the jurisdictions in which actions are brought will reach the same conclusion."

Figure 14. Revenue trend of Yingli Green Energy, 2006-2014.



Source: Yingli Green Energy's annual reports, 2007-2015.

Local content requirements have been another measure to protect domestic solar industries. The Canadian province of Ontario introduced a local content preference rule, which was to require the projects receiving feed-in tariffs to source certain percentage of equipment in Ontario. India also set a local content requirement rule in its National Solar Mission. Under Phase I, India required solar PV project developers using crystalline silicon technology to use cells and modules produced in India. In Batch I, Phase II, India required to use domestically produced cells and modules regardless of technology for 375 MW of the 750 MW program. First Solar, the U.S.-based corporation, showed concerns about this measure in its 2015 report: "This set-aside effectively cuts the ability of First Solar to compete in the Batch I, Phase II program in half." Regarding this issue, the U.S. government requested the WTO dispute settlement consultations with the Government of India in 2013.

Solar manufacturers' expansion to project development business is another factor influencing the increase of the inefficiency of policies. Solar project developing is related to many policy issues such as subsidies, permits, property rights, power purchase agreements, interconnection and transmission arrangements, financing, and construction. As the solar module manufacturers have started developing solar projects, they became to be exposed to more policy issues than before.

Around 2010, many solar module manufacturers started expanding to project development. Since then, the manufacturers have reported the risk factors related to project development. For instance, in its 2014 report, Trina described the possibility of non-compliance of land laws and regulations for its 120MW solar power project in Jiangsu Province. Although it acquired land use right for its project, it did not complete a series of following procedures. Trina was in the process to complete the procedure, but "cannot ensure that the registration process will be completed in a timely manner or at all." Jinko Solar also reported significant delays in the listing of projects in the Subsidy Catalog, which is required to receive central government subsidies in China in its 2015 report. The development of solar projects is highly regulated in China. According to Jinko solar, the solar projects in China "are governed by different laws and regulations, including national and local regulations relating to urban and rural planning, building codes, safety, environmental protection, fire control, utility transmission, engineering and metering and related matters."

Conducting solar project development in the U.S. is also highly regulated. First Solar, the U.S.-based corporation, said in its 2015 report: "We may be unable to acquire or lease land, obtain necessary interconnection and transmission rights, and/or obtain the

approvals, licenses, permits and electric transmission grid interconnection and transmission rights necessary to build and operate PV power plants in a timely and cost effective manner, and regulatory agencies, local communities, labor unions or other third parties may delay, prevent, or increase the cost of construction and operation of the PV plants we intend to build."

In sum, the rise of policy risks has caused by additional policies as well as existing policies. The newly introduced policies to protect domestic solar industry have resulted in increasing risks to the global solar manufacturers. Moreover, since the manufacturers have started expanding to a new business, existing policies have become a new barrier for them.

The responses of the solar multinationals to the changing environment

The results of the qualitative content analysis reveal that the solar multinationals' strategies have deeply changed after the global financial crisis. In the early days of solar market with high demand, the solar multinationals focused on increasing manufacturing capacity and securing raw materials. However, when the demand of modules has decreased after the global financial crisis, the solar multinationals expanded their business to solar project development.

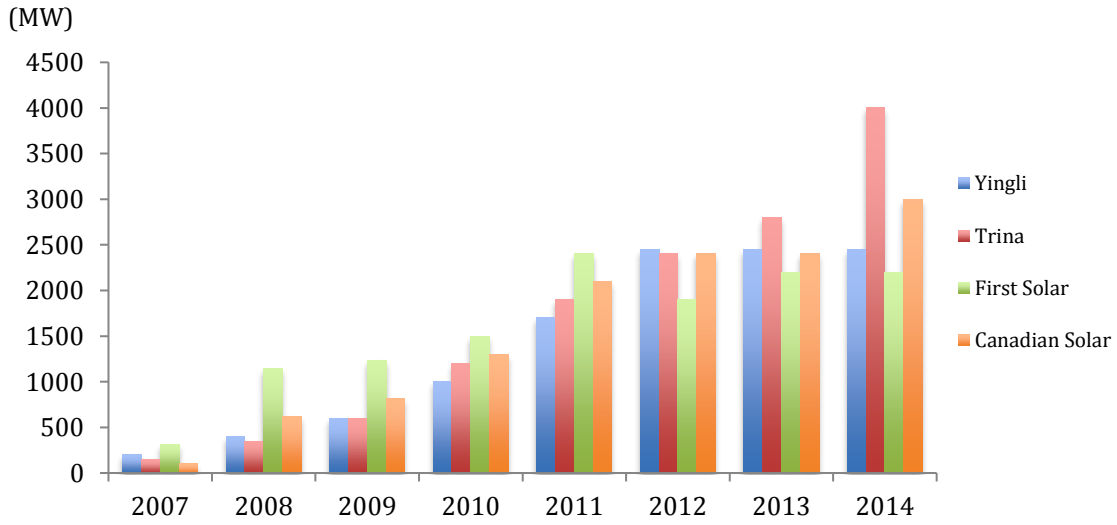
Before the global financial crisis: Going upstream

Responding to the rapidly rising demand was the priority of the solar manufacturers before the global financial crisis. To accelerate production, the

manufacturers had focused on expanding manufacturing capacity, and securing raw materials.

Most of the manufacturers had planned to increase manufacturing capacity. In the 2008 report, Suntech reported: "We intend to capitalize on the rapidly growing market demand for PV products by leveraging our access to low-cost resources and expanding our manufacturing capacity to grow our output and sale." According to its intention, Suntech had significantly expanded its manufacturing capacity since it had launched its business in 2002. Hanwha SolarOne also announced its plan to expand capacity in its 2007 report: "In order to meet the fast-growing market demands for solar products, we plan to significantly expand our production capacity in the next three years." Figure 15 shows that the manufacturing capacity of the four solar module manufacturers has rapidly increased until 2011.

Figure 15. Solar module manufacturing capacity of four major solar manufacturers, 2007-2014.



Note: The data are from the annual reports of each firm. Among 15 manufacturers, only four reported manufacturing capacity every year in their annual reports.

Securing raw materials was also very important due to the shortage of polysilicon. One of the key strategies of the solar manufacturers was to secure polysilicon supply and to form strong relationships with key suppliers of polysilicon. Yingli Green Energy said in its 2007 report: "Stable and reliable polysilicon supplies are critical to our long-term growth and profitability." Trina Solar said in its 2007 report: "In the immediate future, because of the growing demand for solar power products, shortage of polysilicon and rising cost of silicon raw materials, we believe that the competitive arena will increasingly center around securing silicon supply and forming strategic relationships to secure supply of key components and technologies."

The shortage of polysilicon has encouraged some manufacturers to expand to upstream. Yingli Green Energy acquired Cyber Power, a start-up polysilicon manufacturer, in January 2009. It expected to produce 3,000 tons of polysilicon per year through this acquisition. Renesola invested in Linzhou Zhongsheng Semiconductor, a polysilicon manufacturing company in August 2007, and started producing polysilicon in July 2009.

After the global financial crisis: Going downstream

As the prices of solar products have started decreasing, the solar manufacturers' strategies have changed. Expanding manufacturing capacity became less significant. For instance, Jinko Solar adjusted its expansion plan, and decided to maintain its capacity at current level "in response to the changes in the market condition" in 2012. Moreover, since the supply of polysilicon has increased, acquiring raw materials also became less

significant. Under these circumstances, solar module manufacturers' focus has shifted to downstream business.

Thirteen out of the fifteen solar module manufacturers have reported their entrance into solar project development market. Despite the different timings of entrance to the market, most of them have strategically expanded project development after the global financial crisis. Suntech has started project development in 2008 by establishing joint ventures. Trina has entered in the downstream market in 2009, and has announced that it strategically expanded the downstream business in 2013. Canadian Solar has expanded the business since 2012, and acquired Recurrent, a solar developer located in California and Texas, in 2015. Yingli Green Energy has initiated solar project development in China in 2012. Renesola, JA Solar, and Jinko Solar have started in 2011. Sharp and Hanwha SolarOne have entered in the market in 2010.

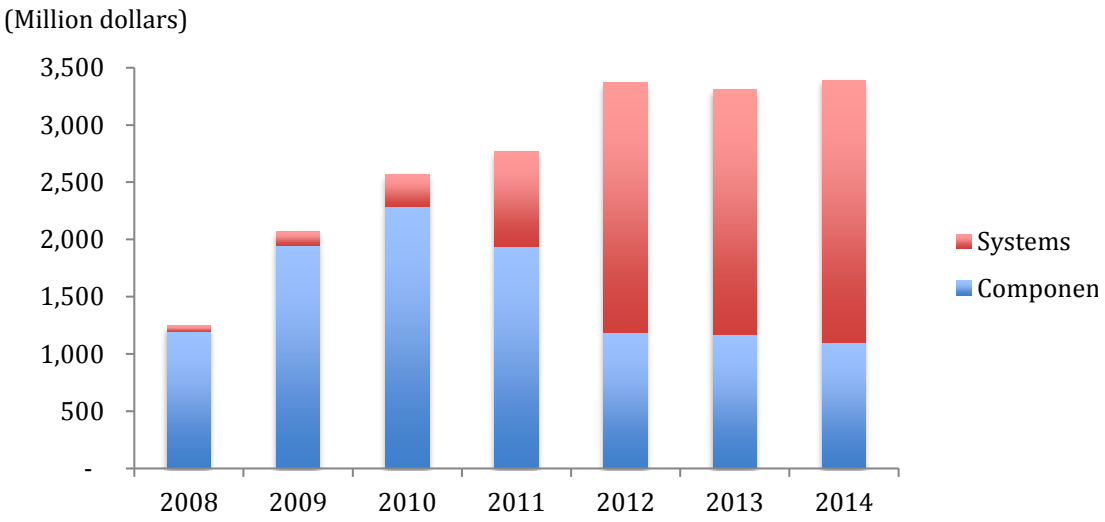
The U.S.-based solar manufacturers have expanded their project development business slightly earlier than the others. SunPower acquired PowerLight Corporation, a large-scale solar power system provider, in January 2007, and established system business segment. In 2010, it acquired SunRay Malta Holdings, a leading European solar power plant project developer, and created Utility and Power Plant segment, which included power plant project development, engineering, procurement and construction (EPC) services, and operations and maintenance services.

First Solar, the other U.S.-based module manufacturer, has actively expanded its project development business. Acquisition was one of the core strategies for expanding the business. It acquired Turner Renewable Energy, which designed and deployed commercial solar projects for utilities in the U.S., in November 2007. In April 2009, First

Solar acquired the project development business of OptiSolar Inc., and in January 2010, it purchased some assets of Edison Mission Group's utility-scale project development pipeline. In July 2010, NextLight Renewable Power, a leading developer of utility-scale solar projects in the southwestern U.S., was acquired. In 2013, First Solar has expanded its global pipeline by acquiring Solar Chile, a Santiago-based solar development company, and has acquired a pipeline of U.S. and Mexico assets from Element Power. Through these activities, First Solar completed a fully integrated systems business. Currently, First Solar's business portfolio includes "project development; engineering and plant optimization; grid integration and plant control systems; project finance; advanced PV modules; inverters and power conversion components; trackers and fixed mounting systems; procurement and construction consulting; operations and maintenance; energy forecasting; and warranties and performance guarantees."

As a result of the expansion of project development business, the business portfolio of First Solar has transformed. The net sales of the systems business has significantly increased since 2010 (Figure 16). Since 2012, the systems business has accounted for more than half of the total revenue. First Solar has transformed into an integrated systems company from a solar module manufacturer in recent ten years.

Figure 16. Net sales of First Solar by segment, 2008-2014.



The other companies have also rapidly expanded the share of their project development business. In Canadian Solar, the total solutions business, which consists primarily of solar power project development, EPC services, and O&M services, accounted for 44.5% of its net revenue in 2014, increasing from 11.5% in 2012. Trina completed 8 projects with the capacity of 233.3 MW as of December 2014, an increase from 2MW of installed system in December 2011.

The struggling solar module market can explain why solar module manufacturers have expanded to downstream business. Sharp explained the rational of changing business model: " (Solar module) market conditions deteriorated even further, due to factors such as continuing price declines caused by excess supply and intense competition. In this context, with the aim of profitability, Sharp worked to change its sale approach from solely focusing on solar cell modules to total systems and establish a business model that is more resilient to changing market conditions and currency rate fluctuations." Contrast to the declining profitability of solar module market, solar project

development business has rapidly increased in recent years. Trina Solar said that the solar project development business was strategically important because the market is "growing quickly in China, supported by favorable government policies." in its 2015 report.

With the changes of business portfolios, the solar module manufacturers are not just manufacturers at this point. These corporations describe themselves as "solar energy company," "global leader in PV industry," or "global provider of solar energy solutions." First Solar positions itself as to "deliver meaningful PV energy solutions to varied energy problems worldwide." It planned to compete with fossil-fuel-based power generation on an economic basis with "minimal subsidies or incentives."

Discussion

The findings do not support the proposition, which was that multinational renewable energy corporation is more likely to engage in policymaking for favorable policies under the challenges of the global market. No evidence was detected that multinational solar corporations have attempted to engage in policymaking. Rather, they have been influenced by national policies and have adapted to the changes.

The global financial crisis has negatively affected the increasing trend of demand in the global solar PV market. With the oversupply of the solar products, which had driven by solar manufacturers' expansion of capacity under increasing trend of demand, this has led declining prices of solar products. Under these circumstances, governments had introduced the policies to protect domestic solar industry. This has negatively affected the sales and profitability of multinational corporations. The decreasing profitability of solar manufacturing has led the solar manufacturers to expand to

downstream business. As they have expanded to downstream business, the manufacturers have faced more policy risks from diverse regulations, permitting and approval processes.

The multinational solar corporations have influenced by traditional renewable energy policies, newly introduced protectionist policies, and existing non-renewable energy policies. The effect of traditional renewable energy policies has not changed much in recent years since they have a similar degree of uncertainty all the time. However, the effect of the new protectionist policies have increased since more countries, especially big markets such as the US, the EU, and India, have introduced those policies to protect domestic industry recently. Meanwhile, the existing non-renewable energy policies have affected solar corporations differently. They were included in the policy risks of solar corporations as the corporations expanded to new business. The permitting and approval processes related to building power plants did not affect the business of multinational solar corporations before they expanded to downstream business, but they became critical policy risks since the corporations started downstream business. As a result, multinational solar corporations' policy risks have expanded and diversified.

The literature on co-evolution of multinational corporations suggested that multinational corporations tended to co-evolve with the external environment under increasing uncertainty, but the findings of this research suggest that they tended to adapt to changes of the environment. Although uncertainty of policies has increased, increasing policies causing inefficiency of their business have been more serious risks for them. Under these circumstances, solar manufacturers adjusted their plans to expand manufacturing capacity, and expanded to downstream business.

The findings show the adaptation of multinational solar corporations to the external environment, but they do not simply show the influence of the external environment on the corporations. Since the corporations have adapted to the changing environment, the external environment has also changed. The regulations and processes related to building power plants have included in relevant policies of the solar multinationals as they expanded to downstream business. The external environment changes by the adapting efforts of multinational corporations. In a broader perspective, multinational corporations evolve with the external environment through adapting to the new challenges from the environment.

It could be argued that multinational solar corporations might attempt to change policies, but they did not report those efforts in their annual reports. This study is limited in finding out corporate behaviors that were not reported in annual reports. Some corporations might engage in policymaking, but might not describe their activities in annual reports. It is also possible that corporations affected policymaking indirectly through industry associations or collaboration with other actors. These indirect activities may not be described in annual reports. This limitation can be partially addressed by the analyses in Chapter 5 and Chapter 6, which will examine the interviews with the representatives of solar corporations. The findings of this study are revisited in the conclusion.

Chapter 4. Politics in the U.S. solar PV field

Introduction

The U.S. solar PV market has gone through significant changes in recent years. Most notably, the size of market has sharply grown. The annual capacity of solar PV installation has enormously increased to 6,212 MW in 2014 from 79 MW in 2005.[109] Currently, large utility scale projects account for a significant share of the market; in 2014, the share of utility scale installation was approximately 60%, while it was only 3% in 2004. This expansion of market size has accompanied the rise of solar PV industry. According to the Solar Foundation, as of November 2014, the U.S. solar industry employed 173,807 workers, which has grown by 86% in recent five years.[110] As of November 2015, Solar Energy Industry Association (SEIA) has 572 member companies.

Policies have played an important role in this rapid development of the solar PV industry. The federal Investment Tax Credit (ITC) for solar has significantly contributed to the rise of solar installation by providing a 30 percent tax credit for residential and commercial solar projects since 2006. Other than the ITC, many federal and state-level policies including the Loan Guarantee Program, net-metering, and Renewable Portfolios Standard (RPS) have encouraged the growth of the U.S. solar industry.

Even under this rapid growth, the U.S. solar market has not always been stable. Plummeting prices of solar products in the global market have led many solar

---

[109] Kann, S. et al., *U.S. Solar Market Insight Report, 2013 Year-in-Review, Executive Summary* (2013) ; Kann, S. et al., *U.S. Solar Market Insight Report, Q1 2015* (2015)
[110] The Solar Foundation, *National Solar Jobs Census 2015*. Washington DC. 2016. http://www.thesolarfoundation.org/wp-content/uploads/2016/10/TSF-2015-National-Solar-Jobs-Census.pdf.

corporations to become bankrupt or be acquired by other companies in recent years. From 2011 to 2014, 71 solar corporations went bankrupt, and 31 companies were acquired by other companies globally, including many U.S. corporations.[111] China's supply of solar products was one of the critical factors affecting the struggles of the solar market. Low-priced solar products started being imported from China into the U.S. in 2010. The annual growth rate of imported Chinese solar products imported into the U.S. was 146% in 2010, and 115% in 2011.[112]

Under these circumstances and perceiving an unfair trade approach from China, the U.S. solar manufacturers became active in trying to shape trade policy to their advantage. In October 2011, SolarWorld headquartered in Germany, and six U.S. solar panel manufacturers submitted a petition concerning solar panels imported from China. They claimed that heavily subsidized Chinese solar panels were illegally dumped in the United States. As a result, the U.S. Commerce Department announced to impose antidumping tariff on Chinese solar panels on December 10, 2012.

This case is interesting in that solar companies attempted to solve a challenge in the market by affecting a trade policy rather than a renewable energy policy. Traditionally, issues of renewable energy have been discussed in the context of renewable energy policies such as government supports. This antidumping tariff case infers that renewable energy issues need to be considered in broader contexts at this point.

---

111 Wesoff, E., 2014. "Rest in Peace: The Fallen Solar Companies of 2014," http://www.greentechmedia.com/articles/read/Honoring-the-fallen-solar-soldiers (December 1, 2014)

112 United States International Trade Commission, Interactive Tariff and Trade DataWeb. Available at: https://dataweb.usitc.gov (Accessed April 28, 2016).

This chapter investigates how diverse actors have framed the renewable energy trade issue through examining the case of the U.S-China solar panel trade issue. While Chapter 3 focused on corporate individual reactions to the external environment, this chapter focuses on the reactions of the domestic and international corporations as political groups. Chapter 3 showed that each solar multinational has tried to adapt to the external environment under rapidly changing market. This finding did not support the prediction of the multinationals' co-evolution literatures, which was that solar multinationals would try to change the external environment. Solar multinationals had barely attempted to change the external environment at least as an individual actor. Then, how do they react to the changing environment as political groups? This chapter answers this question. Due to the significance of the U.S. market in the global solar market and the diversity of organizations and groups that have participated in the policy debates on solar trade, the U.S.-China solar trade dispute can be used as an example of corporations' actions as political groups.

Previous literature showed that issue fields, which were created to address new social concern, evolve based upon the existing matured fields. In this sense, the central actors of matured fields frame the new problem with their logics.[113] Based upon the literature, the proposition is suggested: *The central domestic actors of a renewable energy field have framed renewable energy trade issues with a traditional environmental frame*.

To reveal the political interactions on the U.S.-China solar panel trade issue, a

---

113 O'Sullivan, Niamh, and Brendan O'Dwyer. "The structuration of issue-based fields: Social accountability, social movements and the Equator Principles issue-based field." *Accounting, Organizations and Society* 43 (2015): 33-55.

discourse network analysis was conducted with the newspaper articles from the U.S. top seven newspapers. The data was restricted to U.S. newspapers under the assumption that influential actors on the U.S policy issue communicate with the U.S. media. The coalitions revealed by the discourse network analysis show the political interactions and framings of various actors on the U.S.-China solar panel trade issue.

Trade disputes on solar panels between the U.S. and China

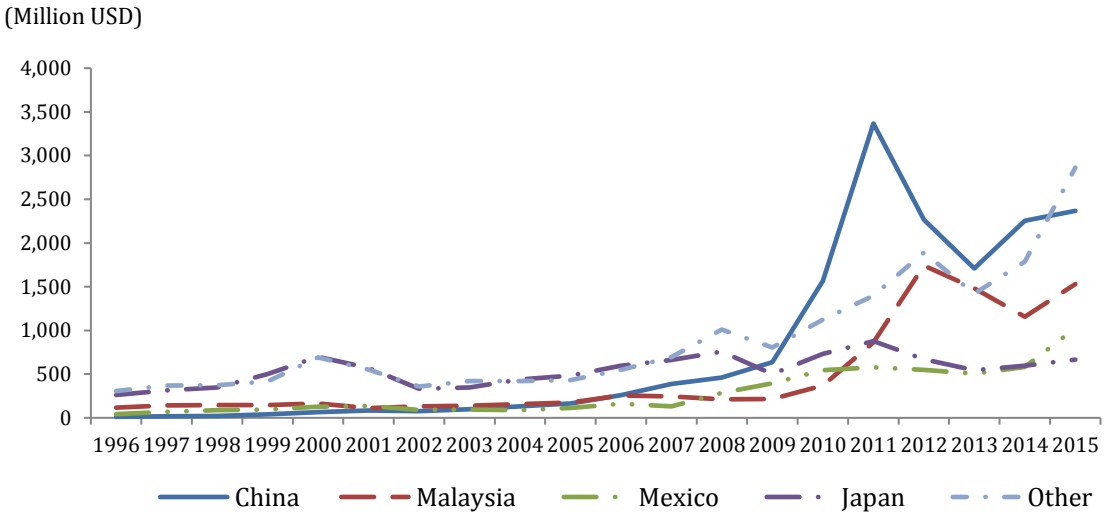
On October 19, 2011, SolarWorld and six other U.S. solar manufacturers submitted a petition to the U.S. Department of Commerce and the U.S. International Trade Commission against Chinese solar manufacturers' trade practices. The petition requested the federal government to impose duties on Chinese imports of solar cells and modules to offset the subsidies from the Chinese government. The petitioners argued that Chinese solar manufacturers benefitted from the subsidies including "massive cash grants; significantly discounted raw material inputs, such as polysilicon and aluminum; heavily discounted or free land, power and water; multi-billion-dollar preferential loans and directed credit; extensive tax exemptions, incentives and rebates; export assistance credits; and export insurance at preferential rates".[114]

The import of solar products from China has significantly increased in 2009. From 2009 to 2011, the import from China has increased by more than five times (Figure 17). Even if the rising trends of imports from all countries are considered, the growth rate of the import from China is noteworthy. This sharp increase has caused large trade deficit

114 "U.S. Solar Industry Files Antidumping and Countervailing Duty Cases Against Imports of Solar Cells and Modules from China," http://www.wileyrein.com/newsroom-pressreleases-555.html (October 19, 2011)

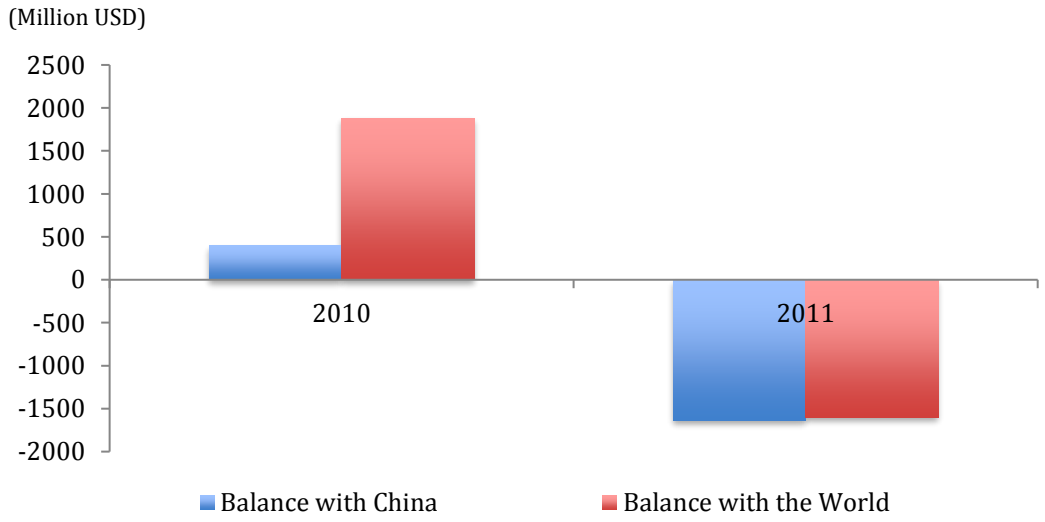
in 2011 (Figure 18). The trade deficit with the world has generated by dramatically increased deficit with China.

Figure 17. U.S. import of photosensitive semiconductor devices including PV cells, 1996-2015.



Source: U.S. Department of Commerce and the U.S. International Trade Commission.

Figure 18. U.S. trade balance of solar goods.



Source: International trade in Environmental Goods 2012 Report, Senator Ron Wyden, February 28, 2012; The U.S. International Trade Commission

In response to the petition of the manufacturers, the U.S. Department of Commerce released its preliminary determination on May 17, 2012. It decided that the crystalline-silicon solar cells from China were subject to antidumping (AD) and countervailing duties (CVD). In October 10, 2012, the U.S. Department of Commerce issued its final determination, which affirmed its preliminary finding. On November 7, 2012, the U.S. International Trade Commission determined the imposition of AD/CVD duties ranging from 22.5 to 255.4 percent on solar cells and modules imported from China.

On December 31, 2013, SolarWorld filed a new petition against solar products from China and Taiwan. Since the duties applied to panels made from Chinese solar cells, Chinese manufacturers were able to avoid the duties by assembling panels from cells produced in Taiwan. This loophole had led SolarWorld to file a new petition. In response to this petition, the U.S. Department of Commerce determined that the imports of solar products from China had been sold in the U.S. at dumping margins from 26.71 to 165.04 percent, and those from Taiwan had been sold at dumping margins from 11.45 to 27.55 percent on December 16, 2014.

In July 2015, the U.S. Department of Commerce conducted an administrative review of the duties on Chinese solar products, and has confirmed that it will keep the duties with revised rates. In January 2016, the U.S. International Trade Administration issued preliminary findings of the second administrative review of the duties on Chinese

solar products. The dumping margin was found to be at 4.53 to 11.47 percent, which was lower than the original dumping margin.

Data and method

A social network analysis provides a useful tool to analyze political coalitions. It is a set of methods for investigating relational data. Relational data concerns the connections, ties, and contacts, and cannot be reduced to individual agents' attribution.[115] In this vein, the advantage of social network analysis is to model the relationship among actors.[116] The choice of social network analysis is natural because political interactions of firms are the main interest of this study.

The method of this study is "discourse network analysis," which combines a content analysis and a social network analysis. A discourse network analysis enables to measure and visualize political discourses in a quantitative way. It also allows researchers to conduct longitudinal analysis and to build discursive structures in a bottom-up approach.[117] As discourse network analysis identifies networks between actors, it enables researchers to discover different levels of coalitions rather than simply classify actors into coalitions.

The data set is established by a content analysis of seven U.S. newspapers: *USA Today, The Wall Street Journal, The New York Times, Los Angeles Times, New York*

---

115 Scott , John, *Social Network Analysis : a Handbook*, (London: SAGE Publications, 1991).
116 Wasserman, Stanley and Faust, Katherine, *Social Network Analysis: Methods and applications*, (New York: Cambridge University Press, 1994).
117 Leifeld, Philip, and Sebastian Haunss. "Political discourse networks and the conflict over software patents in Europe." *European Journal of Political Research* 51, no. 3 (2012): 382-409.

Post, The Washington Post, and New York Daily News. The newspapers were selected because they were either one of the top 5 U.S newspapers by circulation or one of the top 5 U.S. newspapers by digital traffic. Multiple newspapers were used to reduce the possibility of missing important actors. All news articles that included five search terms—*U.S., China, solar, panel, and trade*—were obtained in the period 2009-2014 in LexisNexis, ProQuest, and the Archives of Los Angeles Times. The year of 2009 was selected as the start year as a quick review of the newspaper articles revealed that solar panels from China were mentioned from 2009 onwards. In total, 572 articles were obtained (Table 11).

Table 11. Number of samples by newspaper.

Newspaper	All articles	Samples	
		Articles	Statements
USA Today	19	3	5
Wall Street Journal	192	44	92
New York Times	184	48	84
Los Angeles Times	20	6	12
New York Post	1	-	-
The Washington Post	153	22	38
New York Daily News	3	-	-
Total	572	123	231

Each article was reviewed to assess whether it was related to the topic—the trade dispute on solar panels between the U.S. and China—or if it only includes the search terms. Even if an article was closely related to the topic, it was excluded if it did not include any claim of an actor on the solar panel trade issue. Through this screening procedure, 123 articles were selected as samples.

An entire article was not appropriate for the unit of analysis for this study because

a single article includes multiple claims from various speakers. Therefore, each claim from an actor was given a code as a statement. If a statement was from a representative of an organization, the organization was regarded as a speaker. As for a Congressperson or an expert, an individual was coded as a speaker. The selected newspaper articles included 231 statements.

Analysis of newspaper articles could introduce a selection bias since not all actors release their claims. Moreover, some actors show their claims but remain anonymous. However, this does not critically weaken the validity of this study since being invisible or anonymous mean that they are less active in initiating change. As this study focuses on dominant actors rather than less active actors, newspaper articles can be effectively used.

The variables include organization and four issue categories. The organization of each statement is classified into 13 categories: U.S. state actors, China state actors, State actors in other countries, U.S. solar panel manufacturers, China solar panel manufacturers, Solar panel manufacturers in other countries, U.S. solar corporations other than panel manufacturers, Chinese solar corporations other than panel manufacturers, solar corporations other than panel manufacturers in other countries, U.S. industry association, China industry association, and experts (Table 12).

Table 12. Categories for type of organization.

