UNIVERSITY OF MESSINA

DEPARTMENT OF ECONOMICS

PH. D. IN ECONOMICS, MANAGEMENT AND STATISTICS

XXXII CYCLE

ECOLOGICAL INNOVATION & REVERSE INNOVATION: THE CASE OF CHINA

Candidate:

SUMIT ROY

Supervisors:

Prof. FABRIZIO CESARONI

Prof. GIUSEPPE IOPPOLO

A. Y. 2018-2019

ACKNOWLEDGEMENTS

I started this PhD program with a lot of hopes and I must admit that it turned out to be better than what I had hoped. Since the beginning of this PhD program, I was confused about how to approach everyday challenges. I used to make plans to follow a certain way for research then after a discussion the direction changes. And then, after reading 3 more papers, the direction changes again. Fortunately, I had wonderful people around me from the beginning who, despite my confusions, were always there to help me in the best of their capacity. My supervisor, Prof. Fabrizio Cesaroni has not only been an excellent supervisor but also a friend who advised, guided and helped me to face all the challenges during these three years. He was always available for me during these years and kept stimulating me to explore more and be motivated. I can't thank him enough for all his help and encouragements.

I also express my appreciation to Prof. Giuseppe Ioppolo who had been my co-supervisor. He introduced and included me in a project that provided me with this brilliant opportunity to spend a year in China at Tsinghua University. He encouraged me to participate in academic events and summer schools and had been instrumental in introducing me to lots of researchers from all over the world.

During my three years in PhD, I spent one year at Tsinghua University, Beijing China. I am grateful to Prof. Shi Lei for inviting me to spend time at Tsinghua University. He had been my guide and mentor in China. He introduced me to different groups and industrial parks which has been instrumental for my work. Also, he provided me with the opportunity to be part of his team when he organized the international conference on industrial ecology.

Apart from work, to go and live in China is a challenge. I am very thankful to all my friends there, specially Cong Wei, who has been there to help me with practically everything be it work or daily life. I also extend my gratitude to my colleagues at Tsinghua for their suggestions, our weekly presentations and deep research discussions. I would extend my special thanks to all researchers who made extra effort to make

presentations in English in order for me to understand. I could not imagine my life in China without the help I got from Prof. Shi's team Houlin, Robin, Doryn and MingXing, who helped me to ease my life at university.

I would also like to thank all the other professors in our department at the University of Messina, especially our PhD coordinator Prof. Edoardo Otranto, who always communicated with us about upcoming opportunities and seminars. He guided and helped me through the bureaucratic procedures for applications. Moreover, I extend my thanks to Dr Maria Cristina Cinici who helped me to learn the methods and tools of research helpful for my work.

I also express my gratitude to all my colleagues who always made me feel that I wasn't alone. I was lucky to get great colleagues in my office as well who always helped me and were there to listen to my complaints. I thank Antonio for his suggestions and research discussions. And I thank Valeria Schifilliti and Valeria Naciti for their constant presence for everything. They not only helped me with my work but have been my closest friends and my family in Italy.

My parents have an impact on every aspect of my life. Their trust in their children has been a tremendous source of inspiration. My father who always encouraged me to go further and explore more. And my mother for again letting me go away so far from home. She always looks forward to me to visit home.

Contents

Chapter 1

Introduction

Innovation is something that is new. Business innovation is a novelty introduced to a business system in the form of a product, process or business method, organization structure or new marketing plan. (OECD 2005) defined innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practice". The important point to notice here is that it must be something new.

When we talk about ecological innovation or reverse innovation from a business perspective, we are going to introduce something new. Simply defining, ecological innovation or eco-innovation is a new activity that will somehow directly or indirectly reduce the harmful impact on the environment. One widely accepted definition is given by Kemp and Pearson (2007) "Eco-innovation is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives."

Discussing the drivers of eco-innovation (Horbach 2008) emphasize the importance of research and development adding that R&D brings technological capabilities ("knowledge capital") which is very important for environmental innovation. Further, (De Marchi 2012) have given view on importance of partnerships and R&D cooperation for environmental innovation. Later, (Karakaya, Hidalgo, and Nuur 2014) provided finding on diffusion of eco-innovation, firstly pointing out the importance of it and then saying that market hypothesis, sustainable transitions and the ecological modernization are research streams to understand diffusion of eco-innovation.

Talking about the diffusion of innovation, when the innovation happens to originate from an emerging market and diffuses to a developed market, then it is termed as reverse innovation. Defined by (Govindarajan and Ramamurti 2011; Govindarajan and Trimble 2012) reverse innovation is an innovation adopted first in emerging economies before moving to rich countries or developed economies. Countries with emerging economies are not just large market but a source of innovation. As explained by (Corsi,

Di Minin, and Piccaluga 2014; Von Zedtwitz et al. 2015) an innovation coming from the emerging economy can be so influential that it can be a disruptive innovation in developed countries.

Our research deals with both the concepts in an inclusive manner. Since we are talking about innovation (eco-innovation and reverse innovation) and emerging markets, this research is very much focused on innovations originating from China. During our study, we also try to find a common ground where eco-innovation diffuses from an emerging economy to a developed economy. And we do a detailed study on a mix of Chinese firms and multinationals operating in China evaluating the attributes responsible for eco-innovation.

Research Motivations

We intend to provide a comprehensive study of eco-innovation in China and see if it fits the paradigm of reverse innovation. Our aim has three aspects; firstly, we want to show the research direction on the concepts on eco-innovation and reverse innovation along with the key terms and authors in this field. Secondly, we intend to define a common area between eco-innovation and reverse innovation implying the reverse transfer of eco-innovation. And thirdly, we want to show what brings out the environment performance or eco-innovation in Chinese firms.

Structure of the Thesis

The whole thesis is organized in four chapters wherein three chapters (Chapter 2, Chapter 3, and Chapter4) are three research papers developed during my three-year doctoral program at the University of Messina.

Chapter 2: This chapter includes literature review papers explaining the concepts of eco-innovation and reverse innovation in detail. I

Chapter 3 is a case study paper titles “Reverse Innovation with Environmental Benefits: A case study of multinational firms operating in China”, where we have provided an extension to the concept of reverse innovation as given by (Govindarajan 2017; Govindarajan and Euchner 2012), using the high growth potential of emerging markets (Agarwal and Brem 2012) to explain the emergence of eco-innovation originating from China.

Chapter 4 is a paper titled "Determinants of Eco-Innovation: Environment performance outcome in Chinese firms". It is the study of a mix of 57 Chinese and multinational firms mostly situated in industrial parks in South-East China. We identify the conditions responsible for the eco-innovation in these firms and determine what factors bring out the eco-innovation.

Contributions

This thesis contributes to the research stream of both eco-innovation and reverse innovation with a new perspective. We bring forward an idea of eco-innovation happening within the paradigm of reverse innovation. It is a novel approach to deal with these concepts. Moreover, we used new methodology utilizing NVivo 12 for one paper and using fuzzy set techniques along with QCA software for the other paper.

The previous studies about eco-innovation in China (Zeng et al. 2005; Chen, Cheng, and Dai 2017; H. Peng and Liu 2016; Dong et al. 2014) focused on analysing emission reductions, measuring emission reductions, typology of eco-innovation and cleaner production. We extend this research by providing results on the determinants of eco-innovation using primary data from Chinese firms.

References

Agarwal, Nivedita, and Alexander Brem. 2012. "Frugal and Reverse Innovation-Literature Overview and Case Study Insights from a German MNC in India and China." *Proceedings of the 18th International Conference on Engineering, Technology and Innovation*.

Chen, Jun, Jinhua Cheng, and Sheng Dai. 2017. "Regional Eco-Innovation in China: An Analysis of Eco-Innovation Levels and Influencing Factors." *Journal of Cleaner Production* 153 (November 2012): 1–14. https://doi.org/10.1016/j.jclepro.2017.03.141.

Corsi, Simone, Alberto Di Minin, and Andrea Piccaluga. 2014. "Reverse Innovation at Speres: A Case Study in China." *Research-Technology Management* 57 (4): 28–34. https://doi.org/10.5437/08956308X5704215.

Dong, Ying, Xi Wang, Jun Jin, Yuanbo Qiao, and Lei Shi. 2014. "Effects of Eco-Innovation Typology on Its Performance: Empirical Evidence from Chinese Enterprises." *Journal of Engineering and Technology Management - JET-M* 34: 78–98. https://doi.org/10.1016/j.jengtecman.2013.11.001.

Govindarajan, Vijay. 2017. "What Is Reverse Innovation ?," 4–7. http://www.tuck.dartmouth.edu/people/vg/blog?archive/2009/10/what_is_reverse_innovation.htm.

Govindarajan, Vijay, and Jim Euchner. 2012. "Reverse Innovation." *Research-Technology Management* 55 (6): 13–17. https://doi.org/10.5437/08956308x5506003.

Govindarajan, Vijay, and Ravi Ramamurti. 2011. "Reverse Innovation, Emerging Markets, and

Global Strategy." *Global Strategy Journal* 1 (3–4): 191–205. https://doi.org/10.1111/j.2042-5805.2011.00023.x.

Govindarajan, Vijay, and Chris Trimble. 2012. "Reverse Innovation: A Global Growth Strategy That Could Pre-empt Disruption at Home." *Strategy & Leadership* 40 (5): 5–11. https://doi.org/10.1108/10878571211257122.

Horbach, Jens. 2008. "Determinants of Environmental Innovation-New Evidence from German Panel Data Sources." *Research Policy* 37 (1): 163–73. https://doi.org/10.1016/j.respol.2007.08.006.

Karakaya, Emrah, Antonio Hidalgo, and Cali Nuur. 2014. "Diffusion of Eco-Innovations: A Review." *Renewable and Sustainable Energy Reviews* 33: 392–99. https://doi.org/10.1016/j.rser.2014.01.083.

Kemp, René, and Peter Pearson. 2007. "Final Report MEI Project about Measuring Eco-Innovation." *UM Merit, Maastricht* 32 (3): 121–24.

Marchi, Valentina De. 2012. "Environmental Innovation and R&D Cooperation: Empirical Evidence from Spanish Manufacturing Firms." *Research Policy* 41 (3): 614–23. https://doi.org/10.1016/j.respol.2011.10.002.

OECD. 2005. *Oslo Manual*. *Communities*. Vol. Third edit. https://doi.org/10.1787/9789264065659-es.

Peng, Huatao, and Yang Liu. 2016. "A Comprehensive Analysis of Cleaner Production Policies in China." *Journal of Cleaner Production* 135: 1138–49. https://doi.org/10.1016/j.jclepro.2016.06.190.

Zedtwitz, Max Von, Simone Corsi, Peder Veng S??berg, and Romeo Frega. 2015. "A Typology of Reverse Innovation." *Journal of Product Innovation Management* 32 (1): 12–28. https://doi.org/10.1111/jpim.12181.

Zeng, S. X., C. M. Tam, Vivian W.Y. Tam, and Z. M. Deng. 2005. "Towards Implementation of ISO 14001 Environmental Management Systems in Selected Industries in China." *Journal of Cleaner Production* 13 (7): 645–56. https://doi.org/10.1016/j.jclepro.2003.12.009.

Chapter 2

Defining Eco-Innovation and Reverse Innovation: A literature review

Abstract

In this paper, we put together leading literature dealing with ecological innovation and reverse innovation. We try to identify the research patterns, themes and research direction of both of these concepts. We explore how we can put together both of these concepts. Purposefully, we referred to various overlapping literature in order to get the gist of research direction.

Introduction

Eco-innovation had been extensively studied in the last few years. Eco-innovation is defined in many ways by different authors pointing out the similarities it has with general innovation and also defining the uniqueness of eco-innovation. Innovation defined as introduction of any novelty (Kemp and Pearson 2007) and is an ongoing phenomenon.

Eco-innovation is about innovations with lower environmental impact than relevant alternatives. (Arundel and Kemp 2009). So, any new activity which relates to the business process or results in a new product or new use of product which has a lower environmental impact would be considered an eco-innovation. We considered the two most important research approach in the eco-innovation research area are drivers of eco-innovation and diffusion of eco-innovation. (Horbach, Rammer, and Rennings 2012) pointed out that cost saving is one determinant that triggers reverse innovation, later saying that policy regulations are one of the primary drivers of eco-innovation.

Diffusion of eco-innovation is the transfer of eco-innovation knowledge from the source of origin to other places. (Karakaya, Hidalgo, and Nuur 2014) has stressed the position of diffusion of eco-innovation and pointed out the importance of different factors such as characteristics of the innovations, the adopters and the environment in the diffusion of eco-innovation.

While the diffusion of eco-innovation refers to eco-friendly innovation, the diffusion happens for all kinds of innovation. When any innovation originates from an emerging economy or developing country and diffuses to a developed country then it is called as reverse innovation. This term was brought by authors (Govindarajan and Ramamurti 2011; Govindarajan and Trimble 2012) with respect to management science innovation theories. Reverse innovation is comparatively a lesser researched area of innovation in management sciences. It refers to the innovation originating from emerging economies and moving to developed countries. (Govindarajan and Trimble 2012) defined reverse innovation as an innovation adopted first in emerging economies before moving to rich countries or developed economies.

Our paper is aimed at finding the key concepts from selected literature on eco-innovation and reverse innovation. We intend to identify key authors in this field and study the direction of research in recent years.

This paper would provide following contributions; firstly, highlighting the reach of eco-innovation ideas in the academic research community; secondly, providing a review of selective literature covering the recent and relevant eco-innovation studies; thirdly, explaining the concept and movement of reverse innovation, and showing the reach of eco-innovation in the industrial community.

Web of Science database search

To get the idea of the direction of our research topics we started with the web of science (WOS) database search. We did it for both eco-innovation and for reverse innovation separately.

For eco-innovation search, we used the query *(TS = (eco-innovation OR "Green innovation" OR "Ecological Innovation" OR "Eco-Innovation" OR "Environmental innovation")* and searched for the time period from 2010 to 2018.

We used the terms “Eco-Innovation”, “Green innovation” and “Ecological Innovation” interchangeably as they portray the same or similar idea. The WOS database showed 1514 results.

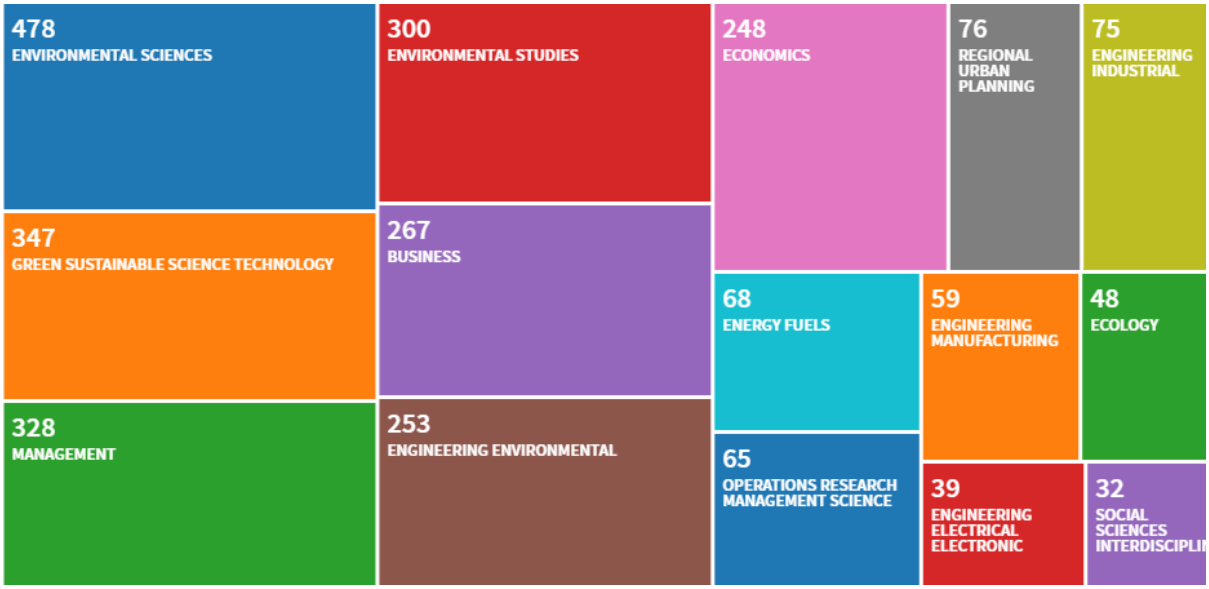


Fig. 1, WOS output: categories. Top 15

Looking at the categories we found most of the work is classified as environmental or green studies, followed by management, business and economics.

Fig.2, Publication journal top 15

By volume, the top journal for publication of eco-innovation work for these years have been the journal of cleaner production, followed by sustainability. Most of the work has been published in journals associated with environment, energy and sustainability. Other is business management and economics.

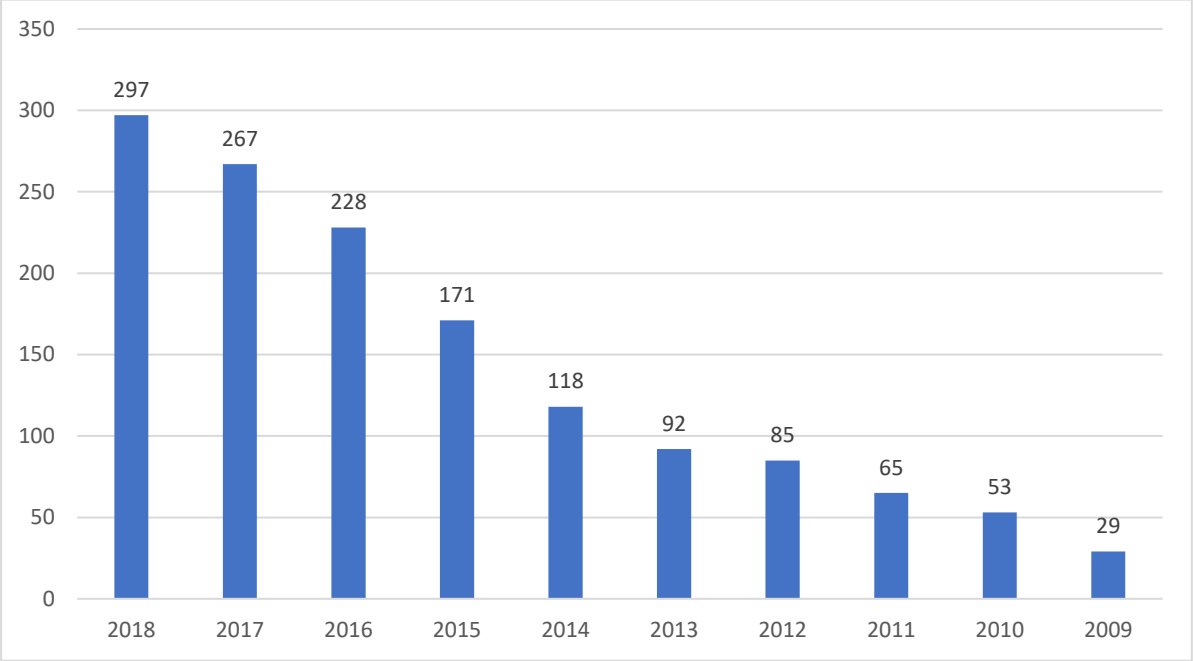


Fig.3, Source: WoS, Publication year

In the last ten years, the publications about eco-innovation have been rising, growing more than 10 times from 2009 to 2018. We also notice that more than 70% of all publications happened in last 5 years only. This growing trend shows that eco-innovation is a growing topic of interest among researchers.

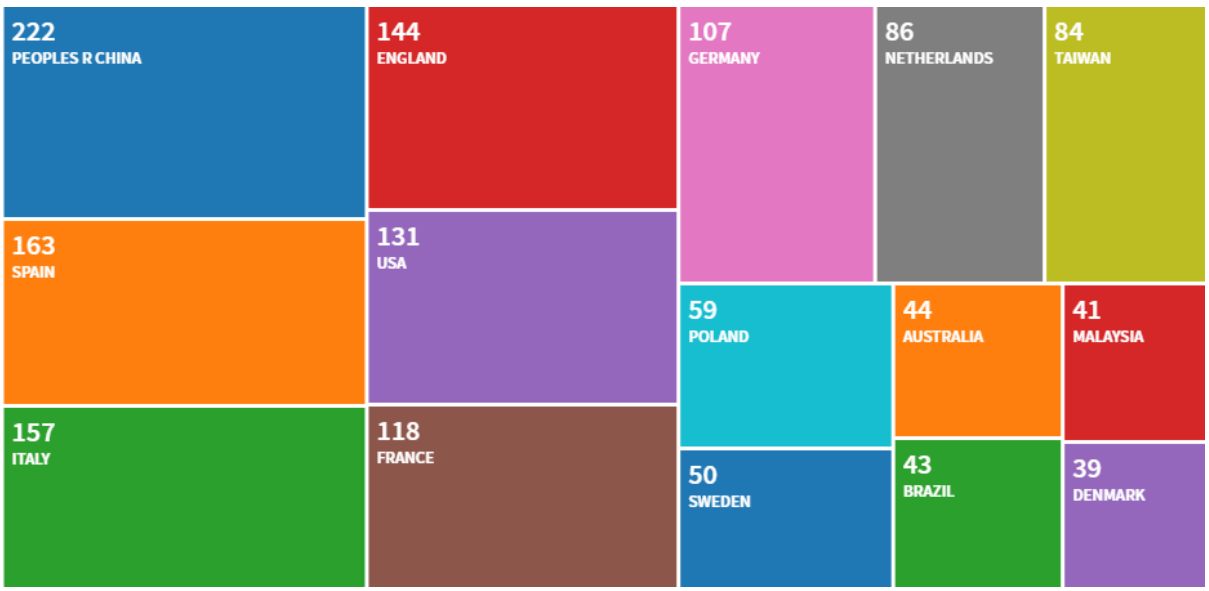


Fig. 4: Countries top 15

A very interesting aspect to notice here is that most of the work in eco-innovation is coming from China. In a separate search, we found that this trend of work originating from China is a recent and growing phenomenon. We further checked for the sources of fund that research centres received to carry on eco-innovation research.

Fig. 5, WoS Output: Funding sources

Most of the articles (951 out of 1514) did not show any link to funding sources. But among 563 articles that were funded for research, we found Chinese agencies as the biggest (about 20%) provider of funds.

We did a similar web of science database search for reverse innovation using the search query (TS= ("Reverse Innovation" OR "Innovation in Reverse" OR Frugal Innovation) for years from 2000 to 2018. The first result that we got was from the year 2007. There is no record of any publication on the WoS database on reverse innovation before 2007. From 2007 to 2018 our results show 243 records. Reverse innovation does not seem to be a highly researched topic but is gaining relevance recently.

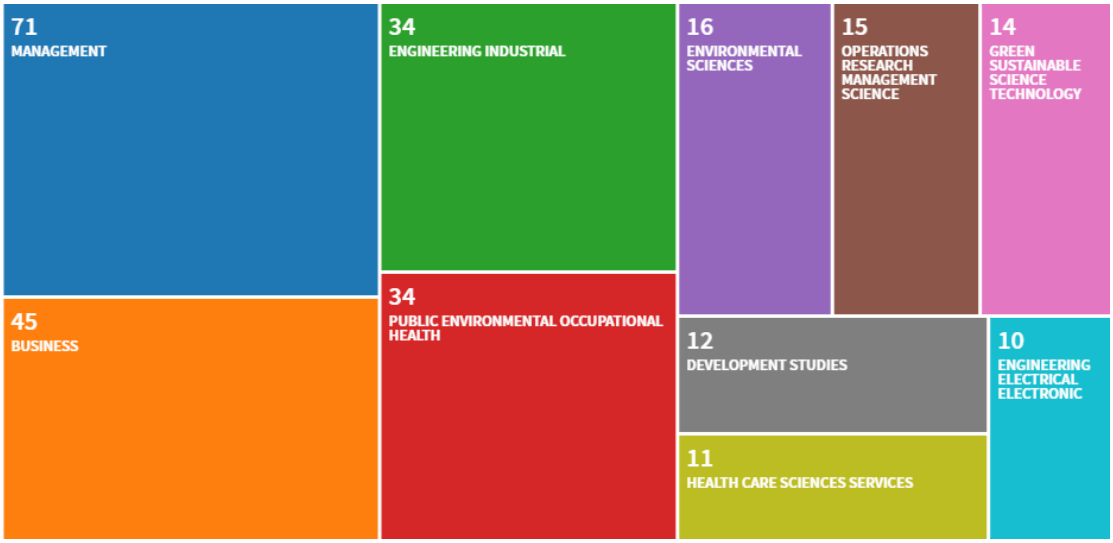


Fig. 6, WoS Output: Category (Reverse Innovation)

Most of the work is in the category of business and management, however, we noticed that many articles on reverse innovation are related to healthcare and clinical studies.

Fig. 7, WoS Output: Source titles (Reverse Innovation)

We further noticed that most of the articles published in the last 10 years are in journal of globalization and health. Although when we look at the research area for all 243 articles, we find that business economics is the most common theme.

