Chapter 1
New Developments in Eco-Innovation Research: Aim of the Book and Overview of the Different Chapters

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1.1 Introduction

Eco-innovations are crucial for reducing the environmental damages arising from economic activities. They can be regarded as one of the main drivers of a successful transition towards sustainable development and for the solution of climate change problems. Companies are increasingly attaching great importance to eco-innovation due to the growing environmental concerns of consumers and governments, but also because of long-run benefits. During the last 15 years, the literature on eco-innovation has been growing fast. The European Commission considers eco-innovation to be key to addressing global environmental and economic challenges. For this purpose, the specially convened 'Eco-Innovation Observatory' provides information and analyses of the trends in eco-innovation.

The book is dedicated to Dr. Klaus Rennings, one of the leading researchers in eco-innovation, who unexpectedly passed away in September 2015. In his memory, we organized a workshop in order to present and discuss ongoing and future developments in eco-innovation research. The workshop on "New Developments in Eco-Innovation Research" took place at the Centre for European Economic Research (ZEW) in Mannheim/Germany in November 2016. Some of the contributions to this book were among the papers presented at the workshop. This chapter introduces the basic concept of eco-innovation and provides an outline of the consecutive chapters.

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Why do we need specific analyses of eco-innovation compared with other innovations? An answer to this question firstly requires a definition of eco-innovation. In the literature, other terms for eco-innovation are green or environmental innovation (e.g. Kemp 2010; Ghisetti and Pontoni 2015; Horbach 2018). We use these terms interchangeably (like e.g. Horbach et al. 2012), although other authors differentiate between them according to whether they effect environmental performance only or also economic performance (e.g. Ghisetti and Pontoni 2015). The Oslo-Manual by the OECD (2005: 46) defines 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 practices, workplace organization or external relations." As such, it subsumes product, process, organizational and marketing innovations. While the Oslo-Manual points out environmental factors and effects of innovation, it does not provide an explicit definition of eco-innovation. A definition of eco-innovation has been developed in the MEI (Measuring Eco-Innovation) project (Kemp and Pearson 2008: 7): "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."

The crucial distinction between eco-innovations and other, conventional innovations is therefore the environmental performance, which incorporates a reduction of the natural resources used as well as of the harmful substances released, irrespective of whether the protection of the environment was initially intended or not (see e.g. Driessen and Hillebrand 2002; Horbach et al. 2012). Furthermore, eco-innovations have specific determinants. A fast growing empirical literature shows that incentives like regulation measures, organizational innovation activities and cost-savings are more important for eco-innovations than for other innovations (see Horbach 2018 for an overview of this literature).

After clarifying the term eco-innovation, it is necessary to recap the historical roots of eco-innovation research to obtain a better understanding of the current state of the art and future trends. In its 'Limits to Growth' report (Meadows et al. 1972), the Club of Rome already pointed out the crucial role of innovation to preserve the environment and discuss innovation in the context of sustainability. The sustainability notion was taken up by the 'International Union for Conservation of Nature (IUCN)', which introduced the term 'sustainable development'. This term was conceptualized and defined within the Brundtland report (WCED 1987: 16) as "Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits—not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth." While the Club of Rome (1972) only lists ecological and economic stability as

sustainability, in the definition of the Brundtland report (WCED 1987) sustainable development includes economic, ecologic and social concerns, which are nowadays the common three dimensions of sustainability. Furthermore, the 'Earth Summit' in Rio in 1992 laid the foundation for global principles on sustainable development and further political ambitions like the UN sustainable development goals. Although eco-innovations emerge in the realm of sustainability concerns, they do not include social aspects. Therefore, the term 'sustainable innovation' has become established as a broader concept of innovation incorporating all three dimensions of sustainability, which distinguishes it from eco-innovations. However, there is no common definition of 'sustainable innovation' due to missing clear-cut definitions of sustainability and innovation (see e.g. Horbach 2005). Klewitz and Hansen (2013) review journal articles from 1987 to 2010 and conclude that the research focus is mainly related to eco-innovation rather than sustainable innovation including all three dimensions of sustainability. In fact, this is not surprising because of possible conflicts between different sustainability dimensions. For example, the introduction of electro-mobility might be accompanied by positive environmental effects and even market opportunities but might also cause a reduction in the number of jobs. An empirical assessment of the sustainability of this innovation would then require a normative weighting between different sustainability dimensions (Horbach 2018).