Category		Description
State	U.S.	U.S. government agencies and legislators
	China	China government agencies, ministries, and legislators
	Other	Government agencies, ministries, and legislators in other countries
Solar panel manufacturer	U.S.	The U.S.-based solar panel manufacturers or the coalitions of them
	China	China-based solar panel manufacturers or the coalitions of them
	Other	Solar panel manufacturers based in the countries other than the U.S. and China or the coalitions of them
Solar corporation other than panel manufacturer	U.S.	The U.S.-based solar corporations other than solar panel manufacturers or the coalitions of them
	China	China-based solar corporations other than solar panel manufacturers or the coalitions of them
	Other	Solar corporations other than solar panel manufacturers based in the countries other than the U.S. and China or the coalitions of them
Industry Association	U.S.	Industry associations or coalitions including more than two different types of organizations located in the U.S.
	China	Industry associations or coalitions including more than two types of organizations located in China
Expert	U.S.	Solar experts including consultants, scholars, researchers and investors in the U.S.
	China	Solar experts including consultants, scholars, researchers and investors in China

Each statement was coded for four categories related to Chinese solar panel issues. The categories were developed by an open coding of sample articles. Three categories are about the frames of Chinese solar panels: “Chinese solar panels benefit the U.S economy,” “Chinese solar panels benefit the affordability of solar energy,” and “the trade practices of Chinese solar panels are fair.” Each category was coded whether the organization agree or disagree with each statement. The other category was about the position on policy: “The tariff on Chinese solar panels is necessary.”

For coding, the software Discourse Network Analyzer was used.[118] This software has been used for coding of texts and building social networks.[119] An affiliation matrix with actors and policy preferences was established, and this matrix was transformed into an actor-by-actor matrix, which includes the number of shared policy stances between actors. Political coalition was derived from this matrix as a network based on the assumption that similarity of policy preferences encourages actors to make a coalition. The coalitions were visualized by using NetDraw, a program for visualizing social network data.

Findings

Prominent actors in the solar panel trade issue field

Various organizations and individuals have revealed their opinions on the U.S.-China solar panel trade issue. Although the solar panel manufacturers in other countries, who released 50 statements, were the most prominent actors, they were not very dominant (Table 13). Many actors in China also actively released their statements. One third of the statements are from the actors based in China.

---

[118] Leifeld, Philip, "Discourse Network Analyzer manual," http://www.philipleifeld.de/discourse-network-analyzer-dna/manual/manual.html. (September 23, 2012)

[119] Fisher, Dana R., Philip Leifeld, and Yoko Iwaki. "Mapping the ideological networks of American climate politics." *Climatic Change* 116, no. 3-4 (2013): 523-545.; Leifeld, Philip, and Sebastian Haunss. "Political discourse networks and the conflict over software patents in Europe." *European Journal of Political Research* 51, no. 3 (2012): 382-409.; Stoddart, Mark CJ, and David B. Tindall. "Canadian news media and the cultural dynamics of multilevel climate governance." *Environmental Politics* 24, no. 3 (2015): 401-422.

Table 13. Number of statement per actor group by issue category.

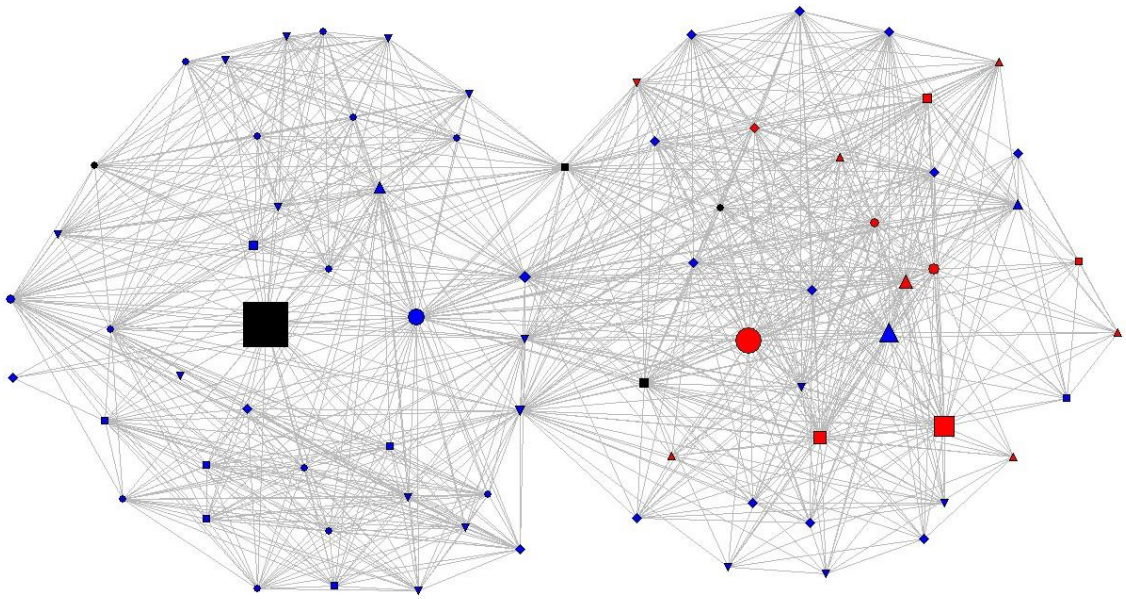
		Chinese solar panels benefit US Economy		Chinese solar panels benefit the affordability of solar energy		The trade practices of Chinese solar panels are fair		The tariff on Chinese solar panels is necessary		Total
		Yes	No	Yes	No	Yes	No	Yes	No	
US	State		9	1			18	1	1	30
	Panel Manufacturer		5			1	2	3		11
	Solar corporation other than panel manufacturer	6	1	1		1	1	1	8	19
	Industry Association	4	2	2		2	4		9	23
	Expert	2	6	3	1		6		3	21
China	State	5		9		6			11	31
	Panel Manufacturer	6		3		11			9	29
	Solar corporation other than panel manufacturer								1	1
	Industry Association	2		2		3			6	13
	Expert								1	1
Other	State						1		1	2
	Panel Manufacturer	1	14	2	1		25	5	2	50
Total		26	37	23	2	24	57	10	52	52

Overall, the positions of the four groups—U.S. state actors, U.S. panel manufacturers, panel manufacturers in other countries, and U.S. experts—tend to be different from the positions of the other actors. These groups agree neither that Chinese solar panels benefit U.S. economy nor that the trade practices of Chinese solar panels are fair. The rest of the groups including U.S. solar corporations other than panel

manufacturers and U.S. industry associations tend to agree on both statements. This shows that the home country of an organization may have no correlation with its position on Chinese solar panels.

Actor congruence network supports that the home country of an organization is not associated with the position of the organization on Chinese solar panels. In the actor congruence network, two coalitions are apparent (Figure 19). The coalition in the left can be named as "anti-Chinese solar panel group," which argues the harms of Chinese solar panels. They argue that Chinese solar panels have no benefit to the U.S. economy and that the trade practices concerning the Chinese panels are questionable. SolarWorld, the biggest black square, is a dominant actor in this coalition. Although this coalition mostly consists of the U.S. actors, it is led by a Germany-based corporation. On the other hand, the other coalition to the right includes diverse actors from the U.S. and China. This coalition can be named as the "pro-Chinese solar panel group," which argues for the benefits of Chinese solar panels. State actors in China and Chinese solar panel manufacturers lead the coalition, but a number of the actors in the U.S. are included in this coalition. One of the main actors in the coalition is the Coalition for Affordable Solar Energy (CASE), which is an industry group based in the United States. CASE was established to fight against SolarWorld's petition. Its members include both U.S. solar installers and Chinese solar panel manufacturers. Other than the CASE, a number of U.S. solar installers are included in the pro-Chinese solar panel group.

Figure 19. Actor congruence network



Note: Node size is a function of statement frequency. Node color indicates the country of origin of each organization. Blue indicates U.S. organizations, Red indicates Chinese organizations, and Black indicates the organizations based on other countries. Node shape indicates the type of organization. Circle indicates state actors, Square indicates solar panel manufacturers, Diamond indicates solar companies other than panel manufacturers, Up triangle indicates industry association, and Down triangle indicates experts.

The anti-Chinese solar panel group has a single dominant actor, SolarWorld. SolarWorld has released 44 statements alone. Other than SolarWorld and Senator Ron Wyden, the actors in the anti-Chinese solar panel group were not very active. A majority of them released only one statement. Compared to the anti-Chinese solar panel group, the pro-Chinese solar panel group has more diversity. There is no single dominant actor. Chinese state actors, Chinese solar manufacturers, industry associations, and the U.S.-based industry coalition actively participated in policy discussion.

Multinational corporations headquartered in other countries have played a critical role in framing the issue of Chinese solar panels in the United States. SolarWorld led the

anti-Chinese solar panel group, while Suntech and Yingli Green Energy were among the most dominant actors in pro-Chinese solar panel group. Compared to these multinational corporations headquartered in other countries, the U.S.-based solar corporations were not dominant in framing. They were divided into two coalitions. The U.S. solar panel manufacturers tended to be in the anti-Chinese solar panel group, and the installers tended to join in the pro-Chinese solar panel group.

Framing in the solar panel trade issue field

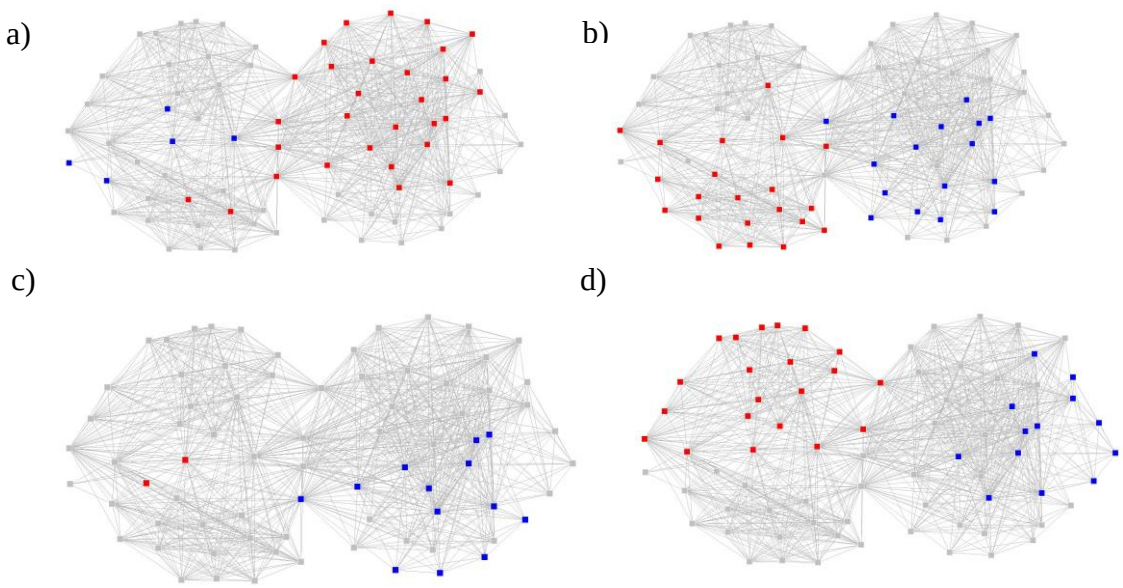
Top 20 frequently used words in the U.S.-China solar panel trade issue shows that the issue was framed as an economic issue rather than an environmental issue. Any word related to the environment was not included in the top 20 frequently used words (Table 14). Rather, a number of words related to economy have frequently used to report the U.S.-China solar panel trade issue. Trade, companies, industry, and manufacturers were included in the frequently used words.

Table 14. Top 20 frequently used words in the U.S.-China solar panel trade issue

Word	Count	Weighted Percentage
solar	1580	2.84%
china	1146	2.06%
chinese	979	1.76%
trade	658	1.18%
energy	554	0.99%
panels	494	0.89%
companies	486	0.87%
industry	396	0.71%
tariffs	382	0.69%
panel	360	0.65%
united	352	0.63%
american	347	0.62%
states	337	0.60%
government	336	0.60%
manufacturers	290	0.52%

The result of the network analyses is consistent with that of the word frequency analysis. The anti-Chinese solar panel group speaks more about the economic and fairness issues than about the affordability of solar energy. Figure 20-c shows that only two actors in the anti-Chinese solar panel group speak about the affordability issue. In contrast, almost all the actors in the anti-Chinese solar panel group speak about either the imported panels' impact on the U.S. economy or the trade practices of the Chinese solar panels (Figure 20-b and 20-d). On the tariff issue, the positions of the group are not consistent. Some organizations agree with the tariff, while the others don't agree or are not interested in it.

Figure 20. Actor congruence network visualized with frames.



Note: Four figures are the same network with different visualization. a) visualizes the stances in "the tariff on Chinese solar panels is necessary." b) visualizes of the stances in "Chinese solar panels benefit the U.S economy." c) visualizes of the stances in "Chinese solar panels benefit the affordability of solar energy." d) visualizes of the stances in "the trade practices of Chinese solar panels are fair." Node color indicates stances in each category. Red indicates "No", Blue indicates "Yes" and Black indicates "no statement available."

For the anti-Chinese solar panel group, "unfair trade practices" of China was a big problem. On September 28, 2010, 181 members of the U.S. House of Representatives wrote to the president to urge the administration to deal with China's unfair trade practices and dominating of the green technology sector. Senator Ron Wyden argued that the American solar industry had been struggling even though the demand for solar energy had been rapidly increasing because "China is cheating." Representative Edward Markey also said "China is eating our breakfast and moving to our lunch and dinner in the renewable energy field." For the actors in the anti-Chinese solar panel group, the problem was that China had attempted to dominate global green technology market using unfair

practices. Rather than focusing on a specific policy, they focused on framing the issue as an economic and trade issue.

On the other hand, the pro-Chinese solar panel group has been more interested in policy than in framings. Most of the actors announced that they were against the tariff on Chinese solar panels. Since most of the organizations have engaged in the debates on Chinese solar panels to stop litigation caused by SolarWorld's petition, their interest was directly on the U.S. policy itself rather than framings for Chinese solar panels.

As part of their fight, they also argued against the framings of the anti-Chinese solar panel group. Some actors argued that the U.S. economy is benefitted from the low-priced Chinese solar panels. For instance, Andrew Beebe, the Chief Commercial Officer of Suntech, a China-based module manufacturer, said a major portion of the U.S. solar industry is other than solar panel manufacturing:

> "Only a small proportion of the American solar industry is involved in the kind of manufacturing SolarWorld does, which the antidumping duties are supposed to help save. About 95,000 of the 100,000 solar-industry jobs in the U.S. are either with upstream producers of capital equipment, polysilicon and the like; manufacturers of complementary components such as racks; or downstream services surrounding solar-project construction, installation and engineering"

Many of the U.S. actors also praised the economic benefits of Chinese solar panels. Lisa Jackson, the head of the Environmental Protection Agency (EPA), said: "employing local residents to install solar panels had environmental and economic benefits, regardless of where the panels were made" after visiting a local solar project using Chinese solar panels. Tony Clifford, the chief executive of Standard Solar, a U.S.

solar installer, said that a trade war with China risked "to slow or halt the momentum of solar installation in the U.S."

Chinese solar panels' contribution to the affordability of solar energy was also an important aspect for the pro-Chinese solar panel group, but it was less critical compared to other frames. The actors in the group argued that Chinese solar panels contribute solving environmental problems by lowering the costs of renewable energy. The Ministry of Commerce of China argued, "The United States has no reason to criticize other countries' efforts to try to improve humanity's environment." Matthew Slaughter, a professor at Dartmouth College said: "If the goal is to spur wide adoption of new energy sources, why should I care if it is produced in China, Germany, Spain, or the U.S.?"

Compared to the anti-Chinese solar panel group, the pro-Chinese solar panel group's arguments on the fairness of trade practices were reactive rather than proactive. Most of the actors denied that Chinese solar panel manufacturers received unfair subsidies from the government. Robert Petrina, managing director of Yingli Green Energy America said: "We are not dumping, nor do we believe that we are unfairly subsidized." The actors said that the success of Chinese solar panels is due to lower costs and better technology. Mark Kingsley, the chief commercial officer of Trina Solar, said that the U.S. tariffs "don't take into account legitimate cost-cutting that Chinese manufacturers have been able to achieve." Their arguments focused on that the trade of Chinese solar products was fair.

Discussion

The findings do not support the proposition, which was that the central domestic

actors of a renewable energy field have framed a renewable energy trade issue with the traditional environmental frame. The U.S.-China solar panel trade issue was framed as an economic and trade issue rather than an environmental issue, which has been a traditional frame of renewable energy, by solar multinational corporations headquartered in other countries. The U.S. solar corporations were not prominent in framing Chinese solar panel issue. They were divided into two coalitions; solar module manufacturers were in the anti-Chinese solar panel coalition, but the other U.S. solar corporations were in the pro-Chinese solar panel coalition.

These findings show that an issue field is not necessarily dominated by the central actors of an existing exchange field. The findings support that an issue field is dominated by the actors, which have strong interests in the issue. SolarWorld initiated changes in existing exchange field, and an issue field was created as other organizations participated in the debate on Chinese solar panels. SolarWorld initiated the changes because it had struggled with rising competition with low-priced Chinese solar panels. Meanwhile, multinational corporations headquartered in China were prominent actors leading the pro-Chinese solar panel coalition. They were active in addressing this issue since it was very critical for their survival in the U.S. market. Chinese manufacturers had to fight against SolarWorld's petition because a policy measure to restrict Chinese solar panels was expected to harm the profitability of them.

SolarWorld and Chinese manufacturers overcame the disadvantage as a foreign organization by strategically collaborating with U.S. organizations. SolarWorld has led the Coalition for American Solar Manufacturing (CASM), whose purpose is to oppose "illegal trade practices" in the solar industry. Many small U.S.-based solar corporations

have joined in the CASM, and it represented around 240 "U.S" solar organizations as of 2013. Chinese solar multinationals have collaborated with U.S. organizations through the CASE. The CASE had a number of large U.S. solar installers such as SunEdison and Solar City as member companies.

The framings of the Chinese solar panel were different from the traditional framing of the solar PV field. The Chinese solar panel issue was framed as an economic and trade issue rather than as an environmental issue. It is not addressed within the traditional framings of renewable energy because it introduced conflicts between industry's interests and the traditional goal of solar energy. Since low-priced Chinese solar panels contributed to achieve the goal of reducing cost in solar energy, a policy measure to restrict Chinese solar panels would conflict with the goal. In this context, the contribution to affordability of solar energy was barely mentioned by anti-Chinese solar panel coalition. They framed the issue from economic and trade perspective.

This chapter shows that multinational solar corporations' reactions to the external environment are more than adapting to changes. Chapter 3 showed that an individual multinational corporation tended to adapt to the environment rather than to attempt to change the environment. However, multinational corporations were more active in changing the external environment through collaborating with other actors. They framed a new challenge differently from the traditional frame, and collaborated with diverse actors from multiple fields.

Since this study focused on the framing of the trade issue, it is limited in explaining how this framing has affected a real policy change. Although the corporations attempted to affect policies through framing an issue, it would not necessarily influence

actual policy changes. Future research can complement the limitation of this research through investigating the relations between framing and actual policy change.

Chapter 5. Solar policies and industry in the United States

Introduction

Since the 1970s, the U.S. government has promoted renewable energy sources through multiple policies including research and development programs, tax credits, and financial assistance. These policies have created, extended, and expanded through a number of acts in recent years. Although the policies have changed in various ways over time, they have a common goal, which is to increase the use of renewable energy.

Recently, a different type of policy has been introduced—the tariff on solar panels imported from China. The tariff has increased the costs of solar energy by adding a tariff on solar products. This policy is different from the other renewable energy policies currently in place in that its goal is not to increase the use of renewable energy, rather it is intended to fix the trade practices of renewable energy products. Moreover, while the other renewable energy policies have benefitted all actors in renewable energy field, the tariff has only benefitted solar panel manufacturers. Most of the actors in the U.S. solar PV field other than the manufacturers were against the tariff, as discussed in Chapter 4. The introduction of the tariff on Chinese solar panels shows that renewable energy policies are more than supports in order to increase the renewable energy installation at this point.

This chapter explores how the U.S. solar industry has affected these changes of national solar policies. As the U.S. solar PV industry grows, the industry has become more actively involved in policy issues. Solar PV corporations have influenced relevant policy issues through industry organizations such as the Solar Energy Industry

Association. They have fought for the extension of the solar investment tax credit, which was extended through 2021 in December 2015. Other than the investment tax credit (ITC), the industry has engaged in diverse policy issues such as transmission, permitting, and trade in federal-level as well as in state-level. Recently, the industry has engaged in the policymaking of the Clean Power Plan (CPP), which requires electricity-generating units to reduce carbon emissions, to take advantage of it as an opportunity to boost the solar market. As the industry has pursued more favorable market conditions through engaging in policy issues, the boundary of relevant solar policies has been expanded to trade policies and climate policies.

In this chapter, the interactions between policies and the solar PV industry are explored. By using qualitative interviews, archival data, and observational data, this chapter describes the evolution of the federal solar policies, the changes of solar market environment from the industry's perspective, and the reactions of the solar corporations to the market changes. Lastly, the interactions between the evolution of the policies and the industry are analyzed.

Data and method

Three data sources were used for the study: qualitative interviews, archival data, and observational data. The interviews were conducted with 24 organizations or individuals in the U.S. solar PV field. Archival data on the U.S. solar policy was obtained from the *govinfo*, the online archive of the Government Publishing Office, and *GovTrack*, the website for tracking federal legislations. Observations in a number of conferences in the U.S. were also used as data.

Two groups of actors in the U.S. solar PV field were interviewed: the executives and managers of solar PV corporations, and the experts of the U.S. solar PV field. The expert refers to an individual who has expertise on solar PV industry, market, or policy. A sampling frame has been set up for each group. The sampling frame for the solar PV corporations was set up based on the list of the members of the Solar Energy Industries Association. Among 450 members, non-profit organizations were excluded. Service providers such as consultancy or legal service providers were also excluded since they were not regarded as solar PV corporations given the minor share of their solar business. Manufacturers of components were excluded for the same reason. Among the remaining 260 companies, 40 companies, which have participated in one of the three trade shows—2015 Solar Power International, 2016 PV Conference and Expo, and 2016 Solar Power International—were selected as samples. A random individual was contacted in the booth of each corporation, and most of the individuals recommended meeting another person who could answer the interview questions. The recommended person was contacted again and was asked to participate to the research. Through this process, 19 representatives from the corporations agreed to be interviewed (see Appendix A).

For setting up the sampling frame for the solar experts, the organizations and individuals that gave their opinions on the Chinese solar panel issue, which was one of the most critical issues of solar PV recently, were listed. Next, the organizations relevant to renewable energy found by Internet search were added. After an interview, some interviewees recommended the experts who had expertise on the topic of the study. These experts were also added in the sampling frame. As a result, the list included 15 experts.

Each expert was contacted via email or phone call, and 5 of them agreed to be interviewed.

All the interviews were conducted in-person except one. One representative of a corporation agreed with an email interview rather than an in-person interview. Some interviewees did not agree to be recorded. In this case, the memo written during the interview was used as data. The interviews were conducted during the period from April 20, 2015 to September 14, 2016. A pre-determined protocol was used for each interview, but the interview questions were modified according to the expertise of each respondent (see Appendix D).

Archival data was obtained from the *govinfo*, the online archive of the Government Publishing Office. All the documents related to solar policies were obtained through searching the title of the documents including 'solar' or 'photovoltaic' in all the publications from the three branches of the federal government. The results of the search showed 1,148 documents. After excluding duplicated documents and the documents that only include the search terms and were not related to solar policy, 218 documents remained. The documents include bills, federal registers, congressional records, and the documents on the U.S. codes. Since these documents did not include some important bills that did not include 'solar' or 'photovoltaic' in the title, additional documents were obtained through searching the bills including 'solar,' in all the enacted bills in the Govtrack. Through this process, 157 enacted bills were added in the dataset.

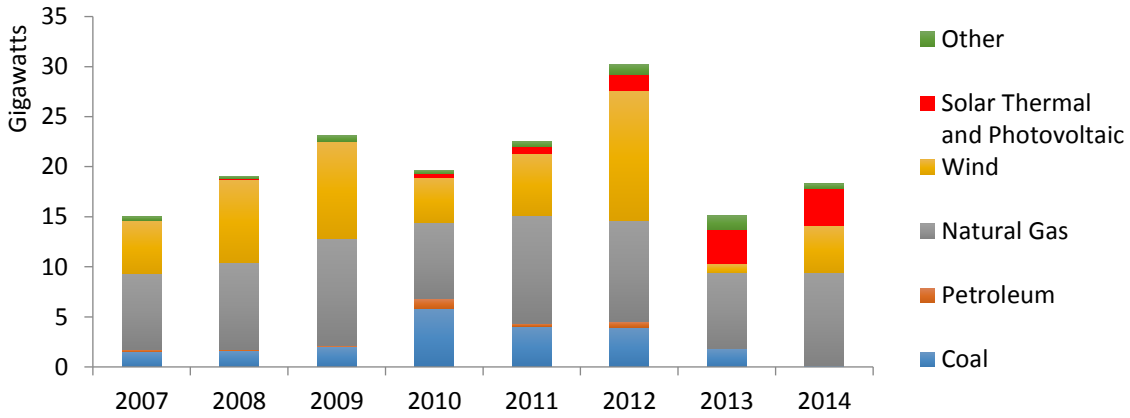
Finally, the memos written through observing conferences were used as data. A number of sessions on diverse topic related to solar PV policy and industry were observed in the 2015 ACORE National Renewable Energy Policy Forum, 2015 Solar

Power International, 2016 PV Conference and Expo, and 2016 Solar Power International (see Appendix C).

Solar PV and industry in the United States

Solar energy installation has significantly increased in recent years. The share of solar energy in electricity generation capacity additions was only 1 percent in 2007, but it has increased to 20 percent in 2014 (Figure 21). Rapid increase of large utility scale projects has driven this dramatic rise of solar installation (Figure 22).

Figure 21. U.S. electricity generation capacity additions, 2007-2014.

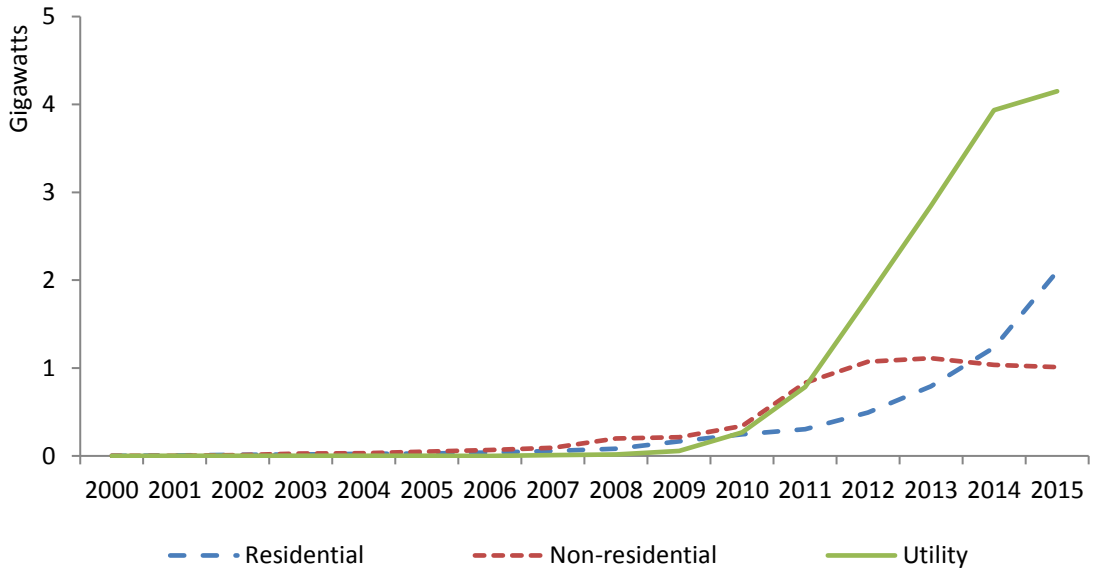


Source: Electric Power Annual 2014; 2013; 2012; 2011; 2010; 2009; 2008; 2007, U.S. Energy Information Administration.

The total PV installation in 2015 was more than seventy times of the installation in 2005. As Figure 20 shows, the solar installation has started taking off around 2010. In 2011, 1,919 MW of solar systems were installed, which represents 109 percent growth over 2010. Since then, PV installation showed sharp growth. Solar installations skyrocketed in 2012. The utility market especially has grown tremendously with the

increase of large-scale projects. In 2011, 28 projects over 10MW were installed, up from 8 projects in 2010. While the share of the utility market was about 1 percent of the total PV installations in 2005, the share has increased to 57 percent in 2015.

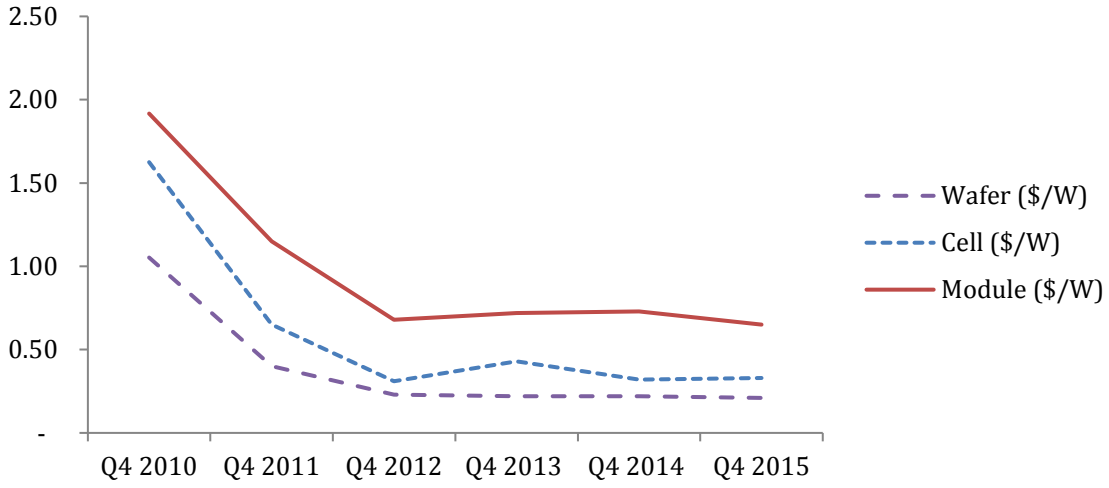
Figure 22. U.S. PV installation by segment, 2000-2015.



Source: U.S. Solar Market Insight Report: 2013 Year-in-Review; U.S. Solar Market Insight Report: 2014 Year-in-Review; U.S. Solar Market Insight Report: 2015 Year-in-Review.

Decreasing system costs have driven the growth of solar PV installation. As for the utility, the average installed PV system price has dropped to $1.3/W in 2015 from $3.2/W in 2011. This was possible due to the reduction of the costs of the solar products. The prices of wafers, cells, and modules significantly decreased during 2010-2012 (Figure 23). Moreover, the competition among companies has been a driver of cost-down by introducing more efficient installation practices, optimization of logistics, and more aggressive bidding.