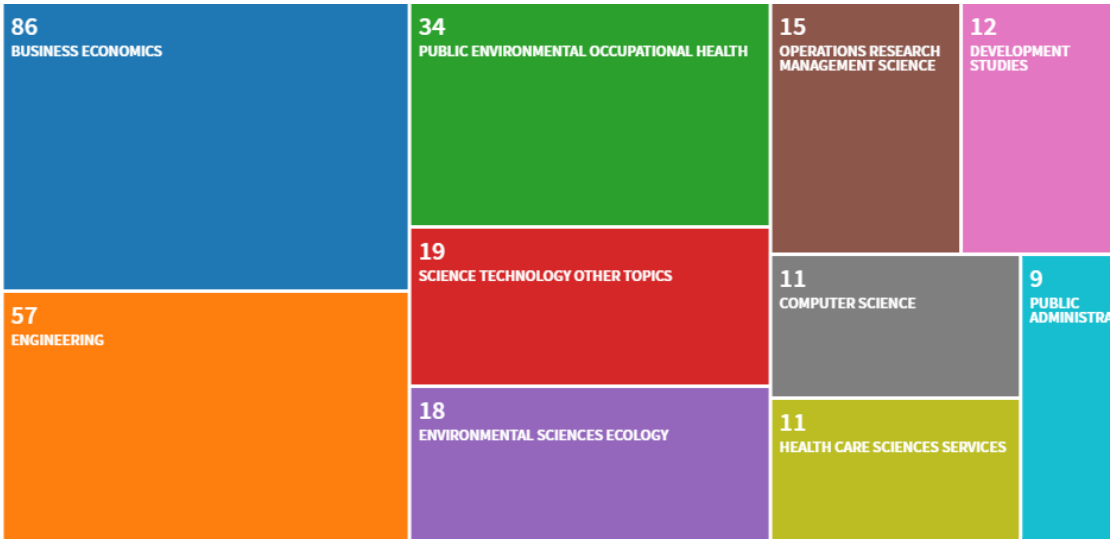


Fig. 8, WoS Output: Research area (Reverse Innovation)

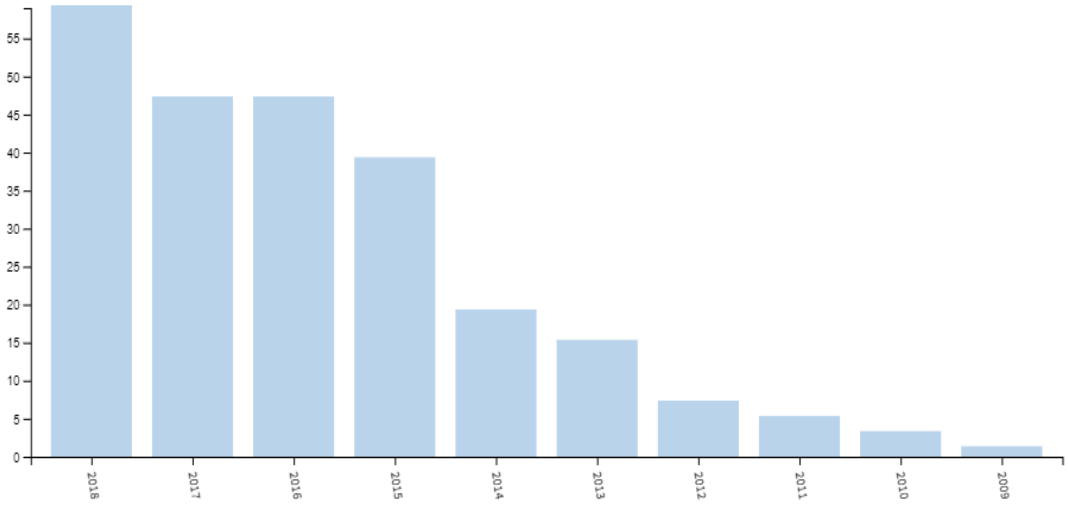


Fig. 9, Source: WoS, Publication year (Reverse Innovation)

Research on reverse innovation is relatively recent. As we saw there is no publication prior to 2007 in the WoS database.

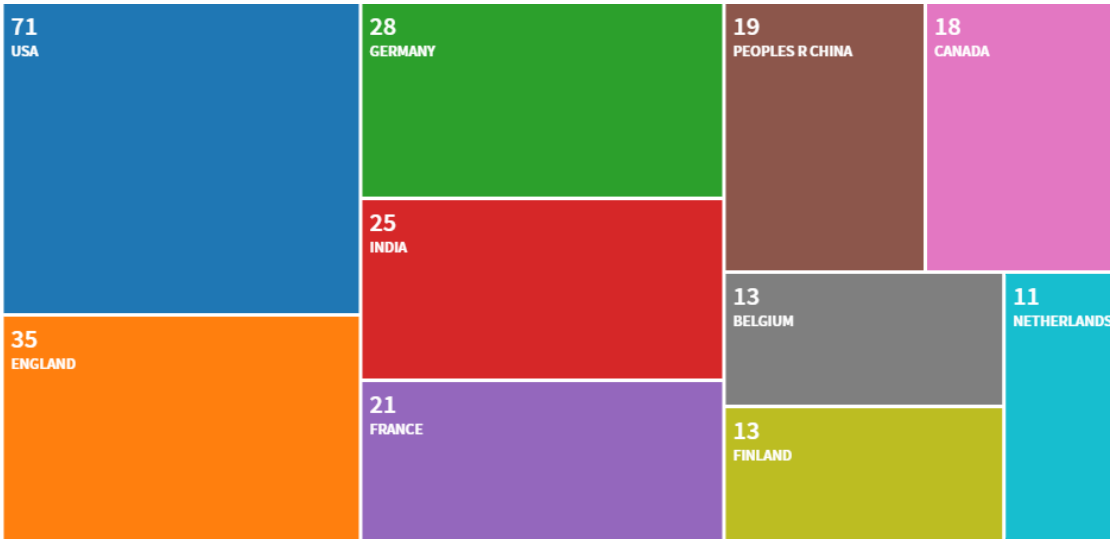


Fig. 10, WoS Output: Countries (Reverse Innovation)

So far, most of all work on reverse innovation has come from North America with the US taking the biggest share. Then there is Europe with England and Germany as the biggest source.

Literature analysis

For eco-innovation, we took 50 recent papers including a couple of papers done on the Chinese context. Further, we also selected 26 papers on reverse innovation. We uploaded these papers on NVivo 12 Plus software to do the detailed analysis.

As we previously noted from the WoS data, China has been the largest source of publication on eco-innovations and certain Chinese agencies as the source of funding for eco-innovation research. Hence, among the 50 papers we used in this analysis, 15 are either originating in China or are focused on eco-innovation in China.

With these selected papers we performed an analysis using NVivo 12 plus. The purpose of the analysis is to find out major authors involved in eco-innovation and reverse innovation research respectively.

NVivo

We used NVivo 12 Plus to perform our analysis. After uploading all the files into the NVivo software, we followed a five-step process to organize the literature in a way that could provide a deeper understanding of the concept.

Step 1: All the files were uploaded from Mendeley after downloading in research information system format (RIS). We organized them in software NVivo in folders. It made it easier to segregate the eco-innovation and reverse innovation files while working further in the software.

Step 2: We filled in the missing information about the uploaded papers and created 'memos' in the software wherever necessary. Like this, we include all the full papers for our analysis, not just the abstracts.

Step 3: Then we ran a text search query "Eco-Innovation" OR "Green innovation" OR "Ecological Innovation" for all files in the eco-innovation folder.

Eco-innovation search query in NVivo: "Ecological Innovation" OR "Eco-Innovation" OR "Environmental Innovation" OR "Green Innovation" OR "sustainable innovation" OR "Environmental product innovation". Searched with broad context coding all paragraph. Broad context is a search feature in NVivo. It means that whenever the search terms were found in any articles, the whole paragraph was coded into the node.

Reverse innovation search query: "Reverse Innovation" OR "Frugal Innovation" OR "Innovation in Reverse" OR "reverse knowledge transfer". Includes search for all reverse innovation articles. Searched with broad context which puts all paragraph for coding.

Step 4: Based on search query results we created respective nodes for eco-innovation and reverse innovation.

Nodes in NVivo are a collection of references about a specific theme, organization place or person. ("NVivo Help Page" n.d.) Nodes help to gather all references to a related material into one place.

Step 5: To identify the main authors in both the concepts we created a chart from the coding showing the number of coding references for each.

Our aim here is to identify the main authors among the papers we selected for our future research. We used this database later on to work on both the concepts in detail.

The first chart (fig.11) shows the main authors in our selected literature of eco-innovation:

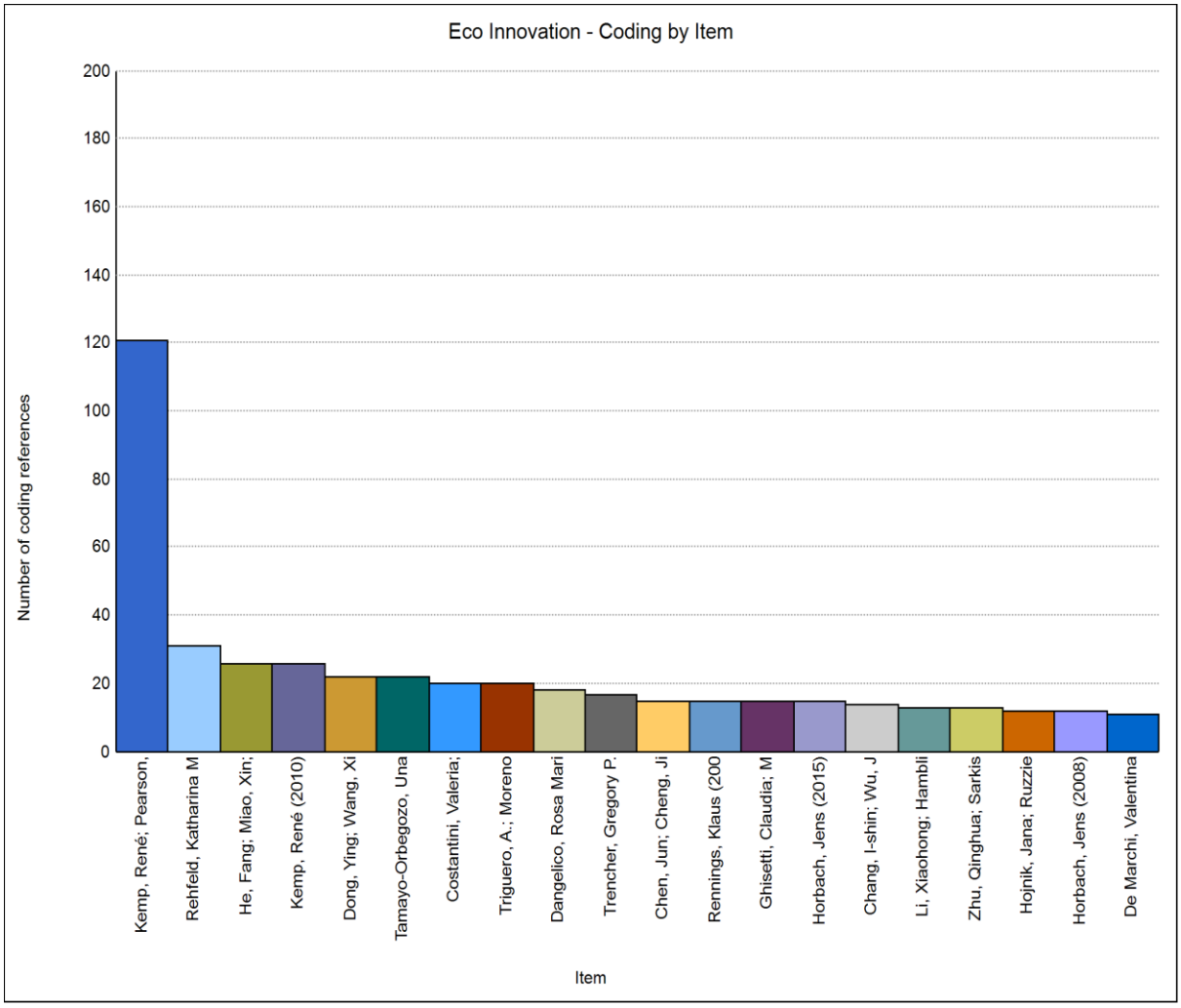


Fig. 11. Eco-Innovation (Authors)

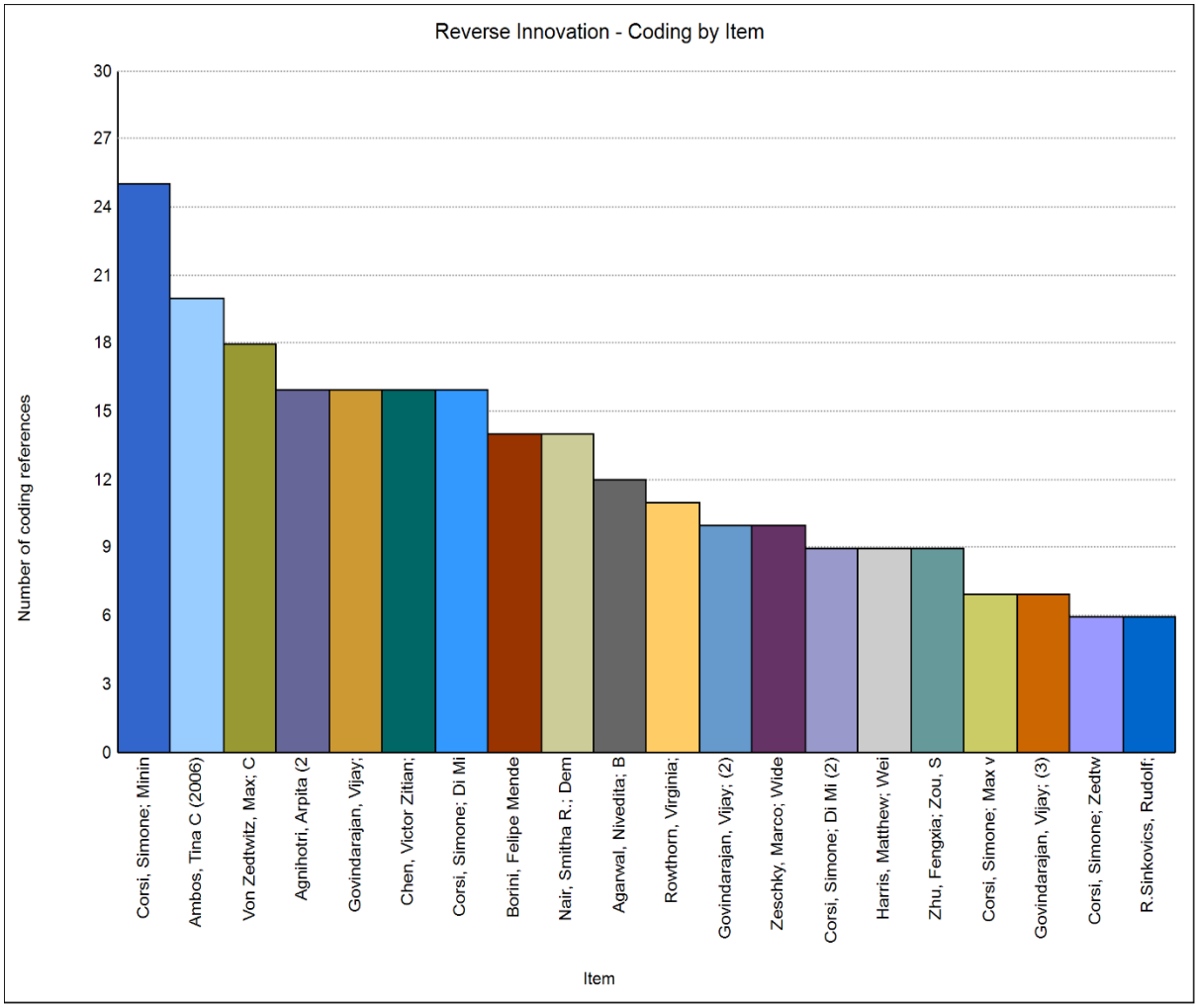


Fig.12 Reverse Innovation (Authors)

Literature

Answering the question that "why should we be interested in eco-innovation and its measurement?" (Arundel and Kemp 2009) have given twin replies. Firstly, the obvious environmental benefits; secondly, the competitiveness of the firms, countries and regions are linked to their ability to 'eco-innovate'. (Horbach 2008) argued that environment management tools and organizational changes and improvements are relevant motivations for eco-innovation.

Eco-innovation in industrial ecology is explained using numerous definitions. In the MEI project for the European Commission eco-innovation is defined as "the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental

risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives". (Kemp and Pearson 2007 p.7)

An alternative version developed by the OECD follows the Oslo Manual by dividing eco-innovations into the product, process, organizational, marketing and institutional innovation (OECD, 2009, forthcoming). It also includes how firms introduce eco-innovations, for instance through modifying existing technology or creating entirely new solutions (OECD, 2008).

Separately (Horbach 2008) has given a detailed study of determinants of eco-innovation classifying all determinants in groups as supply side, demand side and institutional and political influence.

Determinants of environmental innovation

Supply-side	• Technological capabilities • Appropriation problem and market characteristics
Demand-side	• (Expected) market demand (demand-pull hypothesis) • Social awareness of the need for clean production; environmental consciousness and preference for environmentally friendly products
Institutional and political influences	• Environmental policy (incentive-based instruments or regulatory approaches) • Institutional structure: e.g. political opportunities of environmentally oriented groups, organization of information flow, the existence of innovation networks

(Horbach 2008)

Author (Rennings 2000) addressed technological, social and institutional innovation with eco-innovation. He also discussed regulatory effects on eco-innovation emphasizing on the importance of close coordination between environmental policy and eco-innovation policy.

(Kammerer 2008) explained about customer benefit as a determinant for eco-innovation and further supported the importance of policy regulation. (Ghisetti, Marzucchi, and Montresor 2015) argued how crucial are policy instruments for eco-innovation. Further, (Hojnik and Ruzzier 2016) also supported the importance of regulations along with markets factors as important determinants of eco-innovation.

Later, (Pacheco et al. 2017) further identified the critical determinants of eco-innovation as government policy (regulations), resource availability, perception of the strategic relevance, technological advisory, eco-innovation oriented methods, organizational structure and management support, supplier and customer relations as source of innovative ideas; R&D department, cooperation and partnership within supply networks; and Reputation, brand image and profit margin.

Further, a recent study on eco-innovation is China (Cai and Li 2018) gave findings on the determinants of eco-innovation in China, specifying the importance of policy and market factors.

Sor far, we have noticed many authors (Horbach 2008; Rennings 2000; Pacheco et al. 2017; Cai and Li 2018) discussing the policy instruments or regulatory reasons as determinant of eco-innovation. (Bossle et al. 2016) also pointed in their study that policy and regulations are most cited drivers of eco-innovation. Also, the choice and satisfaction of consumers is another driving factor for eco-innovation (Kammerer 2008; Horbach, Rammer, and Rennings 2012; Pacheco et al. 2017). Today's consumer is conscious of the environmental impact of various industrial activities associated with a firm. Their preference clearly incentivises the firms with better environmental goodwill image.

Later authors reasoned about the impact and kinds of eco-innovation. (Rennings 2000) argued that innovation is not only about technology. Innovation included all kinds of organizational, behavioural and institutional change. Authors (Horbach, Rammer, and Rennings 2012) discussed the areas of environmental impact due to eco-innovation, nine areas for process innovation and three areas for product innovation:

- Reduced material use per unit of output
- Reduced energy use per unit of output
- Reduced CO2 emissions
- Reduced emissions of other air pollution
- Reduced water pollution
- Reduced soil pollution
- Reduced noise pollution
- Replacement of hazardous substances
- Recycled waste, water, or materials

The three areas of environmental impact from the aftersales use of a product by its use:

- Reduced energy use
- Reduced air, water, soil or noise emissions
- Improved recycling of products after use

Another approach in this study is the diffusion of eco-innovation. (Karakaya, Hidalgo, and Nuur 2014) highlighted the importance of factors of eco-innovation such as characteristics of the innovations, the adopters and the environment and later argued that lead market hypothesis, sustainable transitions and the ecological modernization appear like some of the relevant leading research streams on the understanding of the diffusion of eco-innovations. Later, authors (Hojnik and Ruzzier 2016) explained the drivers of eco-innovation first during the development phase and later during the diffusion of eco-innovation. Policy and regulations are found to be crucial factors for diffusion of eco-innovation as well, similar to what we notice during development phase. (Brien et al. 2011) also argued about role of policymakers and public administration in implementing a regulatory framework to facilitate the diffusion of eco-innovation. Diffusion of innovation is a result of a mix of factors. (Costantini et al. 2015) in the study of biofuels argued in favour of market factors as "demand-pull" effect and introduction of new technology as "technology push" factor for diffusion. Market pull factors and cost-saving (customer value) are also instrumental during the diffusion of eco-innovation. (Karakaya, Hidalgo, and Nuur 2014; Hojnik and Ruzzier 2016).

All the factors for the diffusion of eco-innovation also work for other innovations. And when this diffusion happens from an emerging economy in a developing country to a developed economy then it is a reverse diffusion of innovation. It is termed as reverse

innovation (Govindarajan and Ramamurti 2011; Govindarajan and Trimble 2012) because traditionally the diffusion of technology, knowledge or innovation happened from developed countries to developing countries.

Obviously, there is a difference between the innovations originating from emerging economies and innovations emerging from developed economies. Innovations occurring in emerging economies tend not to involve technological breakthroughs of the kind that drive innovation in developed countries. (Govindarajan and Ramamurti 2011). Then there are two categories of organizations involved in innovation. There are local firms and there are multinational firms operating through subsidiaries in emerging markets. Multinationals from western countries localize their products and offerings (Agarwal and Brem 2012) to meet the local demand of the market.

Another aspect of reverse innovation is that firms operating in emerging economies are likely to produce low-cost innovations catering to the local market (Govindarajan and Ramamurti 2011). These low-cost innovations are usually more environmentally friendly and resource conservative (Agnihotri 2015) which results due to development in a resource constraint environment. The research & development in emerging economies target local problems and local consumer preferences, and it is important to do so (Govindarajan and Euchner 2012), to understand local problems focus locally and listen to local consumers. Moreover, strong communication between the multinational and its subsidiary (Borini et al. 2012) is critical for the reverse innovation to happen.

References

Agarwal, Nivedita, and Alexander Brem. 2012. "Frugal and Reverse Innovation- Literature Overview and Case Study Insights from a German MNC in India and China." *Proceedings of the 18th International Conference on Engineering, Technology and Innovation*.

Agnihotri, Arpita. 2015. "Low-Cost Innovation in Emerging Markets." *Journal of Strategic Marketing* 23 (5): 399–411. https://doi.org/10.1080/0965254X.2014.970215.

Arundel, Anthony, and René Kemp. 2009. "Measuring Eco-Innovation." *Unu - Merit* 20 (2): 146–146. https://doi.org/10.1111/j.1467-629X.1980.tb00220.x.

Borini, Felipe Mendes, Moacir de Miranda Oliveira, Franciane Freitas Silveira, and

Ronald de Oliveira Concer. 2012. “The Reverse Transfer of Innovation of Foreign Subsidiaries of Brazilian Multinationals.” *European Management Journal* 30 (3): 219–31. https://doi.org/10.1016/j.emj.2012.03.012.

Bossle, Marilia Bonzanini, Marcia Dutra De Barcellos, Luciana Marques Vieira, and Loïc Sauvée. 2016. “The Drivers for Adoption of Eco-Innovation.” *Journal of Cleaner Production* 113: 861–72. https://doi.org/10.1016/j.jclepro.2015.11.033.

Brien, Meghan O, Stefan Giljum, Michal Miedzinski, and Raimund Bleischwitz. 2011. “The Eco-Innovation Challenge: Pathways to a Resource-Efficient Europe,” no. May: 1–124.

Cai, Wugan, and Guangpei Li. 2018. “The Drivers of Eco-Innovation and Its Impact on Performance: Evidence from China.” *Journal of Cleaner Production* 176: 110–18. https://doi.org/10.1016/j.jclepro.2017.12.109.

Chen, Jun, Jinhua Cheng, and Sheng Dai. 2017. “Regional Eco-Innovation in China: An Analysis of Eco-Innovation Levels and Influencing Factors.” *Journal of Cleaner Production* 153 (November 2012): 1–14. https://doi.org/10.1016/j.jclepro.2017.03.141.

Costantini, Valeria, Francesco Crespi, Chiara Martini, and Luca Pennacchio. 2015. “Demand-Pull and Technology-Push Public Support for Eco-Innovation: The Case of the Biofuels Sector.” *Research Policy* 44 (3): 577–95. https://doi.org/10.1016/j.respol.2014.12.011.

Ghisetti, Claudia, Alberto Marzucchi, and Sandro Montresor. 2015. “The Open Eco-Innovation Mode. An Empirical Investigation of Eleven European Countries.” *Research Policy* 44 (5): 1080–93. https://doi.org/10.1016/j.respol.2014.12.001.

Govindarajan, Vijay. 2017. “What Is Reverse Innovation ?,” 4–7. http://www.tuck.dartmouth.edu/people/vg/blog?archive/2009/10/what_is_reverse_innovation.htm.

Govindarajan, Vijay, and Jim Euchner. 2012. “Reverse Innovation.” *Research-Technology Management* 55 (6): 13–17. https://doi.org/10.5437/08956308x5506003.