Despite the definition of the different terms in the context of sustainability, the crucial question is how the industry has responded to this politically driven shift towards sustainable development? One reaction of companies towards the introduction of new regulations or the threat of tougher regulations is innovation. The often criticized and tested (e.g. Rexhäuser and Rammer 2014) 'Porter hypothesis' by Porter and van der Linde (1995) goes even a step further by suggesting that the shift not only encourages innovations but also leads to a competitive advantage. Examples like the 'Montreal Protocol', ratified by all UN member states in 2009, show industries' reaction, which in this case consisted in the creation of innovative products replacing ozone-depleting substances. Another example are 'Environmental Management Systems (EMS)', supporting companies in implementing eco-innovations by helping them overcome barriers. Empirical research has proven the importance of EMS especially for technological innovations that reduce costs (e.g. Rennings et al. 2006; Rehfeld et al. 2007; Wagner 2007, 2008; Khanna et al. 2009; Ziegler and Nogareda 2009).

This movement in politics and the industrial reactions to has also resulted in a change of eco-innovation research. Rennings (2000) raised the question if sustainable innovations—including eco-innovations—call for a particular theory and specific policies or if the same methodological and theoretical frameworks as for conventional innovations applies. Since then, the interest in eco-innovation research has been increasing. This gain in importance in the research field of innovation has also led to literature reviews focusing on different perspectives. Berkhout (2011) provides a review on eco-innovation identifying the four social science research trends: disaggregated empirical analysis, knowledge and technology flows, connection of economic and physical models, and attention to policy and governance of eco-innovation. In a recent overview applying a main path analysis, Barbieri et al.

(2016) have shown that eco-innovation research has so far mainly concentrated on the following fields: determinants of eco-innovation, economic and environmental effects and policy inducement.

Shifts in the research field are the main focus of the review by Türkeli and Kemp (Chap. 2 of this book). They base their review on different bibliometric analyses on Web of Science Core Collection data and can identify seven perspectives researchers take in their analyses of eco-innovation (e.g. supply or demand side). Also the analytical concepts used have been changing, e.g. industrial ecology, industrial symbiosis, and circular economy. The review by Türkeli and Kemp already gives as an impression of how the research in eco-innovation has developed and which future tendencies can be expected. In the following paragraphs, we take a closer look at the current state of empirical research in eco-innovation. We will first draw attention to present reviews provided in the book which cover different focus areas. Next, we discuss current empirical research findings on eco-innovation which set future trends in the research field.

1.2 Current State of the Art in Eco-Innovation

In the last decades, politics, industry and research especially wanted to know if eco-innovations benefit the environment and at the same time reduce costs or increase revenues. The economic effects of eco-innovations are of particular interest for policy-makers to avoid resentment of environmental regulation. Furthermore, evidence of a win-win situation could pave the way for companies voluntarily investing in eco-innovations to gain a competitive advantage. The related empirical research is mainly influenced and encouraged by the so-called Porter hypothesis (Porter and van der Linde 1995). The weak version of this hypothesis postulates that regulation triggers eco-innovation whereas the strong version says that regulation driven eco-innovation even leads to higher competitiveness. The empirical evidence for the weak version is often confirmed (e. g. Demirel and Kesidou 2011; Horbach et al. 2012) whereas there are only mixed results for the strong version (Lanoie et al. 2011).

Ambec and Lanoie (2008) provide an overview on empirical results concerning environmental and economic performance. They show that a positive link cannot always be made. Therefore, they identify seven aspects, distinguished into the increase in revenues and the reduction of costs, in which environmental and economic performance go hand in hand. Nevertheless, they also stress that even after decades of research efforts it is still not clear if environmental performance influences economic performance or vice versa, or if there is another factor influencing both. Also, Orsato (2009) emphasizes that only in some cases environmental performance also leads to an economic benefit. He claims that eco-investments are only beneficial for the company if stakeholders value this action. Ghisetti (Chap. 3) reviews the current state of the art in eco-innovation research by summarizing the main findings on how eco-innovations affect economic performance. She gives an

extensive overview on different levels of economic performance measurement, taking short- and long-term performance into account. Furthermore, she provides new empirical evidence on the economic effects of eco-innovations, using panel data from the Community Innovation Surveys (CIS) on selected European countries and sectors. Chapter 3 also contains first results on the current CIS 2014 on eco-innovation.

The databases and their adaptation to the current political and research agenda already indicate the emergence of new political targets in the realm of eco-innovation and sustainability. As Chap. 2 (Türkeli and Kemp) focuses on the shifts in the research of eco-innovation, the following two Chaps. 4 and 5 provide the policy perspective.