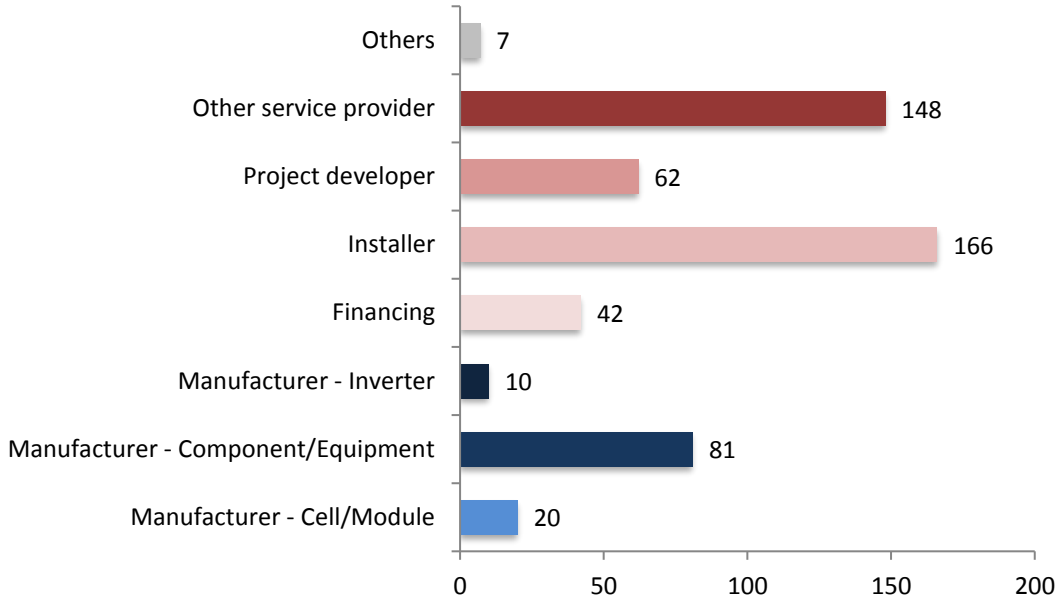
Figure 23. U.S. wafer, cell, module prices. 2010-2015.



Source: U.S. Solar Market Insight Report: 2011 Year-in-Review; U.S. Solar Market Insight Report: 2012 Year-in-Review; U.S. Solar Market Insight Report: 2013 Year-in-Review; U.S. Solar Market Insight Report: 2014 Year-in-Review; U.S. Solar Market Insight Report: 2015 Year-in-Review.

As of November 7, 2015, 543 solar PV corporations were registered as a member of the SEIA. More than 70 percent of these corporations are service providers such as installers, project developers, finance institutions, and consultancy (Figure 24). The manufacturing of solar products such as cells and modules does not account for a significant share in terms of the number of the companies. Only 20 companies are manufacturers of cells and modules.

Figure 24. Member companies of the SEIA by business.



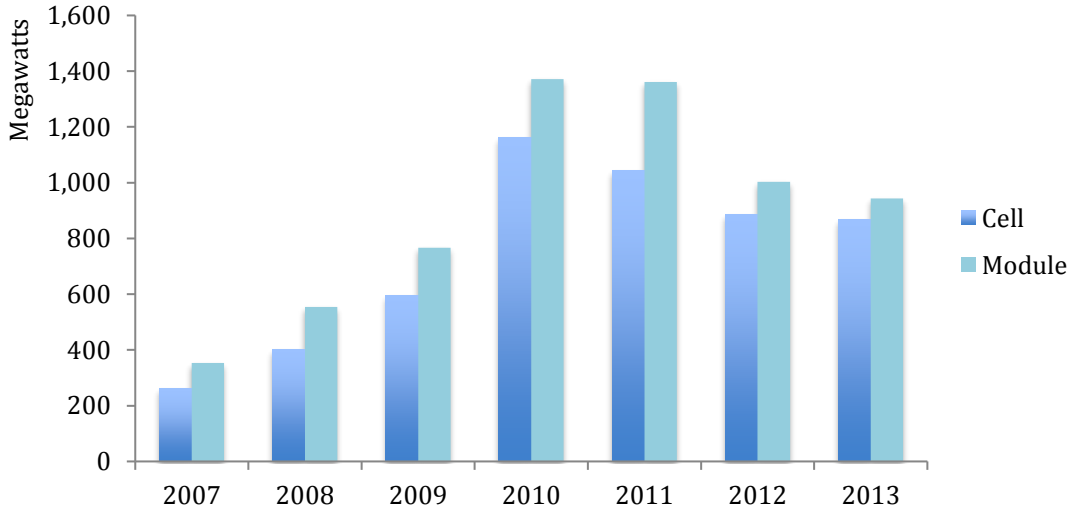
Source: Solar Energy Industry Association, November 7th, 2015.

Figure 25 also supports that manufacturing is not significant in the U.S. solar PV industry. In 2013, the portion of the U.S in the production of solar cells and modules is only about 2 percent. The total production of cell and module has sharply increased in the world in recent years, but it has not increased in the U.S. Figure 26 shows that the production of cells and modules has decreased in the U.S. since 2010.

Figure 25. Solar PV cell and module production, 2007-2013.

Source: http://www.earth-policy.org/?/data_center/C23/; GTM Research

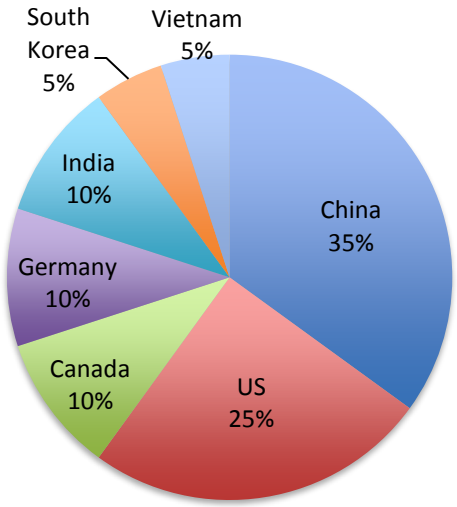
Figure 26. Solar PV cell and module production in the U.S., 2007-2013.



Source: http://www.earth-policy.org/?/data_center/C23/; GTM Research

The U.S. solar manufacturing is dominated by multinational corporations headquartered in other countries. In 2015, among 20 cell and module manufacturers in the U.S., only 5 are headquartered in the U.S. (Figure 27). The manufacturers headquartered in China have the largest share of the U.S. solar cell and module manufacturing. The rest of the corporations are headquartered in Canada, Germany, India, South Korea, and Vietnam.

Figure 27. Location of the headquarters of the U.S. solar cell and module manufacturers, 2015.



Source: Solar Energy Industries Association, November 7th, 2015.

The dominance of the manufacturers headquartered in other countries was partially caused by the recent solar market conditions. In recent years, many solar manufacturers went out of solar business under the imbalance of the solar market. The declining demand due to the global financial crisis and the increasing supply from Chinese manufacturers have introduced challenges to solar manufacturers. Under these

circumstances, since 2011, numerous manufacturers including Solyndra, Helios USA, and BP Solar closed their U.S. production facilities (Table 15).

Table 15. Selected solar PV plant closure in the U.S in 2011-2014.

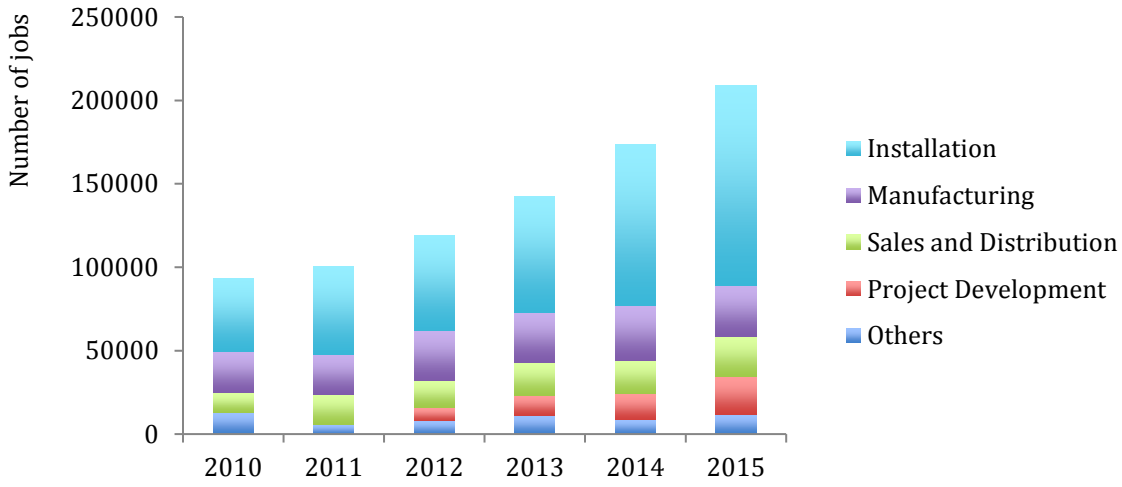
Company	Year Online	Year Closed	State	Products
Abound Solar	2009	2012	CO	Module
Evergreen Solar Inc.	2008	2011	MA	Wafers
Helios USA	2010	2013	WI	Modules
MEMC Southwest Inc.	1995	2011	TX	Ingots
Nanosolar	2009	2013	CA	Modules
MX Solar	2010	2012	NJ	Modules
SolarWorld Americas	2007	2011	CA	Modules
Solon America Corp.	2008	2011	AZ	Modules
Solar Power Industries	2003	2011	PA	Cells, modules
Solyndra Inc.	2010	2011	CA	Modules
Spectra Watt Inc.	2009	2011	NY	Cells
BP Solar	1998	2012	MD	Cells, modules
Energy Conversion Devices	2003	2011	MI	Cells, modules
Suntech	2010	2013	AZ	Modules
Sharp Solar	2003	2014	TN	Modules
Sanyo	2003	2012	CA	Wafers

Source: U.S. Solar Photovoltaic Manufacturing: Industry Trends, Global Competition, Federal Support, Michaela Platzer, January 27, 2015.

While manufacturing has barely contributed to the solar industry development, installation has led the development of industry. In recent years, installation has provided a majority of additional solar jobs driven by massive increase of solar installations (Figure 28). Project development sector has also added increasing number of jobs. In contrast, manufacturing has provided similar number of jobs in recent years. This shows

that the growth U.S. solar industry is driven by the growth of service sectors rather than manufacturing.

Figure 28. Solar energy employment by sector, 2010-2015.



Source: The Solar Foundation, National Solar Jobs Census 2015.

Federal solar policies

In the 1970s, there was a shift of the U.S. energy policy from oil and gas supply to energy conservation and alternative energy sources.[120] Two energy crises during the 1970s, the oil embargo in 1973 and the Iranian Revolution in 1978-1979, have drawn policymakers' attention to the problems of energy markets. These issues include dependence on imports, energy shortages, and productivity issues. Moreover, increasing awareness of environmental degradation has weakened political support for oil and gas.

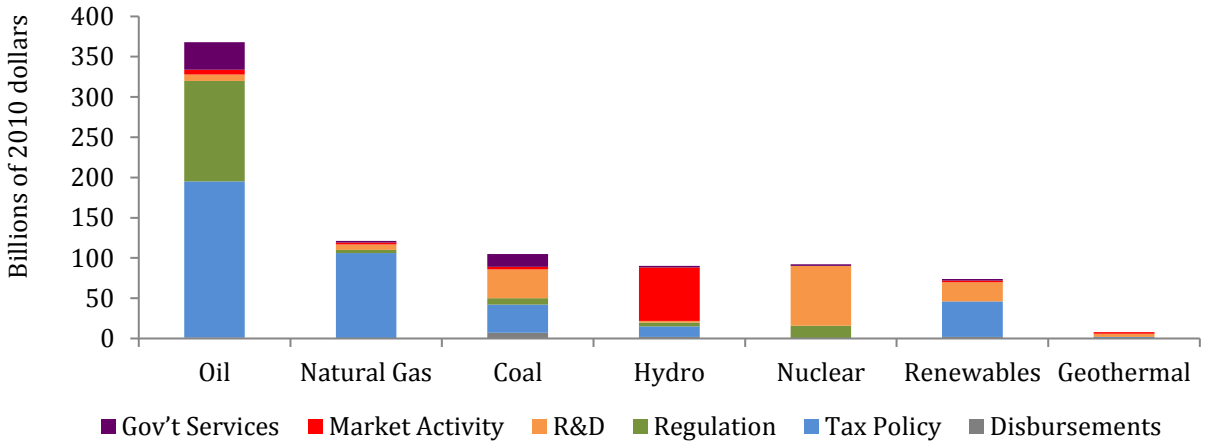
In this context, solar energy has received support from the government since the 1970s. The first major act on solar energy was the Solar Energy Research, Development,

[120] Lazzari, Salvatore, *Energy Tax Policy: History and Current Issues*, CRS Report for Congress, June 10 2008.

and Demonstration Act, enacted in 1974. The act said that the production of solar energy will help "to eliminate the dependence of the United States upon foreign energy sources and promote the national defense."[121] The promotion of solar energy as an alternative energy source began in the 1970s to solve the nation's energy shortage.

In the U.S., solar energy has developed mainly based on two kinds of policy measures: a tax policy and research and development programs. A tax policy has been a main measure to develop renewable energy; the expenditure for tax policy accounted for about 60 percent of the total federal expenditure for renewable energy development (Figure 29). Research and development programs have also been a major policy measure. Renewable energy is one of the energy resources that the federal government has spent the largest amount of its R&D budget on, along with coal and nuclear power.

Figure 29. Federal expenditures for energy development by source, 1950-2010.



Source: 60 Years of Energy Incentives: Analysis of Federal Expenditures for Energy Development, Management Information Services, Inc., October 2011.

[121] Solar Energy Research, Development, and Demonstration Act of 1974, Public Law 93-473. 88 Stat.1431. 1974.

In 1978, four acts that include solar policies were enacted. The Energy Tax Act included an income tax credit to the residents who use solar, wind, and geothermal sources of energy. The credit was a 30 percent of the expenditure up to $2,000 and a 20 percent of the expenditure between $2,000 and $10,000. The Act also included a 10 percent business tax credit for investments in energy properties including solar and wind energy. Another two Acts authorized financial assistance programs for solar energy. The National Energy Conservation Policy Act empowered the Secretary of Energy to direct the Federal National Mortgage Association to make commitments to purchase loans and advances of credit relevant to installing solar energy systems. The Small Business Energy Loan Act empowered the administration to create a solar energy loan program to small business. In the same year, the Solar Photovoltaic Energy Research, Development, Photovoltaic and Demonstration Act was enacted to provide more support for research, development, and demonstration for solar energy. The act included quantified objectives: 1) to double the production of solar PV system each year; 2) to reduce the average cost of installed solar PV energy systems to $1 per peak watt by 1988; and 3) to stimulate the purchase by private buyers of all the solar PV systems in 1988.[122]

In 1980, under the Energy Security Act, the Solar Energy and Energy Conservation Bank Act was enacted. The act was to create Solar Energy and Energy Conservation Bank, which provided financial assistance to the expenditures for residential and commercial energy conserving improvements and solar energy systems. The purpose of the policy was to encourage the use of solar energy, and to "reduce the

[122] Solar Photovoltaic Energy Research, Development, Photovoltaic and Demonstration Act of 1978, Public Law 95-590. 92 Stat. 2513. 1978.

Nation's dependence on foreign sources of energy supplies."[123] Energy security was still a critical driver of promoting solar energy in the 1980s.

The Tax Reform Act of 1986 extended the energy investment credit for solar energy property. In the act, the credit for solar energy was set as 15, 12, and 10 percent in 1986, 1987, and 1988, respectively. The credit has expanded by another acts for the next few years. The Omnibus Budget Reconciliation Act 1989 extended the credit through 1990. In 1992, the Tax Extension Act extended the credit through 1992 again.

In 1989, the Renewable Energy and Energy Efficiency Technology Competitiveness Act was enacted to authorize "aggressive" national programs of research, development, and demonstration of renewable energy and energy efficiency technologies. The act included national goals for the national programs. The specific goals for PV energy systems include: 1) to improve operational reliability of photovoltaic modules to 30 years by 1995; 2) to increase photovoltaic conversion efficiencies by 20 percent by 1995; 3) to decrease new photovoltaic module direct manufacturing costs to $800 per kilowatt by 1995; and 4) to increase cost efficiency of photovoltaic power production to 10 cents per kilowatt hour by 1995. Compared to the goals in the Solar Photovoltaic Energy Research, Development, Photovoltaic and Demonstration Act, these goals were much more specific.

The Energy Policy Act of 2005 created one of the most important policies for solar energy, which was a 30 percent of business investment tax credit for the investments in solar energy properties. The period was from January 2006 through December 2007. This credit was extended for an additional year through 2008 by the Tax

[123] Energy Security Act of 1980, Public Law 96-294, 94 STAT. 611. 1980.

Relief and Health Care Act 2006. In 2008, the Emergency Economic Stabilization Act included an eight-year extension of the credit through December 31, 2016.

This investment tax credit (ITC) was pointed out as one of the most important policies for solar PV industry development in the U.S. by a majority of the actors in the solar PV field. The ITC has helped solar technology to compete with other energy sources. A research manager at the Smart Electric Power Alliance (SEPA) said, "ITC is kind of [the] one and only incentive [that makes investment banks] all interested in investing in solar industries instead of others."[124] The eight-year extension of the ITC was especially beneficial to solar industry. The director of the GW Solar Institute pointed out: "The eight-year certainty of policy encouraged industry to make longer-term investment in terms of business plan, R&D, or large scale projects like utility-scale [projects]."[125] Other than the experts, most of the representatives of the solar PV corporations interviewed also mentioned that the ITC was one of the most important solar policies for them.

The solar ITC was more helpful since the timing of implementation was appropriate. A program manager at Solar Foundation explained, "The investment tax credit came at a period that was really quite well timed because from the mid-2000s, the German solar industry have been ramping up and increasing production and those companies are selling it to the solar industry or able to reach the economies of scale".[126] The solar ITC became a more effective policy since the costs of solar was coming down as a result of the investments in solar PV industry in Germany and Europe.

---

[124] Interview #1
[125] Interview #3
[126] Interview #5

The Energy Policy Act of 2005 has introduced another important policy for solar energy, the loan guarantee program. The act authorized the Department of Energy to guarantee loans for the projects that "avoid, reduce, or sequester air pollutants or anthropogenic emissions of greenhouse gases" or "employ new or significantly improved technologies."[127] The program was to encourage commercial use of new energy technologies in early stages. According to the SEIA, as of August 2016, eleven utility-scale solar power plants have received loan guarantees, whose total capacity is expected to be 2,700MW.

In 2009, the American Recovery and Reinvestment Act (ARRA) extended much support for renewable energy and energy efficiency technologies. It included $16.8 billion in funding for energy efficiency and renewable energy. As for solar energy, the act included a cash grant in lieu of the ITC for solar properties. It also included $6 billion in loan guarantees for renewable energy and electric power transmission programs. Since this act provides broad funding for energy technologies, it has contributed to developing the technologies that were helpful for expanding solar energy: "Most of the energy storage that are large and interesting and supported by utilities today were funded through ARRA and now that the utilities had gotten a taste for energy storage that serving to be able to get permission from their utility commissions to rate-based those types of technologies and start developing their own without federal support".[128] In this context, the ARRA has contributed to building the infrastructure for the expansion of solar energy as well as direct supports such as a cash grant.

---

[127] Energy Policy Act of 2005, Public Law 109–58, 119 Stat. 594, 2005.
[128] Interview #1

The solar ITC, which was expected to expire at the end of 2016, has extended again through 2021 by the Consolidated Appropriations Act in 2016. According to the act, the ITC will be 30 percent by the end of 2019, and it will be adjusted to 26 percent by the end of 2020, and to 22 percent by the end of 2021.

Table 16 summarized the major statutes for solar policy. Solar policies have been developed as a part of the energy policies for the nation's "secure, affordable, and reliable" energy production. The overall direction of the policies was to increase the share of solar energy in the U.S. energy mix. The ITC has contributed this goal by reducing the costs of solar energy. Research and development programs have contributed by reducing the costs by encouraging relevant technology development. Financial assistance such as loan programs has lowered the barriers for the investors of solar installations. This was described as "confluence of policies" by one of the experts interviewed.[129] Since all the policies has served a common goal, solar has significantly grown in the United States.

[129] Interview #1

Table 16. U.S. statute including solar policies.

Year	Statute	Purpose	Solar Policy
1974	Solar Energy Research, Development, and Demonstration Act	To authorize a vigorous Federal program of research, development, and demonstration to assure the utilization of solar energy as a viable source for our national energy needs,	Federal research, development, and demonstration programs
1978	Energy Tax Act	To provide tax incentives for the production and conservation of energy	Creation of tax credit
	National Energy Conservation Policy Act	To reduce the growth in demand for energy in the United States, and to conserve nonrenewable energy resources produced in this Nation and elsewhere, without inhibiting beneficial economic growth	Loan program
	Small Business Energy Loan Act	To create a solar energy and energy conservation loan program	Loan program
	Solar Photovoltaic Energy Research, Development, and Demonstration Act	To establish during the next decade an aggressive research, development, and demonstration program involving solar photovoltaic energy systems and in the long term, to have as an objective the production of electricity from photovoltaic systems cost competitive with utility-generated electricity from conventional sources.	Federal research, development, and demonstration programs
1980	Solar Energy and Energy Conservation Bank Act	To increase the Nation's security by reducing its dependence upon imported oil.	Financial assistance
1986	Tax Reform Act	To reform the internal revenue laws	Extension of tax credit

1989	Renewable Energy and Energy Efficiency Technology Competitiveness Act	To provide Federal assistance and leadership to a program of research, development, and demonstration of renewable energy and energy efficiency technologies, and for other purposes.	Federal research, development, and demonstration programs
1990	Omnibus Budget Reconciliation Act	To provide for reconciliation pursuant to section 4 of the concurrent resolution on the budget for fiscal year 1991	Extension of tax credit
1991	Tax Extension Act	To amend the Internal Revenue Code of 1986	Extension of tax credit
2005	Energy Policy Act	To ensure jobs for our future with secure, affordable, and reliable energy	Creation of tax credit Loan guarantee
2006	Tax Relief and Health Care Act	To amend the Internal Revenue Code of 1986	Extension of tax credit
2008	Emergency Economic Stabilization Act	To provide incentives for energy production and conservation	Extension of tax credit
2009	American Recovery and Reinvestment Act	To make supplemental appropriations for job preservation and creation, infrastructure investment, energy efficiency and science, assistance to the unemployed, and State and local fiscal stabilization	Research grant Loan guarantee
2016	Consolidated Appropriations Act	To make appropriations for military construction, the Department of Veterans Affairs, and related agencies for the fiscal year ending September 30, 2016, and for other purposes	Extension of tax credit

In 2012, a different type of solar policy from these policies was introduced. On December 7, 2012, the U.S. International Trade Commission, the Department of Commerce, issued a countervailing duty order on solar cells from China. The decision was based on the determination of the International Trade Commission that an industry in the U.S. is "materially injured by reason of imports of crystalline silicon photovoltaic cells and modules from China."[130] Since SolarWorld and six other manufacturers submitted petitions on October 19, 2011, the Department of Commerce has investigated the case of the crystalline silicon photovoltaic cells from China. On December 16, 2011, the Department determined that the photovoltaic cells from China have been sold in the U.S. at less than fair value and subsidized by the Government of China.

On February 10, 2015, the International Trade Commission determined that an industry in the U.S. is materially injured by the imports of solar cells from Taiwan as well as China. Based on this determination, the Department of Commerce issued an antidumping duty order on solar cells imported from Taiwan on February 18, 2015. The investigation was initiated by the submission of another anti-dumping petition of SolarWorld regarding the imports of solar cells and panels from Taiwan on December 31, 2013.

The tariff on the solar cells imported from China and Taiwan was different from the solar policies described above in that it serves a different goal. The tariff was determined to fix the "unfair" practices of international trade. In this sense, it is not related to the original goal of the solar policies, which was to increase solar installation. Rather, the tariff could be a barrier to achieve the goal because it increases the costs of

[130] U.S. Department of Commerce, "Crystalline Silicon Photovoltaic Cells and Modules From China," 77 Federal Register 235 (December 6, 2012)

solar products. The introduction of the tariff shows that the boundary of solar policies is expanded to trade policies from energy policies.

Changes of the solar PV market environment

To understand the influence of the solar industry to solar policies, the recent actions of the industry need to be investigated. Before describing the actions, the changes of the external environment of the solar industry are explored in this section to better understand the contexts of the actions of the industry.

Drivers of the growth of the U.S. solar market

Most of the corporations interviewed described that the U.S. solar market has grown very fast in the recent decade. The corporations perceived that the drivers of the growth were government policies, lowered cost, technological innovation, and increased public awareness of solar power.

Government policies were pointed out as one of the most important driver of the development of the solar market. One project developer stated: "When the government got involved and started creating subsidies to encourage people to use alternatives, that's when the boom in the market really started to grow".[131] The policies not only opened up a market, but also they have influenced the market constantly. The solar corporations interviewed agreed that various policies have been affected the solar market and they are still very influential for the market conditions. The policies mentioned included the ITC, net-metering, the Clean Power Plan, the tariff on Chinese solar panels, Renewable

131 Interview #7

Portfolio Standard in several states, state-level credits, state-level domestic procurement requirement, and even building codes.

Many corporations stated that the U.S. solar market has benefitted by sharply decreased cost of solar systems. A module manufacturer stated: "In a short amount of time, the module price came down so fast. That's why the market has grown so fast".[132] One of the other module manufacturers pointed out that cost was a "fundamental" driver. The representative of the manufacturer stated: "I think mostly people go solar for economic reason".[133] The cost of solar has significantly decreased in recent years. A project developer company said that solar beats gas in terms of costs in one of its projects.[134] Over time, the cost of solar has become more competitive compared to conventional energy sources.

Technological innovations have also contributed to the development of the solar market. Two corporations pointed out that the invention of financing vehicles was very important for the development of solar energy. One module manufacturer said that financing was the "biggest innovation for last years," which has led the growth of the residential solar market.[135] Accumulated technical experience has also positively affected the solar market. An installer pointed out: "Technology has advanced to the point where efficiencies are so high that we can build very big projects".[136] He added: "Back in 2009,

[132] Interview #9
[133] Interview #8
[134] Interview #6
[135] Interview #9
[136] Interview #21

you wouldn't hear about building 20MW project, which is now one of small [plants] what we built".[137]

Increased public awareness of solar energy has been one of the drivers of the solar market development. A maintenance service provider stated: "So many more people know and understand the benefits of clean energy. They are willing to pay extra premium for that".[138] People feel solar technology is "real" now. A module manufacturer pointed out: "[Solar] is not theorem of science fiction. People think it as real. They see it on neighbor's home. They see it on kids' school".[139] The maintenance service provider added that commercials of solar technologies on TV and radio stations have led the enhanced awareness.[140] The commercials of solar products and services have led people to think that solar is more commonplace and more preferred.

These four drivers of solar market development are connected one another. Government policies have contributed to lowering the cost, to encouraging technology innovations, and to increasing public awareness of solar technologies. Decreasing cost of solar, technology innovations, and the interests of the public in solar energy have led the government to be more interested in promoting solar energy. People want to go green because they have seen the technology innovations and the rise of many solar corporations. The U.S. solar market has grown based on the positive feedbacks between these drivers.

The ocean of policies

137 Interview #21
138 Interview #21
139 Interview #8
140 Interview #24

The ITC, a 30% tax credit for the investments in solar system, is one of the most important solar policies in the United States. All the corporations interviewed mentioned the ITC. They said that the ITC has led the U.S. solar market to grow and flourish.

Although most of the corporations stated the importance of the ITC in the U.S. solar market, no one has strongly argued for the necessity of the extension of the ITC.[141] Most of the companies said that the solar market will survive without the ITC. A module manufacturer said: "Even if [the] ITC were cut down to 10%, we believe we still see solar grow, but it could actually slow down the growth or development of solar".[142] Some corporations said that the effects of the ITC on their business were not very significant. A module manufacturer said that the ITC would not affect it directly because they don't develop or sell projects, and one service provider did not see significant effect of the expiration of the ITC since they did not participate in the construction side.

Even the corporations in downstream did not strongly argue for the extension of the ITC. An installer said what they want was to know what is going to happen rather than the extension itself: "We are great to have certainty. Nothing changed, but being able to prepare for what might change"[143] A project developer said that the extension of the ITC was important, but it stated that other policies including net-metering, the Clean Power Plan, and the design of electricity rates were also very important.[144]

---

[141] Twelve out of nineteen firm interviews were conducted before the decision of the extension of the ITC in 2016.
[142] Interview #11. Even if the 30 percent ITC expired, 10 percent ITC for commercial projects would have been remained since the 10 percent is based on a different act from the act including the 30 percent ITC.
[143] Interview #21
[144] Interview #6

This infers that a single policy, even the most critical federal policy, does not transform the solar market at this point. Diverse policies across energy, trade, and climate policy influence the solar market in different ways. The solar corporations want solar friendly market institutions rather than a specific policy support. A module manufacturer said: "I think there will come at point where we won't really need subsidies, but we still need policy that's friendly to solar. It doesn't have to be tax subsidy, but you need to have an environment [that] encourages solar".[145] A module manufacturer used the term, "the ocean," when described the policy factors. The representative of the company stated: "Policy factors include a lot of different levels of policies including trade policy, permitting policy and energy policy. It's like what makes the ocean."[146]

Table 17 shows all the policies that were mentioned by the interviewed companies. Various policies including a trade policy and a climate policy have been pointed out as important policies for solar industry. The solar PV corporations perceive that various federal- and state-level policies influence the solar market in different ways. Multinational corporations tend to perceive more policies as important compared to domestic companies. Since most of domestic corporations are smaller than multinational corporations, they were lack of resources and capabilities to monitor all the relevant policies.

[145] Interview #10
[146] Observation #11. The representative of a solar manufacturer did not agree with an interview, but agreed with an informal talk. The quote is from the memo written during the informal talk.

Table 17. U.S. policies mentioned by the interviewed companies.