Govindarajan, Vijay, and Ravi Ramamurti. 2011. “Reverse Innovation, Emerging

Markets, and Global Strategy." *Global Strategy Journal* 1 (3–4): 191–205. https://doi.org/10.1111/j.2042-5805.2011.00023.x.

Govindarajan, Vijay, and Chris Trimble. 2012. "Reverse Innovation: A Global Growth Strategy That Could Pre-empt Disruption at Home." *Strategy & Leadership* 40 (5): 5–11. https://doi.org/10.1108/10878571211257122.

Hojnik, Jana, and Mitja Ruzzier. 2016. "What Drives Eco-Innovation? A Review of an Emerging Literature." *Environmental Innovation and Societal Transitions* 19: 31–41. https://doi.org/10.1016/j.eist.2015.09.006.

Horbach, Jens. 2008. "Determinants of Environmental Innovation-New Evidence from German Panel Data Sources." *Research Policy* 37 (1): 163–73.

Horbach, Jens, Christian Rammer, and Klaus Rennings. 2012. "Determinants of Eco-Innovations by Type of Environmental Impact - The Role of Regulatory Push/Pull, Technology Push and Market Pull." *Ecological Economics* 78: 112–22. https://doi.org/10.1016/j.ecolecon.2012.04.005.

Kammerer, Daniel. 2008. "The Effects of Consumer Benefit and Regulation on Environmental Product Innovation," no. 36.

Karakaya, Emrah, Antonio Hidalgo, and Cali Nuur. 2014. "Diffusion of Eco-Innovations: A Review." *Renewable and Sustainable Energy Reviews* 33: 392–99. https://doi.org/10.1016/j.rser.2014.01.083.

Kemp, René, and Peter Pearson. 2007. "Final Report MEI Project about Measuring Eco-Innovation." *UM Merit, Maastricht* 32 (3): 121–24.

"NVivo Help Page." n.d. Accessed September 9, 2019. http://help-nv10.qsrinternational.com/desktop/welcome/welcome.htm.

Pacheco, Diego Augusto de Jesus, Carla S. ten Caten, Carlos F. Jung, José Luis D. Ribeiro, Helena Victorovna G. Navas, and Virgílio A. Cruz-Machado. 2017. "Eco-Innovation Determinants in Manufacturing SMEs: Systematic Review and Research Directions." *Journal of Cleaner Production* 142: 2277–87. https://doi.org/10.1016/j.jclepro.2016.11.049.

Rennings, Klaus. 2000. "Redefining Innovation - Eco-Innovation Research and the Contribution from Ecological Economics." *Ecological Economics* 32 (2): 319–32. https://doi.org/10.1016/S0921-8009(99)00112-3.

Chapter 3

Reverse Innovation with Environmental Benefits: A case study of multinational firms operating in China

Abstract

This research is about the concept of reverse innovation and its link to ecological innovation. Reverse innovation is the development of new products and processes in emerging markets that then moves or diffuses to developed economies. We perform an inductive study of two international firms operating in the Chinese market. Our study is theoretical and is based on interviews conducted with employees and company information available online. The study shows that there is reverse innovation. And we observe that this reverse innovation turns out to be eco-friendly due to some specific characteristics present in the developing market, and hence be called eco-innovation. We identify three specific characteristics of emerging markets that facilitate the reverse innovation towards eco-innovation: resource constraint, marketplace or cost, and institutional or regulatory, and we call this innovation as reverse eco-innovation. We also observe that other obvious characteristics like partnerships, knowledge transfer are also there in a secondary role. Furthermore, we notice the drivers of reverse innovation in our studied cases.

Introduction

Traditionally the flow of innovation happened from developed economies to emerging economies[1]. But when this happens the other way around i.e. a reverse flow of innovation from emerging economies to developed economies then it is called reverse innovation. A reverse innovation, very simply, is any innovation likely to be adopted first in the developing world (Govindarajan 2017). The innovations in developing economies are focused to serve the local markets, environment and consumer demands.

[1] We use 'emerging economies', 'emerging markets' 'developing countries', and 'developing markets' interchangeably to refer to countries like China, India and other developing Asian and African countries, and likewise 'developed markets', 'developed countries' and 'developed economies' interchangeably to refer to markets of North America, Europe and Japan, as previous literatures have used.

Markets in emerging economies like China and India are demanding low-cost products with reasonable performance with an overall higher value. To keep up with this market demand and local needs, firms in these countries are innovating and coming up with products that are offering usability and performance at a much lower price point as compared to similar product in developed market. Authors (Agarwal and Brem 2012) point out how emerging markets show high growth potential and western organizations are slowly localizing their product development and portfolios to match the needs of entry-level consumers. Localization and innovative approach are offering sustained growth to large multinational firms.

Moreover, innovative processes and business models could help to address the problem of sustainability. Now we see that ecological innovation (product or practices) from emerging markets could be adopted to tackle global sustainability issues. These products, processes (business models) could effectively reduce costs, develop new products, help to meet sustainability targets, etc. Previously, authors (Karakaya, Hidalgo, and Nuur 2014) have discussed the diffusion of eco-innovation. When this diffusion happens from emerging markets towards developed markets then the flow of innovation the same as reverse innovation. Thus, in this situation, inherently putting ecological innovation as reverse innovation. And multinational firms operating in emerging markets are set to use these innovations back in their home country. Firms are also likely to leverage product or technology advantages developed in the emerging markets by bringing products back into its home market (F. Zhu, Zou, and Xu 2017). So, multinationals are poised to utilize the knowledge and technology that they developed in emerging markets back to their home country.

As a result of some specific characteristics of the local markets, which demand specific products at the lower price point and different features the products resulting due to innovations happening in emerging markets are environmentally friendly in nature. In prior research (Agnihotri 2015) has pointed out that as compared to radical and other types of innovation, low-cost innovation is generally more environmentally friendly and resource conservative, as it is simpler in nature.

We studied the companies operating in Chinese markets, as being an emerging market with its fair share of ecological challenges, China qualifies as the best place to study reverse innovation and eco-innovation. Furthermore, previous studies of reverse

innovation in China (Buckley, Clegg, and Tan 2006; M. Peng 2012; Xiaohui and Giroud 2016; R.Sinkovics et al. 2014) have provided insights with discussions ranging from products, strategy and processes; and studies on cleaner production, environmental management; and studies on eco-innovation in China (Zeng et al. 2005; Dong et al. 2014; Wu et al. 2015; H. Peng and Liu 2016; Chen, Cheng, and Dai 2017; He et al. 2018) have given insights on innovation focused on reducing environmental impacts, and later authors discussed on reverse innovation as disruptive innovation (Corsi and Minin 2011; Corsi and Di Minin 2014; Govindarajan and Trimble 2012) talking about more industry and market-based view of reverse innovation. However, there appear to be no studies to observe the specifics of reverse innovation resulting in eco-innovation. We try to bring together the theory of reverse innovation along with ecological innovation and see if with this combination we can look towards the emerging economies as the source of new technologies, products or processes that are eco-friendly in nature. Thus, we try to answer the following question by performing detailed case study on two multinational firms operating in China

How reverse innovation can give rise to eco-innovation? And what are the drivers of reverse innovation that operate in the process?

We conclude by identifying the specific characteristic of emerging markets that facilitate reverse innovation towards eco-innovation.

Reverse Innovation

Reverse innovation is an innovation that originally emerged from a developing market and moved to a developed market. A reverse innovation could be made for the developing market or for the developed market but importantly in always originates from a developing market. Author (Govindarajan 2017) has called it the first half of reverse innovation when products are developed locally for the local market, but at the same time, the firms benefit from their global resource base. And he called the reverse innovation process complete when firms take those innovations and introduce them to the world market.

It has been questioned that why do we need reverse innovation in the first place? We can always get technologies, products, innovations and ideas from developed markets where they already exist. Authors (Govindarajan and Trimble 2012) argued about the pattern of development in emerging economies pointing out at the dissimilar pattern in

addition to local conditions like infrastructures, geographies, cultures, languages and government. Moreover, business leaders accustomed to developed economies fail to understand the needs of developing markets.

Authors (Govindarajan and Trimble 2012) have defined five 'need gaps' that distinguish developed economies from developing economies, and these gaps provide a starting point to reverse innovate.

1. Performance gap: In developed markets products offer higher performance at a higher price whereas developing markets demand products necessarily at a lower price with customised (lower) performance product.
2. The infrastructure gap: Developed countries have an extensive infrastructure in place. New product developments take advantage of it. In developing countries infrastructure is usually absent and when it is there it is new and cutting edge. In both cases, products need to develop differently.
3. The sustainability gap: Environment concern of economic activities is not uniform all over the world. Take an example of air pollution in New Delhi or in Beijing. Moreover, it would be disastrous if the population in emerging economies () would consume like in developed economies. They are likely to innovate to develop new green technologies to bring sustainable economic growth.
4. The regulatory gap: Developed economies often have advanced regulatory systems in place to facilitate safe workplace and consumer rights. These regulations are a result of a legacy of economic growth and traditions. But complex regulatory systems also act as barriers to innovation. In contrast developing economies generally, have less stringent regulatory system.
5. The preferences gap: Consumer preferences are starkly different in emerging economies as compared to developed economies. The difference in preference is due to habits, rituals and cultures.

These gaps cannot be filled by simply adapting innovations from developed economies. Authors (Govindarajan and Trimble 2012) stress the importance of local innovation by starting from scratch to cover these gaps.

Emerging markets have great potential, and any multinational organization working in the emerging market through their subsidiary need a local approach and strategy.

(Agarwal and Brem 2012) emphasize about localization and innovative approach for multinationals in emerging markets. An important aspect of reverse innovation captures the relationship between the subsidiary and the parent firm. Reverse innovation coming from subsidiaries of international firms (Harzing and Noorderhaven 2006) was noticed in the form of knowledge inflows and outflows from subsidiaries. Reverse innovation is naturally set to happen when subsidiary is successful in the local market. When the parent perceives the subsidiary to be highly capable, they are more likely to engage in reverse knowledge transfer with that subsidiary. (Nair, Demirbag, and Mellahi 2016)

Another approach to discussing the concept of reverse innovation is frugal innovation. (Zeschky et al. 2011) defined frugal innovation as "good-enough, affordable products that meet the needs of resource-constrained consumers". Since they are resource-constrained, they are cheaper. When these frugal innovations from emerging markets move to developed markets, they become reverse innovation. Multinationals working in emerging economies are targeting growth and higher market share, but with their portfolio of products designed for western market doesn't do well. Authors (Agarwal and Brem 2012) argues that these multinationals should focus on both frugal and reverse innovation and of course if they manage to launch truly disruptive products, their brand names are likely to help them win market share for their good-enough innovations.

Reverse innovation has great potential. When a successful low-cost innovation moves from an emerging market to the developed market, it comes with knowledge and technology and it can cause a big impact on the market. "When a reverse innovation is embraced by the mainstream, it becomes a powerful force – one that holds tremendous opportunities for those with their eyes open and terrifying risks for incumbents with their eyes shut. They risk losing long-held market position (Govindarajan and Trimble 2012). And when these innovations are done by multinationals working in emerging economies, they also get the advantage of their brand name (Agarwal and Brem 2012).

Building on that, later (Corsi and Minin 2011; Corsi and Di Minin 2014) have given insights into reverse innovation as disruptive innovation. In this case, the technology or product disrupting the market in developed economies originates from the markets of emerging economies. The authors have called emerging markets as the "new laboratory of the global economy".

Eco-Innovation

The idea of ecological innovation has been around for some time with a lot of previous researches (Kemp and Pearson 2007; Arundel and Kemp 2009; De Marchi 2012; Horbach, Rammer, and Rennings 2012; Horbach 2015; Karakaya, Hidalgo, and Nuur 2014) exploring the definitions, drivers, effect and presence of eco-innovation. A widely accepted definition of ecological innovation is given by (Kemp and Pearson 2007, p. 07) "Eco-innovation is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives."

Different authors have discussed the drivers and determinants of eco-innovation, (Kemp and Pontoglio 2011) have reviewed the innovation effects of environmental policy instruments and market instruments. Later, (Horbach, Rammer, and Rennings 2012) gave insights on the role of regulatory, technological and market factors as determinants of eco-innovation.

For example, in China, also the awareness and research about eco-innovation is growing. Previous researches (Dong et al. 2014; Bai et al. 2015; He et al. 2018) have discussed the typology of eco-innovation, (Chen, Cheng, and Dai 2017) presented eco-innovation as core engine for long term economic growth. (Wu et al. 2015) presented a study of Chinese firms in different provinces with a perspective of production and treatment process targeting the efficiency of energy-saving and emission reduction. Later, (Cai and Li 2018) has argued about the importance of market-based factors while talking about higher economic activity due to higher environmental performance.

Eco-Innovation & reverse innovation

Innovative business models and products from emerging markets have proven to be 'frugal' and more efficient; a result of being developed in resource constraint and a much more competitive environment. They can help reduce cost and improve efficiency. The importance of reverse innovation and its future has been discussed recently by the author (Govindarajan 2017) where he states that even though those innovations were designed for developing markets, it will power the future everywhere not just in poor countries increasing firm's completeness and profitability.

Reverse innovations by the virtue of being developed in emerging economies are largely low-cost due to resource constraint. And as pointed by (Agnihotri 2015) in her research of reverse innovation from India, "compared to radical and other types of innovation, low-cost innovation is generally more environmentally friendly and resource conservative, as it is simpler in nature."

The idea that eco-innovation could go in reverse and act within the framework of reverse innovation has not been directly explored before. There are researches exploring the idea of diffusion of technological (product and process) and non-technological (information, ideas) innovation. (Karakaya, Hidalgo, and Nuur 2014) have provided insights on the diffusion of eco-innovation from various literature focusing on attributes or factors affecting the diffusion and adoption of eco-innovation. This diffusion of eco-innovation from developing economies towards developed economies would be classified as reverse eco-innovation.

Moreover, (Kemp 2010) has argued that eco-innovations are driven by environmental regulations and economic concerns. Later (Kemp and Pontoglio 2011) have favoured market-based drivers over policy and regulations as the reason for eco-innovation. It is important as a successful reverse innovation is driven by the local market success of that innovation. First, innovation succeeds locally in emerging markets and then diffuses outside. As pointed by (Nair, Demirbag, and Mellahi 2016) in case of a subsidiary, the parent firm is more likely to adopt the innovation if the subsidiary is successful.

There is a basic characterization of an innovation that categorizes it as eco-innovation. Based on the definition of (Kemp and Pearson 2007), we stipulate 3 points, any of which if satisfied would categorize a particular reverse innovation as eco-innovation (as shown in figure 1). The studies on eco-innovation we reviewed do not cover the aspect of reverse innovation. Thus, we start with the idea of reverse innovation and add the points of eco-innovation (OECD 2005; Kemp and Pearson 2007) to arrive at eco-innovation in reverse.

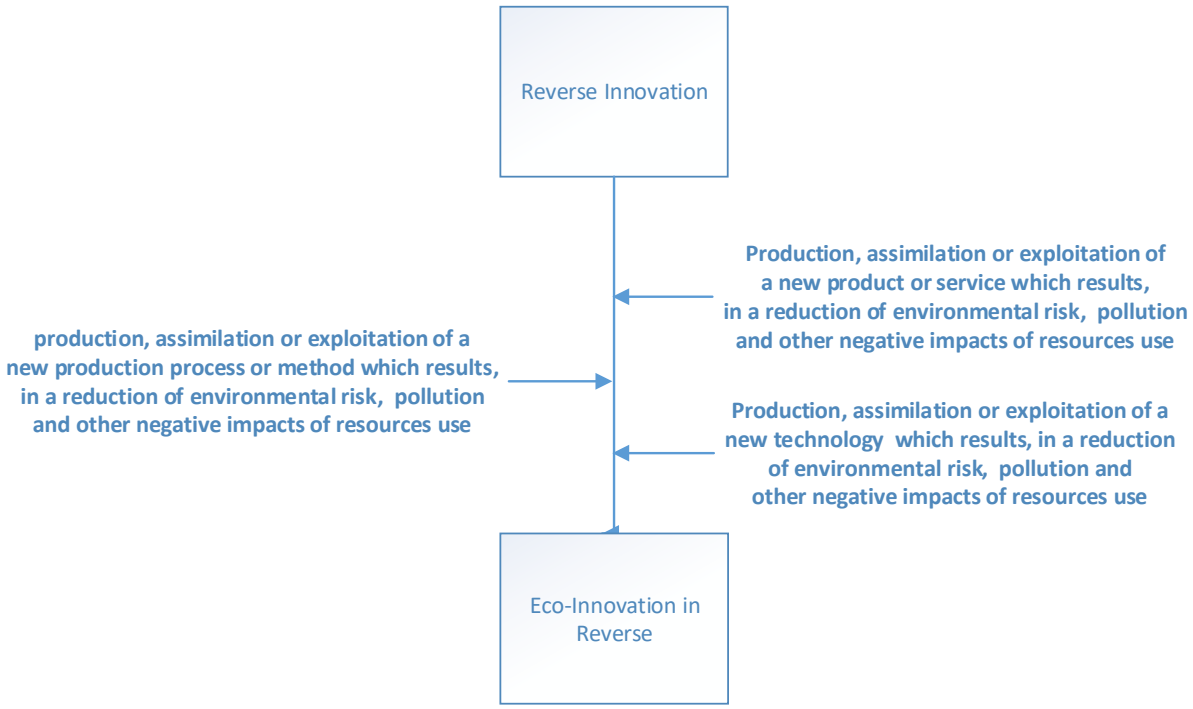


Fig.1. From reverse innovation to Eco-innovation in reverse

Methods

This research aims to understand the reverse innovations that resulted in an eco-friendly product or business process. We studied two large multinational firms operating in China. Since we followed a theoretical approach of research, we attempted to combine multiple data collection methods as suggested by (M. Eisenhardt 2011)- interviews, observations and archival sources.

Data Collection

We conducted semi-structured interviews with two employees in each of the two companies and collected online information about the company. The sample we selected is random as in this type of study the sample cases does not have to be the representative of some population. As pointed by (K. M. Eisenhardt 2007), theoretical sampling simply means that cases are selected because they are particularly suitable for illuminating and extending relationships and logic among constructs. To identify the reverse innovation, we asked questions that would satisfy the concept. The questions used are chosen based on the literature of reverse innovation and eco-innovation. One of the identifiers for reverse innovation was the local growth teams. As given by

(Govindarajan 2017), the organizing principles or the first principles of reverse innovation are as follows: -

- Reverse innovation requires a decentralized, local-market focus
- Most if not all the people and resources dedicated to reverse innovation efforts must be based and managed in the local market
- Local Growth Teams (LGTs) must have P&L responsibility (this is a key hurdle for American multinationals)
- LGTs must have the decision-making authority to choose which products to develop, how to make, sell, and service them - LGTs must have the right (and support) to draw from the company's global resources
- Once tested and proven locally, products developed using reverse innovation must be taken global which may involve pioneering radically new applications, establishing lower price points, and even cannibalizing higher-margin products.
- Reverse innovations can be but are not always disruptive innovations

Since our interviews were semi-structured, the discussions were quite flexible, and during interviews, we explored many other expects not directly related to the questions. We made sure during interviews that we asked questions that would satisfy the identifiers or organizing principles of our concept.

Framework: Identifying Reverse Innovation

Based on the literature of reverse innovation we create a framework of findings on the contribution of four categorical elements to identify reverse innovation. Each of these elements includes many attributes. We check for these attributes to determine the happening of reverse innovation.

- Knowledge and Technology Exchange
    - Development of new knowledge and/or technology
    - Knowledge/technology transfer from owners in developed markets to facilitate local innovation
    - Knowledge/technology transfer to owners in developed markets

    - Common knowledge repository with continuous access
    - Open feedback and encouragement system. Bottom-up and top-down
    - Effective communication among local teams
    - Information exchange among personnel
- Partnerships
    - Using consumers as partners through the feedback system
    - Increasing awareness and involvement of local partners
    - International partners' direct participation in local problems
    - International partners' direct participation to solve international problem using local R&D and teams
    - Accelerating the adoption of knowledge both ways through effective partnership
    - Academic partners
- Financial & markets
    - R&D funding from international owners/partners for innovation targeting local markets
    - R&D funding from international owners for product/process development targeting western markets
    - International partner's funding
    - Local market demand
    - Market demand from developed economies
- Local dynamics
    - Local R&D centres with independent authority
    - R&D dedicated to developing innovation for local markets
    - R&D centres developing innovation for international markets

- Presence of local growth teams
- LGT's decision making authority over the product and consumer choice
- Global resource access to LGT

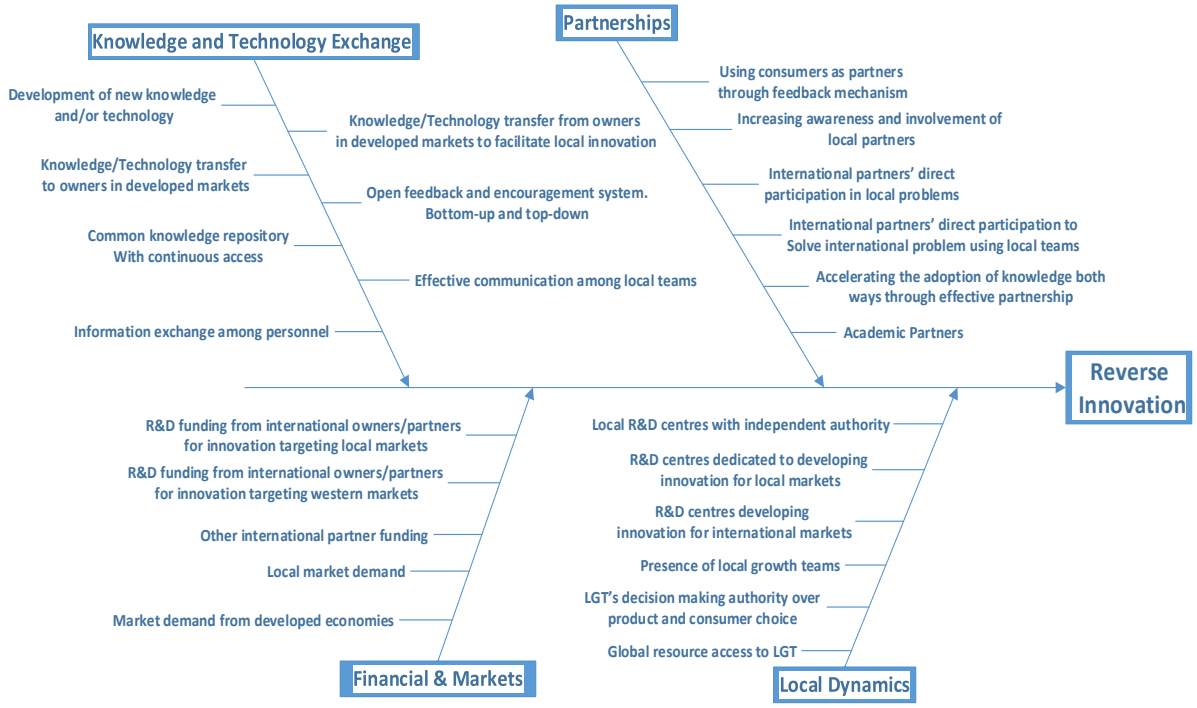


Fig. 2. Elements to identify reverse innovation

Overview

The focus of data collection wasn't to get information about specific products that qualified as reverse eco-innovation but to understand the environment of innovation, transfer of knowledge from and to international R&D centres, diffusion of technologies, cooperation, market demands of innovation, effect of policies etc. within the organization. Since we are trying to identify eco-innovation in reverse innovation, our data collection method focused on the attributes that make those innovation qualify as reverse innovation and eco-innovation. We particularly look for instances when there are common attributes for both innovations.

Participants

We conducted a study on two multinational organizations operating for more than three decades in China.

Organization A: Fast-moving consumer goods, hygiene and healthcare product manufacturing company. The parent company and the headquarters of organization A is located in the U.S. Organization A has been one of the first western companies to enter the Chinese market. It has been in China for 34 years.

Organization B: Pharmaceuticals, healthcare, consumer care and fertilizers. The parent company and head office of organization B is located in Germany. Although organization B has been operating in China for a long time, it worked in partnerships earlier. In its present form it is in China from last 26 years.

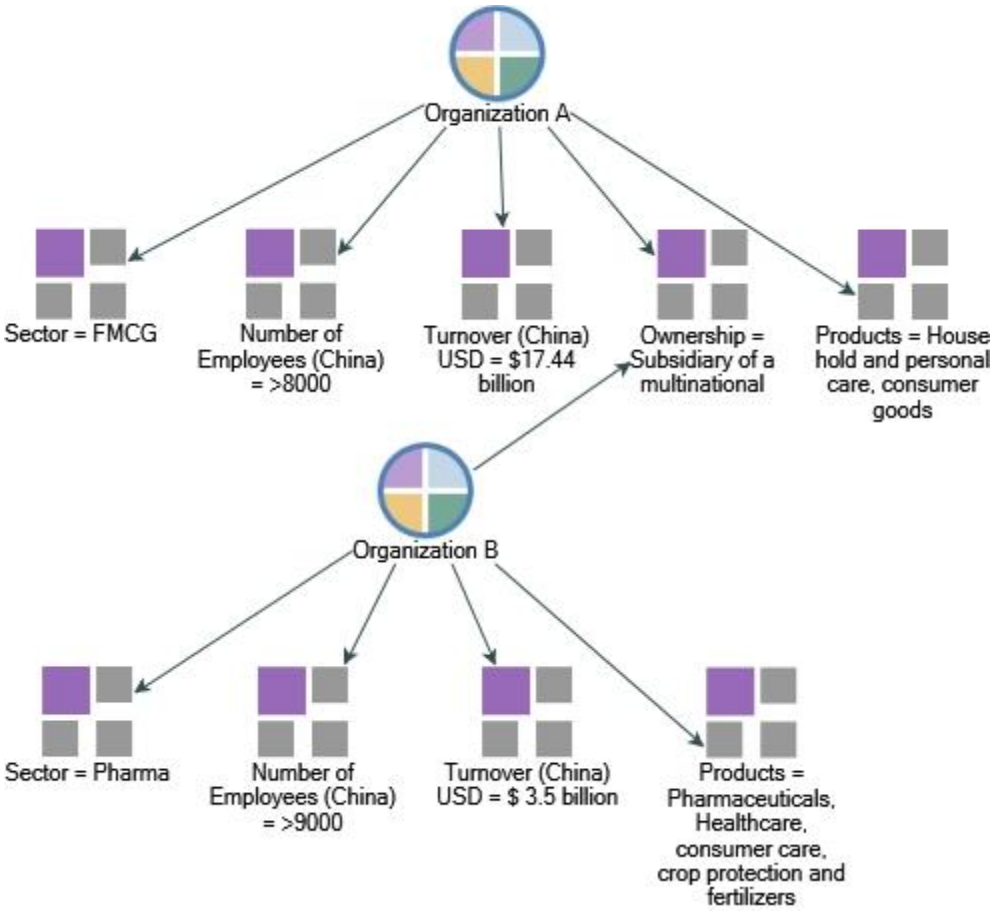


Fig 3. Organizations and their attributes

Data Analysis

We used NVivo 12 Plus to perform our analysis and generate figures. We conducted oral interviews and collected information online. All the oral interviews were recorded as audio files. We followed a six-step process starting from our audio recordings to set the data in NVivo 12 Plus.

Step 1: All the audio recordings were replayed and turned into written transcripts. We had 4 interviews and we created 4 different written transcripts. Like this, we were able to simplify our data entry process. Also, it made it easier to code all the textual data in groups using NVivo and directly link them to files.

Step 2: Systematized the online information about both organizations into two written transcripts, carefully editing the identity of the firms. Now we had two written interview transcripts and one online information transcript for each organization. We named the first organization as *organization A* and second as *organization B*. Then named the transcripts associated with *organization A* as A1, A2 and A3; similarly, transcripts associated with *organization B* were named B1, B2 and B3 respectively.

Step 3: Uploaded all 6 written transcripts in NVivo 12 Plus as *data files.* These transcripts act as our primary data entry source for further NVivo analysis.

Step 4: Within the NVivo software, we organized the classification of interviewees and organizations and entered the information about the organization and interviewees into the classification system. This gave us the attribute relation of interviewees and organizations.

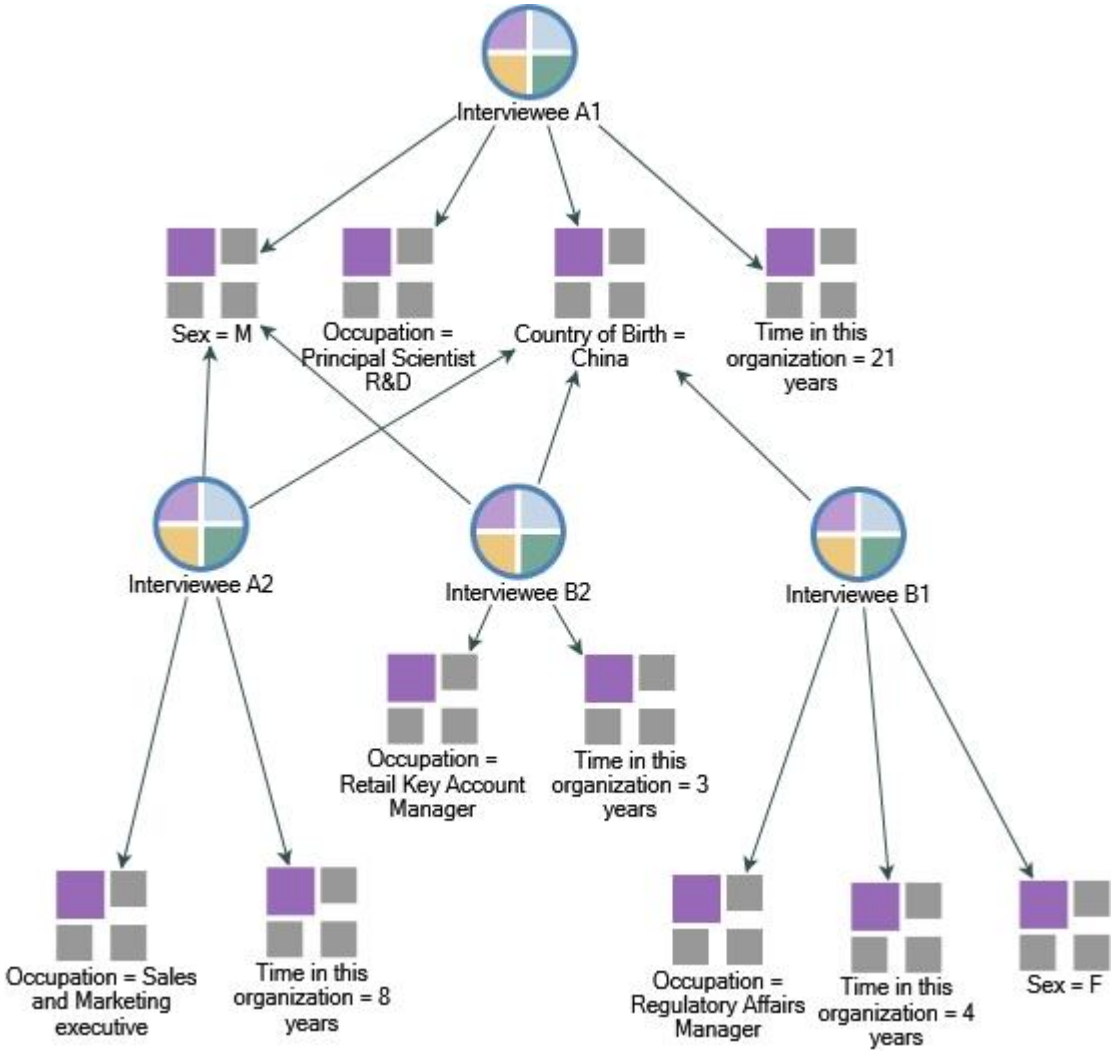


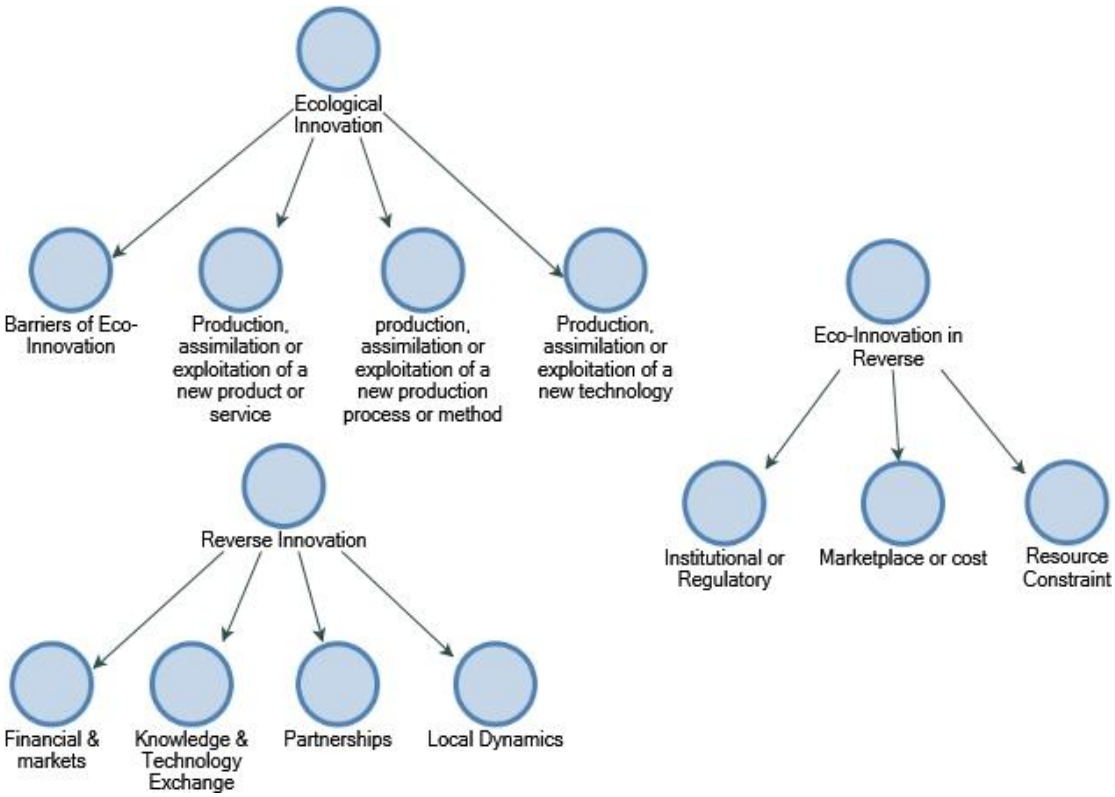
Fig.4. NVivo Output: Respondents and their attributes

Step 5: Based on the literature findings and themes of reverse innovation and eco-innovation, and based on four categorical elements of reverse innovation and their attributes, we created nodes in the NVivo project.

Nodes in NVivo are a collection of references about a specific theme, organization place or person. ("NVivo Help Page" n.d.) Nodes help to gather all references to a related material into one place.

Step 6: At this step, we start to code all our written file transcripts into nodes. By coding, we mean to gather all the references about a particular theme or topic from our written transcript files and bring all those references under that theme node. The central

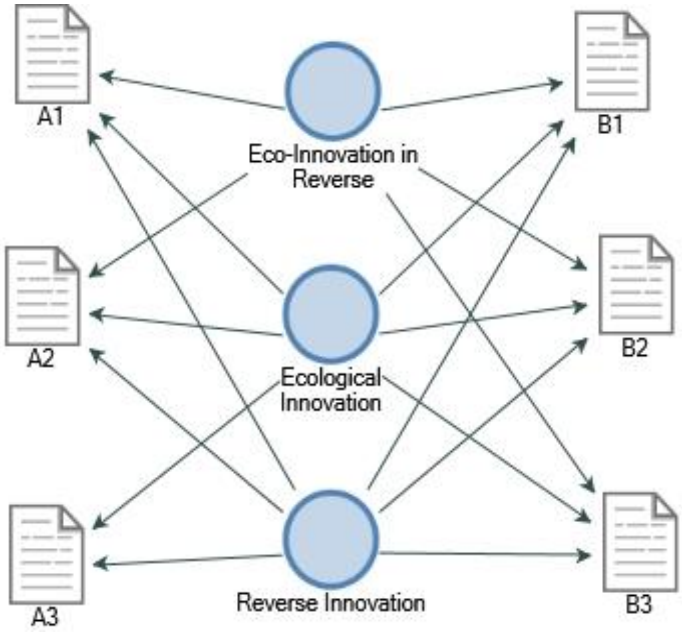
themes are organized in nodes called a parent node, and associated sub-theme nodes are child node.



NVivo Output: Fig.5. NVivo output: Node structure in NVivo

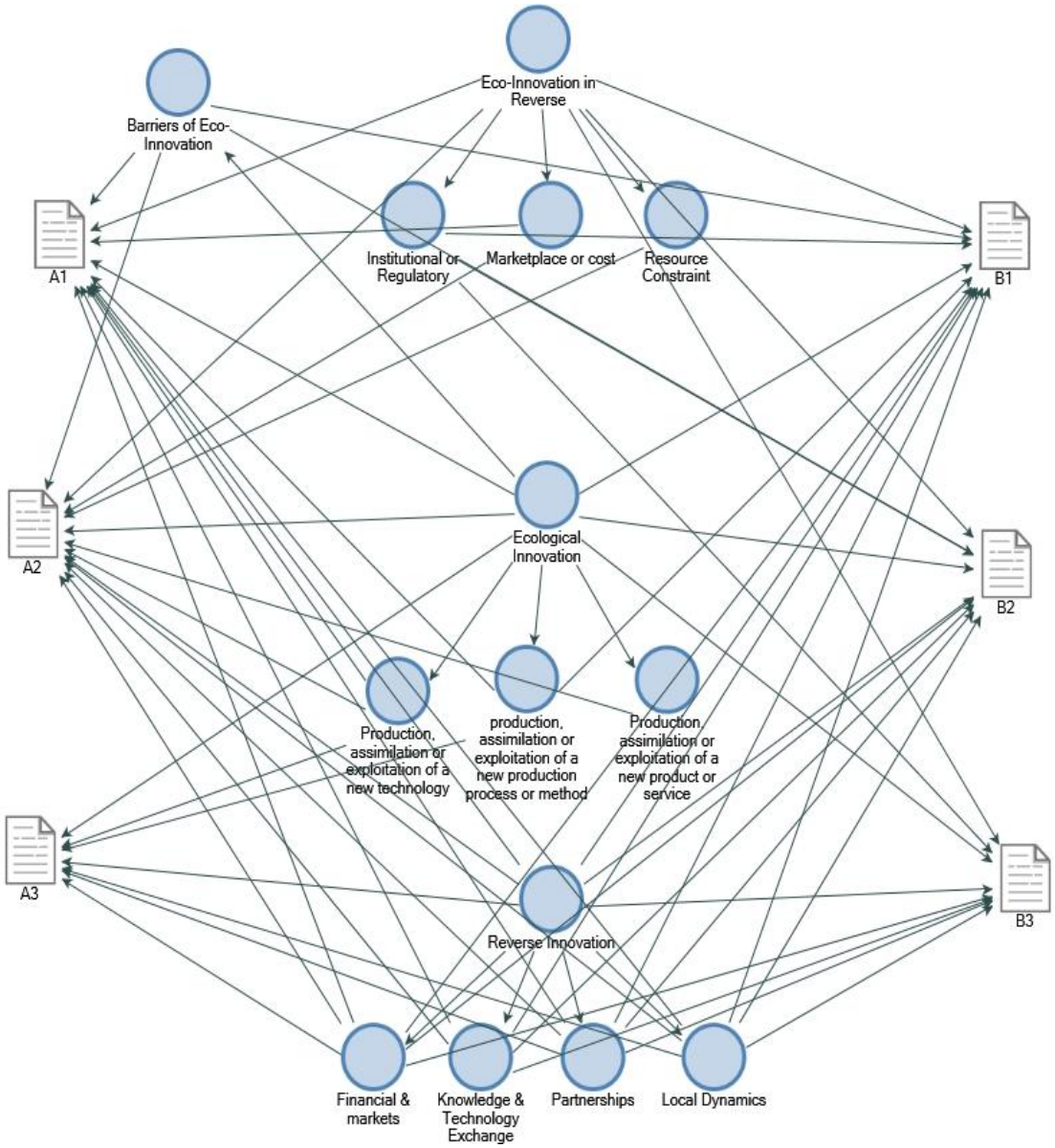
Findings

After we do the complete coding with all six input files, we generate maps in NVivo software to show the coding references and relationships. The first map (*fig.6*) with three original parent nodes show the relationship of each node with data transcript files. We see the presence of reverse innovation and eco-innovation in all six files whereas eco-innovation in reverse has reference from both interviews in *organization A* and *organization B* respectively.



NVivo Output: Fig6. Nodes and files

For further understanding, we generated a project map (*fig.7*) that shows us all the themes (parent nodes) and sub-themes (child nodes) with their references to the input files. Here we notice multiple references of child nodes with all the files, showing eco-innovation and reverse innovation taking place; but noticeably we see that file A1, A2, B1 and B2 have references with *eco-innovation in reverse* with A1, A2 and B1 having reference to the child nodes of eco-innovation reverse. These child-nodes *institutional or regulatory, marketplace or cost and resource constraint a*re the specific characteristics of emerging economies facilitating reverse eco-innovation. This signifies that in both organization A and in organization B there is eco-innovation happening and that innovation is taking place due to one or more of the three specific characteristics.



NVivo Output: Fig.7. All the parent nodes relationship with cases

Eco-Innovation in Reverse

'Reverse innovation' refers to the case where innovation is adopted first in poor (emerging) economies before 'trickling up' to rich countries. (Govindarajan and Ramamurti 2011)

The premise that eco-innovation from emerging markets will move to developed economies and thus qualify as eco-innovation in reverse depends on gaps among eco-innovation driving factors, attributes or characteristics.

The environment of eco-innovation in developed markets is quite different from that of developing market. Innovations occurring in emerging economies tend not to involve

technological breakthroughs of the kind that drive innovation in developed countries. Taking into account the eco-system of reverse innovation (Govindarajan and Trimble 2012; Govindarajan and Ramamurti 2011) and based on the information from our respondents, we identify the difference between eco-innovation happening in emerging markets and developed markets:

	Market demand	Institutional or policy	Collaboration	Resources
Eco-Innovation in developed markets	The demand is high in the market. People pay for eco-friendly products	Pressure form policymakers. strictly implemented and monitored policies.	High level of academic, research and partners collaboration	Resource-rich environment. Developed infrastructure
Eco-innovation in emerging markets	Low demand in local markets. People agree to pay for benefits but not eco-friendly products per se	Low pressure of policymakers. Loose implementation and monitoring	Medium level of academic collaboration. Low level of partner collaboration	Resource constraint environment. Less developed infrastructure

Table 1

Discussions

Eco-innovation is a very talked-about topic and it's getting more and more attention. The respondents from organizations we studied have a very positive outlook towards eco-innovation. In fact, during our study, we found many instances of eco-innovation activities in both organizations. Reverse innovation is something that is still not a very much planned activity. At least that is what we understand from our respondents. They are aware of innovations happening and technologies being transferred both ways, from developed markets to emerging economies and from emerging economies to developed markets. But they aren't aware of reverse innovation terminology. However, we found from our cases that these multinational organizations are investing in emerging markets to conduct R&D activities and many technologies get transferred to the firm's home countries where they use those technologies and knowledge to produce products for

developed markets. So, it does not rule out the fact that even though it's not a planned activity at local level it might be a planned activity for the organization. The multinationals we studied are investing in development of innovation by conducting R&D in emerging markets and then transferring the knowledge to developed markets.

From our interview data, we carefully analyse the patterns of reverse innovation and eco-innovation. After recognizing the categorical elements of reverse innovation and identifying the presence of eco-innovation, we identify three specific characteristics that facilitate the eco-innovation towards reverse innovation: resource constraint, marketplace or cost, and institutional or regulatory.

Resource Constraint

Developing economies offer an altogether different ecosystem for the incubation of innovation. In contrast with the developed economies, innovations in developing economies come into existence in a resource constraint environment. We also considered lack of infrastructure as resource constraint. Since those innovations cater to the local problems, they take into consideration the local resource availability and user-friendliness in a resource constraint environment.

In our case sample, *organization A* developed a fabric cleaning product that requires very less use of water compared to alternative products. This product was designed to be sold in local provinces that dealt with water scarcity. Since it saves water, the product is eco-friendly to use. Although the target of the organization was to develop a product that uses less water due to scarcity, they ended up developing a process that they later used to replicate the development of similar products for developed markets and position it as a waster saving eco-friendly product.

Marketplace or cost

The marketplace or cost of eco-innovation certainly had been one of the strongest drivers to facilitate reverse eco-innovation. It refers to the market demand for eco-innovation locally and internationally, the cost of innovation incurred, and the increase in the cost of product due to eco-innovation. Authors (Govindarajan and Trimble 2012) assert the importance of reverse innovation highlighting the potential for very low price

innovation originating in the developing world to generate new market demand back in the richer economies.

This works in two different ways. Firstly, the local and international market demand for a cost-effective eco-innovation which helps the firms to realize back the investments and the added production cost to the product. Many times, there is no market demand for the new product even if it is eco-friendlier than the already available alternative. In our studied cases, at times companies failed to commercialize the eco-innovation. Moreover, we also noted in *organisation B* that the firm developed the product in an emerging economy and then introduced the new innovated product to other international markets even if they were not able to introduce it into the local emerging market where it was developed or for which it was developed. Secondly, lack of demand for the product, either due to higher costs or due to infrastructure unavailability leads to non-profitability or non-commercialization of innovation. With the lack of local success of innovation in emerging markets organization's typically do not invest in its diffusion into the developed markets.

In our case studies, respondents from both *organization A* and *organization B* stated that generally, it is quite difficult to sell a product to the mass market with a slightly higher cost with the added benefit of eco-innovation. However, the same consumers in the local developing market pay a little extra if they are offered a more featured product (with a direct benefit) at a somewhat higher price point. The respondent from *organization A* specifically pointed out in case of another product developed a few years ago where consumers paid added cost only when they realised the added value with the product, which was not necessarily being eco-friendlier.

Institutional or Regulatory

Institutional or regulatory characteristics refers to the policy instruments. These are generally regulations put forward by local, national or international regulatory bodies. There are many policy frameworks targeting eco-innovation. Past researches have discussed the role of policy framework in eco-innovation. Authors (Rehfeld, Rennings, and Ziegler 2007; Horbach 2008; Kemp and Pontoglio 2011; Horbach, Rammer, and Rennings 2012) have all discussed the role of local policy and regulatory environment in triggering ecological innovation. Once there is a successful eco-innovation then it

diffuses through various channels to the international markets. Other important aspects are partnerships and collaboration. We saw collaborations are one of the most important aspects of reverse innovation. Firms doing academic, local and international collaborations are getting to share their knowledge and technologies. New technologies are being developed with research teams at universities and other labs. Many times, to function in the emerging economies, multinational firms are required to undergo partnerships and collaborations with local partners. This has been very helpful to create innovations focused on local problems. Thus, in many cases, eco-innovations focused solely on local problems.

However, it happened a bit different in one case we studied. There is an interesting example of reverse transfer of eco-innovation without success in a local developing market. It happened with the *organization B.* An eco-friendly product was developed after local R&D at the local R&D centre but the company was unable to introduce it to the local market due to not getting approval from a local regulatory authority. Later, the company shared the knowledge and product with their global R&D and marketing teams situated in east Asian countries, Europe and the US. The company then successfully launched and commercialized the product in other markets. In this case institutional or regulatory system induced a reverse eco-innovation despite not being successful in the local market.

Barriers

During our interviews with both the companies, we discussed certain problems that the organization, managers and local teams were facing in either developing, implementing and marketing the eco-friendly innovation. During interviews, the manager from *organization A* pointed out at the problem of selling a newly innovated product with a slightly higher price tag to the mass market. He stated that “consumers refuse to pay extra”, even though the price increase was slight they still don’t want to pay for it. They would, however, pay for extra features or other benefits. “No one wants to pay for environment…. they will pay only if it benefits them directly”. Moreover, many times consumers are sceptic about the claims of eco-friendly products. They want to continue using what they are using. The key here, especially for the mass market, is to introduce new eco-friendly products at the same price point as the previous running products or justifying the increase in the price by extra features with eco-innovation in hindsight.

Drivers of Reverse Innovation

In our study, we had recognised the element that helps to identify the phenomenon of reverse innovation. While conducting the interviews, we carefully discussed those elements wherever applied. Our respondents were enthusiastic to talk about various aspects of it and based on our discussions we noted down certain barriers and drivers of reverse innovation. There are certain activities and traits which when present drive reverse innovation. These traits induce a healthy innovation environment in firms, we, however, looked at them from the point of view of reverse innovation. All the factors that we noticed can be put under one of the five categories shown in the table below.

Managerial	**Economic/Financial**
Leadership stability	Adequate funding for R&D
Market and consumer awareness	Incentives
Harmony and collaboration among departments and R&D teams	Local market demand for innovation
Resource allotment	**Knowledge/Information**
Training	Free flow of knowledge (parent-subsidiary)
Regulatory	Active and open communication
State-level cooperation	Industry collaboration and partnerships
The relation between participating partner states	Academic partnerships
Existing regulations for collaboration	**Attitude and perception**
Regulations for taxes and tax breaks	Awareness about ecological challenges
	Firm's image
	Culture

Table 2

Leadership stability is important for a healthy innovation culture. Unstable leadership creates confusion among teams about their goals and direction of growth. Same goes for collaboration among different departments within the company. When R&D teams receive proper inputs from marketing teams and proper resources from management, they are better positioned to understand what to work on. Also, training is very important. Our respondents were clearly pointing out the role of training. An interesting

thing to note in our study is from *organization B* where we found that the local training activities conducted in the emerging market were organized by the head office located in a developed market and people who gave training were also from those countries.

We saw in our case example that how the local regulatory environment prevented the introduction of a locally developed innovation in the local market. But this in turn induced the process of diffusion of that product in other markets. This is a very specific case. State regulations have helped in pushing innovation by easier restrictions or by tax breaks to help develop eco-innovation.

Moreover, financial incentives from markets and R&D investments always helps to drive reverse innovation. In both *organisation A* and *organization B* we found that R&D investments came from the head office located in their home countries, and it helped in developing local innovations which in turn were diffused to western markets.