	Federal-level	State-level
Multinational corporations	• Investment tax credit • Tariff on Chinese solar panels • Research Fund • Clean Power Plan • Property assessed clean energy (PACE) financing • National electric codes	• Laws and regulations in every state • Net metering • Electricity rate • Renewable Portfolio Standard • Domestic content requirement
Domestic corporations	• Investment tax credit • Clean Power Plan	• Renewable Portfolio Standard • Net metering

The impact of the globalized solar market

Germany and China have been two most influential countries in the global solar market, but each country had affected the U.S. market in different ways. Germany has significantly contributed to market creation and technology development. The director of GW Solar Institute said, "Germany has met tens of billions of dollars saying we want to create solar market, so they started off and now they have one third of solar in the world".[147] Another expert agreed with Germany's contribution in the market: "German and [European] markets are already sort of taking the lead in creating demand for solar [in mid-2000s]".[148]

Not only Germany contributed to the creation of solar market in the early days of solar PV development, but also it has contributed to solar PV technology development. One of the experts told a case of the U.S. companies learning from Germany: "One experience that happened in Germany is that they had such an aggressive policy to get

[147] Interview #3
[148] Interview #5

solar into their grid that they didn't consider some of the electrical issues that would be incurred on the system by having so much solar all at once. So, they had to go back and retrofit their grid with advanced inverters. I am aware that utility companies in the U.S. saw this and they have been researching the advanced inverters".[149]

Compared to Germany, China's contribution to the global market is controversial. China came to the solar PV market in late-2000s, when solar PV technology and industry were rapidly growing. China manufactured solar products using existing solar technologies. In the words of an expert: "[China wanted] to manufacture all this technology or assemble it and so they spend a lot of money, probably around 15 billion dollars".[150]

In late-2000s, China's efforts focused on exporting solar products rather than on creating domestic demand. An expert pointed out that China targeted international market in the beginning of solar PV development: "China [has seen] the opportunity [in] this booming European clean market. That's why they have this manufacturing sector build up and its initial build is for [export]. It's not for domestic use because at that point the domestic solar electricity was not competitive at all with coal-fired power plants".[151]

Huge investments on solar PV products in China have helped with reducing the costs of solar PV worldwide. According to the Bloomberg New Energy Finance, the prices of solar module have fallen by 80% during 2008-2012.[152] One of the experts said

---

149 Interview #1
150 Interview #3
151 Interview #4
152 Liebreich, Michael, "Bloomberg New Energy Finance Summit," 23 April, 2013, New York.

that this cost reduction is "directly correlated to" China's investments in solar PV.[153] He added that this benefitted the U.S.: "China wants to subsidize homeowners in the U.S. putting on [solar] panels [on their roofs]. That's good for us. It means more business for us".[154] The decrease of the cost of solar products has positively affected the increase of solar installations in the United States.

However, China's investments on solar products have harmed some part of the solar market since it was barely accompanied with demand creation. While Germany's contribution on cost reduction was achieved by technology development, China's contribution was achieved by large-scale manufacturing. Moreover, China did not make much effort to create domestic demand for solar PV compared to its efforts to increase supply. This caused imbalance of demand and supply in the global market. The demand for solar energy has decreased since global financial crisis in 2008 because governments lowered the supports for solar energy, and investors reduced or canceled financing solar projects. In contrast, supply has sharply increased by China's explosive production of solar products. Under these circumstances, solar PV manufacturers competed in terms of price rather than technology. As the manufacturers have difficulty to compete with Chinese firms in terms of price, many solar PV corporations had gone out of the business from 2011 to 2013 around the world.

Under this circumstance, to protect their domestic solar PV manufacturers, governments started introducing policy measures. The EU negotiated with China on a quota and minimum price for solar panels imported from China. Some governments such as India and Canada attempted to increase the use of domestic solar products by requiring

153 Interview #3
154 Interview #3

purchasing domestic products or by providing incentives. The U.S. also introduced an anti-dumping tariff on Chinese solar products. In the U.S., maintaining domestic solar manufacturing was important because manufacturing plays an important role for economic development. An expert said that manufacturing was important, especially in economic recession: "For the United States, especially during the economic recession period, manufacturing holds a key to economic development. That's not only about job creation. That's important for political [reason], for the Congressmen. They have to win this vote from local workers, but fundamentally it's a sector that can keep United States prestigious status in the world economy because if the world once [goes] to green economy or clean economy, clean manufacturing is an incessable component".[155] In this context, the claim for the necessity of a measure to address Chinese solar products has emerged and has been supported.

China's investments in solar PV have caused conflicts in the global market because their efforts were not balanced. In many countries, solar PV markets have been developed by confluence of diverse policies. For instance, in the U.S., there were many different types of policies such as solar ITC, state-level RPS, net metering, and R&D supports, which have increased both demand and supply of the solar market. China's approach that focused on production of solar products has increased supply of the market, which caused rapid changes of the global solar PV market environment. In the U.S, this benefited some industry groups, but it harmed the other industry groups.

Under these circumstances, SolarWorld, which is based on Germany, and six U.S. solar panel manufacturers submitted the petition concerning solar panels imported from

[155] Interview #4

China on October 19, 2011. They claimed that heavily subsidized Chinese solar panels were illegally dumped in the United States. As a result, the U.S. Commerce Department announced to impose antidumping tariff on Chinese solar panels on December 10, 2012. Chinese solar panel manufacturers attempted to avoid the tariff by outsourcing some manufacturing in Taiwan. SolarWorld submitted another petition to deal with this issue, and the U.S. International Trade Commission determined that the U.S. industry is injured by imports of solar PV products from China and Taiwan in January 2015.

Module manufacturers described the period of this trade dispute as "a crisis." A module manufacturer stated: "Declining prices cut a lot of margin for module manufacturers".[156] He added: "It was very difficult business for players even the ones that had big diversified asset." It took an example of Bosch, which was a big solar conglomerate and had exited solar manufacturing at that time.

A China-based module manufacturer stated that the trade dispute has introduced challenges to it. It had an advantage in 2009, which was the starting year of Chinese manufacturers' flooding into the U.S.: "We were able to come into U.S. with an incredible cost advantage over many other producers because of our scale and vertical integration".[157] However, the trade disputes between the U.S. and China since 2011 caused a lot of uncertainty for the company: "It was extremely challenging. There was so much uncertainty. It was very difficult to price ahead for projects in pipeline because we didn't know what the outcome of the case would be." In this context, the representative of the company said that the trade dispute also hurt the U.S. market as well as Chinese solar manufacturing. The trade dispute has introduced uncertainty in the U.S. market.

---

[156] Interview #9
[157] Interview #8

It was hard to figure out whether the tariff on Chinese solar panel was effective for solving this issue. The corporations interviewed perceived the harms of the tariff rather than the benefits of them. No company said that they were benefitted from the tariff. China-based module manufacturers pointed out the negative effects of the tariff. One China-based module manufacturer stated that the tariff has introduced much risk to them since the final rate of the tariff was decided some time after the timing of selling modules to the customers. The representative of the company stated: "We got preliminary decision to lower the tariff to about 15 percent, so all the customers asked us to fall the price our panels lower because they expected the final decision to maintain that lower rate. So the prices came down, and then the government changed mind on July".[158] Another China-based manufacturer also showed concerns on the uncertainty coming from the tariff: "It's a big uncertainty because we don't know where that's going. It might go up and down".[159] The company was extending production outside China to avoid the tariff, and it said that their consumers also want tariff-free modules to "reduce the uncertainty on their side."

Even the U.S.-based corporations did not say that they were benefitted from the tariff. The installers, a majority of the U.S solar corporations, did not want the tariff. The director of GW Solar Institute pointed out: "The bulk of [solar PV] industry do not support [the tariff on Chinese solar panels] because most of the industry is installers".[160] As the tariff increased the costs of solar installation, the tariff affected negatively to installers. Moreover, some corporations have suffered due to the China's reactions to the

158 Interview #9
159 Interview #10
160 Interview #3

tariff. A U.S.-based project developer said that the tariff has negatively affected their business.[161] After the U.S. government set the tariff on the solar modules from China, the Chinese government started an anti-dumping investigation for polysilicon, which is a raw material for solar modules, from the U.S. and South Korea. As a result, the imports of polysilicon from the U.S. were banned in China. The company said that that decision has negatively affected their polysilicon business.

From non-manufacturers' perspective, the tariff has negatively affected solar energy in the United States. A former analyst at the SEIA said that the trade disputes between the U.S. and China would weaken the competitiveness of solar power: "You definitely [are going to] see the price increase if [the U.S. and China] won't be able to reach an agreement." Under these circumstance, she added, "it's [going to] be a very long way that solar industry to catch up with other kind of resources."[162]

It is uncertain how the tariff has influenced the U.S. manufacturers. Since a majority of the U.S. manufacturers have plants outside the U.S., the effect of the tariff for them does not seem very significant. Only the manufacturers based in China mentioned the tariff as one of the significant policies during the interview. According to the interview data, Chinese manufacturers have absorbed the effect of the tariff by adopting strategies such as relocating their plants and reducing costs.[163]

---

[161] Interview #6

[162] Interview #2

[163] One of the reasons why the U.S. manufacturers were barely benefitted by the tariff was that a number of module manufacturers were out of business since 2011. According to the CRS report of Michaela Platzer, Helios USA and MX Solar, two of the seven petitioners of the solar trade case against China closed their plants in 2013 and 2012, respectively.

Policy as a source of risks and conflicts in the market

Despite the rapid growth of the U.S. solar market, the solar corporations have perceived risks and conflicts in the market. Most of these have caused from policies. For the other drivers of market growth, the corporations agreed that those have been positive factors. Among the policies, the ITC and the tariff on the Chinese solar panels have introduced significant risks to the actors in the market although the degrees of impacts were different among them.

The ITC has affected mostly project developers and independent power producers. It has directly influenced the cost of the solar projects. Module manufacturers, however, said that they also have risks due to the undecided ITC extension. One module producer stated: "ITC might be expiring, customers rush into fulfill their projects, and now is a huge spike and we don't have capacity to support it, and neither do we want to expand capacity to meet this demand because next year, the following year of 2017, it's gonna drop. And then, what do you do with the excess of capacity?"[164] The undecided ITC was likely to make a boom-and-bust cycle in the solar market. Since it affects the demand and the supply of the market, the effects have expanded to the whole solar PV value chain.

The tariff on Chinese solar panels has generated risks to solar corporations and conflicts between them. Although the tariff was to address the risks of the U.S. manufacturers in the market, it has caused new risks by introducing the possibility of the increase of solar cost. During the policymaking process, there was conflicts of interests between solar PV corporations. Even after the tariff was set as a policy, the Chinese solar

[164] Interview #9

manufacturers have faced risks since the rate is hard to predict. Moreover, the tariff has caused a new risk to the U.S. polysilicon manufacturers since Chinese government started anti-dumping investigation on the U.S. polysilicon imports.

Other policies than the ITC and the tariff have also posed risks to solar PV corporations. Many corporations perceived risks and uncertainty caused by state-level policies such as Renewable Portfolio Standard, net metering, and incentives. A module manufacturer described state-level policies as "chaotic" since they have kept changing.[165] Many solar PV corporations have seen risks from state-level policies since the policies were undecided for a longer-term or the incentives have decreased.

The reactions of the solar PV industry to the changing environment

The U.S. solar PV corporations have increased manufacturing capacity and have expanded their services under the dramatically rising solar market. Many corporations said that they have been in growth mode in recent years. A module manufacturer said: "We are growing our manufacturing capacity. We also plan to go on EPC in bigger scale."[166] An installer planned to "grow with the industry to provide manpower and services as needed."[167] Expanding business was a natural choice since the U.S. solar industry has enormously grown in recent years.

Reducing costs and improving the quality of products have also been important for the solar PV corporations. Under increasing competition in the market, pursuing lower-cost and better quality products have been a fundamental way to address market

[165] Interview #15
[166] Interview #12
[167] Interview #24

changes for the solar corporations. Solar manufacturers have searched room for improvement for cost-down. A module manufacturer said that they are trying to be "more lean, trying to find ways of streamlining process, try to find ways to alternate more work."[168] However, cost-down was not the only goal for the corporations. They have pursued better quality of their products, and sometimes this increased the cost. A global solar manufacturer said that using a better quality material has increase the cost: "We are using a hundred percent silver paste just to boost our efficiency, and then backseat creates more durable products. So together it creates better electricity price for customers. Costs [are] up a little bit, but quality improvement is much better."[169]

Innovation has been a leading way for the solar corporations under changing market environment. A module manufacturer said that innovation was what it could do under complex policies. The representative of the company said: "Under complicated policies, what we can do is cost-down and innovation. Everyone has same uncertainty. The thing is how aggressively do we innovate." [170]

Other than improving their operations and technologies, the U.S. solar corporations have also expanded their business. Module manufacturers have expanded to downstream business for "higher margin".[171] Recently, downstream business has been the most profitable business in the solar PV value chain. Andrew de Pass, the CEO of Conergy, one of the largest downstream solar companies, said that big players were earning money in downstream: "One can ask a question about some of the relatively three large publicly traded solar integrated companies: SunEdision, SunPower, [and]

---

[168] Interview #13
[169] Interview #9
[170] Observation #11
[171] Interview #10

FirstSolar, and one of the issues that research analyst can't really figure out is where they are making money, and for more we understanding in many cases, they're really not making money under manufacturer at all, just push to the downstream."[172] Conergy itself has also transformed to a downstream company from a manufacturer recently. It has moved to manufacturing when the Chinese corporations have flooded in solar manufacturing, and this has led Conergy into insolvency. After that, the company went downstream. Andrew de Pass said: "We focused fully as a pure play downstream company, and we are completely equipment agnostic."[173]

Although almost all the module manufacturers have been interested in downstream business, the degree of investment has different between them. Module manufacturers based in China has developed and has invested in solar power plants mainly in China and some of other countries except the United States. The representative of one of the module manufacturer based in China said: "In China, we do some project development and EPC work and also in some emerging markets like Africa and Southeast Asia".[174] Two other solar manufacturers based in China also said that their downstream business is conducted mainly in China. One of them explained that their main business is still manufacturing: "This year, we are going to be selling between 4.8 to 5GW. Out of that, less than 1GW will be downstream. So, we are not fully integrated to downstream. We are very different from a company such as FirstSolar".[175]

---

[172] Observation #7
[173] Observation #7
[174] Interview #7
[175] Interview #10. First Solar is a U.S. based solar corporation which is fully integrated to downstream.

The Chinese solar manufacturers have not been active in developing projects in the U.S. because they wanted to avoid competition with utilities, which are their biggest customers. A Chinese module manufacturer said: "We don't [do downstream in the U.S] because we don't want to compete with our biggest customers. We think it's a better strategy for us to partner with our customers, not to compete with them".[176] Utility-scale players have been the largest customers for the solar manufacturers. A module manufacturer said that 95 percent of their business is utility business in the U.S.[177]

The downstream companies have also changed their business portfolio according to market changes. A downstream company has focused on providing operations and maintenance services rather than on EPC since the solar ITC was supposed to be expired in 2017. The representative of the company said: "I know they are expiring in 2017 and so, we chose not to participate in the construction of the project. We developed a line of services that we can provide to the operations and maintenance [to the] company that has a 20-25 years of power purchase agreement".[178] He told that many of the services that his company provided were not its initial plans. The services have been created based on the demand of the market, which has changed over time.

A project developer said that their strategy was to have "flexibility to adapt to the market."[179] The company has covered multiple aspects of the solar business including project development, EPC, and operations and maintenance. It has adjusted its services for different markets and for different clients. The representative of the company said that

[176] Interview #8
[177] Interview #10
[178] Interview #24
[179] Interview #7

"being flexible and being open to the opportunity and being able to adapt quickly to changes" is important in a business like solar energy.[180]

Some corporations have moved to other countries to maintain its competitiveness under changing market conditions. A module manufacturer moved its headquarters to Vietnam from China to avoid the anti-dumping tariff on Chinese solar panels. The manufacturer differentiated it from other Chinese solar manufacturers by focusing on the U.S. and EU with their anti-dumping free products.[181] Some other Chinese manufacturers have also ramp up its manufacturing capacity outside China. One of the Chinese manufacturers had exited the U.S. market due to the tariff, and decided to go back when the antidumping tariff has decreased recently.[182]

Compared to the efforts of adapting to the changing environment, the U.S. solar corporations have not been very active in initiating changes of relevant policies. Among the 19 research participant corporations, only one corporation was hiring a lobbyist to influence relevant policies. Most of them responded that they relied on the SEIA for favorable federal solar policies. For them, federal policies are "high-level," which are difficult to involve in directly. A module manufacturer explained why the solar companies were not actively involving in the tariff on solar panels issue: "The process is so political that is beyond our control. That's like a very high level. You need the government to come to the negotiating table before you can really involve the companies and want the governments are committed to cooperating one another".[183]

---

180 Interview #7
181 Interview #17
182 Interview #16
183 Interview #8

Although most of the individual corporations have not been actively engaged in policymaking, the solar industry has been active as a group. The SEIA has made much effort to extend the ITC through lobbying, political actions, public campaign, grassroots campaign and research. It has initiated dozens of Hill meetings, the lobby days for the SEIA member companies, and the meetings of the CEOs of the companies with policymakers. Through these actions, more than 10 Senate Republicans became active supporters of the ITC, while there were only 2 Republican Senate supporters in the beginning.[184] The SEIA has also hosted solar-only political fundraisers for key Senators. It also attempted to gain supports of the public through publishing opinion editorials in state and local newspapers.

Other than affecting existing policies, the SEIA has engaged in making expected policies more favorable to the solar industry. The SEIA has affected the rule changes of the Clean Power Plan. Compared to the originally proposed rule, the final rule has included stricter carbon reduction goals and all solar technologies included as compliance options.[185] The CPP also included the Clean Energy Incentive Program, which encourages early investments in renewable energy generation. The SEIA has led the working group to examine the design of the program. The solar industry saw both risks and opportunities in the CPP since it could be designed more favorable to natural gas than solar energy. Thus, the industry has motivated to engage in the policymaking process of the CPP.

The solar corporations' individual reactions to the external environment have focused more on adapting to the environment rather than changing it. Although the solar

[184] Observation #14
[185] Observation #9

corporations have attempted to change the relevant policies to be more favorable, the result of the efforts was uncertain because the policies have been affected by diverse factors, which could not be controlled by the solar corporations. Under these circumstances, a safer reaction to the environment has been adapting rather than changing the environment. However, the solar industry has significantly affected the relevant policies as a group. The SEIA has engaged in the policymaking processes for existing policies as well as new policies.

Interactions between policies and industry

The solar policies have expanded in recent years, and most of them have served the goal originated from the energy policy, which has been the secure, affordable, and reliable energy. Recently, non-energy policies have introduced and have influenced solar PV market in the United States. The tariff on the solar panels imported from China has negatively affected to the original goal of the solar policies by increasing the overall costs of solar energy. The Clean Power Plan has designed to mitigate climate change, but has influenced solar PV market as the solar PV industry has involved in the policymaking process of it to take advantage of the policy as an opportunity. The boundary of solar policies has expanded quantitatively and qualitatively in the United States.

The solar PV industry has significantly affected the expansion of the policies directly and indirectly. First, the industry has engaged in policymaking processes to maintain existing policies, which were favorable to them. Second, under the changing external environment, solar corporations have initiated introducing a new policy measure.

Finally, the industry has affected the policy that was not designed for solar energy to take advantage of the policy as an opportunity.

The extension of the ITC is the case of maintaining existing policies. The political actions of the solar PV industry have significantly affected the extension of the ITC in 2016. The SEIA has led the efforts of the solar industry to extend the ITC for more years. All the actors in the solar PV industry have supported the ITC because the ITC was favorable for all the actors in the solar PV industry. The ITC has contributed to the rapid growth of solar energy by reducing the costs of solar installation. By boosting the overall demand of solar energy in the U.S. market, the ITC has benefitted both the upstream and the downstream solar corporations.

The tariff of the Chinese solar panels was introduced in different contexts. The issue of the solar panels imported from China was raised by seven solar manufacturers. The solar PV corporations other than the panel manufacturers did not support the tariff. This caused conflicts among solar corporations since the tariff was expected to benefit some corporations, but to harm the others. Moreover, the tariff could be a barrier to achieve the original goal of the solar policies, which was to increase the installation of solar facilities.

As well as initiating a new policy, the solar PV industry has also engaged in the policymaking of a different type of policy—the CPP. The solar industry was motivated to engage in the CPP since it could have been a risk to them if it was designed to be favorable to natural gas. Moreover, the CPP could have been a chance to expand solar installation if the rules of the CPP were formed in favor of solar energy. Although the CPP did not include solar-related details in the proposed rule, it ended up including more

solar-related details in the final rule. Through the efforts of the solar industry, the CPP has become one of the important solar policies.

Although the solar corporations have engaged in policymaking as a group for common interest of the solar industry, they have also engaged in policymaking for their own interests. The tariff on Chinese solar panel is the case that shows that the solar industry does not necessarily affect policies as a common interest group. Some solar policies have been introduced by the political interactions and conflicts even within the solar industry. An expert pointed out that there is no one direct goal in the solar industry at this point: "It's very much more like a chess set, where everybody is working together in different angles and people are sometimes have in some areas, they might have power. It's not all towards one direct goal".[186]

The U.S. solar industry has influenced relevant policies through cooperating for its common interest. Their efforts have significantly influenced the extension of the ITC, which has been the most important solar policy in the U.S., and the inclusion of solar-relevant policies in the final rule of the CPP. However, individual corporations have also affected policies. The U.S. solar policies are the results of the political interactions and conflicts between the government and the industry, as well as among the actors in the solar industry.

Summary

The U.S. solar PV corporations have perceived risks caused mostly by policies. Since policies have changed or have not been enacted for a longer-term, the corporations

[186] Interview #3

have difficulty to plan their business. Under these circumstances, they attempted to adapt to the environment as well as to initiate changes of the environment to reduce risks. The corporations have enhanced their competitiveness by developing advanced technology and improving operations. They have also expanded to other business in the solar PV value chain to be more flexible, and have their manufacturing moved to other countries to be more competitive in the market. Moreover, to reduce the risks of the external environment, the companies have engaged in relevant policymaking process.

The solar corporations have become involved in policymaking in three ways. First, they have attempted to maintain existing favorable policies. The ITC has extended by the active engagement of the solar industry. Second, they asked policy measure to address the risks in the market. The anti-dumping tariff on Chinese solar panels is an example of the result of this effort. Finally, the solar industry has engaged in the policy that was not designed for solar, which has led to changes within the policy to be more favorable to the solar industry. The CPP has become more favorable through the engagement of the solar industry.

The current mix of solar policies is the results of the interactions between industry and policies. The solar industry has affected policy change, but it has also changed under a changing environment. The industry and policy has changed through interactions under fast changing external environment.

Chapter 6. Solar policies and industry in South Korea

Introduction

The government of South Korea has promoted renewable energy with various policies since it established the Alternative Energy Development Promotion Act in 1987.[187] Based on the policies, the share of new and renewable energy in energy production has increased to 4.1 percent in 2014 from 1.4 percent in 2002.[188] With this increase of renewable energy installation, the renewable energy industry has developed. Many new and existing corporations have invested in renewable energy such as solar PV or wind energy. As of 2013, 245 companies conduct renewable energy business in South Korea.[189]

Since the introduction of the first renewable energy policy, the renewable energy policies have expanded. In the 1990s, the policies focused on supporting the relevant technologies through research grants. In the 2000s, the government adopted many policies to promote the deployment of renewable energy such as subsidy programs, feed-in tariffs, and financial supports, as well as to promote technology development. Since the announcement of the national vision, "Low Carbon Green Growth," in 2008, the government started introducing policies to promote the renewable energy industry as a

---

[187] Alternative energy included eight renewable energy sources and three new energy sources. Renewable energy sources include solar thermal, solar photovoltaic, biomass, wind, hydropower, geothermal, marine energy, and energy from waste. New energy sources include fuel cell, energy from liquefied or gasified coal, and from gasified heavy residual oil, and hydrogen energy. This term, alternative energy, was changed to "new and renewable energy" later. In South Korea, renewable energy sources have been in the same category with new energy sources, and they were promoted under the same policy.
[188] 2014 Statistics on New and Renewable Energy, Ministry of Trade, Industry, and Energy and Korea Energy Agency, November 2015.
[189] New and Renewable Energy Korea; https://www.renewableenergy.or.kr.

new growth engine for the economy. From that point, new types of policies for renewable energy were introduced. While the supports for technology development and the deployment programs have a goal to increase the installations of renewable energy, the new policies have a goal to support domestic renewable energy industry. For instance, these policies include certification programs, supports for renewable energy projects abroad, and government-led demonstration projects. As a result, South Korea has diverse policies on renewable energy, which serve different goals.

This chapter explores how the rise of the solar PV industry has affected the expansion of the national policies on renewable energy in South Korea. The case study of South Korea is expected to add more validation to the findings of the U.S. case study because the contexts of South Korea are different from those of the U.S. South Korea has a much smaller domestic market compared to the U.S.; therefore, it has been more significantly influenced by the globalization of the solar market. In a small domestic market, Korean solar PV industry has developed based on manufacturing. Since the potential of large-scale projects was limited, service providers such as installers and project developers were difficult to develop into large corporations. Korean solar PV manufacturers have exported a significant share of their products because domestic demand was not sufficient. Therefore, the global solar market has significantly influenced the Korean solar PV industry.

In this chapter, an explanation on the interactions between the solar PV policies and the solar PV industry in South Korea is developed. The qualitative interviews with the key actors of the solar PV field in South Korea, the observations in the seminars and workshops, and policy archival data were obtained and were analyzed to build the

explanation. The short history of the renewable energy policies, the recent changes of the solar PV market, and the reactions of the industry to these changes are described. Lastly, the interactions between policy and industry are discussed.

Data and method

Data for this research included qualitative interviews, archival data, and observational data. Semi-structured qualitative interviews were conducted with 21 key actors of the solar PV field in South Korea. Archival data included the reports, press releases, and announcements from the government, which were gathered from the Policy Information Archive and the National Assembly Library.[190] A number of the seminars and workshops on renewable energy industry and policy in South Korea were observed and the memos from them were used as data.

Three groups of the stakeholders in solar PV field were interviewed: 1) the representatives of the solar PV corporations located in South Korea; 2) government officials involving in Korean renewable energy policy; and 3) the experts in the solar PV field.[191] To sample the solar PV corporations, a sampling frame was built based on the list of the members of the Korea Photovoltaic Industry Association (KOPIA). Among the 78 members, the manufacturers of components or equipment were excluded since their solar business tended to be minor contribution to their business. From the remaining corporations, five of them were excluded since they officially announced that they were

[190] Policy Information Archive, http://www.korea.kr/archive/; National Assembly Library, http://www.nanet.go.kr/english/

[191] Government officials were interviewed in South Korea because there were a few key government officials who were in charge of high-level solar policies. In the U.S., most of the important policies were the decision of the Congress. Therefore, it was relatively difficult to find the key actors from the government to be interviewed.

out of solar business. The remaining 40 companies were contacted via emails and phone calls, and 12 companies agreed to be interviewed. The interview questions were communicated beforehand, and each company recommended a representative who was able to answer the questions. The government officials and experts were sampled purposively to represent the key actors of the Korean solar PV field. Specifically, the main speakers of the renewable energy seminars or conferences, the government officials who were in charge of solar policies, the people who were recommended as key actors by other respondents were contacted. Four government officials and seven experts were contacted, and three government officials and six solar experts agreed to be interviewed. As a result, 12 solar companies, 3 government officials, and 6 experts were interviewed (see Appendix B).

Each interview lasted from 30 minutes to 90 minutes. A pre-determined protocol was used for each interview, but the interview questions were modified according to the expertise of each respondent. The interviews were recorded and transcribed. Some respondents rejected to be recorded; in this case, the memo during the interview was used as data. For analysis, themes were developed based on the interview transcripts. Each transcript was coded according to the themes.

Archival data for policy was obtained through searching the term, "New and Renewable Energy" in the websites of the Policy Information Archive. The result showed 1,524 documents. Through a review, the documents that were not related to the topic of the search were excluded, and the remaining 133 documents were used as data. The same protocol was used to search the data at the National Assembly Library, and 33 documents were added. The final data set include 166 documents include the press releases from the

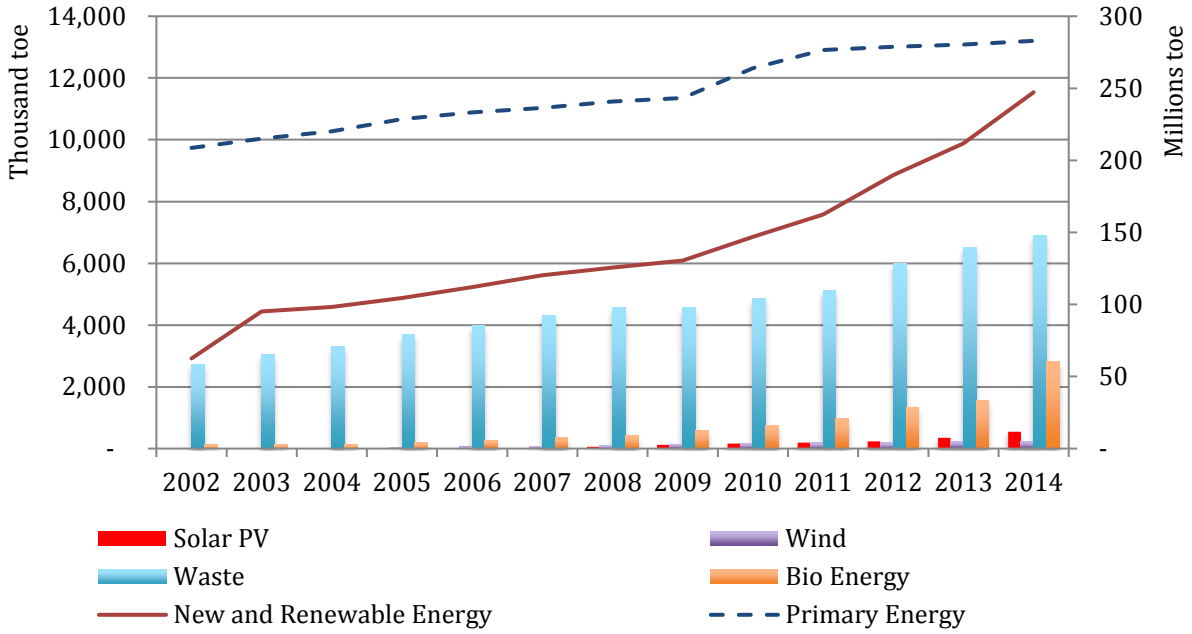
government, policy news articles, statistics, and the Ministries' reports for Congresspersons from 1997 to 2015. This data set was used to establish the history of renewable energy policy in South Korea.

In addition to these two data sets, a number of seminars and workshops on renewable energy industry and policy in South Korea were observed. Observation of key actors in seminars and workshops complemented the data set from the interviews by adding the talks of some of the high-level key actors, who was hard to be contacted for interviews. The observational data was analyzed by using the same themes with interview transcripts.

Solar PV and industry in South Korea

Solar PV has significantly expanded in recent years. In 2014, energy produced by solar PV was more than 200 times of that in 2004. Although solar PV has sharply increased, its share in new and renewable energy production is still small compared to waste and bio energy (Figure 30).