We also noticed the healthy cooperation activities between the head office and Chinese subsidiary in both of our studied cases. The flow of knowledge happened both ways and teams in both places had access to a common knowledge base. In addition, both organisations have collaboration with academic institutions to carry research.

Both organisations are keenly active in being eco-friendly and are committed to introducing greener processes. There is obviously a sense of responsibility towards the environment and intention to have a positive public image. This attitude does create a healthy environment for inducing innovation which when diffuses to western markets becomes a reverse innovation.

Conclusion

We gather information from literature (Govindarajan and Euchner 2012; Agarwal and Brem 2012; Zeschky et al. 2011; F. Zhu, Zou, and Xu 2017; Corsi, Di Minin, and Piccaluga 2014) and find elements arranged in four categories (Knowledge and technology exchange, partnerships, financial & markets, local dynamics) to identify reverse innovation. In the reverse innovation, based on the definition of eco-innovation (Kemp and Pearson 2007; Kemp 2010; Bossle et al. 2016) we looked for traits to qualify them as eco-innovation and hence reverse eco-innovation. Among our studied organizations, based on respondents' replies, we identify three specific characteristics

of innovation in emerging markets that facilitate it towards reverse eco-innovation: *(i) resource constraint, (ii) marketplace or cost, and (iii) institutional or regulatory*. The environment of innovation caused in emerging economies due to these characteristics trigger an eco-innovation which moves towards or diffuses into or spills over to the markets in developed economies. The characteristic of resource constraint visibly affects the development of innovation the most in the local context.

The conversation during interviews brings out many layers of information. We got to understand the role of the market in the successful diffusion of innovation. Consumers generally won't pay extra just because the product is eco-friendly but they expect added value from the product. We also get to know about the drivers of reverse eco-innovation. From our interviews, we also notice the importance of partnerships and collaboration in inducing innovation. They directly affect the reverse innovation in our studied firms. Even though they are not directly contributing to reverse eco-innovation, partnerships and collaborations are important for any innovation.

There are a few limitations in this study. We used two organizations with two interviewees from each organization, then we collected online information about these organizations. Future researchers can extend the findings by conducting more surveys and interviews and conduct a quantitative study as well. A more detailed case study could be conducted as authors (Zott and Huy 2008) did in their two-year study, conducting 50 interviews. Also, more organizations could be included to get a better and more generalised outcome from the study.

References

Agarwal, Nivedita, and Alexander Brem. 2012. "Frugal and Reverse Innovation-Literature Overview and Case Study Insights from a German MNC in India and China." *Proceedings of the 18th International Conference on Engineering, Technology and Innovation*.

Agnihotri, Arpita. 2015. "Low-Cost Innovation in Emerging Markets." *Journal of Strategic Marketing* 23 (5): 399–411. https://doi.org/10.1080/0965254X.2014.970215.

Arundel, Anthony, and René Kemp. 2009. “Measuring Eco-Innovation.” *Unu - Merit* 20 (2): 146–146. https://doi.org/10.1111/j.1467-629X.1980.tb00220.x.

Bai, Yanying, Jie Yin, Yin Yuan, Yajing Guo, and Danna Song. 2015. “An Innovative System for Promoting Cleaner Production : Mandatory Cleaner Production Audits in China.” *Journal of Cleaner Production* 108: 883–90. https://doi.org/10.1016/j.jclepro.2015.07.107.

Bossle, Marilia Bonzanini, Marcia Dutra De Barcellos, Luciana Marques Vieira, and Loïc Sauvée. 2016. “The Drivers for Adoption of Eco-Innovation.” *Journal of Cleaner Production* 113: 861–72. https://doi.org/10.1016/j.jclepro.2015.11.033.

Buckley, Peter J, Jeremy Clegg, and Hui Tan. 2006. “Cultural Awareness in Knowledge Transfer to China — The Role of Guanxi and Mianzi” 41: 275–88. https://doi.org/10.1016/j.jwb.2006.01.008.

Cai, Wugan, and Guangpei Li. 2018. “The Drivers of Eco-Innovation and Its Impact on Performance: Evidence from China.” *Journal of Cleaner Production* 176: 110–18. https://doi.org/10.1016/j.jclepro.2017.12.109.

Chen, Jun, Jinhua Cheng, and Sheng Dai. 2017. “Regional Eco-Innovation in China: An Analysis of Eco-Innovation Levels and Influencing Factors.” *Journal of Cleaner Production* 153 (November 2012): 1–14. https://doi.org/10.1016/j.jclepro.2017.03.141.

Corsi, Simone, and Alberto D I Minin. 2011. “Disruptive Innovation in Reverse; a Theoretical Framework to Look at New Product Development from Emerging Economies.” *Scuola Superiore Sant’Anna Di Pisa*, 1–24. http://www.idm.sssup.it/wp/201104.pdf.

Corsi, Simone, and Alberto Di Minin. 2014. “Disruptive Innovation in Reverse: Adding a Geographical Dimension to Disruptive Innovation Theory.” *Creativity and Innovation Management* 23 (1): 76–90. https://doi.org/10.1111/caim.12043.

Corsi, Simone, Alberto Di Minin, and Andrea Piccaluga. 2014. “Reverse Innovation at Speres: A Case Study in China.” *Research-Technology Management* 57 (4): 28–34. https://doi.org/10.5437/08956308X5704215.

Dong, Ying, Xi Wang, Jun Jin, Yuanbo Qiao, and Lei Shi. 2014. “Effects of Eco-Innovation Typology on Its Performance: Empirical Evidence from Chinese Enterprises.” *Journal of Engineering and Technology Management - JET-M* 34: 78–98. https://doi.org/10.1016/j.jengtecman.2013.11.001.

Eisenhardt, Kathleen M. 2007. “THEORY BUILDING FROM CASES : OPPORTUNITIES AND CHALLENGES.” *Academy of Management Journal* 50 (1): 25–32.

Eisenhardt, M. 2011. “Building Theories from Case.” *Academy of Management Journal* 14 (4): 532–50.

Govindarajan, Vijay. 2017. “What Is Reverse Innovation ?,” 4–7. http://www.tuck.dartmouth.edu/people/vg/blog?archive/2009/10/what_is_reverse_innovation.htm.

Govindarajan, Vijay, and Jim Euchner. 2012. “Reverse Innovation: An Interview with Vijay Govindarajan.” *Research Technology Management* 55 (6): 13–17. https://doi.org/10.5437/08956308X5506003.

Govindarajan, Vijay, and Ravi Ramamurti. 2011. “Reverse Innovation, Emerging Markets, and Global Strategy.” *Global Strategy Journal* 1 (3–4): 191–205. https://doi.org/10.1111/j.2042-5805.2011.00023.x.

Govindarajan, Vijay, and Chris Trimble. 2012. “Reverse Innovation: A Global Growth Strategy That Could Pre-empt Disruption at Home.” *Strategy & Leadership* 40 (5): 5–11. https://doi.org/10.1108/10878571211257122.

Harzing, Anne-wil, and Niels Noorderhaven. 2006. “Knowledge Flows in MNCs : An Empirical Test and Extension of Gupta and Govindarajan ’ s Typology of Subsidiary Roles.” *International Business Review* 15: 195–214. https://doi.org/10.1016/j.ibusrev.2006.01.001.

He, Fang, Xin Miao, Christina W.Y. Wong, and Stacy Lee. 2018. “Contemporary Corporate Eco-Innovation Research: A Systematic Review.” *Journal of Cleaner Production* 174: 502–26. https://doi.org/10.1016/j.jclepro.2017.10.314.

Horbach, Jens. 2008. “Determinants of Environmental Innovation-New Evidence from German Panel Data Sources.” *Research Policy* 37 (1): 163–73. https://doi.org/10.1016/j.respol.2007.08.006.

———. 2015. “Empirical Determinants of Eco-Innovation in European Countries Using the Community Innovation Survey.” *Environmental Innovation and Societal Transitions* 19: 1–14. https://doi.org/10.1016/j.eist.2015.09.005.

Horbach, Jens, Christian Rammer, and Klaus Rennings. 2012. “Determinants of Eco-Innovations by Type of Environmental Impact - The Role of Regulatory Push/Pull, Technology Push and Market Pull.” *Ecological Economics* 78: 112–22. https://doi.org/10.1016/j.ecolecon.2012.04.005.

Karakaya, Emrah, Antonio Hidalgo, and Cali Nuur. 2014. “Diffusion of Eco-Innovations: A Review.” *Renewable and Sustainable Energy Reviews* 33: 392–99. https://doi.org/10.1016/j.rser.2014.01.083.

Kemp, René. 2010. “Eco-Innovation: Definition, Measurement and Open Research Issues.” *Economia Politica* 27 (3): 397–420. https://doi.org/10.1428/33131.

Kemp, René, and Peter Pearson. 2007. “Final Report MEI Project about Measuring Eco-Innovation.” *UM Merit, Maastricht* 32 (3): 121–24.

Kemp, René, and Serena Pontoglio. 2011. “The Innovation Effects of Environmental Policy Instruments - A Typical Case of the Blind Men and the Elephant?” *Ecological Economics* 72: 28–36. https://doi.org/10.1016/j.ecolecon.2011.09.014.

Liu, Xiaohui, and Axèle Giroud. 2016. “International Knowledge Flows in the Context of Emerging-Economy MNEs and Increasing Global Mobility.” *International Business Review* 25 (1): 125–29. https://doi.org/10.1016/j.ibusrev.2015.07.008.

Marchi, Valentina De. 2012. “Environmental Innovation and R&D Cooperation: Empirical Evidence from Spanish Manufacturing Firms.” *Research Policy* 41 (3): 614–23. https://doi.org/10.1016/j.respol.2011.10.002.

Nair, Smitha R., Mehmet Demirbag, and Kamel Mellahi. 2016. “Reverse Knowledge Transfer in Emerging Market Multinationals: The Indian Context.” *International Business Review* 25 (1): 152–64. https://doi.org/10.1016/j.ibusrev.2015.02.011.

“NVivo Help Page.” n.d. Accessed September 9, 2019. http://help-nv10.qsrinternational.com/desktop/welcome/welcome.htm.

OECD. 2005. *Oslo Manual*. *Communities*. Vol. Third edit. https://doi.org/10.1787/9789264065659-es.

Peng, Huatao, and Yang Liu. 2016. “A Comprehensive Analysis of Cleaner Production Policies in China.” *Journal of Cleaner Production* 135: 1138–49. https://doi.org/10.1016/j.jclepro.2016.06.190.

Peng, Mike. 2012. “The Global Strategy of Emerging Multinationals from China” 107: 97–107. https://doi.org/10.1111/j.2042-5805.2012.01030.x.

R.Sinkovics, Rudolf, Yamin Mo, Khalid Nadvi, and Yingying ZhangZhang. 2014. “Rising Powers from Emerging Markets — The Changing Face of International Business.” *International Business Review* 23: 675–79. http://dx.doi.org/10.1016/j.ibusrev.2014.04.001.

Rehfeld, Katharina Maria, Klaus Rennings, and Andreas Ziegler. 2007. “Integrated Product Policy and Environmental Product Innovations: An Empirical Analysis.” *Ecological Economics* 61 (1): 91–100. https://doi.org/10.1016/j.ecolecon.2006.02.003.

Wu, Jie, Lin Lv, Jiasen Sun, and Xiang Ji. 2015. “A Comprehensive Analysis of China’s Regional Energy Saving and Emission Reduction Efficiency : From Production and Treatment Perspectives.” *Energy Policy* 84: 166–76. https://doi.org/10.1016/j.enpol.2015.05.005.

Zeng, S. X., C. M. Tam, Vivian W.Y. Tam, and Z. M. Deng. 2005. “Towards Implementation of ISO 14001 Environmental Management Systems in Selected Industries in China.” *Journal of Cleaner Production* 13 (7): 645–56. https://doi.org/10.1016/j.jclepro.2003.12.009.

Zeschky, Marco, Bastian Widenmayer, Oliver Gassmann, Marco Zeschky, Bastian Widenmayer, and Oliver Gassmann. 2011. “FRUGAL INNOVATION IN EMERGING” 6308 (April). https://doi.org/10.5437/08956308X5404007.

Zhu, Fengxia, Shaoming Zou, and Hui Xu. 2017. “Launching Reverse-Innovated Product from Emerging Markets to MNC’s Home Market: A Theoretical Framework for MNC’s Decisions.” *International Business Review* 26 (1): 156–63. https://doi.org/10.1016/j.ibusrev.2016.06.003.

Zott, Christoph, and Quy Nguyen Huy. 2008. “How Entrepreneurs Use Symbolic Management to Acquire Resources.” *Administrative Science Quarterly* 52 (1): 70–105. https://doi.org/10.2189/asqu.52.1.70.

Chapter 4

Determinants of Eco-Innovation: Environment performance outcome in Chinese firms

Abstract

Eco-Innovation has been generally adopted by firms to meet the demand to reduce the environmental impact caused by their actions. Eco-innovation in terms of product and process innovation is influenced by factors such as the desire for resource efficiency, policy regulation instruments, market factors, R&D and cooperation among different partners. Firms are facing pressure to act "eco-friendly" in order to keep up with the changing environment and stay competitive. Chinese firms are influenced by these factors as well particularly in recent years.

In this study, we observe selected Chinese enterprises in eco-innovation parks. We identify different environmental benefits within the enterprise and by the end-user as the firm's *environmental performance* while considering the presence and absence of certain factors and conditions that are inducing them. We use fuzzy set theory for data arrangement and Qualitative Comparative Analysis (QCA) as our methodology while using fsQCA package as a software tool. All data used are primary data collected using questionnaire and interviews for three years 2015-2017.

Our results show that many combinations of those factors affect the environment performance outcome in Chinese firms. However, the presence of market factors and R&D activities are clearly driving the eco-innovation more than other factors, while cooperation activities have a minimum influence on performance.

Keywords: Eco-Innovation, QCA, China, fuzzy-set method, environment benefits

Introduction

The concept of eco-innovation has been creating a buzz in recent years. There is a growing awareness among ordinary people and among businesses about the harmful ecological impact caused by various firms. In other words, firms have to take responsible actions to mitigate that impact. One way is to take actions to innovate their products and/or processes that would reduce the impact. These innovations qualify as

ecological innovation. Prior literature has talked about various definitions of eco-innovation, its effects; and importantly, its determinants, which in other words we refer to as the factors affecting eco-innovation. (Rennings 2000) defined eco-innovation with a perspective of technological, social and institutional innovation. (Kemp 2010; Kemp and Pontoglio 2011) stressed on the importance of policy (regulation) and concluded that policy is economically motivated. The definition of eco-innovation has evolved over time with the context and progress of work in this field. Then what is new in our paper here?

In this paper, we discuss the presence of eco-innovation in Chinese firms. We try to find out which factors are affecting the eco-innovation activities in the observed firms and what are the main factors that influence those activities. This paper focuses on Chinese firms specifically. Moreover, we are putting to use a relatively lesser-known upcoming but efficient newer methodology known as *Qualitative Comparative Analysis* to do this investigation. The question arises why eco-innovation and why specifically Chinese firms?

There are many reasons for a firm to act on eco-innovation. Firstly, eco-innovation is becoming a need for firms due to increasing awareness about the negative environmental impacts of enterprises. These innovations are there to reduce these impacts at different levels of activities. Different authors have identified the functions of eco-innovation. "Eco-innovations alleviate environmental impacts or lead to a reduction in energy use and are, therefore, crucial for climate protection." (Horbach 2015). Then we see that several times firms invest in eco-innovation to improve their reputation by voluntary actions.

Moreover, there is a need for firms to act under pressure from different institutional bodies. There are policies put together by different government bodies to make firms meet certain criteria. This can be due to the participation of states in international treaties to adhere to pre-decided standards like 2015 Paris climate treaty, or firms are under pressure to do so due to involvement in international trade where they are required to meet standards of their trading partner countries. A study of 328 Australian and New Zealand firms has revealed that the pressure from secondary stakeholders (industry watchdogs, media) does contribute to the adoption of ISO 14001 which results in better environment performance (Castka and Prajogo 2013). In order to trade in

international markets, firms are required to adhere to the standardization of environmental management procedure. A study of Chinese firms has indicated that the major motivation to undergo environmental standards was to seek entrance to international markets (Zeng et al. 2005).

Chinese firms have started to follow the path of systematic eco-innovation in recent years. However, in the Chinese context, it remains a largely unexplored paradigm. "…in the context of sustainable development and the construction of an ecological civilization, China's overall level of eco-innovation among its various provinces exhibits an increasing trend" (Chen, Cheng, and Dai 2017). There has recent awareness about eco-innovation activities among Chinse firms but the academic literature has not covered up much for many reasons. Firstly, there is an absence of first-hand company-level data about eco-innovation for Chinese companies. Secondly, past eco-innovation researches in Chinese context have been very generic although they point out to an increase in eco-innovation activities and suggestions for a more profound study. We try to fill that gap by attempting to collect primary data and do initial analysis on eco-innovation among Chinese firms.

We try to answer the following question in this paper using our data from Chinese firms:

Among Chinese firms what factor/s have the strongest influence on environment performance outcome in terms of ecological Innovation?

We mention 'environment performance outcome' as the set of indicators or factors identified in our studied sample. Eco-innovation as environment performance outcome is actually the environment benefits obtained. The factors are diverse, including external and internal factors as will be explained later in this paper. To perform our analysis, we used the QCA methodology and fsQCA software package developed by Charles Ragin. The practical goal of QCA more generally, is to explore evidence descriptively and configurationally, with an eye toward the different ways conditions may combine to produce a given outcome. (Ragin 2007). We identified and grouped factors based on literature, and analysed their influence on outcome in different combinations.

From the literature, we group together all the policy-related factors and call them policy instruments. These factors are either pushed by state or local authorities or are required by firms to fulfil in order to gain government grants or procurements. Similarly, we

grouped market factors like demand and cost of input and call them market instruments. We followed a similar pattern to determine our other factors to be used as inputs for our analysis.

This paper is organized into four sections. Section 1 is the introduction to the research idea and the research question.

Section 2 of this paper consists of a detailed literature review on eco-innovation and synthesis of eco-innovation terms used by various authors developing into terms and respective category assigned in our questionnaire later.

Section 3 elaborates on the methodology including a short overview of the questionnaire and data setting according to QCA fuzzy set, coding and data calibration for fsQCA package.

Section 4 includes the discussion and results with a truth table.

Literature Review

Eco-Innovation & it's scope

The curiosity over the definition of eco-innovation has been there for quite some time. Since the idea became famous due to rising awareness about environmental challenges, many new definitions kept coming up over the years. Commonly understood as any new activities in a firm that contribute to reducing harmful impact on the environment, with time the definitions have evolved. In the last many years, eco-innovation has been described with closely related but different characterizations. However, different editions of the OSLO manual (OECD 2005) have been a benchmark for many authors to give their own relevant definitions. OSLO manual has been developed jointly by OECD and Eurostat. It is extremely relevant for us as it had been a guideline for all eco-innovation surveys and past researches.

One widely accepted definition is given by Kemp and Pearson (2007) "Eco-innovation is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives."

OSLO manual (2005) defines an innovative firm as the one that has implemented an innovation during the period under review. Building upon that it says that the product/process innovative firm is one that has implemented a new or significantly improved product or process during the period under review. The time period is an important factor as the measurement of eco-innovation must be defined in a time period. However, after determining the period under review, the important aspect to keep the all-inclusive view is to define the scope of factors on eco-innovation. That includes innovation oriented towards achieving environmental benefits within the enterprise and later during the use of the product at the consumer level. The scope of eco-innovation is wider than discussed earlier. (Brien et al. 2011) argue that eco-innovation goes beyond eco-industries to encompass innovation in the way resources are sourced and products are designed, produced, used, re-used and recycled across all sectors. This includes technological and non-technological changes that benefit both the economy and the environment. Resource efficiency means using fewer resources to achieve the same or improved output (resource input/output). It is an input-output measure of technical ability to produce "more from less".(Brien et al. 2011)

Authors (Arundel and Kemp 2009) argued about the coverage of eco-innovation research stating that eco-innovation research and data collection should not be limited to such environmentally motivated innovations, but should encompass all products, processes, or organizational innovations with environmental benefits. Later they discuss the idea of innovation-oriented towards resource use, energy efficiency, greenhouse gas reduction, waste minimization, reuse and recycling, new materials (for example nanotechnology-based) and eco-design.

Thus, the scope of eco-innovation goes way beyond the traditional idea encompassing a far more holistic view of the concept discussing about innovation within the firm, innovation benefitting at consumer level, innovation to maximize the sourcing, utilization and reuse of resources, technological and non-technological innovation, innovation covering both product and processes, using newer materials and newer designs.

Furthermore, there is an exhaustive discussion about the determinants of eco-innovation. We can initially categorize the determinants as external and internal determinants. Among external determinants, there are factors like environmental regulations, taxes, government grants, federal incentives etc. These are factors mostly related to government and policy directly affecting the eco-innovation. In past, numerous authors (Kemp and Pontoglio 2011; Kammerer 2008; Rehfeld, Rennings, and Ziegler 2007; Horbach, Rammer, and Rennings 2012; Horbach 2008, 2015; Ghisetti and Pontoni 2015; Rennings 2000) have discussed and termed these factors. We go with the term *environment policy instruments* as used by Kemp and Pontoglio to refer to all government and policy-related factors affecting eco-innovation. Additionally, there are external factors related to the market. This includes demand for eco-innovation or ecologically innovated products and cost of basic resources and material. Previously, authors (Kemp and Pontoglio 2011; Kammerer 2008; Hojnik, Ruzzier, and Manolova 2018) have discussed market factors and we use the term *market-based instruments* to refer to all market-related factors. Then there are pollution taxes and emission trading systems which are facilitated by policies but function in the market thus overlapping policy and market-based instruments.

"What the case study literature shows is that the specifics of the policy and the situation in which they are applied are all-important for the outcomes." (Kemp and Pontoglio 2011). Categorically, policy instruments and market instruments are central to the eco-innovation activities. (Kemp and Pontoglio 2011; Rehfeld, Rennings, and Ziegler 2007; Kammerer 2008). These authors further reason about the missed role of policy and market instruments, highlighting the importance of policy instruments, then (Kemp and Pontoglio 2011) discounted the role of only policy effect on eco-innovation "policy instruments cannot be usefully ranked with regard to their effects on eco-innovation, and the often expressed view that market-based approaches such as pollution taxes and emission trading systems are better for promoting eco-innovation is not brought out by the case study literature or by survey analysis and seems only warranted for non-innovative, or marginally-innovative, changes." Later they have reasoned in favour of market-based instruments, however pointing out the role of regulations in stimulating innovation. Further, (Kammerer 2008) also talked about market instruments as *market pull* factors of eco-innovation.

Further, among internal factors, we have research and development, internal cooperation, and the targets to achieve resource efficiency. Authors have argued about the importance of research and development along with some aspects of policy instruments. (Ghisetti and Pontoni 2015) have pointed towards regulatory stringency as most important among policy instruments as a determinant of eco-innovation. And have further concluded R&D as a less likely determinant of eco-innovation. But (Rehfeld, Rennings, and Ziegler 2007) have argued earlier that environmental policy is a driver for environment product innovation, even if the positive effect is rather weak. Moreover, they have clearly pointed out the importance of R&D activities, market factors and firm's individual characteristics having an influence on eco-innovation.

Also, cooperation activities or collaborations of firms with various stakeholders and R&D activities have a varying degree of influence over eco-innovation. Collaboration is an important part of the innovation activities of many firms. (Manual and Data 2009). Collaboration can involve the joint development of new products, processes or other innovations with customers and suppliers, as well as horizontal work with other enterprises or public research bodies.

Structural Interpretation & Theory

Based on the insights from the authors, we construe the eco-innovation affecting and being caused by (a) resource efficiency, (b) Institutional reasons or policy-based instruments, (c) Market instruments, (d) Firm's soft image (goodwill and reputation), (e) Cooperation activities

Resource efficiency or positive environmental effects can be explicit goals or side-effects of innovations. They can occur within the respective companies or through customer use of products or services (Horbach, Rammer, and Rennings 2012). Resource efficiency has a twofold function with eco-innovation. On one hand, firms attempt to introduce a process innovation to reduce the use of materials and energy, reduce pollution, and improve recycling processes all within the enterprise. On the other hand, the purpose is also to achieve a product innovation that will provide environmental benefits during the use of goods or service. By knowing the environmental benefits obtained at the enterprise level and consumer level, this factor helps us to understand the outcome realised after going through the innovation process.

Institutional reasons or policy-based instruments are mostly pushed factors introduced by authorities. It is seen in three different ways. Eco-innovations are found to be driven by environmental (regulation) and economic concerns (Kemp 2010). Firstly, the local or state authorities ask the firms to do certain innovation activities as a requirement. These requirements are communicated with a policy framework usually designed to meet environmental sustainability goals. Secondly, firms are asked to invest a certain percentage of their profits in some specific eco-innovation actions by the same authorities. Sometimes these authorities also provide tax breaks or other monetary benefits against investments to promote eco-innovation activities. Thirdly, those authorities put a regulation on firms involved in any way with any state actors to meet a minimum benchmark for eco-innovation in order to keep working with them. Environmental regulations and their execution significantly influence environmental performance, indicating that under the same conditions—with stricter environmental regulation and more stringent regulatory implementation—environmental performance will be better (Dong et al. 2014).