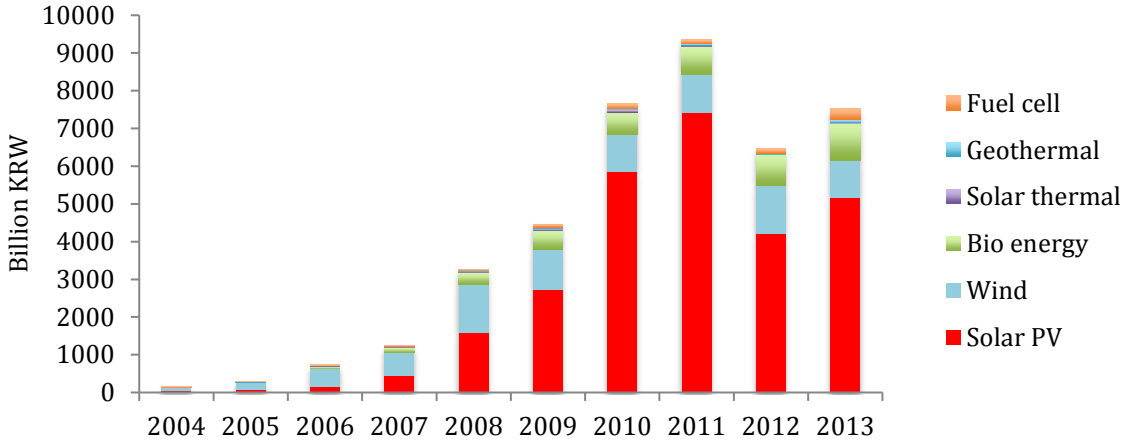
Figure 30. Energy production in South Korea, 2002-2014.



Source: New and Renewable Energy Korea, https://www.renewableenergy.or.kr/

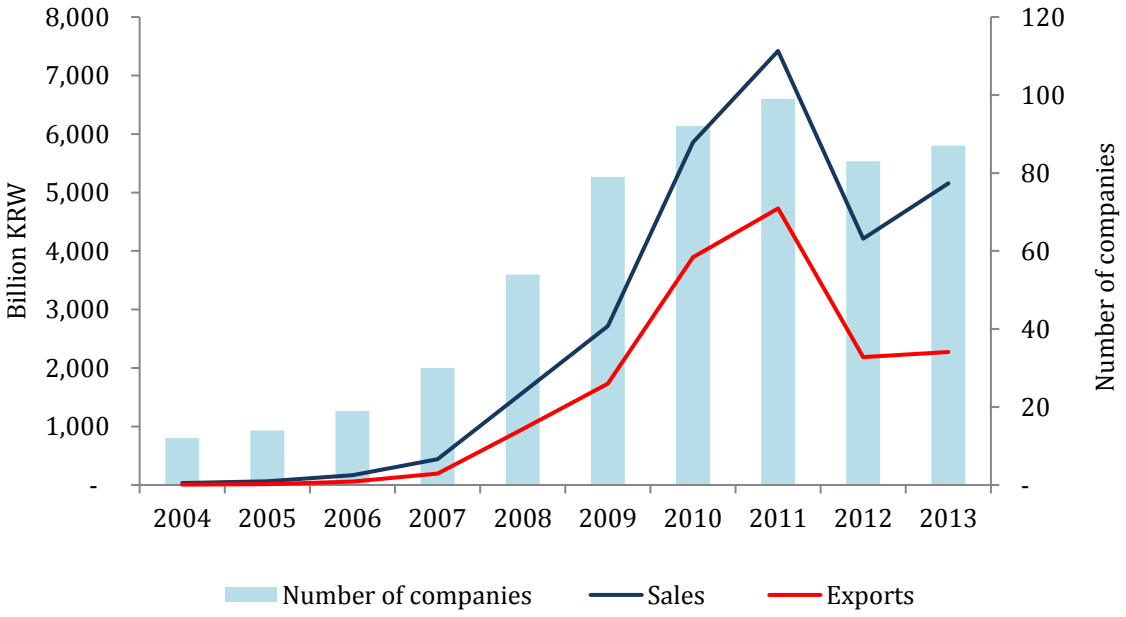
While solar PV accounts for a small share of renewable energy, it has created a larger industry compared to other renewable energy sources. Figure 31 shows that solar PV has generated about 70 percent of the sales of renewable energy products in 2013. Since the mid-2000s, the number of solar PV corporations and the sales of solar PV products have significantly increased (Figure 32). Although the size of solar PV industry has shrunk in terms of sales, exports, and the number of companies in 2012 and 2013, solar PV still has the largest share in the renewable energy industry in South Korea.

Figure 31. Sales of renewable energy products in South Korea, 2004-2013.



Source: New and Renewable Energy Korea; Korea Energy Agency

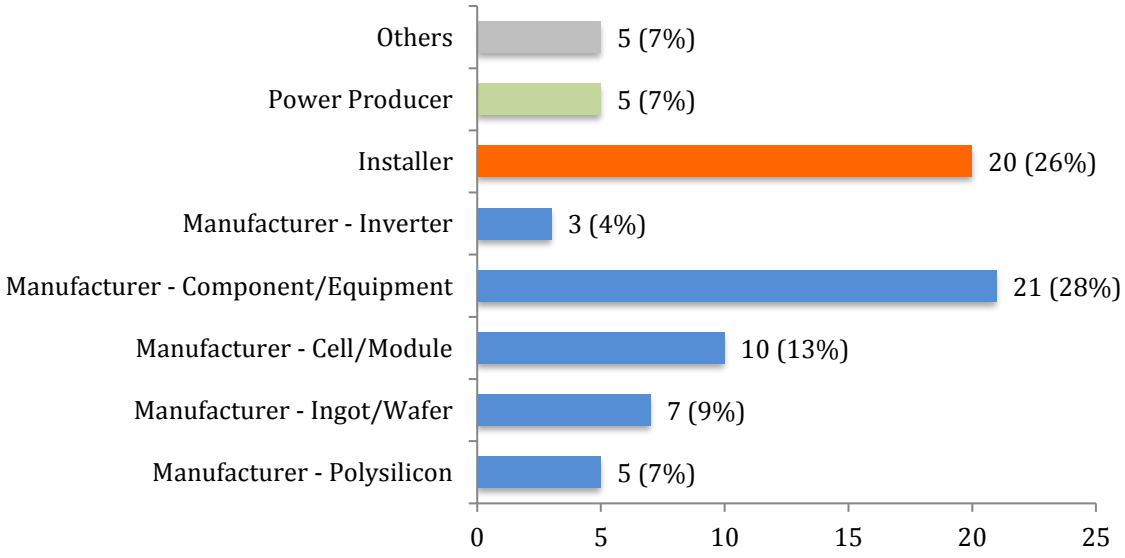
Figure 32. Number of Solar PV corporations, sales, and exports, 2004-2013.



Source: New and Renewable Energy Korea; Korea Energy Agency

Manufacturing has been the base of the solar PV industry in South Korea. As of June 2015, more than 60 percent of the members of the KOPIA are manufacturers (Figure 33). Manufacturers of components and equipment accounted for 28 percent of the solar PV corporations. However, most of the corporations have conducted solar business as one of their businesses and the share of solar PV business was not significant in terms of revenue. Thus, these corporations tend not to be referred as solar PV corporations. Installers have the same issue. Many installers have entered into the solar PV market based on their experience in other business area, and the share of solar PV business was not very significant compared to the other businesses. Some corporations conduct solar PV projects as main business, but the size of them is small due to their short history.

Figure 33. Number of members of the Korea Photovoltaic Industry Association by business.



Source: KOPIA, June 7th, 2015.

In this context, Korean solar PV industry has been led by large manufacturers of polysilicon, ingot/wafer, and cell/module. Table 18 shows that a large portion of sales in solar PV industry has generated from these manufacturers. The total sales of these products accounted for more than 80 percent of the total solar PV sales in 2010. The manufacturers of these products have exported a majority share of their products. Seventy six percent of polysilicon, cell, and modules, and sixty four percent of ingot and wafer were exported in 2010. In total, South Korea exported almost 70 percent of the solar PV products in 2010.

Table 18. Sales and exports by product in 2010.

	Sales (100 million KRW)	Exports (100 million KRW)	Exports/Sales
Polysilicon	14,500	11,050	76%
Ingot/Wafer	8,700	5,593	64%
Cell	5,760	4,349	76%
Module	20,578	15,620	76%
Inverter	1,300	664	51%
Component	3,560	742	21%
Equipment	4,600	2,700	59%
Total	58,998	40,718	69%

Source: Status and Future of Solar Photovoltaic Industry, KOPIA, June 24th 2011.

In sum, although solar PV has accounted for a small share of renewable energy sources, it has significantly contributed to the development of renewable energy industry in South Korea. Korean solar PV industry has developed based on manufacturing. In a small domestic market, a large share of the solar PV products has been exported.

National solar policies

In 1997, Korean government established the First Basic Plan for Technology Development, Application, and Deployment of New and Renewable Energy. The Plan set the goal of 2 percent of renewable energy in total energy production by 2006.[192] To achieve the goal, the Plan focused on technology development in eleven new and renewable energy sources. Solar PV, solar thermal, fuel cell, and integrated gasification combination cycle (IGCC) were pursued as main investment fields since those were expected to be competitive globally and to significantly contribute to energy production. The government expected to commercialize these renewable energy technologies by 2006.

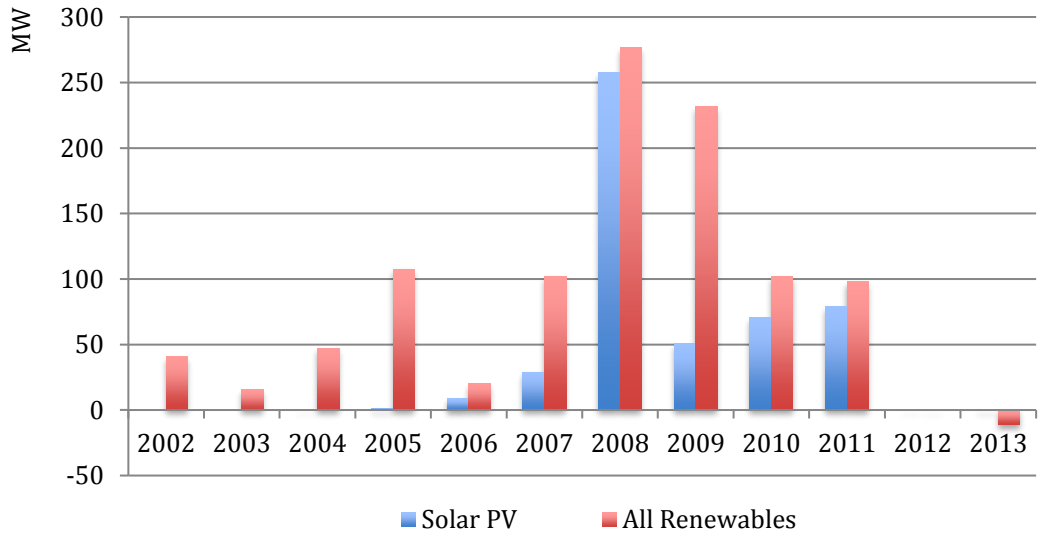
The First Plan focused on technology development, but it did not include plans to create market for developed technologies or to build infrastructure for industry. In this backdrop, the Second Basic Plan for Technology Development, Application, and Deployment of New and Renewable Energy, which was established in 2003, included the plans for deployment of new and renewable energy as well as the plans for technology development. It pursued to develop three main technologies—solar PV, wind, and fuel cell—and to apply developed technologies by implementing actual projects. To increase the deployment of renewable energy sources, a number of plans were included such as renewable energy mandatory use for public buildings, home subsidy program, and a feed-in tariff (FIT). The goal was to provide 5 percent of energy with renewable energy sources by 2011.[193]

---

[192] Ministry of Knowledge Economy and Korea Energy Management Corporation. *2005 New and Renewable Energy White Paper*. 2006. p 202.
[193] Ibid., p 204-211.

The FIT has significantly contributed to increasing solar PV installation since it was introduced in 2002. The capacity of solar PV installations has been increased to about 9-fold of the capacity of 2007 level in 2008 (Figure 34). There was a rush of solar PV installation in 2008 because the government announced that the FIT of solar PV will be decreased starting from October due to financial burden of the government in April, 2008. In 2008, the government also announced that the FIT will be repealed in 2011 to minimize financial burden.[194]

Figure 34. Additional capacity of solar PV plants receiving feed-in tariff, 2002-2013.



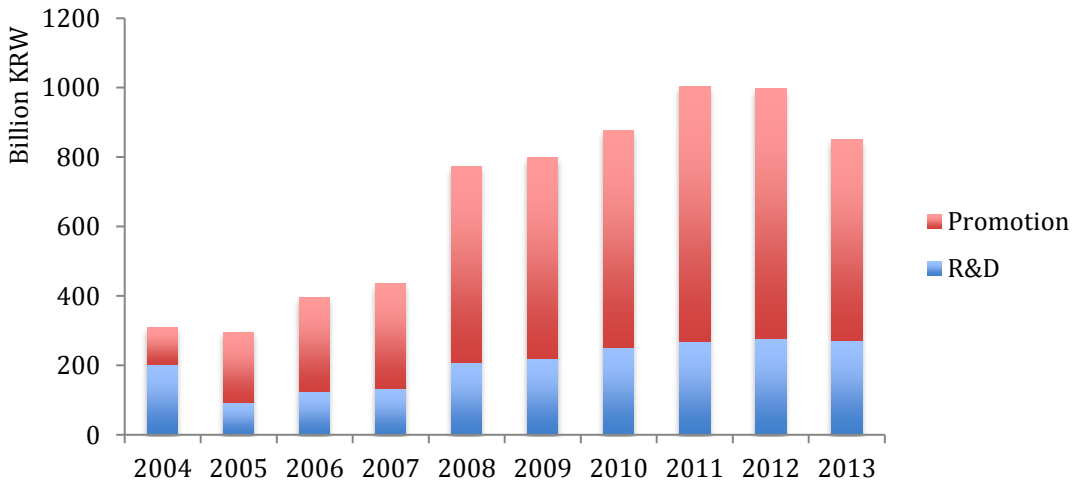
Source: A Study on Revitalization of Citizens' Participatory Renewable Energy, Je-Nam Kim, Parliamentary audit package, 2014-P-1.

On August 15, 2008, President Lee Myung-bak declared the country's vision for "Low Carbon, Green Growth." Under this vision, the Korean government aimed that Korea will become the world's seventh largest green economic power by 2020 and the

[194] Ministry of Knowledge Economy, "Announcement of the revision of the feed-in tariff for the solar photovoltaic," *Press Release* (April 26, 2008)

fifth largest by 2050.[195] Green energy business, which includes four renewable energy fields—solar PV, wind, fuel cell, IGCC—was declared as a new growth engine. In this context, the Ministry of Knowledge Economy (MKE) revealed its plan to promote four renewable energy fields by investing in technology development.[196] In 2008, the Ministry planned to invest 194 billion KRW in renewable energy technology development, which was increased by 60% compared to 2007.[197] After the declaration of the Low Carbon, Green Growth, the government spending on new and renewable energy has sharply increased (Figure 35).

Figure 35. Government spending on new and renewable energy, 2004-2013.



Source: Korea Energy Agency; Ministry of Trade, Industry, and Energy

[195] Ministry of Government Legislation, Laws on Green Growth in Korea, 11-1170000-000341-14, 2009.
[196] Ministry of Knowledge Economy has named the Ministry of Trade, Industry, and Energy in 2013.
[197] Ministry of Knowledge Economy, "Promoting New and Renewable Energy as a New Growth Engine," *Press Release*, (July 29, 2008)

The experts of Korean solar PV field said that the effects of the Low Carbon Green Growth were not very beneficial to the solar PV industry although the government emphasized the importance of industry development. An expert from the Korea Society for New and Renewable Energy pointed out that the vision did not include detailed policies that would be helpful: "We had very strong domestic deployment programs such as the FIT or the RPS, so the vision was not meaningful. There was no detail about how to develop industry. We could not give land for free or provide loan to certain companies like China did. Therefore, there was no case that the government provided something to companies directly. There was a saying that the government would provide financing for exports but I don't think that was very helpful for business".[198] A former head of the New and Renewable Energy Center (NREC) at the Korea Energy Agency, pointed out that renewable energy was marginal in Green Growth strategy: "In Korea, green energy included nuclear power. Green Growth was for nuclear power rather than promoting solar PV or wind energy".[199]

Apparently, however, a series of plans to promote renewable energy had been released after the Low Carbon Green Growth. At the end of 2008, the Third Basic Plan for Technology Development, Application, and Deployment of New and Renewable Energy was released. The plan set two goals: 1) To provide 11 percent of energy with new and renewable energy sources by 2030; and 2) Industrialization of new and renewable energy as a green growth engine. The lack of advanced technologies and industrial infrastructure were pointed out as the problems of renewable energy development by the government. In 2008, the government assessed the domestic

198 Interview #32
199 Interview #33

technology level of solar PV, wind, and fuel cell as 50-70 percent of the technology level of advanced countries.[200] Moreover, due to the weak domestic industry, South Korea had imported main renewable energy products from other countries. To solve these issues, Korean government set plans to promote industrialization of renewable energy. It established technology road map and product road map for each renewable energy technology. For solar PV, a road map for cost-down of solar PV system was set. The development and commercialization of advanced solar PV technologies was set as another goal.

In 2009, the MKE announced the plan for increasing the use of domestically produced renewable energy products.[201] The Ministry planned to lead the projects to install domestically produced wind turbines, and to revise the certification program for solar products to reduce the quantity of low-priced imported products in the market. Moreover, to promote the exports of renewable energy products, the Ministry expanded the supports for domestic corporations' participation to foreign trade shows and established an organization to lead the supports for renewable energy corporations' development of foreign market under the Korea Trade-Investment Agency.

In the same year, the Ministry announced the plan to strengthen the industry infrastructure for renewable energy.[202] To promote solar PV industry, it planned to create 100MW-scale domestic market by the pilot implementation of the Renewable Portfolio

---

200 Ministry of Knowledge Economy, "Third Basic Plan for Technology Development, Application, and Deployment of New and Renewable Energy," December 2008.
201 Ministry of Knowledge Economy, "Establish 2009 Implementation Plan of New and Renewable Energy," *Press Release* (April 30, 2009)
202 Ministry of Knowledge Economy, "The Plans to Strengthen the Industry Infrastructure for New and Renewable Energy," August 2009.

Standard (RPS). To secure the sustainable growth engine for solar PV industry, the R&D supports for second- and third-generation solar PV technologies were expanded.

In 2010, the Ministry declared its goal of the fifth largest renewable energy economy by 2015.[203] It planned to promote solar PV as the second semi-conductor industry, which is one of the leading export industries in South Korea. To achieve this goal, the Ministry planned to pursue four strategies: 1) Strategic R&D supports and commercialization; 2) Market creation for industrialization; 3) Promotion of export industry; and 4) Strengthening the base for industry growth. With these strategies, the Ministry expected to achieve the exports of 36.2 billion USD, and to create 1.1 billion jobs by 2015.

Although the goal was very ambitious, the solar PV industry did not feel that they were significantly benefitted from this policy. A former head of the NREC said: "It was just a rhetoric. If there is a national agenda, it should be followed by policy tools, measures, financing and budget plans, but there was only a slogan without tools or measures".[204] An executive from a solar corporation said that the R&D supports from the government, which were increased by this policy was not very helpful for them because they were struggling with shrinking exports due to the rise of Chinese manufacturers. She said: "R&D was an unrealistic story when we could not export our products. The government intended to promote industry by technology development, but that was not the thing that the market needed. What was necessary was to create a big market".[205]

---

[203] Ministry of Knowledge Economy, "Investing 40,000 billion KRW, Becoming the fifth largest renewable energy economy by 2015," *Press Release* (October 13, 2010)
[204] Interview #33
[205] Interview #38

Other than the targets and R&D supports, the government has also established the policies to support the industry directly. In 2011, the NREC introduced the programs to support small and medium-sized enterprises of new and renewable energy. The programs included feasibility study support, international exhibitions support, international certificate acquirement support, new and renewable energy expert consulting center, hosting Korea energy show, and developing demonstration projects in foreign countries. Han, Jong-hyun, the head of international relations at the NREC, explained the background of the implementation of these policies: "The year of 2011 was the right timing to implement these programs since the technologies were developed, domestic market was saturated, the global investments were increasing, and the Korean firms wanted to expand their business as a new growth engine."[206]

As part of the supporting policies for domestic renewable energy corporations, the Korea Energy Agency has implemented a hybrid energy project with the Asian Development Bank in Philippines to establish "a stepping stone for SME's overseas business" since 2012. Han, Jong-hyun said that this project helped the Korean corporations participated in the project with obtaining track records: "This would be helpful for Korean companies to participate similar projects in the future."[207] He also pointed out that this project showed that Korean products were good quality products that could be used in tropical islands.

The Renewable Portfolio Standard (RPS) was introduced in 2012. According to "the Enforcement Decree of the Act on the Promotion of the Development, Use and Diffusion of New and Renewable Energy," which include the rules for the RPS, the

[206] Observation #25
[207] Observation #25

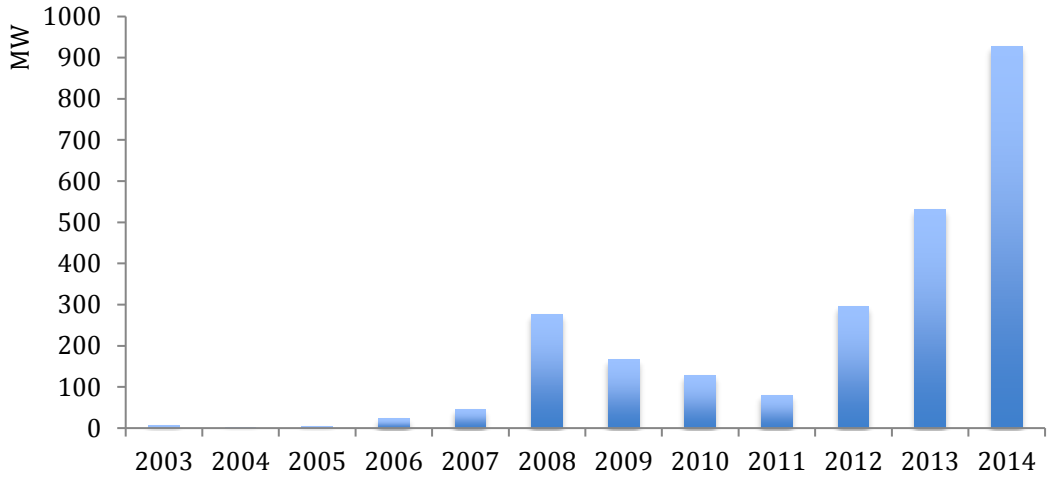
power utilities that own plants generating more than 500MW are required to supply a certain percentage of the volume of electricity generation using new and renewable energy.[208] Thirteen big power producers including six government-affiliated organizations are subject to the RPS. Through the implementation of the RPS, the government expected to significantly increase the share of renewables, to lower the costs of renewables through competition, and to create a large-scale renewable energy market, which will contribute to the development of domestic industry. To promote solar PV, additional annual targets for solar PV were set. A former head of the NREC, pointed out that domestic market expansion without financial burdens of the government was the most important reason to adopt the RPS: "The purpose of the RPS was to create the market-driven system without adding government money. The FIT requires exponentially increasing government supports".[209]

Apparently, the RPS was successful to increase solar PV installation. Since the introduction of the RPS in 2012, the solar PV installation has enormously increased (Figure 36). In 2012, the installation of solar PV has been almost four times of the installation of the previous year. In 2013 and 2014, the installation has been twice of that of the previous year. This sharp increase of solar PV installation was unexpected at the timing of the introduction of the RPS. The government set additional targets of solar PV installation to promote solar PV market, but the solar PV installation has much exceeded the targets. Under this circumstance, the additional targets for solar PV have been a barrier of the expansion of solar PV rather than a driver of it.

---

[208] Ministry of Knowledge Economy, "The Enforcement Decree of the Act on the Promotion of the Development, Use and Diffusion of New and Renewable Energy," (September 17, 2010)
[209] Interview #25

Figure 36. Solar PV installation, 2003-2014.



Source: 2014 Statistics on the Dissemination of New and Renewable Energy, MOTIE and KEA.

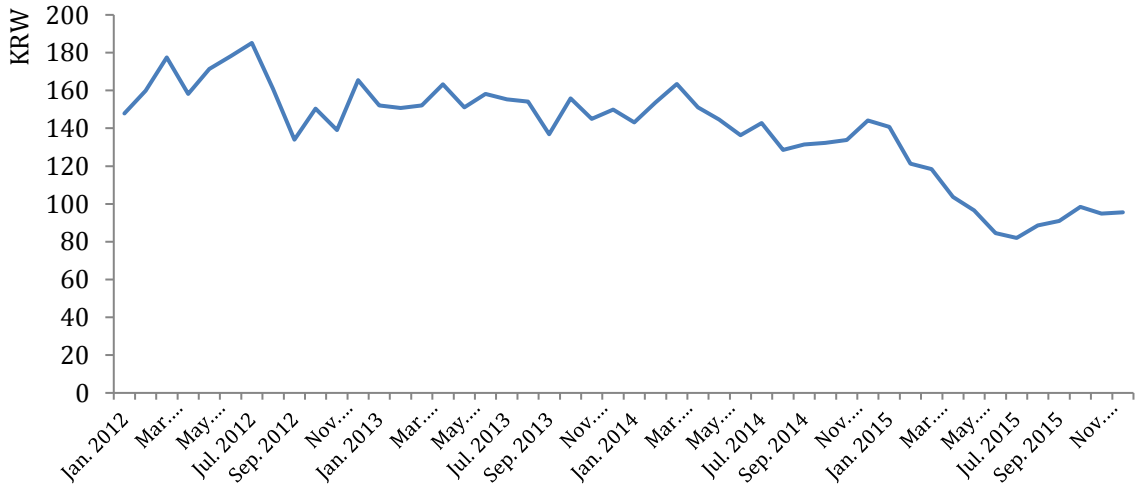
One of the experts said that the more important driver of the solar installation was the increase of low-priced solar PV products rather than the introduction of the RPS: "The prices of the products were enormously dropped due to the large-scale investments in manufacturing and the global financial crisis. Actually, declining prices of the products was one of the reasons of this trend. We do not see the introduction of the RPS as the driver of increasing solar installation".[210] One of the other experts pointed out another reason that solar PV has been more competitive than other renewable energy sources: "There was no other option other than solar PV. [Power utilities] could not install wind power due to lack of permit. The raw materials for bioenergy needed to be imported from other countries such as Indonesia. Fuel cells were expensive".[211]

---

[210] Interview #30
[211] Interview #31

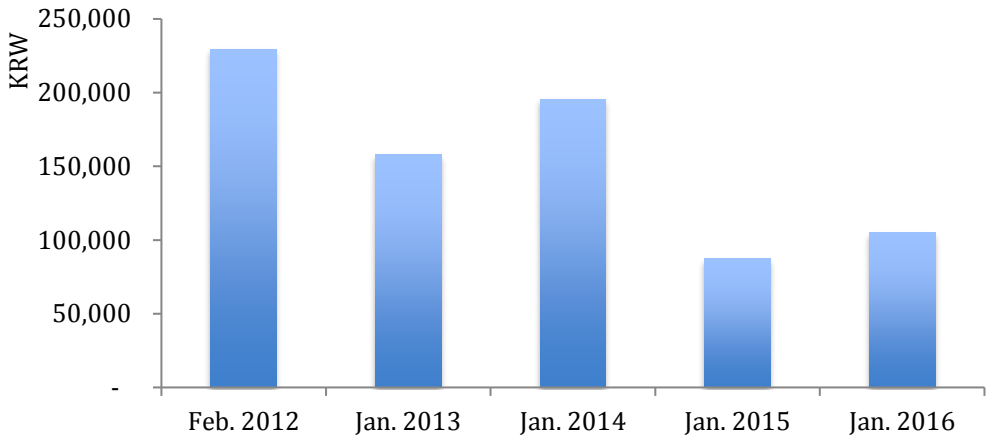
Under the sharp rise of solar PV installation, the solar PV project owners had struggled with decreasing profits and market uncertainty. The revenue of solar PV projects is from System Marginal Price (SMP) plus Renewable Energy Certificates (RECs). The SMP has been decreased continually since 2012 (Figure 37). The prices of RECs have fluctuated (Figure 38). Under this circumstance, the project owners had difficulty to finance their projects because it was hard to predict the revenue from solar PV projects.

Figure 37. System marginal price, 2012-2015.



Source: "System Marginal Price," Electric Power Statistics Information System, http://epsis.kpx.or.kr/epsis/ekmaStaticMain.do?cmd=004013&flag=&locale=KR (accessed June 30, 2016)

Figure 38. The prices of Renewable Energy Certificates, 2012-2016.



Source: Korea Power Exchange, http://rec.kpx.info/index.jsp

Under this unexpected increase of solar PV installation, the government revised the targets for solar PV in 2013. The target for solar PV for 2014-2015 has increased to 1.5GW from 1.2GW.[212] Since the oversupply of the solar RECs has continued after this measure, the government repealed additional targets for solar PV in 2016. Since then, solar PV has competed with other renewable energy sources without any limitation.

The government also attempted to support the owners of small-scale solar PV projects, who had struggled with selling the RECs to power utilities under severe competition. The government has expanded the size of government-led auction for RECs from 100MW to 150MW per year, and 30 percent of the quantity of RECs were assigned to small-scale solar PV projects in 2013. In the first half of 2016, the government-led auction has increased to 210MW, and a 60 percent of the quantity of RECs were assigned to the projects less than 100KW. A government official who was in charge of solar

[212] Ministry of Trade, Industry, and Energy, "Making a stepping stone for taking off new and renewable energy," *Press Release*, October 27, 2013.

policies said that their focus was on the small-scale solar PV producers: "Currently, we focus on solar PV producers, especially small-scale producers for policymaking. They are having the most difficult time. We want to increase the competitiveness of the weakest players".[213]

In 2014, the Fourth Basic Plan for New and Renewable Energy was released. The target for renewable energy has weakened from 11 percent by 2030 to 11 percent by 2035. The government planned to shift to "public-private partnership" from "government-driven" renewable energy market.[214] The investments from private sector were expected to be encouraged by designing market-friendly policies, establishing business models, and deregulation. The details of the RPS have been changed to allow more flexibility in the market. The plan also included the measures to promote domestic corporations to expand to overseas markets: the expansion of financial supports, provision of information and human resources, and international relations to find business opportunities for renewable energy corporations. The government planned to develop renewable energy projects through cooperating with the government of other countries and international organizations.