Market instruments are also seen in three ways. Firstly, firms tend to eco-innovate to keep up with consumer demands. Modern consumers are becoming environmentally responsible and firms have to meet their expectations. Second, it is the competition from other firms that are pushing them to keep up their efforts to remain innovative and eco-innovative. This also relates to the demand for eco-innovation. Firms involved in international business activities tend to stay more eco-innovative as the awareness in different markets (especially western markets) are much higher. "Internationalization leads to the adoption of eco-innovation, and this relationship seems to be stronger in medium-sized companies"(Hojnik, Ruzzier, and Manolova 2018). Thirdly, the cost of materials, energy and other resources also make firms to switch for alternative substitutes.

Further, the authors (Rehfeld, Rennings, and Ziegler 2007) have described soft factors as voluntary agreements or environmental labelling (standard certifications) that may stimulate environmental product innovation. According to the descriptive analysis of environmental product innovators, economic aspects (i.e. higher prices) rather than soft factors appear to be the major obstacles to the commercial exploitation of environmental products and thus also to environmental product innovations (Rehfeld, Rennings, and Ziegler 2007). Undoubting, the soft factors have been a driving reason

for eco-innovation but without the market incentive, there's always an obstacle for committing to eco-innovation.

Firm's soft image (goodwill and reputation) is a critical factor for economic success as well. Particularly consumer goods firms these days are exceedingly aware of their positive image. There are numerous social media channels and popular media platforms that are critically judgemental of any flaw. In other types of firms as well, public image is a very important issue. Eco-innovation activities improve the reputation of firms and help to keep a positive image. Moreover, a lot many firms take voluntary eco-innovation initiatives to improve their public image. The positive and significant impact of social pressure on enterprises' willingness to adopt/develop clear production technologies, it would be necessary to increase the appropriate social pressure to influence their perceived economic risk and behaviour intention (Zhang, Yang, and Bi 2013).

Cooperation activities are instrumental in eco-innovation. External green supply chain management (GSCM) practices typically require some level of cooperation with external stakeholders or partners such as suppliers and customers. The performance outcomes include direct environmental (with an emphasis on pollution reduction), economic, and operational performance outcomes from the adoption of the GSCM practices. (Q. Zhu, Sarkis, and Lai 2013). Previous researches have shown how different cooperation partners have induced innovation by sharing technologies and many times developing innovation together. A common example is a university-industry cooperation. Research has shown that green innovations require a higher degree of cooperation with external actors such as suppliers, knowledge-intensive business services and research institutes than conventional innovations (De Marchi 2012). Also end-user cooperation has been instrumental in developing eco-innovation. Users were basically co-developing the novel green product or service from the very beginning of the innovation process (Zimmerling, Purtik, and Welpe 2017).

The five factors triggering the performance outcome rather do not act in isolation. They complement each other in bringing eco-innovation, so there is a fair amount of interrelationship among the factors. For example, (Rehfeld, Rennings, and Ziegler 2007) have pointed out a relationship between market instruments and policy instruments by stating that the success of diffusion of environmentally innovative

products depends on the price but improvements in the relative price require environmentally favourable policy instruments like reduced VAT rates.

It is important to remember that one factor alone will have very little to no effect on eco-innovation. There is always a combination of external factors and firm's actions that have a varying degree of influence on achieving eco-innovation in any firm.

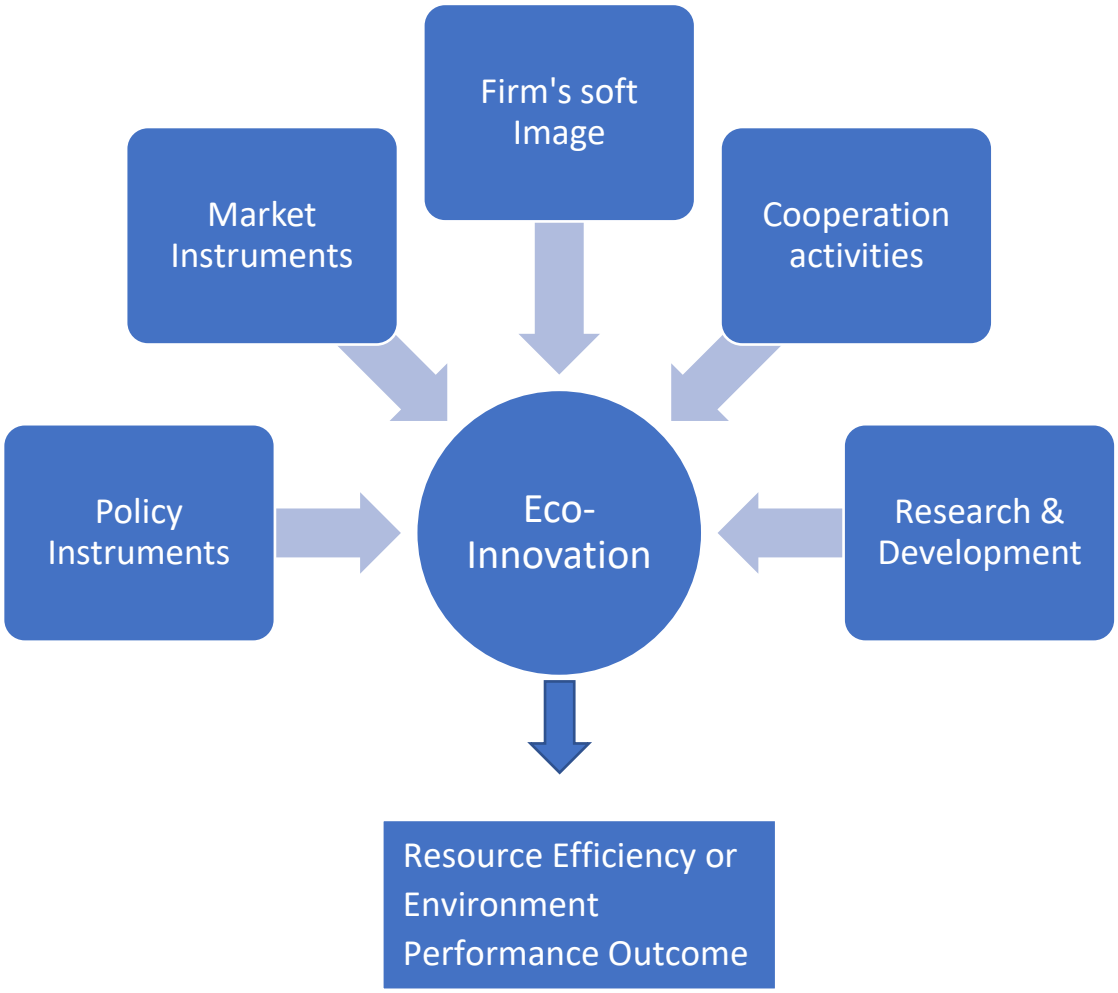


Fig. 1. Relationship between factors, eco-innovation and performance

Methodology

In this research, we deal with primary data from Chinese companies. We collected all the data ourselves using a well-structured questionnaire based on the theory and literature. The data collection primarily focused on ecological innovation. In the European context, there have been many previous attempts to collect and analyse company-level data for eco-innovation. However, it has been non-existent in the

Chinese context. It nevertheless provided us with a head start in terms of the basic structure of the questionnaire.

We chose to study Chinese firms mainly due to two reasons. Firstly, the economic growth in China has brought Chinese companies in the front specifically for manufacturing firms. China is considered the manufacturing centre of the world and ecological innovation among manufacturers in China is becoming gaining awareness. At the same time, we read a lot in international media about pollution in China. Secondly, there is an absence of first-hand company-level data about eco-innovation for Chinese companies. Environmental regulation has a significant influence on a firm's environmental performance and competitiveness while the implementation of environmental regulation only has significant effect on a firm's environmental performance…..that means China has established effective environmental regulations and spurred improvements in the environmental performance of its enterprises (Dong et al. 2014). Chinese firms have started to follow the path of systematic eco-innovation in recent years. However, in the Chinese context, it remains a largely unexplored paradigm. "…in the context of sustainable development and the construction of an ecological civilization, China's overall level of eco-innovation among its various provinces exhibits an increasing trend" (Chen, Cheng, and Dai 2017). Moreover, in China, the mandatory cleaner production audit system has given positive results in terms of pollution prevention and pollution reduction (Bai et al. 2015).

Chinese work culture and companies behave quite differently as compared to their European counterparts. For example, when we were working on the questionnaire, we had to keep in mind the Chinese regulatory system and sensitiveness. Also, for traditional reasons, Chinese companies on many occasions wouldn't be very willing to answer questions about their work. Moreover, we faced hurdles due to language as well.

The firms we targeted are situated in at least 3 different industrial parks in China with some firms also functioning independently outside the industrial parks.

Most of the firms we received data from are located in 2 different industrial park, first, Suzhou Industrial Park, a major industrial park in China located in Suzhou which is a key city situated in south-eastern Jiangsu Province of East China; and second from China Yixing Industrial Park for Environmental Science & Technology (ES&TP) which is a national Hi-Tech Industrial Development Zone situated in Yixing county in

Southern Jiangsu province of China. Moreover, some firms are from other locations outside the industrial parks. For our research studying firms from industrial parks is best suited as the industrial parks in China are the first places where firms started to implement environmentally friendly practices and adopted an eco-innovation culture. And some firms from outside industrial parks created diversity in our sample data.

Questionnaire

The questionnaire we used is an adapted and edited version of *The Community Innovation Survey* (CIS) based innovation statistics of the EU science and technology statistics.[2] Our questionnaire is built on the last version of the CIS survey that was published by Eurostat in 2014. The original survey consisted of four innovation categories; product, process, organizational and marketing innovation. However, we used only product and process innovation questions as it better suits our research requirements and added other relevant questions specific to the Chinese context and our research requirements.

Since we used the CIS survey, the definition of product innovation and process innovation that is used in the questionnaire precisely follows the definition given by the OECD in OSLO manual.

A **product innovation** is the market introduction of a **new** or **significantly** improved **good or service** with respect to its capabilities, user-friendliness, components or sub-systems.

A **process innovation** is the implementation of a **new** or **significantly** improved production process, distribution method, or supporting activity.

In addition, both product and process innovation:

- **Must be new to the enterprise**, but they **do not need to be new to the market**.
- The innovation could have been originally developed by the enterprise or by other enterprises or organizations.

---

2 Community Innovation Survey - Eurostat

"Community Innovation Survey - Eurostat". 2017. *Ec.Europa.Eu*. https://ec.europa.eu/eurostat/web/microdata/community-innovation-survey.

Fig. (2) shows the definition of product innovation and process innovation:

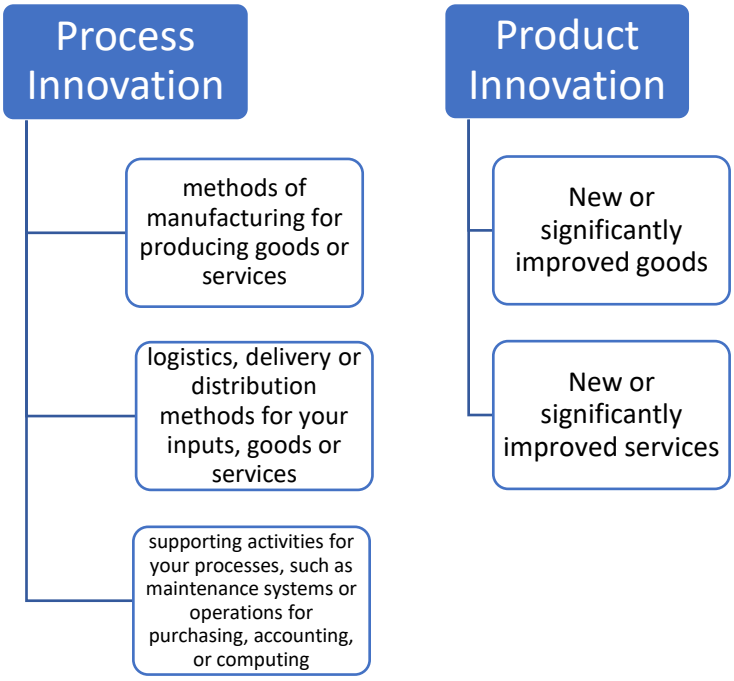


Fig. 2 Defining product innovation and process innovation (OECD 2005)

The product and process innovation in the context of eco-innovation results in environmental benefits realized. In our questionnaire, we have a section specifically asking about the environmental benefits obtained within the enterprise and environmental benefits obtained during the consumption or use of goods or service. These questions were present in the original CIS questionnaire based on the definition from OECD. Fig. (3) shows the benefits realised as used in the questionnaire.

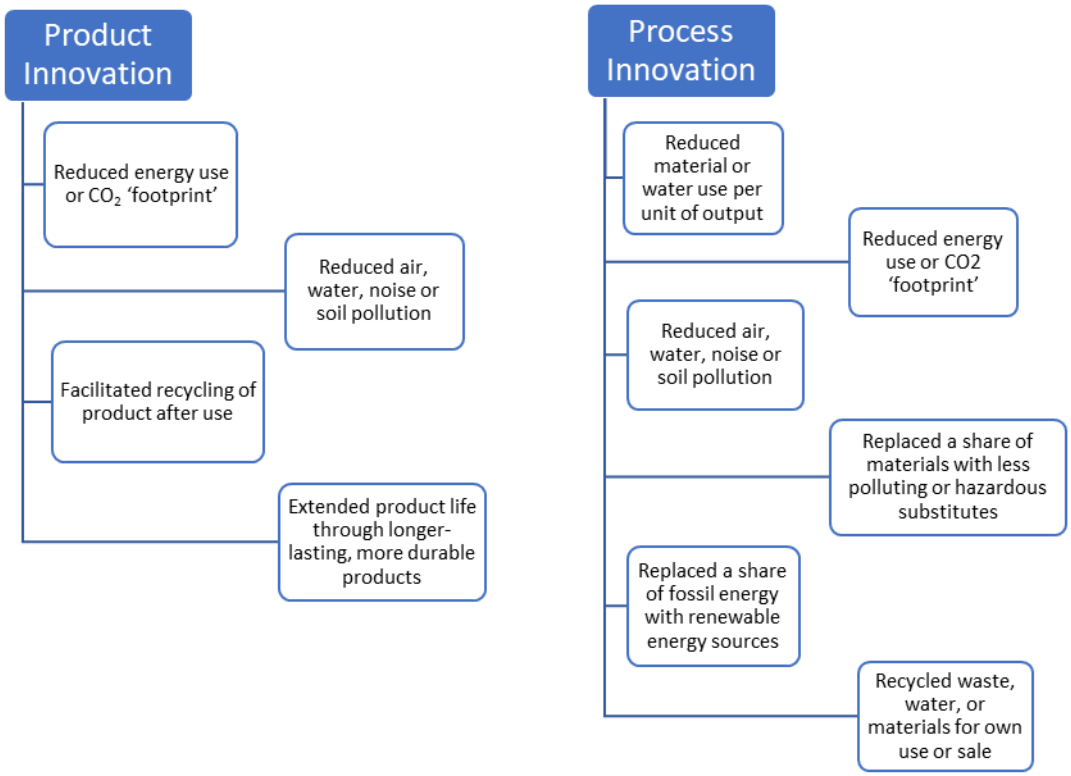


Fig. 3 Environmental benefits obtained (Realizing Eco-innovation)

In the case of product innovation, all four categories mentioned (Fig.3) are at the end-user level, it is where the product gets consumed. So the consumers act as a cooperation partner. Since novel green innovations are often systemic in nature and require changes in consumption behaviour, end-user integration along the innovation process may be particularly relevant for the success of such products and services. (Zimmerling, Purtik, and Welpe 2017)

As been pointed out by (Arundel and Kemp 2009) "for measuring eco-innovation, no single method or indicator is likely to be sufficient." Thus, we attempt to use a combination of indicators responsible for eco-innovation and used the questionnaire to capture those indicators.

Our final questionnaire was of 10 pages including the questions, multiple-choice responses, space for written replies, all definitions and descriptions. All the questions and response options were coded systematically to simplify the data collection process. The final questionnaire was also translated into the Chinese language. The questionnaire was delivered to the target companies into two different online formats

and also in normal .pdf format. Moreover, for a few companies, we conducted the interviews on-site and requested the responsible managers to complete the questionnaire.

In total, we received replies from 65 companies. After careful assessment, we removed incomplete and incoherent replies and selected 57 companies for our analysis.

Data Setting (fuzzy set & QCA)

The questionnaire was designed in a way to complement the prior definition of eco-innovation given by various authors and by OSLO manual.

The responses to the questionnaire we received came to us in different forms through an online platform and offline methods, which was further required to be arranged in order to fit our methodological procedure in the qualitative comparative analysis (QCA) where we used fuzzy set for analysis.

In the fuzzy set analysis, both the causal conditions and the outcome are represented using fuzzy sets. The basic idea behind fuzzy sets is to permit the scaling of membership scores and this allows partial or fuzzy membership. A membership score of 1 indicates full membership in a set; scores close to 1 (e.g., .8 or .9) indicate strong but partial membership in a set; scores less than .5 but greater than 0 (e.g., .2 and .3) indicate that objects are more “out” than “in” a set, but still weak members of the set; a score of 0 indicates full non-membership in the set. Thus, fuzzy sets combine qualitative and quantitative assessment: 1 and 0 are qualitative assignments (“fully in” and “fully out”, respectively); values between 0 and 1 (non-inclusive) indicate a degree of membership (Ragin 2000). The 0.5 score is also qualitatively anchored, for it indicates the point of maximum ambiguity (fuzziness) in the assessment of whether a case is more "in" or "out" of a set.” (Ragin 2007). Hence, fuzzy scores show that to what degree a certain case belongs to a set.

We used qualitative comparative analysis (QCA) technique as our methodology and fsQCA package as a software tool. QCA uses crisp set and fuzzy sets to indicate the presence or absence of a condition. In crisp set, each case is assigned either 0 or 1, showing presence or absence of a certain condition. However, fuzzy sets increased the scope of QCA by allowing to assign any score in the interval between 0-1 (Ragin 2007). For analysis, fsQCA utilizes data in the form of output and conditions where both

conditions and output are to be used in either fuzzy or crisp set for entering in the software tool.

In our investigation, we utilized the fuzzy set approach of QCA. One of the strengths of QCA is that it allows to group data in a smaller number of conditions utilizing all the relevance of it. It is very useful in our context as it made possible for us to exploit maximum available conditions.

In our data, we have 57 different cases with varying degree of scores for each case. We arranged our data to assign them relevant fuzzy set scores in order to be tested in fsQCA.

Setting fuzzy scores from the questionnaire

We followed a simple procedure to assign fuzzy set scores to the responses we received in our questionnaire.

Below is the screenshot of a part of our questionnaire. This is an example of how we assigned scores initially before grouping the responses. Here we are showing it to explain how we actually assigned the fuzzy set scores to our responses.

During 2015 to 2017, how important were the following factors in driving your enterprise's decisions to introduce innovations with environmental benefits?

	Degree of importance				
	High	**Medium**	**Low**	**Not relevant**	
	3	*2*	*1*	*0*	
Existing environmental regulations	☐	☐	☐	☐	*ENEREG*
Existing environmental taxes, charges or fees	☐	☐	☐	☐	*ENETX*
Environmental regulations or taxes expected in the future	☐	☐	☐	☐	*ENREGF*
Government grants, subsidies or other financial incentives for environmental innovations	☐	☐	☐	☐	*ENGRA*
Current or expected market demand for environmental innovations	☐	☐	☐	☐	*ENDEM*
Improving your enterprise's reputation	☐	☐	☐	☐	*ENREP*
Voluntary actions or initiatives for environmental good practice within your sector	☐	☐	☐	☐	*ENAGR*
High cost of energy, water or materials	☐	☐	☐	☐	*ENCOST*
Need to meet requirements for public procurement contracts	☐	☐	☐	☐	*ENREQU*

Here we have responses in the form of *Degree of importance: High, Medium, Low & Not Relevant*. So, we assigned a score to each response in questionnaire assigning *High-1, Medium-0.66, Low-0.33 and Not Relevant-0*. This way of score assigning is as per the fuzzy set logic. A value of 1 shows the case is 'fully in' the set, and 0 shows that the case is 'fully out' of the set. Similarly, 0.66 indicate 'more in than out' and 0.33 indicates 'more out than in'.

Calibration

For analysis, the fsQCA software tool allows us to provide a group of input conditions and one output condition. Thus, we were able to put together different factors from our questionnaire and group them into conditions. We followed a three-step procedure to arrive at our truth table:

- We followed the evidence from different authors as we discussed in literature review and theory, and decided to create our 5 input conditions and one output measure.
- Then we coded the conditions and output to indicate full membership, partial membership, partial non-membership and full non-membership.
- Finally, we constructed a truth table with 2^k rows, where k is the number of input conditions we used in our analysis.

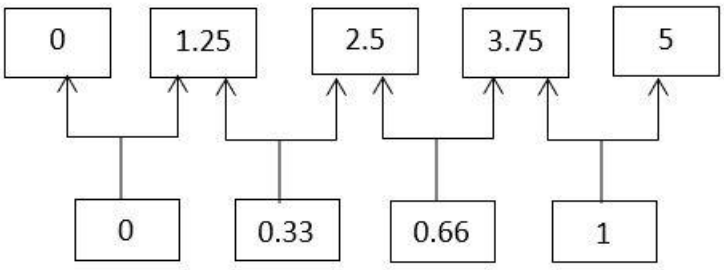
Scores and Coding

Condition 1. Based on the evidence from various authors, we decided to create our first input condition using replies within policy instruments. These conditions are either pushed by state or local authorities or are required by firms to fulfil in order to gain government grants or procurements.

- Existing environmental regulations (ENERG)
- Existing environmental taxes, charges or fees (ENETX)
- Environmental regulations or taxes expected in the future (ENREGF)

- Government grants, subsidies or other financial incentives for environmental innovations (ENGRA)
- Need to meet requirements for public procurement contracts (ENREQU)

The fuzzy set scores of these five conditions are added-up and used to create a new condition, and took X as the sum of all five (see table 1). The first input condition for fsQCA **ENRTP** was created based on the value of X as follows:
ENERG+ENETX+ENREGF+ENGRA+ENREQU = (X)
Since the replies are already given fuzzy scores, the minimum value of X can 0 when all replies are *not relevant* and the maximum value can be 5 when all replies are *High*. New values are assigned to **ENRTP** based on fuzzy score range as follows:



Based on the added values we categorise our sample into sets and assign them a fuzzy score:

Values 0-1.25 received a fuzzy score of 0 indicating fully out of the set.
Values 1.26-2.5 receive a fuzzy score of 0.33 indicating more out of set than in.
Values 2.56-3.75 receive a fuzzy score of 0.66 indicating more in the set than out of the set.
Values higher than 3.75 receive fuzzy score of 1 indicating fully in the set.

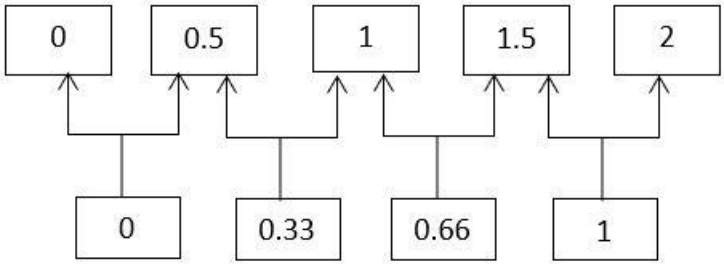
Condition 2.

Similarly, a second condition is created by combining replies from ENREP and ENAGR as they both represent the soft image of the firm.

- Improving your enterprise's reputation (ENREP)
- Voluntary actions or initiatives for environmental good practice within your sector (ENAGR)

We sum up (ENREP+ENAGR= Y). Since the replies are already given fuzzy scores, the minimum value of Y can be 0 when both replies are *not relevant* and the maximum value can be 2 when both replies are *High*. Combining replies from these two conditions

together we get our second input condition **ENRPV** with its assigned fuzzy scores as follows:

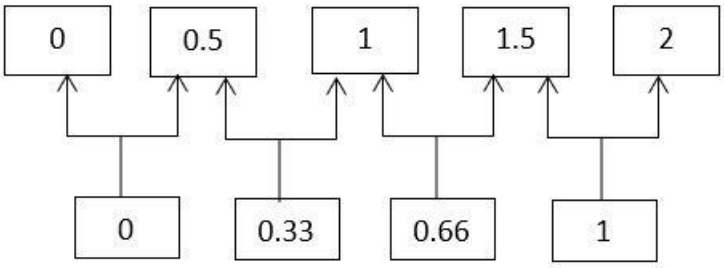


Condition 3

For the third input condition replies from ENDEM and ENCOST are combined together as they represent the market demand and cost of input materials.