In sum, solar PV policies have expanded from supporting technology development to supporting industry in South Korea (Table 19). In the 1990s, the policies focused on R&D supports, and then in the 2000s, a number of policies to promote deployment were adopted. Since the announcement of the national vision Low Carbon Green Growth in 2008, many policies to promote renewable energy industry as a new

---

[213] Interview #27
[214] Ministry of Industry, Trade, and Energy, The Fourth Basic Plan for New and Renewable Energy, September 2014.

growth engine have been adopted. Government supports for domestic industry has expanded to the supports for exports in recent years. As a result, promoting industry has become a policy goal as important as the original goal of renewable energy policy, which is to increase the share of renewable energy in national energy mix.

Table 19. The Policies included in the Basic Plan for Technology Development, Application, and Deployment of New and Renewable Energy.

		1st Plan (1997)	2nd Plan (2003)	3rd Plan (2008)	4th Plan (2014)
Planning Period		1997-2006	2003-2012	2009-2030	2014-2035
New and Renewable Energy Target		2% by 2006	5% by 2011	11% by 2030	11% by 2035
Policies	Technology development	• R&D supports (solar PV, solar thermal, fuel cell, IGCC)	• R&D supports (solar PV, wind, fuel cell) • Implementing projects with developed technologies	• Set technical/product roadmaps by renewable energy source	• Set goals for cost reduction • Expand R&D projects for exports
	Deployment		• Renewable energy mandatory use for public buildings • Home subsidy program • Feed-in tariff	• Green Home One Million Program • Renewable Portfolio Standard	• Solar lease program • Revision of the RPS
	Industrialization			• Select strategic technologies for industrialization • Certification program	• Test beds for solar PV, wind, and fuel cells • Strengthen certification program
	Promotion of Export				• Financial supports for export companies • Establish database for foreign market • Project development by international relations

Changes of the solar PV market environment

Korean solar PV corporations described that the solar market before 2010 was very favorable due to low level of competition. A polysilicon manufacturer said: "It was a supplier's market. The market was enormously good since there was a shortfall in upstream. We select customers. We sell our products to the customers only with long-term purchase agreement".[215] An ingot and wafer manufacturer also stated that it "sold every product with good price" until 2010.[216] Low level of competition had enabled solar PV corporations to gain much profit in the market. An installer stated: "It was a conservative market that domestic module and inverter producers won large-scale projects with more than tripled prices and monopolized the market".[217]

The rise of Chinese manufacturers has significantly changed the market environment. Around 2009, Chinese manufacturers have started putting large-scale investments across all the value chains of solar PV. A solar cell manufacturer stated: "Chinese solar manufacturers transformed existing industry structure by vertical integration. They brought a deep change as they produced everything from polysilicon to module with large-scale and very aggressive investments".[218] To make things worse, the global demand for solar products has decreased after the global financial crisis in 2007 and 2008. An ingot and wafer manufacturer stated: "Solar market has suddenly shrunk. The demand for solar products has continually decreased. Companies have produced

[215] Interview #35
[216] Interview #37
[217] Interview #42
[218] Interview #38

more, so the supply has risen. The prices have dropped and the companies had to compete each other".[219]

Under these unfavorable market conditions, many Korean solar PV corporations have exited solar business during 2011-2013. For instance, KAM, a polysilicon company, was liquidated. LG Silicon was out of its wafer business. Mirinet Solar, a cell manufacturer, was bankrupt. Two module manufacturers, Kyungdong Solar and Symphony Energy, were out of solar business.[220] Other than these corporations that officially announced that they were out of solar business, many corporations have scaled down their solar business after 2010.[221] Samsung, one of the biggest players in Korean solar market, announced that it stopped investing in solar energy in 2014.

During this period, national policies have not been very helpful to address the struggle of Korean solar PV industry. The government's R&D supports, which have increased after the announcement of the Low Carbon Green Growth, were not very beneficial for the solar corporations. A cell manufacturer said that the R&D funding from the government in 2010 was not beneficial at all: "We were trying hard to survive. [We wanted the government] to create market, even additional 1MW market, with the R&D money. Since China has distributed their low-priced products in Europe and the global market, so we could not sell our products at all. When we could not export the products, R&D was like a fairy tale".[222] Moreover, even when the R&D funding was successful for developing advanced technology, the technology has become outdated in the global

---

[219] Interview #37
[220] KOPIA, "Status and Forecast of Solar PV Industry," December 16th, 2013.
[221] When the author contacted each solar PV corporation for recruiting interviewees, a number of companies declined the interview saying that they were out of solar business or the share of their solar business was very small.
[222] Interview #38

market at the timing of development. An ingot and wafer manufacturer said: "The plan was to develop an advanced technology within three years, but the technology has become outdated after one or two years. It would be outdated technology even if it were successfully developed. More advanced technology was introduced in the market".[223]

The implementation of the RPS in 2012 was not very beneficial for the Korean industry, either. An installer said: "There was no big difference [after the implementation of the RPS]. I think it was 250MW-scale. It was too small. At that time, the global market size was about 10GW. There were complaints how we can promote industry with less than 5 percent [of the global market]".[224] A cell manufacturer said that fluctuating prices of the RECs made them difficult to run its business in a stable manner: "The RPS is market-based, so there was uncertainty in the market due to fluctuating prices. It was hard to acquiring financing with this uncertainty. Also, the government has kept changing detailed rules of the RPS. The uncertainty created by these factors became risks to us. We had difficulty to sell our products and to collect bills from our customers".[225] A module manufacturer raised another difficulty due to fluctuating prices of RECs. Since the prices of RECs are declining, its customers prefer low-priced Chinese modules to reduce the total cost: "[Domestic companies] tend to use domestically-produced products, but now it is more possible that they may use Chinese products because the prices of the RECs are suddenly dropped".[226] A corporation developing solar projects globally said that the declining profits due to the RPS was one of the drivers for them to go abroad. "Under the RPS, each power producer meets the commitment through bidding. Thus, the prices

[223] Interview #36
[224] Interview #43
[225] Interview #38
[226] Interview #40

should be lower and lower. The biggest change after the implementation of the RPS was to go abroad".[227]

Domestic policies have been limited in promoting solar manufacturing because direct supports for manufacturing were not easy for the government. The policies promoting deployment were able to affect downstream of the solar PV value chain, but the effects on upstream were limited. An ingot and wafer company explained why government policy was limited: "National policies are more influential to downstream. There are a couple of steps between a power producer and us. For instance, there are LG, a cell manufacturer, and Hyundai, a module manufacturer, and Samsung Everland, an installer. If there is a policy to increase installation, it affects a power producer. Then Samsung Everland should use the product of Hyundai, and Hyundai should use the product of LG, and LG should use our product. If Samsung Everland uses Chinese modules, we would not benefit from the policy. This is why the government should consider each value chain. For instance, the government can require the use of domestically-produced wafers, cells, and modules for installation. If it only cares about the end of the chain, the power producers will use imported cheap products".[228]

There has been no policy that directly benefitted solar PV manufacturers. The government official who was in charge of the Korean solar policies stated that there was no direct policy support for upstream solar manufacturing. Rather, the government has used indirect supports: "Policy supports for manufacturing can be loans or financial

[227] Interview #41
[228] Interview #37

supports. We require certified products, so there is a possibility that certified products are domestically-produced ones, which can be indirect supports".[229]

Moreover, Korean government could not directly affect China's dumping of solar PV products. An installer said: "The U.S. posed anti-dumping tariffs on Chinese products, and Europe also established a quota on them. These two players have power to fight against China, but Korea or Japan may have a bigger counter punch if they posed anti-dumping tariffs. So, we cannot do".[230] An expert from the KOPIA pointed out two reasons why South Korea did not solve the issue of Chinese solar products as an international trade issue. "First, Korean market is very small and Chinese modules imported were not large in quantity. Korean big solar module manufacturers export significant amount of their products. How did we measure the loss in this circumstance? Second, the petition should be from industry. A majority of the companies except cell and module manufacturers had no reason to submit petition because they used Chinese products. For Hyundai and LG, solar products are not the only export products to China. If they raise a dumping issue, China can do some retaliatory actions in other industry. South Korea trades hundred trillions KRW in a year with China. We need to consider if Korean government wants [an antidumping action] because of this small [solar] market".[231]

Under these circumstances, for some Korean solar PV manufacturers, the policies of other countries were more helpful than domestic policies. Many interviewed corporations stated that the antidumping measures of the U.S. to Chinese manufacturers

---

[229] Interview #27
[230] Interview #44
[231] Interview #29. Hyundai and LG are the two of the biggest solar cell and module manufacturers in South Korea.

had saved them. An expert from the KOPIA stated: “Korean solar cells and modules have been selling because Chinese products have lost their price competitiveness in the market due to the antidumping measure”.[232] An ingot and wafer company said: “Due to the antidumping tariff on Chinese products, some customers are buying our products. We have benefitted directly and indirectly”.[233]

The solar market conditions were not favorable to downstream installers and project developers, either. Although the market has increased based on the RPS, the profit from a solar project has significantly declined. Since the total investment of a project has decreased due to reduced costs of products, the margin for installers has significantly decreased. An installer said: “The margins are decreasing, so the size of the market should increase. However, the domestic market was not dramatically increased”.[234] In this circumstance, large corporations have attempted to go abroad. A project developer stated that they were developing projects in developing countries: “We have developed many projects in the Third World countries such as African and Southeast countries because the costs of land and human resources are low”.[235]

In sum, with the increasing competition in the global solar market, Korean solar PV corporations have struggled to survive. Government policies have not been very effective to help the survival of industry since it was hard to help manufacturers directly and the increase of domestic market was not enough to promote industry, even installers. Under this circumstance, for some Korean solar corporations, the policies of other

[232] Interview #29
[233] Interview #37
[234] Interview #43
[235] Interview #41

countries such as the anti-dumping measure in the U.S. were more helpful rather than domestic policies.

The reactions of the solar PV industry to the changing environment

As the market environment has become less favorable to Korean solar PV corporations, they have reacted to the environment with multiple strategies. They have attempted to reduce the costs, and to develop advanced technologies to differentiate their products. The corporations have also expanded their business to other fields, have expanded business globally, and have made policy suggestions to the government.

Although the Korean solar PV corporations have pursued technology development and cost reduction continually, those efforts were not enough to guarantee survival in the market. Since low-prices products were flooded in the market from China, it was not easy to compete with Chinese manufacturers in terms of price. As of May, 2015, the prices of Chinese solar modules are 15-20 percent cheaper than the prices of Korean solar modules in the EU spot market.[236] Moreover, solar PV technologies were not very difficult for latecomers to catch up in a short time. Therefore, the developed technologies were not very effective to differentiate their products with those of other manufacturers. An ingot and wafer manufacturer said: "China also do research and development. It catches up advanced technologies fast. The solar technologies are not very advanced technology. I believe that China is able to do (catch-up)".[237]

[236] KOPIA, "The Status of Solar PV Industry and the Tasks for Domestic Industry," August 20th, 2015.
[237] Interview #37

Under these difficulties, the Korean solar PV corporations expanded their business areas. Some corporations expanded to other value chains of solar PV business. A polysilicon manufacturer has invested in independent power producer (IPP) business using the accumulated cash through polysilicon business since 2012. The interviewee from the manufacturer said: "IPP was relatively easy for us to do compared to other solar PV business because we produce and sell electricity by investment. We had much cash. Solar PV is all about financing".[238] An ingot and wafer manufacturer said that it also considered investing in IPP business, but gave up due to its financial status.[239] A cell manufacturer has expanded its business to module manufacturing in 2011 and has pursued IPP business since 2012. However, it had struggled with the IPP business because of its low credit rating: "We want to develop large-scale overseas projects but it is not easy because we are a manufacturer and we have low credit rating".[240]

Since the margins from upstream manufacturing have shrunk, most Korean PV corporations have attempted to expand their business to downstream. This was not easy because developing solar PV projects require large-scale investments. Due to the struggling in the declining market, Korean solar manufacturers were lack of cash to invest in new projects and they did not have good credit ratings to finance for the projects. Therefore, only a few large corporations could consider expanding to downstream business. Moreover, most of Korean solar PV corporations in downstream were mid- and small-sized firms, so they did not have sufficient resources and capabilities to develop large-scale projects.

---

238 Interview #35
239 Interview #36
240 Interview #38

Korean corporations have also attempted to expand to overseas market. An ingot and wafer manufacturer had exported almost all the products to Europe, but after the global financial crisis, it has developed other markets: "We had only Europe [as a customer], but we have expanded to other countries to survive".[241] Expanding to overseas market was not always successful. A power producer has invested in solar PV projects in the United States, but it was not successful due to their lack of information and experience: "We have invested in 300 MW solar PV project in Nevada. We did not have much understanding of the U.S. renewable energy policy, so we invested without having power purchase agreement. The power purchase agreement was not successful as we expected. Now the conditions have much changed, so we are attempting to sell our share".[242]

A project developer said that Korean solar corporations should go abroad since most profitable business opportunities were already gone in Korea: "The countries such as the U.S. and Japan have invested in many solar PV projects in Korea and have exited with much profits. In early days, we could have enormous profits with 1MW project, but now we have to do 10MW or 20MW projects. Under this circumstances, we have to go abroad".[243]

Other than these efforts, Korean solar PV corporations have suggested policy change to the government. The research participant corporations said that they have made suggestions through the meetings with government officials or the industry associations such as KOPIA, Korea New and Renewable Energy Association (KNREA), and

241 Interview #37
242 Interview #45
243 Interview #41

Independent Power Producer Association. The corporations agreed that most of their suggestions have not been accepted by the government. Since solar policy is part of the energy policy, it was hard to make changes of solar policy. A cell manufacturer said: "Renewable energy is one of the energy sectors. Doesn't it hard to change the top-level energy policy [to change solar policy]? The more the policy is up-level, it is harder to touch."[244]

Solar policies in South Korea have established related to upper level government plans such as the National Energy Plan, the Basic Plan for Technology Development, Application, and Deployment of New and Renewable Energy, and the Basic Power Supply Plan. Moreover, renewable energy policies include multiple sources of new and renewable energy; therefore, it is not easy to change the details of the policy only for solar PV. Many research participants pointed out that the fundamental way to promote solar PV is to change the direction of energy policy. An installer said: "The government's nuclear power-friendly policies should be changed. Of course the RPS or the FIT are important, but more importantly, the unrealistic pricing of electricity, and the policies designed to win favors from [energy-intensive] companies should be changed".[245]

Korean solar PV corporations have attempted to adapt to the changing market conditions through technology development and cost reduction, but these strategies were limited in strengthening their competitiveness in the global market. They also looked for more opportunities in abroad and in other solar PV value chains, but only a few corporations with strong financial status and resources could be successful in expanding their business. Under these difficulties, they have suggested government policies for

[244] Interview #38
[245] Interview #42

more favorable market conditions, but the policies were not easy to be changed since the solar policies were closely related to upper-level energy policies.

Interactions between policies and industry

Since solar PV is one of the minor energy sources, solar policies have evolved within the boundary of energy policy in South Korea. The policies for renewable energy have established based on the existing energy policies, which have designed for fossil energy. A former government official pointed out that renewable energy sources are dependent on the existing energy system: "The scale of one nuclear power plant is 1GW. We need three or four thousands solar PV power plants for getting 1GW. Which would be easier to manage, one plant or three or four thousand power plants? Renewable energy sources cannot move independently. In other words, it is a dependent variable".[246] The existing energy system has been significantly influenced by the national energy policies. An expert stated that the influence of the government to the energy system is enormous: "In South Korea, the government decides how many coal power plants and gas power plants by setting the supply plans. The government decides how much subsidies for solar PV will be spent. It also decides to stop the subsidies and to introduce the RPS in replacement of the FIT. In South Korea, a 90 percent [of energy system] is the government".[247]

Under these circumstances, the effects of the industry into the energy policy were limited in South Korea. Even for the policies for renewable energy sources, the solar PV industry was one of many interest groups. For instance, the stakeholders of the RPS

[246] Interview #26
[247] Interview #28

include power producers, solar PV industry, wind industry, and the industries of other renewable energy sources. When the RPS has launched in 2012, power producers claimed that the target, 11 percent of energy supply by renewable energy sources by 2030, was too challenging. This target has revised to 11 percent by 2035 in 2014. A government official said that they made the policy "flexible" considering the requests from power producers.[248] The solar PV industry has also engaged in the policymaking process of the RPS. Around 2010, the KOPIA suggested to the government creating more than 500MW market in a year by policies.[249] After discussions, the government confirmed creating 1.2GW market in four years through setting an annual additional target for solar PV. This shows that multiple interest groups have influenced the policymaking process, and solar PV industry is one of them.

Although the solar PV industry has hardly affect the top-level energy policies, it has affected some lower-level policies or the details of policies. Other than the additional targets of solar PV, the government has created the policies to support solar PV industry. As mentioned above, diverse policies have introduced to support domestic industry and the industry's exports of their products. Some policies have set details considering domestic corporations. For instance, the Solar Lease Program requires participant organizations to form a consortium including a domestic manufacturer. The requests from the solar PV manufacturing that domestic manufacturing needs to have priorities in the RPS or any deployment program seem to be considered in designing this policy.[250]

[248] Interview #27
[249] Interview #33
[250] Interview #27

After the globalization of solar PV market, national deployment policies for renewable energy did not guarantee the rise of solar PV industry. Under the RPS, power producers are the players that directly affecting the solar PV market. Solar PV industry will be benefitted only if the power producers use domestically-produced products and services. Power producers have no reason to use domestically-produced products or services if they are more expensive. An expert pointed out the interest of power producers: "Power producers pursue their own benefits under the deployment policy. They can use both foreign products and domestic products. They are just playing in the market".[251]

Under these circumstances, the government has ended up establishing different types of policies to support the solar PV industry. The government has supported the exports of solar PV corporations by providing resources and capabilities. These policies did not serve the goal of the existing renewable energy deployment policies, which was to increase the share of renewables in national energy mix. The goal of these policies was to promote domestic solar PV industry, and to boost the exports of the industry. With the globalization of the solar PV market, Korean solar PV policies were evolved into two different groups in terms of policy goal. There have been some policies to increase solar PV installations, and the others have established to boost domestic solar PV industry.

Summary

Renewable energy policies have expanded in South Korea since the government started promoting renewable energy sources in 1980s. In early days, the policies have

[251] Interview #32

focused on increasing the share of renewable energy in the national energy mix through technology development and deployment programs. Over time, diverse policies have been adopted to support domestic renewable energy industry, which was the goal that could not be served by traditional deployment policies.

Globalization of the solar PV market has affected this expansion of the policies in South Korea. R&D supports, which have much increased since 2008, were not very effective because other countries have developed advanced technologies earlier than Korean corporations. Deployment programs such as the FIT and the RPS did not directly benefit domestic solar manufacturing because solar projects owners could use imported solar products, which became much cheaper since China's investments in solar PV.

Under these circumstances, the government ended up introducing different types of policies to support solar PV industry. Since the announcement of the Low Carbon Green Growth in 2008, the government has implemented diverse policies including certification programs, building test beds for renewable energy projects, and the supports for export corporations. As a result, the solar PV policies has expanded and diversified in South Korea.

These findings show that the rise of industry has influenced the expansion of national policies on renewables. The relation between the industry and the policies was not a one-way influence. Rather, the policies and the industry have changed through interaction. Once the government established a new policy, the industry reacted to the changes by the policy directly and indirectly in the changing contexts of the global market. Based on these reactions, the government revised the policy or introduced a new

policy to address the issues raised by the industry. These continuing interactions have resulted in the expanded and diversified solar PV policies in South Korea.

Chapter 7. The evolution of solar policies

Introduction

Chapter 5 and 6 explored the diversified national solar policies in the U.S. and South Korea. By synthesizing the findings of these two cases, this chapter examines how national solar policies have changed through the interactions with industry under rapidly changing global market.

This chapter starts with describing the changes of the global solar market and the domestic solar markets in the U.S. and South Korea. Next, the changes of solar policies in two countries and the causal mechanism of policy change are analyzed. Based on this analysis, the factors affecting the difference of solar policies in two countries are described. The next section discusses the characteristics of the recent changes of renewable energy policies. Finally, the limitation of the study is discussed.

The global solar market and the changes of the domestic solar markets

The globalization of solar PV industry has accelerated by the rise of Chinese solar manufacturers around 2010. Since the Chinese manufacturers have exported enormous amount of solar products, the global solar market has deeply changed. Many solar manufacturers have gone out of business, and some of them have expanded their business to downstream to find another source of revenue. Meanwhile, as Chinese products have significantly lowered the cost of solar installation, global solar installation has sharply increased in recent years. Under this circumstance, more corporations have entered the downstream solar market and this has accelerated the growth of solar installation.

Through this recent change, a global solar PV value chain has been created. Many solar PV manufacturers export a significant share of their products. Large project developers look for projects all around the world. Many solar corporations have become multinational corporations.

Under this rapid change of the global market, domestic solar markets have faced risks and conflicts. In the U.S., solar manufacturers perceived much risk under rapidly decreasing prices of solar products. This has caused the solar trade dispute between the U.S. and China, which was initiated by the petition of the U.S. solar manufacturers. The trade dispute has introduced much uncertainty in the solar market because it was hard to predict which policy measure would be implemented. Moreover, since the U.S. downstream companies have benefitted from low-priced Chinese solar panels, the trade dispute has generated conflicts of interests between the upstream and the downstream corporations. The efforts of the solar manufacturers to reduce market risks have generated additional risks and conflicts in the market.

In South Korea, the impact of the Chinese solar products to the solar market was more serious than in the U.S. because Korean solar PV industry has grown based on manufacturing. Many corporations have reduced the investments on solar products or have gone out of solar business. Although low-priced Chinese solar panels have benefitted installers by reducing cost, the installers have not significantly grown in South Korea due to a small size of domestic market. Korean solar manufacturers only barely engaged in making policy measures to address Chinese solar panels directly like the U.S. manufacturers did because for most of them, solar business was only a small part of their whole business. Large solar manufacturers have main business other than solar PV,

whose products were exported to other countries including China. Therefore, they did not find any reason to initiate trade dispute with China. Meanwhile, small solar manufacturers did not have sufficient political power to directly engage in initiating a policy measure. Moreover, Korean government did not have a strong motivation to raise a trade dispute with China on solar panel issue since China is a critical trade partner importing many products manufactured in Korea.

The risks that Korean solar manufacturers have faced were not only from domestic market, but also from the markets of other countries. They could not compete with Chinese manufacturers in terms of price in the markets of other countries, where they exported a significant share of their products. In this sense, the reactions of other countries to the Chinese solar panel issue were as important as the reaction of Korean government. Many Korean solar manufacturers perceived that the tariff on the Chinese solar panels in the U.S. were more helpful for them with surviving in the market than any domestic policy measure.

Domestic solar policies have also introduced risks in domestic markets. In the U.S., the extension of the ITC was uncertain until the decision of multiple-year extension in 2016. This has generated risks to both upstream and downstream corporations. Downstream corporations have difficulty to make a long-term investment plan since they could not predict the rate of return. Upstream corporations had difficulty to address unstable demand in the market. There was a spike of the demand of solar products just before the expiration of the ITC, but solar manufacturers could not invest in capacity expansion because the increase of demand was because of the rush of the solar projects to take advantage of the ITC before expiration.

Korean solar corporations have also faced uncertainty caused by domestic policies. After the introduction of the RPS in 2012, the profit from a solar project was not easy to predict due to fluctuating prices of the RECs. Project developers have difficulty in financing due to the uncertainty of the revenue of projects. Under this fluctuating market, the Korean government has changed the details of the RPS, and this has caused more uncertainty in the market. The change of the rules of the RPS has influenced the market; therefore, it became harder to predict the future trend of the solar market.

In sum, both the globalization of solar market and domestic policies have introduced risks and uncertainty to the industries in the U.S. and South Korea. The flood of Chinese solar products to the global solar PV market has generated much risk to the solar manufacturers. The reactions of the U.S. solar manufacturers have generated additional risks by introducing trade dispute between the U.S. and China. Since Korean solar PV industry is export-driven, it has been significantly affected by the trade dispute as well as the flood of Chinese solar panels. Domestic policies have also posed risks to solar corporations since they have not been consistent.

Diversified policies and solar industry

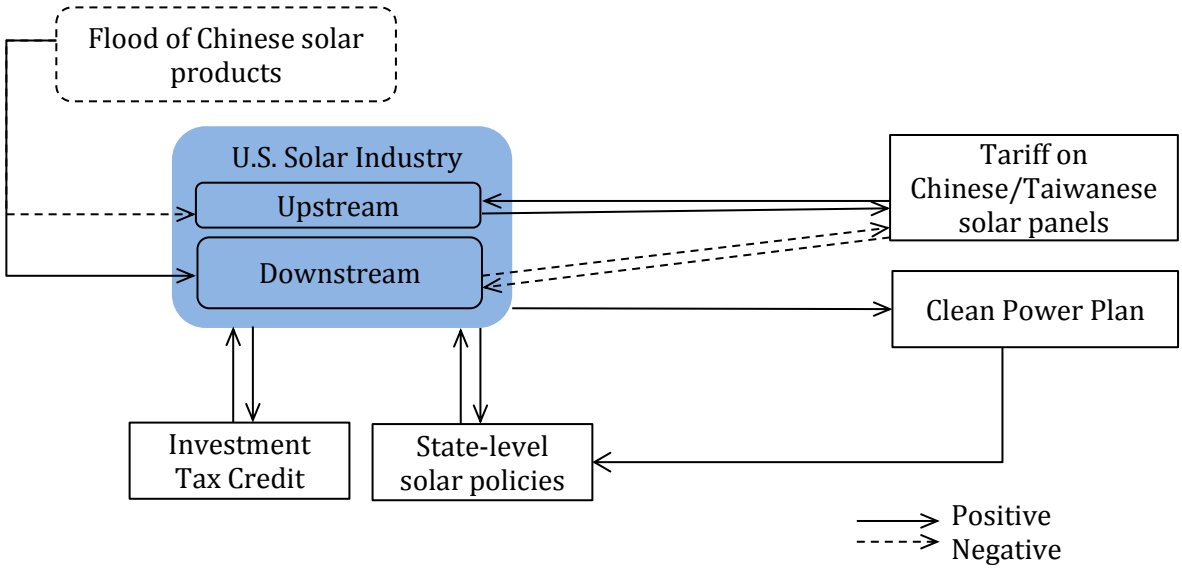
Solar policies have diversified with the changes of the market environment in the U.S. and South Korea. In the U.S., the ITC has been extended for multiple years, and the tariffs on the solar panels imported from China and Taiwan have been introduced. Moreover, the solar industry has engaged in the policymaking process of the CPP. In South Korea, the FIT was replaced with the RPS in 2012. In addition, the policies to

promote industry and the exports of solar products and services have been implemented in recent years.

In the U.S., in the early days of the solar market, two kinds of policies affected the solar market: a tax policy and research and development programs. Over time, other types of policies also became important. The loan guarantee program has encouraged investing in utility-scale solar projects. The tariff on the solar panels from China and Taiwan has benefitted the domestic solar manufacturers. Recently, the solar industry has engages in designing and implementing the CPP.

Solar industry's engagement has significantly led to this diversification of the policies. It attempted to maintain existing policies, which were favorable to solar industry. Solar industry has actively engaged in the extension of the ITC. As well as attempting to maintain existing policies, the industry also tried to overcome a market challenge through asking governmental measure to address the challenge. The tariff on the solar panels from China and Taiwan has introduced through the political activities of SolarWorld and other solar manufacturers. As the political power of the solar industry has grown, the industry also engaged in non-solar policies, which was expected to affect solar industry. The CPP was originally not necessarily favorable to solar industry, but the engagement of the solar industry has led to include some rules that were favorable to solar energy in the final rule of the CPP. Figure 39 shows the interactions between solar PV industry and policies in the United States.

Figure 39. Interactions between solar industry and policy in the U.S.

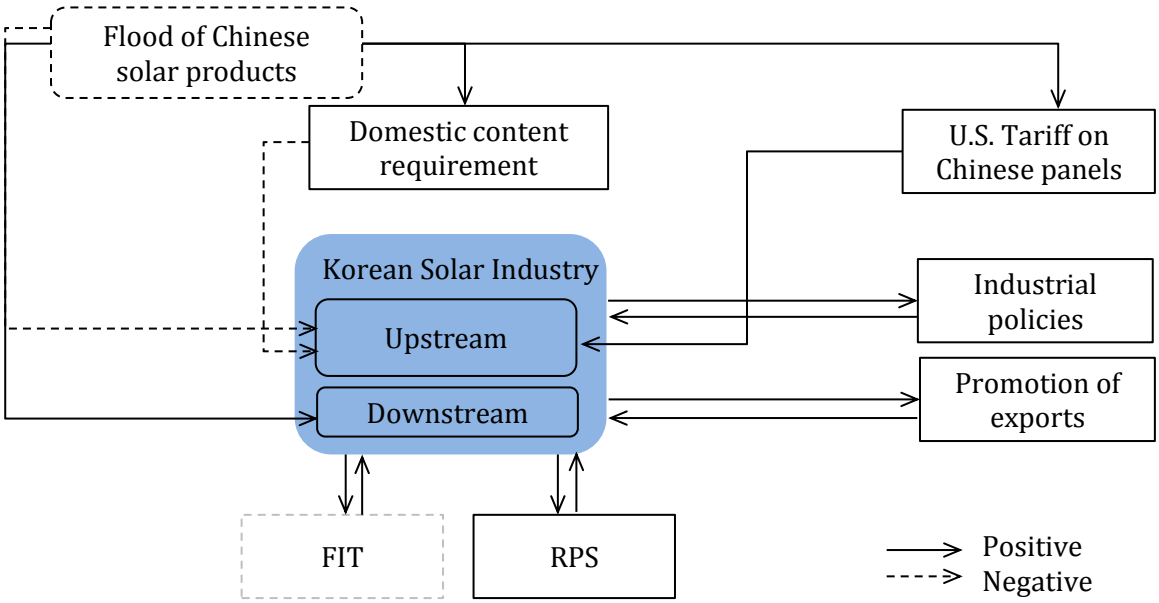


In South Korea, the solar policies have also diversified. Since the declaration of Low Carbon Green Growth as a national vision, many policies to promote solar industry have been introduced. In the early days of solar market development, the government pursued both increasing solar installation and developing industry by the FIT and R&D support programs. However, after the globalization of the solar market, R&D support programs were not very helpful for solar PV industry since the manufacturers were more interested in surviving in the market rather than in developing technologies, which were for long-term growth. The solar corporations asked the government to engage in the international trade dispute on solar products. For the Korean solar corporations exporting a large share of their products, the rise of protectionism in many countries caused by the flood of Chinese solar panels was very risky.

Rather than engaging actively in the international trade dispute, Korean government has introduced the policies to support exports. It provided financial supports

for exporters, and built international relations for solar corporations to enable developing solar projects abroad. These policies were different from the original renewable energy policies in that they do not contribute to increase solar installation in South Korea. These interactions between solar industry and policies are shown in Figure 40.

Figure 40. Interactions between solar industry and policy in South Korea.



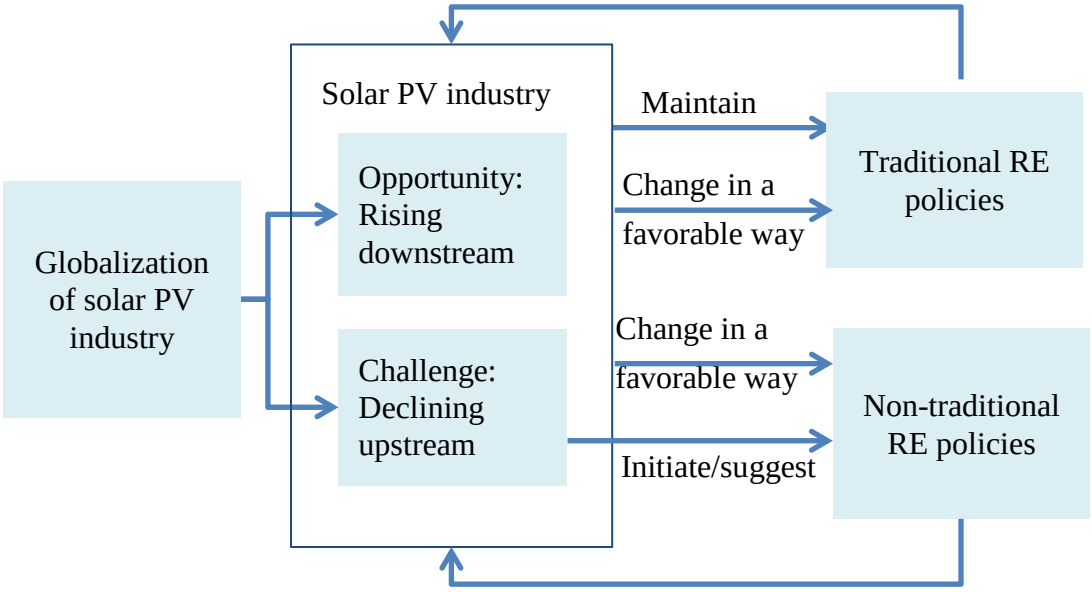
In both countries, the solar policies have diversified, and the solar industry has influenced this change. New types of policies have emerged because existing policies could not address the challenges in the solar market, and these challenges are mostly from the global market. In the U.S., the tariff has been implemented under the rising imports of low-priced Chinese solar panels. Korean solar companies have struggled under the international trade disputes and the policies of other countries to protect their domestic market. The government of Korea has introduced some measures to promote solar industry and the exports of solar corporations. These policies have been

implemented in the context that the industry has asked for a policy measure to address the international trade issue.

Other than asking for a new measure to address market challenges, the industry also attempted to maintain favorable policies and to change the detailed rules of policies. The U.S. solar industry has affected the extension of the ITC, and the detailed rules of the CPP. Korean solar PV industry has suggested to the government the necessity of changing the rules of the RPS since the RPS has introduced much uncertainty in the solar market.

Figure 41 shows the causal mechanism of renewable energy policy change developed by the cases of two countries. Globalization of solar PV industry has positively affected the growth of downstream solar industry, but has posed challenges on upstream solar industry. Under these circumstances, struggling upstream industry has attempted to initiate or to suggest new policies such as the tariffs, industrial policies, or the supports for exports. These policies are different from traditional renewable energy policies in that they were introduced to protect domestic industry. Meanwhile, the whole solar industry has engaged in policymaking to maintain existing traditional renewable energy policies, and to make both traditional and non-traditional renewable energy policies more favorable for the solar PV industry. Globalization of solar PV industry has affected these efforts indirectly by leading the rise of downstream solar industry.

Figure 41. Causal mechanism of renewable energy policy change.



Factors for policy divergence

As renewable energy policies have been diversified in these two countries, the difference in policies between them has increased. Comparing the cases suggests three factors affecting policy divergence between the U.S. and South Korea: solar PV industry structure, energy policy structure, and the importance of domestic market.

Solar PV industry structure

While the growth of solar PV industry has been driven by downstream industry in the U.S., the solar PV industry in South Korea has grown based on upstream industry. This difference of solar PV industry structure has caused different effect of the globalization of solar PV industry. In the U.S., although the flood of Chinese solar products into the global market has negatively affected solar manufacturing, it has

benefitted downstream solar corporations, which were much larger compared to manufacturing. On the other hand, increasing supply of Chinese solar products has seriously weakened Korean solar manufacturers. Due to the small size of downstream industry, South Korean has not benefitted much from decreasing prices of Chinese solar products.

Under the increasing supply of low-priced Chinese solar products, U.S. solar industry has sharply grown based on the dramatic rise of solar installation. As the industry became larger, it had more political power to influence policies. This helped the solar industry to influence relevant policies. With increased resources and capabilities, the U.S. solar industry has affected the extension of the ITC, and the addition of detailed rules favorable to solar industry in the CPP.

In South Korea, solar PV industry has not significantly grown because solar manufacturers, which accounted for a majority of solar corporations, had faced severe competition with Chinese manufacturers in the global market. Under this circumstance, many corporations went out of solar business in recent years. Although solar installation has sharply increased, this did not significantly contribute to the growth of solar industry since most of the projects were small-scale. Therefore, it was difficult for the Korean solar industry to have enough political power to influence relevant policies. Compared to the U.S., the influence of Korean solar industry to policies was less significant.

The difference in solar PV industry structure has caused the difference in the effect of the globalized solar PV industry on each country. The U.S. solar industry has much benefitted, but Korean solar industry has faced more challenges than opportunities.

This has led to a different degree of political power, which has affected the industries' capacity to engage in relevant policies.

Energy policy structure

Most of the solar PV policies have been implemented through the enactment of acts in the U.S., while those have introduced under the higher-level of national energy policies in South Korea. Since solar PV policies were a part of the energy policies such as the Basic Plan for Technology Development, Application, and Deployment of New and Renewable Energy, and the National Energy Plan, the Korean solar industry's engagement in solar PV policies has been limited. The target share of solar PV in national energy mix were decided by the higher-level energy policies, and the policies were designed based on the target. On the other hand, the U.S. energy policies were less hierarchical. The major solar PV policies were not very closely related to other policies. The ITC has been introduced and extended through several separate acts. Funding and financial assistance for solar PV has also been implemented through the enactment of an act. This enabled the U.S. solar PV industry to engage in each policy issue with less difficulty compared to the Korean solar PV industry.

Importance of domestic market

The U.S. government posed a direct policy measure to address flooding Chinese solar panels, but South Korea did not. Korean government was not motivated to introduce a policy measure to restrict the imports of Chinese solar panels since the size of solar PV industry has not significant compared to other industry sectors. Restriction on Chinese

solar panels was risky because it could cause any type of retaliatory actions. Since China is one of the biggest markets for Korean industries, a retaliatory action could harm other industries severely. Even large Korean solar PV corporations did not want any policy to restrict the imports of Chinese solar panels. For most of them, solar products are one of their businesses, and the share of solar business was not significant. They did not want to have any risk of retaliatory action due to one of their minor business area. Moreover, domestic market was not one of the major markets for most of the Korean manufacturers. As they exported almost 70% of their solar products, protecting domestic market was not very important for them.

Compared to South Korea, the U.S. domestic market was more important for the U.S. solar manufacturers. The U.S. is one of the largest solar PV markets worldwide. Therefore, protecting domestic market was a critical issue for the U.S. solar manufacturers for survival. In this context, SolarWorld and several other U.S. manufacturers have initiated introducing a new measure to restrict the imports of Chinese solar panels by submitting a petition.

Complicated and murky renewable energy policies

In recent years, more policies have been included into renewable energy policies. Traditional renewable energy policies have been support policies such as FIT and RPS, which promote the use of renewable energy. Recent policies on renewables are not necessarily implemented to increase the use of renewable energy. The purposes of these policies are to fix unfair international trade practices, to promote the exports of domestic corporations, or to increase the use of domestically-produced facilities in domestic

market. Most of these policies do not contribute to achieving the goal of the traditional renewable energy policies.

In this sense, renewable energy policies are not necessarily environmental policies. At this point, they are environmental policies, trade policies, and industrial policies. Before the globalization of renewable energy industry, traditional renewable energy policies have been able to promote both the use of renewable energy and the growth of industry. However, the globalized industry has posed challenges to these efforts. Traditional renewable energy policies can expand the use of renewable energy, but they do not necessarily develop a domestic industry. Under these circumstances, different types of policies including industrial policies and trade policies were introduced to complement the traditional renewable energy policies.

Some of these non-traditional renewable energy policies conflict with traditional renewable energy policies. The policies to promote domestically-produced products may negatively affect achieving the goal of the traditional policies by reducing the use of low-priced foreign products. Some non-traditional renewable energy policies could also conflict with global trade rules. The U.S. anti-dumping tariff on Chinese solar panels has caused trade dispute with China as China submitted a complaint to the WTO. Moreover, there are less transparent policies to protect domestic industry. Certification programs or government-driven renewable energy project development programs could be used as a policy measure to develop domestic corporations. It is not easy to find out how these "murky" industrial policies affect the use of renewable energy locally and globally.

Limitation

The causal mechanism of renewable energy policy change is limited in being generalized due to the specific contexts of two case countries. Since each country has its own political, economic, and social contexts, these two country-level case studies are not easily generalized. Future research can complement this limitation by expanding case countries, and by conducting a quantitative large N-study. Despite this limitation, the two cases do allow insight into drivers of firm behavior and policy response that are relevant for these major actors, as well as providing the basis for future inquiries

Chapter 8. Conclusion

This research explores how the globalized renewable energy industry has changed national renewable energy policies through three analyses. The findings of the three analyses reveal that the globalized renewable energy industry has led the diversification of national renewable energy policies by increasing international interactions between actors, by posing new challenges to domestic renewable energy industries, which were addressed through additional policy measures, and by introducing opportunities to the industries to grow, which resulted in more political power of the industries.

Analysis 1 shows that solar multinational corporations have adapted to the changes of the global market rather than attempted to change national policies. It does not find any evidence of the effect of an individual solar multinational corporation on national policies. Rather, national policies, especially the policy measures to protect domestic industry, have affected the risks that multinational corporations face. They attempted to adapt to these increasing risks by expanding their business to downstream. This expansion has led them to face new policy risks.

Analysis 2 reveals that solar multinationals have affected national policies through engaging in framing of a policy issue. In the U.S., the solar multinationals headquartered in other countries have dominated the framing of the issue of Chinese solar panels. Although Analysis 1 shows that an individual multinational corporation has barely influenced national policies, Analysis 2 identifies that it has affected national policies indirectly through framing.

Finally, Analysis 3 finds that the globalization of solar industry has affected the diversification of national solar policies. It changed the market conditions that solar

industry faced, and led the industry to initiate or suggest new policies. Moreover, the globalization of solar industry has led the growth of downstream solar industry by decreasing the costs of solar products. The growing downstream industry has strengthened the political power of the solar industry, which has helped the industry to engage in policymaking to maintain existing favorable policies, to make existing policies favorable, or to make non-solar policies favorable.

Interpretation of the findings of Analysis 1 and Analysis 2

The findings of Analysis 1 have an apparent inconsistency with those of Analysis 2. Analysis 2 finds the effect of multinational corporations on policies, while Analysis 1 does not find it. This inconsistency arises from differences in topical focus and method, and therefore relates more to the scoping of the analyses than to a theoretically fundamental divergence. In this sense, the two outcomes provide partial complementarity that gives a more complete picture of firm and policy responses. Three reasons can explain this inconsistency.

First, there was difference between the analyses in terms of the focus of an activity for policy engagement. Analysis 1 focused on the actual engagement of multinational renewable energy corporations in policymaking, while Analysis 2 focused on framing a policy issue. Framing a policy issue is a more indirect engagement in policymaking compared to other engagements such as lobbying. Therefore, it can be said that renewable energy corporations' engagement in policymaking was indirect rather than direct. In the interviews, a few multinational solar PV manufacturers said that they could not actively engage in the U.S. policy issues because they are a non-U.S. manufacturer.

However, these manufacturers have participated in framing the Chinese solar panel issue in the U.S. This suggests that multinational corporations adopted indirect ways to engage in policies since their capabilities for policy engagement were limited in non-home countries.

Second, Analysis 1 does not capture the behaviors of all the multinational corporations since the data was limited to the annual reports of the global top 15 solar module manufacturers. There is a possibility that non-top 15 solar module manufacturers actively participated in policies. For instance, SolarWorld, the dominant actor in framing the Chinese solar panel issue in the U.S., was not included in the top 15 module manufacturers.

Third, the annual reports might not include all the actual activities of the solar module manufacturers for policy change. Since lobbying is a sensitive issue, corporations might attempt to avoid describing their efforts to change policies in their annual reports.

In this sense, the findings of Analysis 1 and Analysis 2 complement each other rather than conflict. In combination, they show that multinational corporations' policy engagement tend to be more indirect rather than direct. They engaged in policies through framing a policy issue and collaborating with other actors. Moreover, less globally dominant multinational corporations can be more active than dominant corporations for a specific policy issue. While Analysis 1 focuses on the direct policy engagements of large multinational corporations, Analysis 2 shows broader and indirect policy engagements of multinational corporations including less dominant corporations.

Evaluating the propositions

Proposition 1. Multinational renewable energy corporations are more likely to engage in policymaking for favorable policies under the challenges of the global market.

Proposition 1 was not supported by Analysis 1. Under the challenges of the global market, multinational corporations tended to adapt to the changes. Analysis 1 did not find any evidence of the engagement of multinational solar corporations in policymaking. The interviews with multinational solar corporations in Analysis 3 were also consistent with the findings of Analysis 1. Multinational solar corporations did not actively engage in policymaking individually.

Proposition 2. The central domestic actors of a renewable energy field have framed renewable energy trade issues with a traditional environmental frame.

The findings of Analysis 2 did not support Proposition 2. The trade of Chinese solar panel was framed by multinational corporations headquartered in other countries. The central actors in the U.S. solar PV field, large manufacturers and installers, were not actively engaging in the debates on Chinese solar panels. The issue was not framed with the traditional frame of the U.S. solar PV field, which was an environmental frame. Economic frame and international trade frame were dominant in framing the Chinese solar panel issue.

Proposition 3. The growth of domestic renewable energy industries has caused the diversification of national renewable energy policies as renewable energy industries have become globalized.

Analysis 3 supported Proposition 3. The solar PV industry has caused the diversification of national solar PV policies in the U.S. and South Korea. The globalization of solar PV industry has influenced national policies by posing a new challenge to the solar PV industry. Under this circumstance, the industry has initiated or suggested new policies. Moreover, the globalization of solar PV industry has affected the growth of domestic solar industries by boosting downstream business. This has influenced national solar policies by increasing the political power of the solar industries. The industries have engaged in policymaking of both traditional and non-traditional renewable energy policies.

Contributions to the literature

Overall, this research contributes to the literature on trade and the environment. Although the existing literature explains increasing renewable energy installation with the rise of international trade of renewable energy products, the rise of renewable energy protectionism is not well understood. The conflicts between environmental regulations and global trade rules were discussed, but the current conflicts between national industrial and trade policies on the environment with the international trade of environmental goods have not received much attention. This research fills this gap by

exploring the contexts of the recent rise of protectionist measures under the globalized renewable energy industry.

The literature on protectionism will also be benefited from this research. The rise of green protectionism has been a concern after the global financial crisis, but the causal mechanism of green protectionism has not been identified. This research fills this gap by suggesting the mechanism of the rise of protectionist measures in renewable energy. The research shows that the globalized renewable energy industry has led countries to adopt protectionist measures, and that national contexts have influenced countries' adoption of different types of policy measures.

Each analysis contributes to different literature streams. Analysis 1 contributes to the literature on institutional change and multinational corporations by showing how multinational corporations interact with national policies. The literature on the co-evolution of multinational corporations suggested that multinational corporations have evolved with the uncertain external environment, but the pattern of co-evolution has not been well understood. Analysis 1 shows that multinational corporations have interacted with national policies by adapting to the changing environment rather than by directly engaging in.

Analysis 2 contributes to elaborating the concept of an issue field. It shows how actors interact within an issue field, and which actors are dominant in an issue field. An issue field was not necessarily dominated by the central actors of an existing field. The actors with strong interest were dominant in framing of the issue by collaborating with other actors. The findings add understanding to the literature on an issue field by showing how actors collaborate and interact to lead framing of an issue field.

Finally, Analysis 3 complements the literature on policy convergence. It suggests that globalization of industry influences the diversification of national policies through changing the market conditions of domestic industries as well as the industries itself. Analysis 3 contributes to the literature on policy convergence by revealing that globalization can influence policy divergence in various ways in diverse contexts. While existing literature tends to find the effects of multiple aspects of globalization on policy convergence, this research suggests that a single aspect of globalization may affect the changes of national policies in various ways.

Policy implications

Under the current global renewable energy market, a single policy is difficult to promote both the installation of renewable energy as well as the domestic renewable energy industry. Traditional renewable energy policies such as FIT or RPS would contribute to increasing the share of renewable energy in a national energy mix, but it is uncertain if these policies would promote domestic renewable energy industry. Especially, manufacturing is hard to be promoted through policies under the globalized industry because existing manufacturers are producing renewable energy products with very competitive prices and are providing them all over the world. Therefore, a new actor would be difficult to compete with them.

Compared to manufacturing, installation is inherently local. Therefore, renewable energy policies can still boost domestic downstream industry. FIT and RPS could expand business opportunities for installers by increasing the size of a domestic market. Even if global project developers take advantage of the business opportunities, most of the

construction should be done by local installers. In this sense, boosting installation of renewable energy facilities could positively affect domestic industries to some degree.

In this context, a well-designed renewable energy policy is still able to develop a domestic industry even under the globalized renewable energy market. From industry's perspective, the key of the renewable energy policy is to enable the industry to predict future market. The policy should provide a positive signal to the market, which shows that the market conditions will be favorable to industry. The U.S. solar corporations had difficulty in making investment plans due to the late decision of the extension of the ITC, and Korean solar corporations had been struggling with fluctuating prices of energy source in recent years. What they need was a consistent policy signal enabling them to predict the conditions of the future market.

Moreover, to promote renewable energy, which is more matured than the past, a broader perspective is necessary. The policies on electricity grid, permitting, and utility rates are significantly affecting renewable energy business at this point. In the early stage of renewable energy development, these issues were not very important since the share of renewable energy was negligible. Since the share of renewable energy will continuously increase, these issues will be more critical in the future.

Finally and most importantly, this research suggests a benefit from an international policy on renewable energy trade. The international trade disputes among countries on renewable energy products have been a barrier to reduce the cost of renewable energy. In this context, Environmental Goods Agreement (EGA) has been negotiated among 14 countries, which represent an 86 percent of global trade of environmental goods, to eliminate the tariffs on environmental goods since July 2014.

This is expected to contribute to expanding renewable energy installation globally through reducing the cost of renewable energy products. Moreover, considering that newly adopted national trade policies on renewables have introduced different kinds of risks to industry, this initiative is expected to reduce risks that the industry face. In this sense, the EGA would encourage the development of renewable energy industry as well as promote the installation of renewables.

International policies focusing on tariffs, however, would be limited in addressing the rise of murky policies to protect domestic renewable energy industry. Many other protectionist measures other than tariffs have been implemented under the globalization of solar PV industry. As other renewable energy industries grow and are globalized, protectionist measures could increase, which would not be limited in transparent policy measures. Therefore, an international mechanism including broader trade issues such as non-tariff policies would contribute to encouraging renewable energy development.

Limitation and future work

Some limitations of this research yield future research opportunities. First, since the data for Analysis 1 was limited to the annual reports of the solar PV corporations, the behaviors of the corporations that were not described in the annual reports were limitedly addressed. Although the interviews with solar multinational corporations for Analysis 3 were able to partially complement the limitation of data, the interviews did not cover all the multinational corporations in Analysis 1. Interviews with all top fifteen corporations are expected to reveal more detailed contexts of the behaviors of solar multinationals under the challenges of the global market. In addition, using quantitative data such as

lobbying spending of the multinational renewable energy corporations would be able to complement the limitation of the analysis.

Analysis 2 shows the political interactions among actors to change a policy, but it is limited in revealing the actual effect of the framing on policy change. The analysis shows prominent actors focusing on the framing of the issue. It can be argued that the framing does not necessarily significantly affect policy change. Lobbying or other political activities could be more effective in influencing policies. Future research would be able to complement this analysis by investigating the actual effect of framing on policy change.

Finally, Analysis 3 is limited in generalizing due to the specific contexts of two case countries. Especially, to explain the global context of renewable energy, China needs to be included in the analysis. Future research on the renewable energy policy change in China would complement this research by adding a case with different political and economic contexts. Moreover, a quantitative large-N study on the divergence of renewable energy policies with diverse countries would complement this research by enabling generalization of the findings of this study.

Overall, this research explored the contexts of the recent rise of renewable energy protectionism. The future of renewable energy is uncertain since renewable energy is an issue of energy, the environment, trade, economy, and global politics at this point. The increasing trend of nationalism would introduce more uncertainty since national policies for domestic interests are expected to conflict with the increasing international trade and the global trade rules. The most important future work will be to observe ongoing discussions and actions on renewable energy trade and to provide knowledge on them.

Appendix A. List of interviews for the U.S. case study

Interview number	Category	Name	Organization	Headquarters
Interview #1	Expert	Miriam Makhyoun	Solar Electric Power Association	US
Interview #2	Expert	Vanessa He	Solar Energy Industry Association	US
Interview #3	Expert	Amit Ronen	GW Solar Institute	US
Interview #4	Expert		Anonymous	US
Interview #5	Expert	Alexander Winn	Solar Foundation	US
Interview #6	Firm - Project developer	Polly Shaw	SunEdison	US
Interview #7	Firm - Project developer		Anonymous	Germany
Interview #8	Firm – Cell/Module manufacturer		Anonymous	China
Interview #9	Firm – Cell/Module manufacturer		Anonymous	China
Interview #10	Firm – Cell/Module manufacturer		Anonymous	China
Interview #11	Firm – Cell/Module manufacturer	Sam Yoon	Hanwha Q cell	South Korea
Interview #12	Firm – Cell/Module manufacturer		Anonymous	India
Interview #13	Firm – Cell/Module manufacturer		Anonymous	US
Interview #14	Firm – Cell/Module manufacturer		Anonymous	Japan
Interview #15	Firm – Cell/Module manufacturer	Gary Conger	Recom	Germany
Interview #16	Firm – Cell/Module manufacturer		Anonymous	China
Interview #17	Firm – Cell/Module manufacturer		Anonymous	Vietnam
Interview #18	Firm - Inverter manufacturer		Anonymous	US
Interview #19	Firm - Inverter manufacturer		Anonymous	US
Interview #20	Firm - Inverter manufacturer		Anonymous	US
Interview #21	Firm - Installer		Anonymous	US
Interview #22	Firm - Installer	Scott Cavanagh	Anar Solar	US
Interview #23	Firm - Installer	Matthew Harrison	Baja Construction	US
Interview #24	Firm - Installer		Anonymous	US

Appendix B. List of interviews for the South Korea case study

Interview number	Category	Name	Organization	Headquarters
Interview #25	Government	Nam, Kiwoong	Mirae Energy-Code Research Institute (Korea Energy Agency)	South Korea
Interview #26	Government	Han, Young-Bae	Korea Energy Agency	South Korea
Interview #27	Government		Anonymous	South Korea
Interview #28	Expert	Kim, Joojin	Kim & Chang	South Korea
Interview #29	Expert		Anonymous	South Korea
Interview #30	Expert		Anonymous	South Korea
Interview #31	Expert		Anonymous	South Korea
Interview #32	Expert	Lee, Sanghoon	Korea Society for New and Renewable Energy	South Korea
Interview #33	Expert	Lee, Sungho	Chonbuk National University (Korea Energy Agency/KOPIA)	South Korea
Interview #34	Firm - Polysilicon manufacturer		Anonymous	South Korea
Interview #35	Firm - Polysilicon manufacturer		Anonymous	South Korea
Interview #36	Firm - Ingot and wafer manufacturer	Nam, Wallace W.	Woongjin Energy	South Korea
Interview #37	Firm - Ingot and wafer manufacturer		Anonymous	South Korea
Interview #38	Firm - Cell manufacturer		Anonymous	South Korea
Interview #39	Firm - Module manufacturer		Anonymous	South Korea
Interview #40	Firm - Module manufacturer		Anonymous	South Korea
Interview #41	Firm - Module manufacturer		Anonymous	South Korea
Interview #42	Firm - Installer	Jeong, Doowoon	I-Solar Energy	South Korea
Interview #43	Firm - Installer	Shin, Sungyong	KC Solar Energy	South Korea
Interview #44	Firm - Installer	Oh, Kyo-Sun	LS IS	South Korea
Interview #45	Firm - Power producer		Anonymous	South Korea

Appendix C. List of observations

Observation number	Country	Date	Event	Session	Venue
Observation #1	US	Apr. 23th, 2015	ACORE National Renewable Energy Policy Forum	Opening Keynote	The Westin Washington DC
Observation #2				Energy Sector Transformation – Lead, Follow, or Move Out of the Way	
Observation #3				Will Congress Act? Tax Reform, Extension or Bust	
Observation #4				Stop, Start – the Path to Policy Certainty and Lowering Clean Transportation Costs	
Observation #5				Outside the Beltway – Successes and Obstacles in Red, Blue and Purple States	
Observation #6		Sep.15th, 2015	2015 Solar Power International	International Markets: Best Practices from Around the World to Drive the U.S. Market	Anaheim Convention Center
Observation #7				Surviving in a Highly Competitive Environment	
Observation #8				Join the Fight to Extend the ITC	
Observation #9		Sep.16th, 2015		Beyond the fence: The impact of Clean Power Plan	
Observation #10				General session	
Observation #11				Informal talk with a multinational solar manufacturer	
Observation #12		Feb. 24th, 2016	2016 PV Conference and Expo	Keynote and Opening Session	Westin Boston Waterfront
Observation #13				Rethinking Utility Rate Design	
Observation #14		Feb. 25th, 2016		The Investment Tax Credit Extension! What It Means for the Solar Industry and How you Can Help Protect It	
Observation #15		Sep.12th, 2016	2016 Solar Power International	Welcome & Opening General Session	Las Vegas Convention

Observation #16		Sep 13th, 2016		General session - Solar Plus: How Solar Got Smart	Center
Observation #17				Clean Power Plan: Path forward	
Observation #18		Sep 14th, 2016		The View from Here: The Future of the U.S. Solar Industry	
Observation #19	South Korea	June 25, 2015	Reaction and Choice of South Korea in the Beginning of The Era of the Global Solar Photovoltaic		National Assembly Member's Office Building
Observation #20		June 30, 2015	Policy Forum for Revitalization of New and Renewable Energy		National Assembly Library
Observation #21		July 9, 2015	Advancing into Foreign Market and Financial Support of New and Renewable Energy		Hyundai Hillstate Gallary
Observation #22		July 13, 2015	Changes of Domestic Energy Policy in Declining International Energy Prices		National Assembly Member's Office Building
Observation #23		May 31, 2016	Seminar on International Cooperation in New and Renewable Energy Industries	Cooperation in Renewable Energy	Seoul Plaza Hotel
Observation #24				Cooperation in New Energy Industry	
Observation #25				Cooperation in New Energy Industry 2	

Appendix D. Interview questions

1. Questions for the executives and managers of solar photovoltaic companies

1) Could you talk about your background in solar PV field?
2) Could you describe the solar PV business in your company? When did your company start your solar photovoltaic business for the first time?
3) How was the market environment when your company started the business?
4) Could you describe the changes of market environment in recent years?
5) How has your company addressed those changes?
6) How do you think government policies affect the solar photovoltaic business of your company?
7) Do you make suggestions on government policies? If yes, how do you do it? Do you collaborate with any organization (industry organizations, solar PV firms, other manufacturing firms) for influencing government policies?
8) Are you satisfied with current government policies on solar energy? Which additional policy do you think is necessary? Or do you suggest any revision of policy?

2. Questions for the government officials

1) Could you talk about your background in solar PV field?
2) Could you describe the solar PV policies that you have worked on? How the policy is related to other policies (such as industrial policy, energy policy)?

3) What was the purpose of the policy [a policy that the interviewee has engaged in]?
4) What was the expected output of the policy?
5) Which stakeholders were considered during the policymaking? Which stakeholders were important?
6) How have the stakeholders reacted to the policy?
7) How did you address those reactions?
8) Do you have any plan to revise the policy?
9) What do you think the ideal direction of solar policy should be?

3. Questions for the experts in the solar photovoltaic fields

1) Could you talk about your background in solar PV (renewable energy) field? How long have you been working in solar PV (renewable energy) field?
2) Which policies do you think have been important for the development of solar PV industry in the U.S.?
3) What do you think is the most important policy agenda of solar PV at this point?
4) Who do you think are the most influential actors for that policy agenda?
5) Overall, how do you think the market environment of the U.S. solar PV industry has changed?
6) Which factors do you think have been important for the U.S solar PV market environments?
7) Who do you think are the most influential actors in the U.S. solar PV market?

8) Do you see any effect of globalization of solar PV market on the U.S. solar PV field? If yes, what are the effects?

Bibliography

Aggarwal, Vinod K., and Simon J. Evenett. "A Fragmenting Global Economy: A Weakened WTO, Mega FTAs, and Murky protectionism." *Swiss Political Science Review* 19, no. 4 (2013): 550-557.

Aggarwal, Vinod K., and Simon J. Evenett. "Industrial policy choice during the crisis era." *Oxford Review of Economic Policy* 28, no. 2 (2012): 261-283.

American Wind Energy Association, "US wind power jobs hit record, up 20 percent in 2016," http://www.awea.org/MediaCenter/pressrelease.aspx?ItemNumber=8736 (April 12, 2016).

Battilana, Julie, Bernard Leca, and Eva Boxenbaum. "2 how actors change institutions: towards a theory of institutional entrepreneurship." *The Academy of Management Annals* 3, no. 1 (2009): 65-107.

Bird, Lori, Mark Bolinger, Troy Gagliano, Ryan Wiser, Matthew Brown, and Brian Parsons. "Policies and market factors driving wind power development in the United States," *Energy Policy* 33, no. 11 (2005): 1397-1407.

Bollen, Yelter, Ferdi De Ville, and Jan Orbie. "EU trade policy: persistent liberalisation, contentious protectionism." *Journal of European Integration* 38, no. 3 (2016): 279-294.

Bowman, Edward H. "Content analysis of annual reports for corporate strategy and risk." *Interfaces* 14, no. 1 (1984): 61-71.

Brennan, Niamh. "Reporting intellectual capital in annual reports: evidence from Ireland." *Accounting, Auditing & Accountability Journal* 14, no. 4 (2001): 423-436.