- Current and expected market demand for environmental innovation (ENDEM)
- High cost of energy, water or materials (ENCOST)

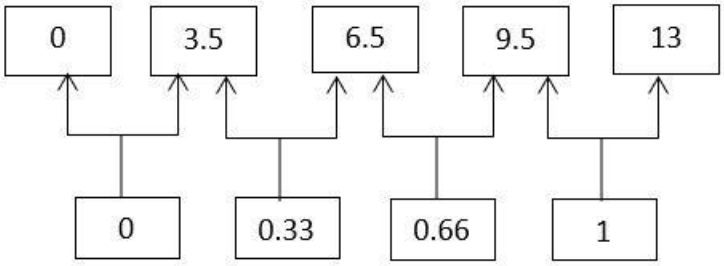
We sum up (ENDEM+ENCOST= Z). Since the replies are already given fuzzy scores, the minimum value of Z can 0 when both replies are *not relevant* and the maximum value can be 2 when both replies are *High*. Combining replies from these two conditions together we get our third input condition **MRKT** with its assigned fuzzy scores as follows:



Condition 4

The fourth input condition is based on innovation-cooperation partner and their location. In our questionnaire we have questions about eight different types of cooperation partners in five different locations, giving us 40 units of possible replies for each firm. The condition cooperation captures the degree of diversity in two ways, firstly by type of cooperation partner and secondly by the location of the cooperation partner.

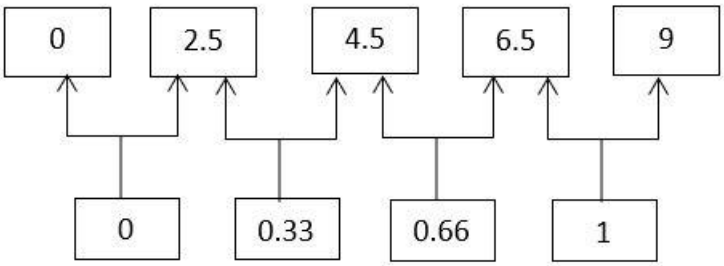
In our questionnaire we have locations including local regions, western countries and eastern countries; and type of cooperation partners include universities, governments, suppliers, consumers, etc. The maximum number of replies we received from a firm is 13. By simple distribution taking 0 as a minimum value and 13 as the maximum value we assign a fuzzy score for our input condition as follows:



The fourth input condition showing fuzzy set score of cooperation is **CO.**

Condition 5.

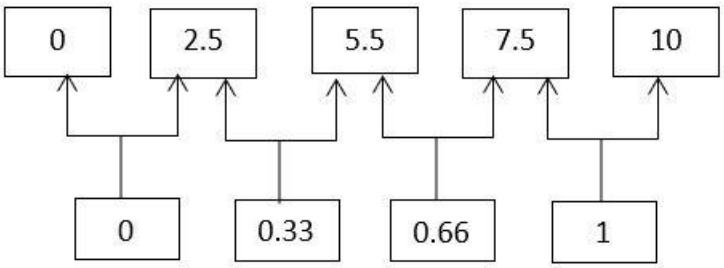
For the fifth input condition, we used 9 different units of research and development data. It means, in our questionnaire, we asked questions about 9 different types of R&D. We asked questions about in-house and external R&D. With the minimum value of zero when there is no R&D and a maximum value of 9, we decided to assign a fuzzy score accordingly. A fuzzy set score was assigned to create input condition **R&D** as follows:



Output condition

After five input conditions for fsQCA, one output condition was created using the replies for questions on environmental benefits obtained from innovation activities. There are a total of 10 questions in the questionnaire with binary replies. We asked questions about environmental benefits obtained within the enterprise and environmental benefits obtained during the consumption or use of good or service as

shown in fig. (3) before. It shows the environment performance outcome achieved or eco-innovation realised. We create our output condition as **Performance** based on the number of 'yes' replies received. The minimum value is zero when no eco-innovation took place so no performance and the maximum value is 10 with all performance achieved. Hence, we assign a fuzzy score for output performance as follows:



Thus, after arranging all the data and calibrating it according to the fsQCA software tool we have five input conditions (causal conditions) and one output condition.

Input conditions:

- **ENRTP**: All policy instruments and regulations
- **ENRPV**: Goodwill and reputation
- **MRKT**: Market factors and Cost of inputs
- **CO**: Cooperation
- **R&D**: Research and Technology

Output condition:

- **Performance:** Environmental benefits

Outcome Measure	Performance 1.00 Achieving eco-innovation standards 0.66 Partially achieving eco-innovation 0.33 Minimum eco-innovation observed 0.00 No eco-innovation noticed
Input Conditions	Policy Instruments (enrtp) 1.00 High impact of policy on firm's eco-innovation 0.66 Medium impact of policy on firm's eco-innovation 0.33 Low impact of policy on firm's eco-innovation 0.00 No effect of policy measures or policy measures absent Soft Image (enrpv) 1.00 Eco-innovation done to create a positive image 0.66 Some eco-innovation done voluntarily 0.33 Few voluntary activities 0.00 Almost no voluntary eco-innovation activities by the firm Market Instruments (mrkt) 1.00 High influence of growing demand and cost of resources 0.66 Medium influence from the market on eco-innovation 0.33 Low influence from the market on eco-innovation 0.00 No impact on eco-innovation activities Cooperation (co) 1.00 Strong cooperation activities involving many partners 0.66 Medium level cooperation involving fewer partners

	0.33 Low-level cooperation activities 0.00 Low or no cooperation activities Research and Development (r&d) 1.00 High focus and investment in R&D, both external and internal 0.66 Medium focus and investment in R&D 0.33 Low focus and investment in R&D 0.00 Almost zero or zero R&D activities

Table 1: Fuzzy scores for each condition

Analysis

We run our analysis in fsQCA. First, we feed the data into the fsQCA software in the form of five input conditions and one output. Then we analyse using the fuzzy truth table algorithm function within the software. Here we construct a truth table with 2^k rows, where k is the number of causal conditions (input conditions). We have 5 causal conditions, so we get a truth table with 32 rows. In the next step, the number of rows in the truth table is reduced by coding within the software by removing all the rows without any case (number=0), thus creating a commonly accepted frequency threshold of 1 (Greckhamer, Misangyi, and Fiss 2013) that would result in inclusion of all the cases and removing all configurations without any case. Then we assign performance as 1 when the consistency is more than 80% which we chose as our threshold and performance as 0 for all cases with consistency below our threshold of 80% (Ragin and Fiss 2008). This means that we consider performance to be present by showing **(1)** only when our post-analysis consistency is more than 80%. The fuzzy score for performance that we used before to input data into the system is used to create a set of samples. At this stage we assign score 1 to performance cases on system generated consistency. This step gives us a truth table with simplified combinations. Eventually, fsQCA generates the following truth table:

enrtp	enrpv	mrkt	co	r&d	number	performance	raw consist.
0	1	1	1	1	2	1	0.937833
1	1	1	1	1	5	1	0.928649
1	0	1	1	1	1	1	0.906594
1	0	1	0	1	5	1	0.873592
1	1	1	0	1	20	1	0.86708
0	0	1	0	1	1	1	0.841444
0	1	1	0	1	5	1	0.825773
1	1	1	0	0	4	0	0.789539
1	1	0	1	1	1	0	0.74717
0	1	0	0	1	1	0	0.731076
0	1	0	1	1	1	0	0.705128
1	0	0	0	0	2	0	0.6675
1	0	0	0	1	1	0	0.665835
0	0	0	0	0	5	0	0.611582
0	0	0	0	1	3	0	0.559925

Table 2: Truth table

This truth table comprises all the 57 companies involved in the investigation, including the ones which showed environmental performance outcome, and those which did not show performance.

The truth table shows all the input conditions and the output (performance) in different combinations. The column ‘number’ shows the number of cases (companies) representing each combination of conditions. Performance shows the environmental benefits obtained or eco-innovation realised which are given score 1 when consistency is over 80%.

Discussion

Results from fsQCA Truth Table

- Out of 57 companies, there are a total of 39 cases (companies) that showed positive environment performance (1) and in the remaining 18 cases, environment performance outcome is absent.
- The combination of condition with performance (1) having the highest number of cases (20 cases) has a consistency of almost 87%. However, in this situation the condition cooperation (**CO**) is absent. But policy instruments (enrtp), soft

image of the firm (enrpv), market instruments (mrkt), and research (r&d) are present.

- The conditions **mrkt** and **r&d** are present in all 39 cases where performance is present (1)
- Market instrument **mrkt** is absent from all 18 cases where performance outcome is absent
- There are 2 cases in the first row with performance and high consistency even though policy instruments are absent there

We see that the presence of market instruments and R&D is most important for environment performance outcome to be present. As performance represents environmental benefits achieved by eco-innovation, it means the presence or absence of eco-innovation is highly impacted by market instruments and R&D. However, we cannot discount the importance of other input factors like policy instruments and soft image of the firm as their presence marks the majority of cases showing eco-innovation.

But we can certainly say that the absence of cooperation activities (co) have minimum effect on our outcome. 31 out of 38 cases still showed positive environmental performance outcome even when ***co*** is absent.

So, we can clearly say here that the presence of market instruments along with other conditions in combinations has been the strongest driver in the process of realizing eco-innovation among Chinese firms. However, it is noticeable that the absence of cooperation did not strongly affect performance. Although its presence may facilitate performance when another condition is absent.

Moreover, the presence of R&D is a very deciding factor. We see r&d is still present in many cases where performance didn't happen. We can perhaps say that r&d in these cases did not transform into performance due to the absence of other conditions, notably market factors that provide a financial incentive.

Followed by truth table the fsQCA software provides some analysis of truth table showing the models with different combinations with cases. FsQCA presents three solutions to each truth table analysis: (1) a "complex" solution that avoids using any counterfactual cases (rows without cases— "remainders"); (2) a "parsimonious" solution, which permits the use of any remainder that will yield simpler (or fewer)

recipes; and (3) an "intermediate" solution, which uses only the remainders that survive counterfactual analysis based on theoretical and substantive knowledge (which is input by the user). Generally, intermediate solutions are best. (Ragin 2008)

In the analysis, the sign ~ before a condition signifies the absence of that condition.

For complex solution we get solution for all 15 rows as our truth table is already coded to show rows only where there is at least one case. So, any rows without cases (remainders) are already taken out.

****

TRUTH TABLE ANALYSIS

****

Model: performance = f(enrtp, enrpv, mrkt, co, r&d)

Rows: 15

--- COMPLEX SOLUTION ---

frequency cutoff: 1.000000

consistency cutoff: 0.825773

	Raw Coverage	Consistency
mrkt*~co*r&d	0.630871	0.846072
enrtp*mrkt*r&d	0.699472	0.888703
enrpv*mrkt*r&d	0.691029	0.830901

Intermediate solutions are more inclusive and easier to interpret, but the parsimonious solutions show which conditions are essential to distinguish between positive and negative cases. Following this approach, attribute configurations that are part of both intermediary and parsimonious solutions are referred to as core conditions, whereas those present in intermediate but not in parsimonious solutions are referred to as complementary conditions. (Abbate et al. 2018)

--- PARSIMONIOUS SOLUTION ---

	Raw Coverage	Consistency
mrkt*r&d	0.787599	0.824813

In this analysis, the parsimonious solution only portrays conditions **mrkt** and **r&d** as we noticed in the truth table, these two conditions are present in all 39 cases where performance is present.

--- INTERMEDIATE SOLUTION ---

	Raw coverage	Consistency
r&d*~co*mrkt	0.630871	0.846072
r&d*mrkt*enrpv	0.691029	0.830901
r&d*mrkt*enrtp	0.699472	0.888703

Mrkt and **r&d** are our core conditions, and the rest are our complementary conditions.

Enrtp: Policy Instruments	Complementary condition
Enrpv: Goodwill & Reputation	Complementary condition
Mrkt: Market Instruments	Core condition
Co: Cooperation	Complementary condition
R&d: Research and development	Core condition
Overall Solution Coverage	0.778628
Overall Solution Consistency	0.838829

The core conditions (**mrkt** and **r&d**) are those which trigger our outcome (performance) the most. The common conditions from parsimonious solution and intermediate solution are reflecting what we noticed in the truth table before.

Also, we can clearly notice in the first combination of the intermediate solution, our core conditions **r&d** and **mrkt** are present whereas complementary condition **~co**

(cooperation) is absent, we still get a suitable consistency of more than 84% without the presence of cooperation.

Further Discussion

We did get results by going through the structural process of analysis using fsQCA on our questionnaire data, but then, in addition to that, we were fortunate to have an in-depth understanding of issues and challenges related to innovation, eco-innovation, market situations, etc. from high-level management's perspective by doing meetings and interviews.

The QCA finding is in line with the thoughts of managers we interviewed, where they pointed out that any implementation of eco-innovation activity is a cost. So, they undertake these activities mostly because through different policy regulations they are made to act for eco-innovation including putting investments in eco-innovation R&D; or they do so when they have a financial incentive from the market in form of higher demand of eco-innovation where their customers are willing to pay more for environmentally friendly products or services, or in form of bringing down the cost of resources. Many of the firms included in our survey are equipment manufacturing firms (where they are directing in manufacturing of environment-friendly equipment), with many firms specifically manufacturing environmental products for other firms. Hence, it goes two ways for these firms. Firstly, investment in eco-friendly processes within their setup require investments in environmental products, training, new hiring, etc. Secondly, their customer faces the same challenges of high cost again thus making it expensive, difficult and slow process.

Hence, to introduce and implement any innovation activities directed towards achieving better environmental performance or eco-innovation requires motivations and incentives. Market instruments provide that motivation and incentive; firstly, by providing higher market demand for environmental innovation in form of product demand or technology demand; and secondly, high cost of resources and energy makes them undergo innovation to reduce consumption and/or switch to better eco-friendly resources. Eco-innovation behaviour is proven to be helpful in boosting a firm's environmental performance, and then, indirectly enhancing its economic performance (Cai and Li 2018).

This also explains the presence of R&D in all cases with performance. Since cooperation is absent and has little to no role in our performance outcome, the market factors could play a role in encouraging internal or external research and development activities which in turn help to trigger eco-innovation along with market factors.

Market instruments are pull factors from the firm's point of view. As are the soft image factors where firms voluntarily go under eco-innovation process to keep a good public image. But then there are push factors which are mainly policy instruments.

Conclusion

We notice two different interpretations. In our analysis, we see that market instrument or economic factors are more at play among Chinese companies. And policy instruments which are mostly regulatory in nature are although important but not the most important factor for driving eco-innovation performance. Perhaps in China, the policy framework and regulations for eco-innovation are not strict or not strictly implemented so the companies are motivated more by financial incentives coming from market instruments. Moreover, importantly, cooperation activities have little to no role in triggering eco-innovation among Chinese firms.

There is consensus within the literature (Kemp and Pontoglio 2011; Kammerer 2008; Horbach 2008; Horbach, Rammer, and Rennings 2012; Rehfeld, Rennings, and Ziegler 2007) about the role of policy framework in inducing eco-innovation. Past researchers have provided results from other countries using econometric analysis. "A very important outcome of our econometric analysis is that environmental regulation, environmental management tools, and general organizational changes and improvements are highly relevant motivations for environmental innovation" (Horbach 2008). Further (Horbach 2015) gave evidence about that among East European countries environment awareness leading to eco-innovation is more dependent on subsidies. The previous example from China related to cleaner production has shown similar results. The experience of promoting and implementing a mandatory cleaner production audit system in China has shown that the legislative foundation is key (Bai et al. 2015).

However, (Rehfeld, Rennings, and Ziegler 2007) have also argued in favour of market factors for success of eco-innovation, "…the broad diffusion of environmentally innovative products from local or regional niche markets to international or global mass

markets depends crucially on price." but keeping along with their earlier support for policy instruments as a driver for better prices od eco-friendly products. The results are further supported by a recent study in China "the market-based instrument is effective in inducing eco-innovation, while a command and control instrument does not" (Cai and Li 2018).

Even when the policy regulations are a factor for eco-innovation, the companies would do the minimum to avoid penalties. This has been confirmed by a few managers during our interviews and also covered in previous research. For most manufacturers, especially for those in developing countries such as China, a major objective is to avoid economic loss (risk) due to penalties from any environmentally-oriented malfeasance (Q. Zhu, Sarkis, and Lai 2013).

Our results only partially support the previous findings which although are not done on Chinese companies' data but are in the same field. We also notice a weak effect of cooperation activities on eco-innovation among Chinese companies. And since we find that R&D is present along with market factors it might be possible that R&D activities are incentivised by market factors, as in the absence of cooperation the technology transfer is not quite common. This point of view of our finding needs to be further explored.

Thus, this paper contributes to the literature by providing a new perspective on eco-innovation using Chinese data, especially highlighting the importance of market instruments as a determinant of eco-innovation among Chinese companies. These findings are apparently different from what we saw in previous results involving companies from western countries. For example, a study of German manufacturing companies done by (Rehfeld, Rennings, and Ziegler 2007) shows that certification of the environmental management system to EU Eco-Management and Audit Scheme has significantly positive effect on environment product innovations. But we didn't test our sample on this criterion. It could be done in future research.

This study has some limitations. Firstly, the data used here is the generic primary data of 57 Chinese companies. We can get more accurate information based on the sector of operation of firms and also regional performances with a specific and larger dataset. Future research could cover that aspect.

References

Abbate, Tindara, Fabrizio Cesaroni, Maria Cristina Cinici, and Massimo Villari. 2018. "Business Models for Developing Smart Cities. A Fuzzy Set Qualitative Comparative Analysis of an IoT Platform." *Technological Forecasting and Social Change*, no. April: 1–11. https://doi.org/10.1016/j.techfore.2018.07.031.

Arundel, Anthony, and René Kemp. 2009. "Measuring Eco-Innovation." *Unu - Merit* 20 (2): 146–146. https://doi.org/10.1111/j.1467-629X.1980.tb00220.x.

Bai, Yanying, Jie Yin, Yin Yuan, Yajing Guo, and Danna Song. 2015. "An Innovative System for Promoting Cleaner Production : Mandatory Cleaner Production Audits in China." *Journal of Cleaner Production* 108: 883–90. https://doi.org/10.1016/j.jclepro.2015.07.107.

Brien, Meghan O, Stefan Giljum, Michal Miedzinski, and Raimund Bleischwitz. 2011. "The Eco-Innovation Challenge: Pathways to a Resource-Efficient Europe," no. May: 1–124.

Cai, Wugan, and Guangpei Li. 2018. "The Drivers of Eco-Innovation and Its Impact on Performance: Evidence from China." *Journal of Cleaner Production* 176: 110–18. https://doi.org/10.1016/j.jclepro.2017.12.109.

Castka, Pavel, and Daniel Prajogo. 2013. "The Effect of Pressure from Secondary Stakeholders on the Internalization of ISO 14001." *Journal of Cleaner Production* 47 (January 2018): 245–52. https://doi.org/10.1016/j.jclepro.2012.12.034.

Chen, Jun, Jinhua Cheng, and Sheng Dai. 2017. "Regional Eco-Innovation in China: An Analysis of Eco-Innovation Levels and Influencing Factors." *Journal of Cleaner Production* 153 (November 2012): 1–14. https://doi.org/10.1016/j.jclepro.2017.03.141.

Dong, Ying, Xi Wang, Jun Jin, Yuanbo Qiao, and Lei Shi. 2014. "Effects of Eco-Innovation Typology on Its Performance: Empirical Evidence from Chinese Enterprises." *Journal of Engineering and Technology Management - JET-M* 34: 78–98. https://doi.org/10.1016/j.jengtecman.2013.11.001.

Ghisetti, Claudia, and Federico Pontoni. 2015. “Investigating Policy and R&D Effects on Environmental Innovation: A Meta-Analysis.” *Ecological Economics* 118: 57–66. https://doi.org/10.1016/j.ecolecon.2015.07.009.

Greckhamer, Thomas, Vilmos F. Misangyi, and Peer C. Fiss. 2013. *The Two QCAs: From a Small-N to a Large-N Set Theoretic Approach*. *Research in the Sociology of Organizations*. Vol. 38. Emerald Group Publishing Limited. https://doi.org/10.1108/S0733-558X(2013)0000038007.

Hojnik, Jana, Mitja Ruzzier, and Tatiana S. Manolova. 2018. “Internationalization and Economic Performance: The Mediating Role of Eco-Innovation.” *Journal of Cleaner Production* 171: 1312–23. https://doi.org/10.1016/j.jclepro.2017.10.111.

Horbach, Jens. 2008. “Determinants of Environmental Innovation-New Evidence from German Panel Data Sources.” *Research Policy* 37 (1): 163–73. https://doi.org/10.1016/j.respol.2007.08.006.

———. 2015. “Empirical Determinants of Eco-Innovation in European Countries Using the Community Innovation Survey.” *Environmental Innovation and Societal Transitions* 19: 1–14. https://doi.org/10.1016/j.eist.2015.09.005.

Horbach, Jens, Christian Rammer, and Klaus Rennings. 2012. “Determinants of Eco-Innovations by Type of Environmental Impact - The Role of Regulatory Push/Pull, Technology Push and Market Pull.” *Ecological Economics* 78: 112–22. https://doi.org/10.1016/j.ecolecon.2012.04.005.

Kammerer, Daniel. 2008. “The Effects of Consumer Benefit and Regulation on Environmental Product Innovation,” no. 36.

Kemp, René. 2010. “Eco-Innovation: Definition, Measurement and Open Research Issues.” *Economia Politica* 27 (3): 397–420. https://doi.org/10.1428/33131.

Kemp, René, and Peter Pearson. 2007. “Final Report MEI Project about Measuring Eco-Innovation.” *UM Merit, Maastricht* 32 (3): 121–24.

Kemp, René, and Serena Pontoglio. 2011. “The Innovation Effects of Environmental Policy Instruments - A Typical Case of the Blind Men and the Elephant?” *Ecological Economics* 72: 28–36. https://doi.org/10.1016/j.ecolecon.2011.09.014.

Manual, Oslo, and Interpreting Innovation Data. 2009. “TARGETING NEW GROWTH AREAS Collaboration by Innovating Firms.” *Technology*, 80–81.

Marchi, Valentina De. 2012. “Environmental Innovation and R&D Cooperation: Empirical Evidence from Spanish Manufacturing Firms.” *Research Policy* 41 (3): 614–23. https://doi.org/10.1016/j.respol.2011.10.002.

OECD. 2005. *Oslo Manual*. *Communities*. Vol. Third edit. https://doi.org/10.1787/9789264065659-es.

Ragin, Charles C. 2008. “What Is Qualitative Comparative Analysis (QCA)?” *ESRC Research Methods Festival*, 1–19. https://doi.org/10.1016/0921-5093(89)90627-8.

Ragin, Charles C. 2000. “Fuzzy-Set SociaI Science.” *The University of Chicago Press*, 352. http://www.compasss.org/wpseries/Curchod2002b.pdf.

———. 2007. “Qualitative Comparative Analysis Using Fuzzy Sets (FsQCA).” *Configurational Comparative Analysis*, 87–121. https://doi.org/http://dx.doi.org/10.4135/9781452226569.n5 Print.

Rehfeld, Katharina Maria, Klaus Rennings, and Andreas Ziegler. 2007. “Integrated Product Policy and Environmental Product Innovations: An Empirical Analysis.” *Ecological Economics* 61 (1): 91–100. https://doi.org/10.1016/j.ecolecon.2006.02.003.

Rennings, Klaus. 2000. “Redefining Innovation - Eco-Innovation Research and the Contribution from Ecological Economics.” *Ecological Economics* 32 (2): 319–32. https://doi.org/10.1016/S0921-8009(99)00112-3.

Zeng, S. X., C. M. Tam, Vivian W.Y. Tam, and Z. M. Deng. 2005. “Towards Implementation of ISO 14001 Environmental Management Systems in Selected Industries in China.” *Journal of Cleaner Production* 13 (7): 645–56. https://doi.org/10.1016/j.jclepro.2003.12.009.

Zhang, Bing, Shuchong Yang, and Jun Bi. 2013. “Enterprises ’ Willingness to Adopt / Develop Cleaner Production Technologies : An Empirical Study in Changshu , China.” *Journal of Cleaner Production* 40: 62–70. https://doi.org/10.1016/j.jclepro.2010.12.009.

Zhu, Qinghua, Joseph Sarkis, and Kee hung Lai. 2013. “Institutional-Based Antecedents and Performance Outcomes of Internal and External Green Supply Chain Management Practices.” *Journal of Purchasing and Supply Management* 19 (2): 106–17. https://doi.org/10.1016/j.pursup.2012.12.001.

Zimmerling, Eric, Henrike Purtik, and Isabell M. Welpe. 2017. “End-Users as Co-Developers for Novel Green Products and Services – an Exploratory Case Study Analysis of the Innovation Process in Incumbent Firms.” *Journal of Cleaner Production* 162: S51–58. https://doi.org/10.1016/j.jclepro.2016.05.160.

Overall Conclusion

This thesis is primarily focused on the study of the concepts of reverse innovation and ecological innovation.

The second chapter consists of the introduction of both the concepts in a detailed manner and further built up upon the leading research done on these concepts in recent years. This part of the research also highlights major authors active in both areas of research. Moreover, since the thesis is focused on studying Chinese companies, the second chapter also provided an overview of selected Chinese literature.

The next chapter introduced a framework for identification of reverse innovation based on previous literature. The four elements we identified are: *(i) knowledge and technology exchange, (ii) partnerships, (iii) financial & markets and (iv) local dynamics.* We did a case study analysis and found reverse innovation. Among these recognised reverse innovations, eco-innovations were identified. After analysis, we found three specific characteristics of innovation in emerging markets that facilitate it towards reverse eco-innovation: *(i) resource constraint, (ii) marketplace or cost, and (iii) institutional or regulatory.* Moreover, from our studies and replies of our respondents from both organisations, we found drivers of reverse innovation.