Bruvoll, Annegrete, and Hege Medin. "Factors behind the environmental Kuznets curve. A decomposition of the changes in air pollution." *Environmental and Resource Economics* 24, no. 1 (2003): 27-48.

Busch, Per-Olof, and Helge Jörgens. "International patterns of environmental policy change and convergence." *Environmental Policy and Governance* 15, no. 2 (2005): 80-101.

Campbell, John L. *Institutional change and globalization*. Princeton: Princeton University Press, 2004.

Cantwell, J., Dunning, J. H., & Lundan, S. M. "An evolutionary approach to understanding international business activity: The co-evolution of MNEs and the institutional environment." *Journal of International Business Studies*, 41 (2010), 567–586.

Caprotti, Federico. "Golden sun, green economy: market security and the US/EU-China 'solar trade war'." *Asian Geographer* 32, no. 2 (2015): 99-115.

Carbaugh, Bob, and M. St Brown. "Industrial policy and renewable energy: Trade conflicts." *Journal of International and Global Economic Studies* 5, no. 1 (2012): 1-16.

Cole, Matthew A. "Trade, the pollution haven hypothesis and the environmental Kuznets curve: examining the linkages." *Ecological economics* 48, no. 1 (2004): 71-81.

Copeland, Brian R., and M. Scott Taylor. *Trade and the environment: Theory and evidence*. Princeton University Press, 2003.

Dal Bó, Ernesto. "Regulatory capture: a review." *Oxford Review of Economic Policy* 22, no. 2 (2006): 203-225.

DiMaggio, P. J. "Interest and Agency in Institutional Theory", in *Institutional Patterns and Organizations: Culture and Environment*, 3-22, Zucker, Lynne G, Ballinger Pub Co, 1988.

DiMaggio, Paul, and Walter W. Powell. "The iron cage revisited: Collective rationality and institutional isomorphism in organizational fields." *American Sociological Review* 48, no. 2 (1983): 147-160.

Dong, Baomin, Jiong Gong, and Xin Zhao. "FDI and environmental regulation: pollution haven or a race to the top?." *Journal of Regulatory Economics* 41, no. 2 (2012): 216-237.

Drezner, Daniel W. "Globalization and policy convergence." International studies review 3, no. 1 (2001): 53-78.

Dunford, Michael, Kyoung H. Lee, Weidong Liu, and Godfrey Yeung. "Geographical interdependence, international trade and economic dynamics: The Chinese and German solar energy industries." *European Urban and Regional Studies* (2013): 3-13.

Duriau, Vincent J., Rhonda K. Reger, and Michael D. Pfarrer. "A content analysis of the content analysis literature in organization studies: Research themes, data sources, and methodological refinements." *Organizational Research Methods* 10, no. 1 (2007): 5-34.

Earth Policy Institute. "Datacenter: Climate, Energy and Transportation," http://www.earth-policy.org/?/data_center/C23/. (accessed August 4, 2016)

Electric Power Statistics Information System. “System Marginal Price,” http://epsis.kpx.or.kr/epsis/ekmaStaticMain.do?cmd=004013&flag=&locale=KR (accessed June 30, 2016)

Energy Information Administration, *Electric Power Annual 1994 Volume I*, 1995.

Energy Information Administration. *Electric Power Annual 2007.* Washington DC: US Department of Energy. 2009. http://www.eia.gov/electricity/annual/archive/03482007.pdf.

Energy Information Administration. *Electric Power Annual 2008.* Washington DC: US Department of Energy. 2010. http://www.eia.gov/electricity/annual/archive/03482008.pdf.

Energy Information Administration. *Electric Power Annual 2009.* Washington DC: US Department of Energy. 2011. http://www.eia.gov/electricity/annual/archive/03482009.pdf

Energy Information Administration. *Electric Power Annual 2010.* Washington DC: US Department of Energy. 2011. http://www.eia.gov/electricity/annual/archive/03482010.pdf

Energy Information Administration. *Electric Power Annual 2011.* Washington DC: US Department of Energy. 2013. http://www.eia.gov/electricity/annual/archive/03482011.pdf

Energy Information Administration. *Electric Power Annual 2012.* Washington DC: US Department of Energy. 2013. http://www.eia.gov/electricity/annual/archive/03482012.pdf

Energy Information Administration. *Electric Power Annual 2013.* Washington DC: US Department of Energy. 2015. http://www.eia.gov/electricity/annual/archive/03482013.pdf

Energy Information Administration. *Electric Power Annual 2014.* Washington DC: US Department of Energy. 2016. http://www.eia.gov/electricity/annual/archive/03482014.pdf

Energy Policy Act of 2005, Public Law 109–58, 119 STAT. 594, 2005.

Energy Security Act of 1980, Public Law 96-294, 94 STAT. 611. 1980.

Erixon, Fredrik. "The rising trend of green protectionism: Biofuels and the European Union." ECIPE Occasional Paper 2 (2012).

Eskeland, Gunnar S., and Ann E. Harrison. "Moving to greener pastures? Multinationals and the pollution haven hypothesis." *Journal of development economics* 70, no. 1 (2003): 1-23.

Esty, Daniel C. "Bridging the trade-environment divide." *The Journal of Economic Perspectives* 15, no. 3 (2001): 113-130.

Etzioni, Amitai. "The capture theory of regulations—Revisited." Society 46, no. 4 (2009): 319-323.

Evenett, Simon J., and John Whalley. "Resist green protectionism–or pay the price at Copenhagen." The Collapse of Global Trade, Murky Protectionism and the Crisis: Recommendations for the G20 (2009): 93-98.

Ferroukhi, Rabia, Arslan Khalid, Michael Renner and Álvaro López-Peña. *Renewable Energy and Jobs: Annual Review 2016.* Masdar City: International Renewable Energy Agency, 2016.

Fisher, Dana R., Philip Leifeld, and Yoko Iwaki. "Mapping the ideological networks of American climate politics." *Climatic Change* 116, no. 3-4 (2013): 523-545.

Fligstein, Neil. "Markets as politics: A political-cultural approach to market institutions." *American Sociological Review* (1996): 656-673.

Fligstein, Neil. "Social skill and institutional theory." *American Behavioral Scientist* 40, no. 4 (1997): 397-405.

Fligstein, Neil. "Social skill and the theory of fields." *Sociological Theory* 19, no. 2 (2001): 105-125.

Fligstein, Neil. *The architecture of markets: An economic sociology of twenty-first-century capitalist societies*. Princeton: Princeton University Press, 2002.

Frankel, Jeffrey A. "Environmental Effects of International Trade." HKS Faculty Research Working Paper Series RWP09-006 (2009).

Frankel, Jeffrey A., and Andrew K. Rose. "Is trade good or bad for the environment? Sorting out the causality." *Review of Economics and Statistics* 87, no. 1 (2005): 85-91.

Gan, Lin, Gunnar S. Eskeland, and Hans H. Kolshus. "Green electricity market development: Lessons from Europe and the US." *Energy Policy* 35, no. 1 (2007): 144-155.

Garud, Raghu, Sanjay Jain, and Arun Kumaraswamy. "Institutional entrepreneurship in the sponsorship of common technological standards: The case of Sun Microsystems and Java." *Academy of Management Journal* 45, no. 1 (2002): 196-214.

George, Alexander L., and Andrew Bennett. *Case studies and theory development in the social sciences*. (Massachusetts: MIT Press, 2005).

Greenwood, Royston, and Christopher R. Hinings. "Understanding radical organizational change: Bringing together the old and the new institutionalism." *Academy of Management Review* 21, no. 4 (1996): 1022-1054.

Greenwood, Royston, and Roy Suddaby. "Institutional entrepreneurship in mature fields: The big five accounting firms." *Academy of Management Journal* 49, no. 1 (2006): 27-48.

Greenwood, Royston, Roy Suddaby, and Christopher R. Hinings. "Theorizing change: The role of professional associations in the transformation of institutionalized fields." *Academy of Management Journal* 45, no. 1 (2002): 58-80.

Grossman, Gene M., and Alan B. Krueger. *Environmental Impacts of a North American Free Trade Agreement*. No. w3914. National Bureau of Economic Research, 1991.

Harrison, Kathryn. "Ideas and environmental standard‐setting: a comparative study of regulation of the pulp and paper Industry." *Governance* 15, no. 1 (2002): 65-96.

Haveman, Heather A., and Hayagreeva Rao. "Structuring a theory of moral sentiments: institutional and organizational coevolution in the early thrift industry 1." *American Journal of Sociology* 102, no. 6 (1997): 1606-1651.

Heichel, Stephan, Jessica Pape, and Thomas Sommerer. "Is there convergence in convergence research? An overview of empirical studies on policy convergence." *Journal of European Public Policy* 12, no. 5 (2005): 817-840.

Heidenreich, Martin. "The social embeddedness of multinational companies: a literature review." *Socio-Economic Review* (2012): 549-579.

Hirsch, Paul M., and Michael Lounsbury. "Ending the family quarrel toward a reconciliation of "old" and "new" institutionalisms." *American Behavioral Scientist* 40, no. 4 (1997): 406-418.

Hoffman, Andrew J. "Institutional evolution and change: Environmentalism and the US chemical industry." *Academy of Management Journal* 42, no. 4 (1999): 351-371.

Holzinger, Katharina, Christoph Knill, and Bas Arts. *Environmental Policy Convergence in Europe: The impact of international institutions and trade*. (Cambridge: Cambridge University Press, 2008).

Honeyman, Cory, Shayle Kann MJ Shiao, Jade Jones, Austin Perea, Colin Smith, Benjamin Gallagher, Scott Moskowitz, Justin Baca, Shawn Rumery, Aaron Holm, and Katie O'Brien. *U.S. Solar Market Insight Report: 2015, Executive Summary*, Solar Energy Industries Association and GTM Research. 2015.

Howlett, Michael. "The judicialization of Canadian environmental policy, 1980–1990: A test of the Canada-United States convergence thesis." *Canadian Journal of Political Science* 27, no. 01 (1994): 99-127.

Hufbauer, Gary Clyde, and Jared C. Woollacott. *Trade Disputes Between China and the United States: Growing Pains so Far, Worse Ahead?* Peterson Institute for International Economics, Working Paper Series, December 2010.

IEA, IEA Statistics. http://www.iea.org/statistics/

IEA-PVPS, *Trends 2015: In Photovoltaic Applications Executive Summary*, International Energy Agency, 2015. http://www.iea-pvps.org/fileadmin/dam/public/report/national/IEA-PVPS_-_Trends_2015_-_Executive_Summary_-_Final.pdf

IEA-PVPS, *2014 Snapshot of Global PV Markets*, International Energy Agency, 2015. http://www.iea-pvps.org/fileadmin/dam/public/report/technical/PVPS_report_-_A_Snapshot_of_Global_PV_-_1992-2014.pdf

IEA, *The Impact of the Financial and Economic Crisis on Global Energy Investment*, IEA Background paper for the G8 Energy Ministers' Meeting, May 24-25, 2009.

IEA, *Trends 2013 in Photovoltaic Application: Survey Report of Selected IEA Countries between 1992 and 2012*, Report IEA-PVPS T1-23:2013. 2013. http://iea-pvps.org/fileadmin/dam/public/report/statistics/FINAL_TRENDS_v1.02.pdf

IEA, *2016 Renewables Information*, Paris: International Energy Agency, 2016.

IHS Markit. "Leading Solar Module Suppliers Extend Dominance in 2013; Chinese Still on Top," http://press.ihs.com/press-release/design-supply-chain-media/leading-solar-_module-suppliers-extend-dominance-2013-chinese (April 30, 2014).

IEA, *World Energy Outlook 2016*, Paris: IEA. 2016. https://www.iea.org/media/publications/weo/WEO2016Chapter1.pdf.

IEA, "Statistics," http://www.iea.org/statistics/.

IEA, *World Energy Outlook 2009*, Paris: IEA. 2009. http://www.worldenergyoutlook.org/media/weowebsite/2009/WEO2009.pdf.

Jacobs, David. *Renewable energy policy convergence in the EU: the evolution of feed-in tariffs in Germany, Spain and France*. (New York: Routledge, 2016).

Jänicke, Martin. "Conditions for environmental policy success: an international comparison." *Environmentalist* 12, no. 1 (1992): 47-58.

Johnson, Anna, and Staffan Jacobsson. "Inducement and blocking mechanisms in the development of a new industry: the case of renewable energy technology in Sweden." *Technology and the market: demand, users and innovation*, Edward Elgar, Cheltenham (2001): 89-111.

Kann, Shayle, MJ Shiao, Shyam Mehta, Cory Honeyman, Nicole Litvak, Jade Jones, Justin Baca, Will Lent, and Shawn Rumery. *U.S. Solar Market Insight Report: 2013, Executive Summary*, Solar Energy Industries Association and GTM Research. 2013.

Kann, Shayle, MJ Shiao, Cory Honeyman, Nicole Litvak, Jade Jones, Leandra Cooper, Tom Kimbis, Justin Baca, Shawn Rumery, and Aaron Holm, "U.S. Solar Market Insight Report, Q1 2015, Executive Summary" Greentech Media and Solar Energy Industries Association, 2015.

Kann, Shayle, MJ Shiao, Cory Honeyman, Nicole Litvak, Jade Jones, Leandra Cooper, Tom Kimbis, Justin Baca, Shawn Rumery, and Aaron Holm. *U.S. Solar Market Insight Report: 2014, Executive Summary*, Solar Energy Industries Association and GTM Research. 2014.

Kann, Shayle, MJ Shiao, Shyam Mehta, Cory Honeyman, Nicole Litvak, Jade Jones, Justin Baca, Will Lent, and Shawn Rumery. "U.S. Solar Market Insight Report, 2013 Year-in-Review, Executive Summary," Greentech Media and Solar Energy Industries Association, 2014.

Kann, Shayle, Shyam Mehta, MJ Shiao, Andrew Krulewitz, Carolyn Campbell, Scott

Burger, Nicole Litvak, Justin Baca, Will Lent, and Shawn Rumery. *U.S. Solar Market Insight Report: 2012, Executive Summary*, Solar Energy Industries Association and GTM Research. 2012.

Kearsley, Aaron, and Mary Riddel. "A further inquiry into the Pollution Haven Hypothesis and the Environmental Kuznets Curve." *Ecological Economics* 69, no. 4 (2010): 905-919.

Kee, Hiau Looi, Cristina Neagu, and Alessandro Nicita. "Is protectionism on the rise? Assessing national trade policies during the crisis of 2008." *Review of Economics and Statistics* 95, no. 1 (2013): 342-346.

Kern, Kristine, Helge Jörgens, and Martin Jänicke. "The diffusion of environmental policy innovations: a contribution to the globalisation of environmental policy." WZB Discussion Paper, No. FS II 01-302 (2001).

Khwaja, Asim Ijaz, and Atif Mian. "Do lenders favor politically connected firms? Rent provision in an emerging financial market." *The Quarterly Journal of Economics* (2005): 1371-1411.

Kim, Je-Nam, A Study on Revitalization of Citizens' Participatory Renewable Energy, , Parliamentary audit package, 2014-P-1.

Kimbis, Tom, Scott Fenn, Justin Baca, Will Lent, Shawn Rumery, Mari Hernandez,,Shayle Kann, Shyam Mehta, MJ Shiao, Andrew Krulewitz, and Carolyn Campbell. *U.S. Solar Market Insight Report: 2011, Executive Summary*, Solar Energy Industries Association and GTM Research. 2011.

Konisky, David M. "Regulatory competition and environmental enforcement: Is there a race to the bottom?." *American Journal of Political Science* 51, no. 4 (2007): 853-872.

Korea Photovoltaic Industry Association, "Search for member companies," http://www.kopia.asia/bbs/member_detail_search.php (accessed June 7, 2015)

Korea Photovoltaic Industry Association, "Status and Forecast of Solar PV Industry," December 16th, 2013.

Korea Photovoltaic Industry Association. "Status and Future of Solar PV Industry,", June 24th 2011.

Korea Photovoltaic Industry Association. "The Status of Solar PV Industry and the Tasks for Domestic Industry,"August 20th, 2015.

Korea Power Exchange. "REC Trading System," http://rec.kpx.info/index.jsp

Kostova, Tatiana, Kendall Roth, and Tina M. Dacin. "Institutional theory in the study of multinational corporations: A critique and new directions." *Academy of Management Review* 33, no. 4 (2008): 994-1006.

Laffont, Jean-Jacques, and Jean Tirole. "The politics of government decision-making: A theory of regulatory capture." *The Quarterly Journal of Economics* (1991): 1089-1127.

Lajili, Kaouthar, and Daniel Zéghal. "A content analysis of risk management disclosures in Canadian annual reports." *Canadian Journal of Administrative Sciences/Revue Canadienne des Sciences de l'Administration* 22, no. 2 (2005): 125-142.

Lawrence, Thomas B., Cynthia Hardy, and Nelson Phillips. "Institutional effects of interorganizational collaboration: The emergence of proto-institutions." *Academy of Management Journal 45,* no. 1 (2002): 281-290.

Lazzari, Salvatore. "Energy Tax Policy: History and Current Issues," CRS Report for Congress RL33578, 2008.

Leifeld, Philip, "Discourse Network Analyzer manual," 2012. http://www.philipleifeld.de/discourse-network-analyzer-dna/manual/manual.html.

Leifeld, Philip, and Sebastian Haunss. "Political discourse networks and the conflict over software patents in Europe." *European Journal of Political Research* 51, no. 3 (2012): 382-409.

Leifeld, Philip, and Sebastian Haunss. "Political discourse networks and the conflict over software patents in Europe." *European Journal of Political Research* 51, no. 3 (2012): 382-409.

Levihn, Fabian, Cali Nuur, and Henrik Blomgren. "Corporate response to climate change mitigation: What can we learn from annual reports of European industries?" *International Journal of Industrial Engineering and Management* 2, no. 3 (2011): 77-86.

Levy, David, and Maureen Scully. "The institutional entrepreneur as modern prince: The strategic face of power in contested fields." *Organization Studies* 28, no. 7 (2007): 971-991.

Lewis, Joanna I. " The Rise of Renewable Energy Protectionism: Emerging Trade Conflicts and Implications for Low Carbon Development." *Global Environmental Politics* (2014); 10-35.

Lewis, Joanna I., and Ryan H. Wiser. "Fostering a renewable energy technology industry: An international comparison of wind industry policy support mechanisms," *Energy policy* 35, no. 3 (2007): 1844-1857

Liebreich, Michael, "Global Trends in Clean Energy Investment," Bloomberg EMEA Summit, London, October 12, 2015.

Liebreich, Michael. "Bloomberg New Energy Finance Summit, Presentation, New York, 23 April, 2013.

Lopez, Anthony, Billy Roberts, Donna Heimiller, Nate Blair, and Gian Porro. *U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis.* NREL/TP-6A20-51946. 2012.

Lounsbury, Michael, Heather Geraci, and Ronit Waismel-Manor, "Policy Discourse, Logics, and Practice Standards: Centralizing the Solid-Waste Management Field," in *Organizations, Policy, and the Natural Environment*, ed. Andrew Hoffman and Marc Ventresca (California: Stanford University Press, 2002): 327-342.

Lund, Peter D. "Effects of energy policies on industry expansion in renewable energy." *Renewable Energy* 34, no. 1 (2009): 53-64.

Maguire, Steve, Cynthia Hardy, and Thomas B. Lawrence. "Institutional entrepreneurship in emerging fields: HIV/AIDS treatment advocacy in Canada." *Academy of Management Journal* 47, no. 5 (2004): 657-679.

Management Information Services, *60 Years of Energy Incentives: Analysis of Federal Expenditures for Energy Development*, Washington DC: Management Information Services, 2011.

Meijer, Ineke SM, Marko P. Hekkert, and Joop FM Koppenjan. "How perceived uncertainties influence transitions; the case of micro-CHP in the Netherlands." *Technological Forecasting and Social Change* 74, no. 4 (2007): 519-537.

Meyer, John W., and Brian Rowan. "Institutionalized organizations: Formal structure as myth and ceremony." *American Journal of Sociology* (1977): 340-363.

Millimet, Daniel L., and Jayjit Roy. "Empirical tests of the pollution haven hypothesis when environmental regulation is endogenous." Journal of Applied Econometrics (2015).

Ministry of Government Legislation, Laws on Green Growth in Korea, 11-1170000-000341-14, 2009.

Ministry of Industry, Trade, and Energy, The Fourth Basic Plan for New and Renewable Energy, September 2014.

Ministry of Knowledge Economy and Korea Energy Management Corporation. *2012 New and Renewable Energy White Paper*. 2012.

Ministry of Knowledge Economy and Korea Energy Management Corporation. *2005 New and Renewable Energy White Paper*. 2006.

Ministry of Knowledge Economy, "Announcement of the revision of the feed-in tariff for the solar photovoltaic," *Press Release* (April 26, 2008)

Ministry of Knowledge Economy, "Establish 2009 Implementation Plan of New and Renewable Energy," *Press Release* (April 30, 2009)

Ministry of Knowledge Economy, "Investing 40,000 billion KRW, Becoming the fifth largest renewable energy economy by 2015," *Press Release* (October 13, 2010)

Ministry of Knowledge Economy, “Promoting New and Renewable Energy as a New Growth Engine,” *Press Release*, (July 29, 2008)

Ministry of Knowledge Economy, “The Enforcement Decree of the Act on the Promotion of the Development, Use and Diffusion of New and Renewable Energy,” (September 17, 2010)

Ministry of Knowledge Economy, “The Plans to Strengthen the Industry Infrastructure for New and Renewable Energy,” August 2009.

Ministry of Knowledge Economy, “Third Basic Plan for Technology Development, Application, and Deployment of New and Renewable Energy,” December 2012.

Ministry of Trade, Industry, and Energy and Korea Energy Agency. *New and Renewable Energy Statistics 2014*. Yongin: Korean Energy Agency, 2015.

Ministry of Trade, Industry, and Energy, “Making a stepping stone for taking off new and renewable energy,” *Press Release*, October 27, 2013.

Mio, Chiara, and Andrea Venturelli. "Non-financial Information About Sustainable Development and Environmental Policy in the Annual Reports of Listed Companies: Evidence from Italy and the UK." *Corporate Social Responsibility and Environmental Management* 20, no. 6 (2013): 340-358.

Moe, Espen. "Vested interests, energy efficiency and renewables in Japan," *Energy Policy* 40 (2012): 260-273.

New and Renewable Energy Korea. “Industry Statistics,” New and Renewable Energy Korea, https://www.renewableenergy.or.kr/spc/stats/indust_hard/selectIndustHard.do?searchSttstcsSeCode=NR0099&searchStartYear=2014&searchEndYear=2014. (accessed June 20, 2016)

Niskala, Mikael, and Michael Pretes. "Environmental reporting in Finland: A note on the use of annual reports." *Accounting, Organizations and Society* 20, no. 6 (1995): 457-466.

North, Douglass C. *Understanding the process of economic change*. (New Delhi: Academic Foundation, 2006.)

O'Sullivan, Niamh, and Brendan O'Dwyer. "The structuration of issue-based fields: Social accountability, social movements and the Equator Principles issue-based field." *Accounting, Organizations and Society* 43 (2015): 33-55.

Oliver, Christine. "Strategic responses to institutional processes." *Academy of Management Review* 16, no. 1 (1991): 145-179.

Pethig, Rüdiger. "Pollution, welfare, and environmental policy in the theory of comparative advantage." *Journal of Environmental Economics and Management* 2, no. 3 (1976): 160-169.

Platzer, Michaela. "U.S. Solar Photovoltaic Manufacturing: Industry Trends, Global Competition," Federal Support, January 27, 2015.

Policy Briefing. "Policy Information Archive," http://www.korea.kr/archive/ (accessed May 7, 2016) (in Korean)

Potoski, Matthew. "Clean air federalism: Do states race to the bottom?." *Public Administration Review* 61, no. 3 (2001): 335-343.

Prakash, Aseem, and Matthew Potoski. "Racing to the bottom? Trade, environmental governance, and ISO 14001." *American Journal of Political Science* 50, no. 2 (2006): 350-364.

REN 21, *Renewables 2009: Global Status Report*, Paris: Renewable Energy Policy

Network for the 21st Century, 2009.

REN 21, *Renewables 2010: Global Status Report*, Paris: Renewable Energy Policy Network for the 21st Century, 2010.

REN 21, *Renewables 2011: Global Status Report*, Paris: Renewable Energy Policy Network for the 21st Century, 2011.

REN 21, *Renewables 2012: Global Status Report*, Paris: Renewable Energy Policy Network for the 21st Century, 2012.

REN 21, *Renewables 2013: Global Status Report*, Paris: Renewable Energy Policy Network for the 21st Century, 2013.

REN 21, *Renewables 2014: Global Status Report*, Paris: Renewable Energy Policy Network for the 21st Century, 2014.

REN 21, *Renewables 2015: Global Status Report*, Paris: Renewable Energy Policy Network for the 21st Century, 2015.

REN 21, *Renewables 2016: Global Status Report*, Paris: Renewable Energy Policy Network for the 21st Century, 2016.

Renewable Energy Focus magazine, http://www.renewableenergyfocus.com.

Renewable Energy World. "2015 Top Ten PV Cell Manufacturers", Renewable Energy World. http://www.renewableenergyworld.com/articles/2016/04/2015-top-ten-pv-cell- manufacturers.html, April 8, 2016.

Reppelin-Hill, Valerie. "Trade and environment: An empirical analysis of the technology effect in the steel industry." *Journal of Environmental Economics and Management* 38, no. 3 (1999): 283-301.

Riaz, Suhaib. "The global financial crisis: an institutional theory analysis." *Critical Perspectives on International Business* 5, no. 1/2 (2009): 26-35.

Scott , John, 1991. *Social Network Analysis : a handbook*, (London: SAGE Publications, 1991)

Seo, Myeong-Gu, and WE Douglas Creed. "Institutional contradictions, praxis, and institutional change: A dialectical perspective." *Academy of Management Review* 27, no. 2 (2002): 222-247.

Solar Energy Industries Association. "Membership Directory," http://www.seia.org/directory (accessed November 7, 2015)

Solar Energy Research, Development, and Demonstration Act of 1974, Public Law 93-473. 88 Stat.1431. 1974.

Solar Photovoltaic Energy Research, Development, Photovoltaic and Demonstration Act of 1978, Public Law 95-590. 92 Stat. 2513. 1978.

Spiller, Pablo T., and Mariano Tommasi. "The institutions of regulation: An application to public utilities." In *Handbook of New Institutional Economics*, (Springer, 2005). 515-543.

Stemler, Steve. "An overview of content analysis." *Practical Assessment, Research & Evaluation* 7, no. 17 (2001): 137-146.

Stern, David I. "Explaining changes in global sulfur emissions: an econometric decomposition approach." *Ecological Economics* 42, no. 1 (2002): 201-220.

Stern, David I. "Progress on the environmental Kuznets curve?." *Environment and Development Economics* 3, no. 02 (1998): 173-196.

Stigler, George J. "The theory of economic regulation." *The Bell Journal of Economics and Management Science* (1971): 3-21.

Stoddart, Mark CJ, and David B. Tindall. "Canadian news media and the cultural dynamics of multilevel climate governance." *Environmental Politics* 24, no. 3 (2015): 401-422.

Suri, Vivek, and Duane Chapman. "Economic growth, trade and energy: implications for the environmental Kuznets curve." *Ecological Economics* 25, no. 2 (1998): 195-208.

Taylor, Michael, Kathleen Daniel, Andrei Ilas and Eun Young So. *Renewable Power Generation Cost in 2014*, Masdar City: IRENA, January 2015. https://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Power_Costs_2014_report.pdf.

The Solar Foundation, *National Solar Jobs Census 2015*, Washington DC: The Solar Foundation, 2016.

The World Bank, "World Bank Open Data", http://data.worldbank.org (accessed October 10, 2016)

United Nations, UN Comtrade Database. https://comtrade.un.org/data/

U.S. Department of Commerce, "Crystalline Silicon Photovoltaic Cells and Modules From China," 77 Federal Register 235 (December 6, 2012)

US International Trade Commission. "The USITC Interactive Tariff and Trade DataWeb," https://dataweb.usitc.gov/scripts/user_set.asp. (accessed April 25, 2016)

Van Wijk, Jakomijn, Wouter Stam, Tom Elfring, Charlene Zietsma, and Frank Den Hond. "Activists and incumbents structuring change: The interplay of agency, culture, and networks in field evolution." *Academy of Management Journal* 56, no. 2 (2013): 358-386.

Vogel, David. *Trading up: Consumer and environmental regulation in a global economy*. Harvard University Press, 2009.

Voituriez, Tancrède, and Xin Wang. "Real challenges behind the EU–China PV trade dispute settlement." *Climate Policy* 15, no. 5 (2015): 670-677.

Waller, David S., and Roman Lanis. "Corporate social responsibility (CSR) disclosure of advertising agencies: an exploratory analysis of six holding companies' annual reports." *Journal of Advertising* 38, no. 1 (2009): 109-122.

Wasserman, Stanley and Faust, Katherine, *Social Network Analysis: Methods and Applications* 19th ed., (New York: Cambridge University Press, 1994).

Weber, Robert Philip. *Basic Content Analysis*. No. 49. (London: Sage, 1990).

Wesoff, E., 2014. "Rest in Peace: The Fallen Solar Companies of 2014," http://www.greentechmedia.com/articles/read/Honoring-the-fallen-solar-soldiers (December 1, 2014)

Whiteman, Adrian, Tobias Rinke, Javier Esparrago and Samah Elsayed. *Renewables Capacity Statistics 2016.* Masdar City: International Renewable Energy Agency, 2016.

Wiley Rein. "U.S. Solar Industry Files Antidumping and Countervailing Duty Cases Against Imports of Solar Cells and Modules from China," http://www.wileyrein.com/newsroom-pressreleases-555.html (October 19, 2011)

World Trade Organization, “Index of Dispute Issues,” https://www.wto.org/english/tratop_e/dispu_e/dispu_subjects_index_e.htm (accessed October 10, 2016).

World Trade Organization, “Disputes by country/territory.” https://www.wto.org/english/tratop_e/dispu_e/dispu_by_country_e.htm (accessed March 30, 2017)

Wyden, Ron. “International trade in Environmental Goods 2012 Report: Losing the Environmental Goods Economy to China,” February 28, 2012. https://www.wyden.senate.gov/imo/media/doc/02282012-Environmental-Goods-China-Trade-Report.pdf

Yin, Robert K. *Case Study Research: Design and Methods*. Sage publications, 2013.

Zhao, Zhen-Yu, Jian Zuo, Lei-Lei Fan, and George Zillante. "Impacts of renewable energy regulations on the structure of power generation in China–a critical analysis," *Renewable Energy* 36, no. 1 (2011): 24-30.

Zietsma, Charlene, Peter Groenewegen, Danielle Logue, and Cr Hinings. "Field or fields? Building the scaffolding for cumulation of research on institutional fields." *Academy of Management Annals* (2016).