The fourth chapter is about the determinants of eco-innovation among Chinese firms. In our study of 57 companies, we saw market factors as the most important determinant of eco-innovation followed by policy instruments which are regulatory. Market factors include financial incentives and are "pull" factors whereas policy instruments are mostly "push" in nature. Chinese firms are more motivated by market factors and do the minimum to fulfil any policy requirements. Even when policy regulations are among the factors of eco-innovation, the companies would do the minimum to avoid penalties. Moreover, importantly, we found that cooperation activities have little to no role in triggering eco-innovation among Chinese firms.

This thesis contributes to the idea of reverse innovation and eco-innovation with a new perspective. Firstly, the relation between both concepts is a new approach. Eco-friendly innovations originating from emerging economies and diffusing towards western economies is a novel idea. Secondly, the study is China-focused. We first studied the relationship between both concepts in the Chinese context and later analysed data from 57 Chinese companies. Thirdly, this thesis proposes a new perspective towards eco-

innovation, especially highlighting the importance of market instruments as determinant of eco-innovation among Chinese companies.

Moreover, this research acts as an introduction to further explore the concepts of reverse innovation and eco-innovation in the Chinese context. Taking a clue from the case studies in the third chapter, future research could be built on ideas of eco-friendly innovations originating from China and diffusing globally. One chapter in this thesis focused on two multinational companies with subsidiaries in China, it would be interesting to see how wholly-owned Chinese companies operate under a similar paradigm. Also, in chapter four where we studied a mix of 57 companies in China; future research on eco-innovation could segregate companies based on sector of work and increase the data set to study if the determinants of eco-innovation remain similar.

Appendix 1.

Implementing reverse innovation: GE's experience with ultrasound

The case study is based on the first author's (Govindarajan and Ramamurti 2011) **role as a participant-observer in GE for two years as its chief innovation consultant.**

After successfully launching high-end, high-priced ultrasound machines in the United States in 1979, General Electric (GE) looked for additional markets overseas. China seemed to offer huge potential, but after more than a decade of presence there, GE's annual sales in 1995 were a mere $5 million and growing slowly. Yet, by 2009, GE was the market leader, with a 30 percent share. How did GE make it happen? In 1996, the company entered into a joint venture

with a Chinese company, Haiying, and soon took full ownership. Subsequently, GE chose to leave the venture with a great deal of autonomy. Over time, the unit evolved into what came to be known within GE as a 'local growth team' (LGT). The LGT discovered that in the U.S., performance mattered most, followed by features. But in China, price mattered most, followed by portability. More than 90 percent of China's population relied on poorly funded, low-tech hospitals or basic clinics in rural villages. Because transportation was difficult, ultrasound machines had to travel to patients, not the other way around. Therefore, portability and ultralow prices were essential. As the LGT pushed ultrasound machines deeper into rural areas, it found that doctors were less familiar with ultrasounds. Its response— more training, online health guides, simpler key- boards, and built-in pre-sets for certain tasks. GE could not produce machines meeting these

criteria while operating in the glocalization mode. Its existing products could not simply be scaled down, defeatured, or adapted. It needed to create a new price-performance paradigm rather than simply shifting along the price-performance curve it already understood. GE concluded that it needed a zero- based effort to create a new price-performance curve. Only the LGT could execute a zero-based effort.

Rather than following the obvious path (i.e., trying to miniaturize existing hardware), the China LGT adopted hardware that had already been miniaturized—standard laptop computers—and then shifted most of the muscle inside an ultrasound machine from hardware to software. In 2002, GE launched its first 'compact' ultrasound machine. The

team in China remained under local control under the direction of a general manager. Its functional heads did not report to functional heads in GE Medical's global headquarters in Milwaukee. The LGT had its own profit and loss responsibility, along with the power to set its own strategy. It was a complete business managing its own value chain, including product development, manufacturing, and supply chain management.

By 2008, the LGT product development team had grown fourfold, from 16 to 70 engineers; the business as a whole from 132 to 339 personnel, most recruited locally. The team reported directly to Omar Ishrak, the leader of the global clinical systems business, a unit that included all ultrasound machines plus patient monitoring equipment. As a result, the team's resources were protected. In addition, Ishrak was able to help the LGT gain access to GE's global resource base, particularly software expertise. For example, to the core team of 13, Ishrak added three experts from other countries, including a visionary product developer in Israel. Ishrak also oversaw frequent and productive interactions between the LGT in China and the global R&D centers, enabling the transfer of knowledge—and, in some cases, existing software modules—to the China team without con- straining their efforts. He also made the leaders of the China LGT members of the Ultrasound Council, which consisted of ultrasound leaders worldwide who met three times a year to share engineering and business insights. Ishrak evaluated the leaders of the China LGT on a broad and distinct set of criteria, not just on short- term financial outcomes and not using the same metrics used in the global business. For example, he expected faster new product introductions in China because the government approval process for new product releases was less intricate. As it turned out, compact ultrasounds developed for China also had a market elsewhere. This included the U.S., where they were used in unexpected ways—especially in emergency rooms and operating rooms and to guide anaesthesiologists' placement of needles and catheters. Just six years after launch, compact ultrasounds were a $278 million global product line for GE and growing at 50 to 60 percent per year.

As this case shows, reverse innovation, properly implemented, can do more than help DMNEs win in emerging markets like China. It also can reinvigorate their global product divisions and assure their continued vitality in traditional markets for years to come.

Appendix 2: **Questions for Interview For Chapter 3**

These questions were used during oral interviews for the case study in chapter 3.

Background (Basic)

- Can you briefly introduce yourself? Work experience.
- How long have you been with this company/organization? In what capacities?
- What is your current position and what are your main responsibilities and objectives?
- What are your personal objectives in relation to innovation?
- What are your personal objectives in relation to sustainability?
- What are your company/organization's objectives in relation to reducing the harmful ecological impact (sustainability)?
- How do you work daily towards meeting those objectives?
- What process do you follow and what inputs do you need?
- Is your company a subsidiary? Where is your company's HO located?

Innovation

- Is there a dedicated R&D centre focused on product/process innovation?
- Where is this R&D centre located?
- Are the R&D people working on local problems?
- Are you aware of innovation activities in your company focused on market and/or sustainability targets?

Eco-Innovation

- Is there product/process innovation focused on environmental benefits?
- What environment benefits did you achieve? Are these benefits for the organisation or for the consumer?
- What are the motivations for carrying out innovation for environmental benefits? Push/Pull/Voluntary
- If your organisation didn't carry any EI, what are the potential reasons for it?

Reverse Innovation I

- When developing any new product/process/BM what is your market focus(target)?

- Where are the people and the resources dedicated to innovation located?
- Are you aware of local growth teams within your company (engineer, designer, analyst/data scientist, marketing executive)?
- Do local growth teams have decision making authority over product choice and customer approach?
- Do LGT have access to the company's global resources?
- Does your department communicate with other departments regularly regarding innovation?

Reverse Innovation (Partners and cooperation)

- Does your company have global partners who share innovation knowledge?
- Are there innovation co-operation partners? What kind of partners are these (suppliers, clients, competitors, other organisations, universities, govt.)? Where are they located?
- What are the main sources of funds for carrying out any innovation activity? Could you possibly breakdown the financial support from different sources?
- Was any eco-innovation activity as mentioned before, done in participation with or funded by any partners?

Closing questions

- Who do you think I should interview next?
- Would you be willing to be contacted later if clarification of this interview is needed?
- Would you be willing to provide the findings and analysis of this research with comments?

Appendix 3: **Questionnaire for Chapter 4**

The Innovation Survey 2017

PR China

Innovation Survey 2017

This survey collects information on your enterprise's **innovations and innovation activities** during the three years 2015 to 2017 inclusive.

An **innovation** is the introduction of a new or significantly improved product, process, organisational method, or marketing method by your enterprise.

An innovation must have characteristics or intended uses that are new or which provide a significant improvement over what was previously used or sold by your enterprise. However, an innovation can fail or take time to prove itself.

An innovation need only be new or significantly improved for your enterprise. It could have been originally developed or used by other enterprises or organisations.

Innovation activities include the acquisition of machinery, equipment, buildings, software, and licenses; engineering and development work, feasibility studies, design, training, R&D and marketing when they are specifically undertaken to develop and/or implement a product or process innovation. This includes also all types of R&D consisting of research and development activities to create new knowledge or solve scientific or technical problems.

This survey is done purely for the purpose of **academic research** at School of Environment, Tsinghua University, Beijing. We **do not** share your company data with any person, organization or third party.

Questions asked in this survey are mostly multiple choices. It may take approximately 20-25 minutes to finish them.

Please complete **all** questions, unless otherwise instructed.

Person we should contact if there are any queries regarding the form:

Name: _____
Job title: _____
Organisation: _____
Phone: _____
E-mail: _____

1. General information about the enterprise

Name of enterprise

_____

ID

Address

_____

NUTS

Postal code _____ **Main activity**

_____*NACE*

1.1 In 2015, was your enterprise part of an enterprise group? (Two or more enterprises under common ownership.) *GP*

Yes ☐ In which country is the head office of your group located? _____ *HO*

No ☐

If your enterprise is part of an enterprise group: Please answer all further questions about your enterprise only for its own activities in [your country]. Exclude all subsidiaries or parent enterprises.

1.2 During the three years 2015 to 2017, did your enterprise:

	Yes *1*	**No** *0*	
Merge with or take over another enterprise or a part of another enterprise ☐	☐		*ENMRG*
Sell, close or contract out some of the tasks or functions of your enterprise ☐	☐		*ENOUT*

1.3 In which geographic markets did your enterprise sell goods and/or services during the three years 2015 to 2017?

	Yes *1*	**No** *0*	
A. Local / regional within [your country]	☐	☐	*MARLOC*
B. National (other regions of [your country])	☐	☐	*MARNAT*
C. Other Asian or associated countries*	☐	☐	*MARASI*
D. All other countries	☐	☐	*MAROTH*
Which of these geographic areas was your largest market in terms of turnover during the three years 2015 to 2017? (Give corresponding letter)	_____		*LARMAR*

*: Include the following Asian and associated countries: Japan, South Korea, Indonesia, Philippines, Vietnam, Laos,

2. Product innovation (good or service)

A product innovation is the market introduction of a **new** or **significantly** improved **good or service** with respect to its capabilities, user friendliness, components or sub-systems.

- Product innovations (new or improved) **must be new to your enterprise**, but they **do not need to be new to your market**.
- Product innovations could have been originally developed by your enterprise or by other enterprises or organisations.

2.1 During the three years 2015 to 2017, did your enterprise introduce:

	Yes *1*	**No** *0*	
Goods innovations: New or significantly improved goods (exclude the simple resale of new goods and changes of a solely aesthetic nature)	☐	☐	*INPDGD*
Service innovations: New or significantly improved services	☐	☐	*INPDSV*

If no to all options, go to section 3

Otherwise, go to question 2.2

2.2 Who developed these product innovations?

Tick all that apply

	Goods innovations		**Service innovations**	
Your enterprise by itself	☐	*INITGD*	☐	*INITSV*
Your enterprise together with other enterprises or organisations (within china)	☐	*INTOGD*	☐	*INTOSV*
Your enterprise together with other enterprises or organisations (from Europe or North America)	☐	*INTEUGD*	☐	*INTEUSV*
Your enterprise together with other enterprises or organisations (from other East Asian Countries)	☐	*INTASGD*	☐	*INTASSV*
Your enterprise by adapting or modifying goods or services originally developed by other enterprises or organisations	☐	*INADGD*	☐	*INADSV*
Other enterprises or organisations	☐	*INOTHGD*	☐	*INOTHSV*

2.3 Were any of your product innovations (goods or services) during the three years 2015 to 2017:

		Yes	No	
		1	*0*	
New to your market?	Your enterprise introduced a new or significantly improved product onto your market before your competitors (it may have already been available in other markets)	☐	☐	*NEWMKT*
Only new to your enterprise?	Your enterprise introduced a new or significantly improved product that was already available from your competitors in your market	☐	☐	*NEWFRM*

2.4 To the best of your knowledge, were <u>any</u> of your product innovations during the three years 2015 to 2017:

(Please tick one option in every row)

	Yes	No	Don't know	
	1	*0*	*2*	
A first in [your region]	☐	☐	☐	*INPDFC*
A first in China	☐	☐	☐	*INPDFE*
A world first	☐	☐	☐	*INPDFW*

3. Process innovation

A process innovation is the implementation of a **new** or **significantly** improved production process, distribution method, or supporting activity.

- Process innovations **must be new to your enterprise**, but they **do not need to be new to your market**.
- The innovation could have been originally developed by your enterprise or by other enterprises or organisations.

3.1 During the three years 2015 to 2017, did your enterprise introduce:

	Yes	No	
	1	*0*	
New or significantly improved methods of manufacturing for producing goods or services	☐	☐	*INPSPD*
New or significantly improved logistics, delivery or distribution methods for your inputs, goods or services	☐	☐	*INPSLG*
New or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing	☐	☐	*INPSSU*

If no to all options, go to section 4

Otherwise, go to question 3.2

3.2 Who developed these process innovations?

	Tick all that apply	
Your enterprise by itself	☐	*INITPS*
Your enterprise together with other enterprises or organisations* (within china)	☐	*INTOPS*
Your enterprise together with other enterprises or organisation* (from Europe or United States of America)	☐	*INADPS*
Your enterprise together with other enterprises or organisation* (from other East Asian Countries)	☐	*INASDPS*
Your enterprise by adapting or modifying processes originally developed by other enterprises or organisations	☐	*INOTHPS*

**: Include independent enterprises plus other parts of your enterprise group (subsidiaries, sister enterprises, head office, etc). Organisations include universities, research institutes, non-profits, etc.*

3.3 Were any of your process innovations introduced during the three years 2015 to 2017 new to your market?

	INPSNM
Yes	☐ *1*
No	☐ *0*
Don't know	☐ *2*

4. Activities and expenditures for product and process innovations

4.1 During the three years 2015 to 2017, did your enterprise engage in the following innovation activities:

		Yes *1*	**No** *0*	
In-house R&D	Research and development activities undertaken by your enterprise to create new knowledge or to solve scientific or technical problems (include software development in-house that meets this requirement) If yes, did your enterprise perform R&D during the three years 2015 to 2017: Continuously (your enterprise had permanent R&D staff in-house) ☐ *1* Occasionally (as needed only) ☐ *2*	☐	☐	*RRDIN* *RDENG*
External R&D	Your enterprise contracted-out R&D to other enterprises (include enterprises in your own group) or to public or private research organisations	☐	☐	*RRDEX*
Acquisition of machinery, equipment, software & buildings	Acquisition of advanced machinery, equipment, software and buildings to be used for **new or significantly improved products or processes**	☐	☐	*RMAC*
Acquisition of existing knowledge from other enterprises or organisations	Acquisition of existing know-how, copyrighted works, patented and non-patented inventions, etc. from other enterprises or organisations for the development of **new or significantly improved products and processes**	☐	☐	*ROEK*

Training for innovative activities	In-house or contracted out training for your personnel specifically for the development and/or introduction of **new or significantly improved products and processes**	☐	☐	*RTR*
Market introduction of innovations	In-house or contracted out activities for the market introduction **of your new or significantly improved goods or services,** including market research and launch advertising	☐	☐	*RMAR*
Design	In-house or contracted out activities to alter the shape, appearance or usability of goods or services	☐	☐	*RDSG*
Other	Other in-house or contracted out activities to **implement new or significantly improved products and processes** such as feasibility studies, testing, tooling up, industrial engineering, etc.	☐	☐	*RPRE*

4.2 How much did your enterprise spend on each of the following innovation activities in <u>2017</u> only? Innovation activities are defined in question 4.1 above. Include current expenditures (including labour costs, contracted-out activities, and other related costs) as well as capital expenditures on buildings and equipment.

Please fill in '0' if your enterprise had no expenditures for an activity in 2017

Please estimate if you lack precise accounting data

In-house R&D (Include current expenditures including labour costs and capital expenditures on buildings and equipment specifically for R&D)	☐☐☐☐☐☐☐☐	*RRDINX*
External R&D	☐☐☐☐☐☐☐☐	*RRDEXX*
Acquisition of machinery, equipment, software & buildings (Exclude expenditures on these items that are for R&D)	☐☐☐☐☐☐☐☐	*RMACX*
Acquisition of existing knowledge from other enterprises or organisations	☐☐☐☐☐☐☐☐	*ROEKX*
All other innovation activities including design, training, marketing, and other relevant activities	☐☐☐☐☐☐☐☐	*ROTRX*

4.3 Were any of your product or process innovations during the three years 2015 to 2017 done specifically for:

		Yes	No	
Domestic Chinese Market	The product innovation was done keeping in mind the market in China only.	☐	☐	*DOMMKT*
European or US Market	The product innovation was done keeping in mind that it will be exported to European or U.S market.	☐	☐	*EUSMKT*
East Asian Market	The product innovation was done keeping in mind that it will be exported to East Asian market like Japan, South Korea, etc.	☐	☐	*EASMKT*
First China then International Market	The product innovation was done for Chinese market first but with a future vision to introduce the product in international market.	☐	☐	*CINMKT*

5. Financial support for innovation activities (as defined in 4.1)

During the three years 2015 to 2017, what was the major source of funding for your enterprises' innovation activities:

5.1 Public financial support for innovation activities from the following levels of government: Include financial support via tax credits or deductions, grants, subsidised loans, and loan guarantees. Exclude R&D and other innovation activities conducted entirely for the public sector under contract.

	Yes	No	
	1	*0*	
Local or regional authorities	☐	☐	*FUNLOC*
Central government (including central government agencies or ministries)	☐	☐	*FUNGMT*
Approximately (in percentage %) of total innovation funding			*PBFUN*

5.2 Financial support from firms and organizations from developed countries (Like US or Japan)

	Yes	No	
Partner firms and companies	☐	☐	*FUNPAT*
Holding firms and companies	☐	☐	*FUNHOL*
Approximately (in percentage %) of total innovation funding			*PVFUN*

5.3 Financial support from other international organizations* and agencies*

	Yes	No	
Please Specify……	*1*	*0*	
……	☐	☐	*FUNINT*
Approximately (in percentage %) of total innovation funding			*INTFUN*

6. Co-operation for product and process innovation activities (as defined in 4.1)

6.1 During the three years 2015 to 2017**, did your enterprise co-operate on any of your innovation activities with other enterprises or organisations?** Innovation co-operation is active participation with other enterprises or organisations on innovation activities. Both partners do not need to commercially benefit. Exclude pure contracting out of work with no active co-operation.

No ☐ *(**Go to section 7**)* *CO*
Yes ☐ *(Go to question 6.2)*

6.2 Please indicate the type of innovation co-operation partner by location

(Tick all that apply)

Type of co-operation partner	[Your Region]	Other China	United States or Europe	Other East Asian Countries	All other countries
A. Other enterprises within your enterprise group	☐ *Co11*	☐ *Co12*	☐ *Co13*	☐ *Co14*	☐ *Co15*
B. Suppliers of equipment, materials, components, or software	☐ *Co21*	☐ *Co22*	☐ *Co23*	☐ *Co24*	☐ *Co25*
C. Clients or customers from the private sector	☐ *Co311*	☐ *Co312*	☐ *Co313*	☐ *Co314*	☐ *Co315*
D. Clients or customers from the public sector*	☐ *Co321*	☐ *Co322*	☐ *Co323*	☐ *Co324*	☐ *Co325*
E. Competitors or other enterprises in your sector	☐ *Co41*	☐ *Co42*	☐ *Co43*	☐ *Co44*	☐ *Co45*
F. Consultants or commercial labs	☐ *Co51*	☐ *Co52*	☐ *Co53*	☐ *Co54*	☐ *Co55*
G. Universities or other higher education institutes	☐ *Co61*	☐ *Co62*	☐ *Co63*	☐ *Co64*	☐ *Co65*
H. Government, public or private research institutes	☐ *Co71*	☐ *Co72*	☐ *Co73*	☐ *Co74*	☐ *Co75*

6.3 Which type of co-operation partner was the most valuable for your enterprise's innovation activities? (Give corresponding letter) _____ *PMOS*

7. Intellectual property rights and licensing

7.1 During the three years 2015 to 2017, did your enterprise:

	Yes	No	
	1	*0*	
Apply for a patent	☐	☐	*PROPAT*
Apply for a utility model	☐	☐	*PROUM*
Register an industrial design right	☐	☐	*PRODSG*
Register a trademark	☐	☐	*PROTM*

7.2 If yes for 7.1, then how many of each (Please provide a value)

Number of patents applied / received / in process	……	*NOPT*
Number of Utility Models applied / received / in process	…….	*NOUM*
Number of Registered Industrial Design Right	…….	*NOIDR*
	……..	*NORT*

7.3 During the three years 2015 to 2017, did your enterprise:

	Yes	No	
	1	*0*	
License out or sell a patent, industrial design right, copyright or trademark to another enterprise, university or research institute	☐	☐	*PROLOT*
License in* or buy a patent, industrial design right, copyright or trademark owned by another enterprise, university or research institute	☐	☐	*PROLIN*

*Exclude the acquisition of licenses for common software for desktop and laptop computers such as operating systems, word processing, spreadsheets, etc.)

8. Innovations with environmental benefits

An innovation with environmental benefits is a new or significantly improved product (good or service), process, organizational method or marketing method that creates environmental benefits compared to alternatives.

- The environmental benefits can be the primary objective of the innovation or a by-product of other objectives.
- The environmental benefits of an innovation can occur during the production of a good or service, or during its consumption or use by the end user of a product. The end user can be an individual, another enterprise, the Government, etc.

8.1 During the three years 2015 to 2017, did your enterprise introduce a product (good or service), process innovation with any of the following environmental benefits?

	Yes	No	
Environmental benefits obtained <u>within your enterprise</u>	*1*	*0*	
Reduced material or water use per unit of output	☐	☐	*ECOMAT*
Reduced energy use or CO_2 'footprint' (reduce total CO_2 production)	☐	☐	*ECOENO*
Reduced air, water, noise or soil pollution	☐	☐	*ECOPOL*
Replaced a share of materials with less polluting or hazardous substitutes	☐	☐	*ECOSUB*
Replaced a share of fossil energy with renewable energy sources	☐	☐	*ECOREP*
Recycled waste, water, or materials for own use or sale	☐	☐	*ECOREC*

Environmental benefits obtained during the consumption or use of a good or service <u>by the end user</u>

Reduced energy use or CO_2 'footprint'	☐	☐	*ECOENU*
Reduced air, water, noise or soil pollution	☐	☐	*ECOPOS*
Facilitated recycling of product after use	☐	☐	*ECOREA*
Extended product life through longer-lasting, more durable products	☐	☐	*ECOEXT*

8.2 During 2015 to 2017, how important were the following factors in driving your enterprise's decisions to introduce innovations with environmental benefits?

	Degree of importance				
	High	**Medium**	**Low**	**Not relevant**	
	3	*2*	*1*	*0*	
Existing environmental regulations	☐	☐	☐	☐	*ENEREG*
Existing environmental taxes, charges or fees	☐	☐	☐	☐	*ENETX*
Environmental regulations or taxes expected in the future	☐	☐	☐	☐	*ENREGF*
Government grants, subsidies or other financial incentives for environmental innovations	☐	☐	☐	☐	*ENGRA*
Current or expected market demand for environmental innovations	☐	☐	☐	☐	*ENDEM*
Improving your enterprise's reputation	☐	☐	☐	☐	*ENREP*
Voluntary actions or initiatives for environmental good practice within your sector	☐	☐	☐	☐	*ENAGR*
High cost of energy, water or materials	☐	☐	☐	☐	*ENCOST*
Need to meet requirements for public procurement contracts	☐	☐	☐	☐	*ENREQU*

8.3 Does your enterprise have procedures in place to regularly identify and reduce your enterprise's environmental impacts? (For example preparing environmental audits, setting environmental performance goals, ISO 14001 certification, ISO 50001 certification, etc).

No	☐ (***Go to section 10***)	*0*	*ENVID*
Yes	☐	*1*	

If your enterprise had any procedures in place, when were they implemented?

	(Tick all that apply)	
Some procedures were implemented before 2015	☐	*ENVBF*
Some procedures were implemented or significantly changed between 2015 and 2017	☐	*ENVBT*

9. Basic economic information on your enterprise

9.1 What was your enterprise's total turnover for 2015 and 2017?[3] Turnover is defined as the market sales of goods and services (Include all taxes except VAT)

2015	2017

TURN15

TURN17

9.2 What was the percentage of your total turnover from sales to clients outside your country?

Please insert '0' if your enterprise had no sales outside your country

2015		2017	
	%		%

SLO15

SLO17

9.3 What was your enterprise's average number of employees in 2015 and 2017?

2015	2017

EMP15

EMP17

9.4 Approximately what percentage of your enterprise's employees in 2017 had a tertiary degree?

	EMPUD	
0%	☐	*0*
1% to less than 5%	☐	*1*
5% to less than 10%	☐	*2*
10% to less than 25%	☐	*3*
25% to less than 50%	☐	*4*
50% to less than 75%	☐	*5*
75% or more	☐	*6*

[3] Give turnover in '000 of national currency units. *Leave space for up to nine digits*.