At the latest the UN Agenda 2030, adopted at the United Nations Sustainable Development Summit in 2015, initiates a new era in the political agenda setting with the transition to sustainable development. It is also on the European and on national agendas. Such a global goal is only reachable with technological changes and innovation on different levels. Although the first steps have been made with the UN resolution "Transforming our world: the 2030 Agenda for Sustainable Development" (A/RES/70/1) (United Nations 2015), the very details determining at which level policies should be implanted are unclear. Especially innovations incorporating environmental and social concerns are important to address global challenges like climate change and to pave the way for long-term transformation. These interrelated innovations are also called socio-technical systems and are the focus of Chap. 4. Jacob (Chap. 4) disaggregates the elements of such systems based on a literature review. He classifies different challenges and obstacles and specifies options to counteract them. Finally, he summarizes the findings with a toolbox for transformative environmental policies.

Despite this general view on environmental policy making, the introduction of product standards provides a possibility to meet sustainable development goals and supports the transformation process. Environmental product standards (EPS) enable firms to signal environmentally friendly aspects of their products to overcome information asymmetry. Although firms face rather high costs, they voluntarily engage in the certification process to convince consumers of their product in order to acquire customers. Recently, more and more certificates and labels have popped up and with this increasing number of certificates it becomes more difficult for firms, consumers and policy makers to judge the quality of a label and therefore the labelled product itself. Moreover, firms have more difficulties choosing suitable labels for specific products. Roger (Chap. 5) provides a systematic overview on EPS and how they support eco-innovation. For this purpose, different types of labels are distinguished and illustrated by best-practice examples. Additionally, Roger also provides the drivers of a successful implementation of EPS.

1.3 New Empirical Findings and Ways Forward

Although research in eco-innovation can be still classified as a young research line, especially in the last decade the number of publications in this field has risen enormously. This can be traced back to the historical developments and political agenda setting but also to a change in consumers' behavior and preferences as well as managers' attitude towards environmental friendly products, e.g. firms incorporating economic as well as environmental targets in their business plans.

Thus, an understanding of the drivers of eco-innovations is important for all actors and therefore a main empirical research topic (see e.g. Barbieri et al. 2016 for an overview). These determinants are roughly differentiated into supply side, demand side, as well as institutional and political influences (Horbach 2008). The research conducted on this topic is based on firm level data (e.g. Demirel and Kesidou 2011; Horbach et al. 2012), which allow the inclusion of different explanatory variables depending on the database. Empirical studies have confirmed regulation as a key driver of innovation (e.g. Cleff and Rennings 1999; Horbach 2008; Barbieri et al. 2016).

Recent trends in eco-innovation research also take further determinants into account. Demirel and Kesidou (2011) bring together the three types of determinants—regulation, supply and demand side—in their study on over 1500 UK firms based on a 2006 survey. Peng and Liu (2016) focus on managerial awareness in their study on 144 firms in China. Horbach (2016) analyses in particular Eastern European countries in an analysis on 19 European countries. His study shows that especially regulation and subsidies trigger eco-innovation in these countries and moreover that firms in Eastern Europe depend on a technology transfer from Western countries. Another study by Horbach et al. (2012) shows that besides regulation also environmental management tools and R&D investments drive eco-innovations. This perspective is also picked up by Ziegler (Chap. 6). His analysis is based on the German manufacturing sector, includes over 300 firms, and focuses on technological innovation. Ziegler shows that R&D activities are important for all types of technological innovation. Furthermore, the analysis reveals environmental organizational measures—certified or not—as a crucial driver of environmental technological innovations.

The studies discussed above focus on large firms, whereas others particularly concentrate on SMEs. Klewitz et al. (2012) show the influential role of intermediaries like local authorities in triggering eco-innovation in SMEs. Triguero et al. (2013) provide a study on SMEs in 27 European countries, disentangling the effect of different drivers on specific types of eco-innovation. Chapter 7 contributes to this rather new research area of eco-innovation in SMEs. Horbach (Chap. 7) analyses the effect of pro environmental behavior on firm's economic performance. He confirms the general result that resource efficiency measures trigger economic performance also in SMEs. However, differentiating between measures, he also shows the positive effect of increasing renewables and the negative effect of the reduction of water consumption on the financial performance. Furthermore, firms' and

employees' self-perceived identification with green values support eco-innovations. The research on SMEs is still in its early stage and will get more prominent in the future, as more data on SMEs will hopefully be available.

Another current development in eco-innovation research is the connection to sustainability. As introduced above, sustainability comprises economic, environmental and social dimensions. Firms' voluntary sustainable measures are commonly described as corporate social responsibility (CSR). Especially in the last years, research on the effect of CSR on financial performance of firms has gained importance and numerous studies indicate a positive relation (see meta-analyses by Orlitzky et al. 2003 and Margolis et al. 2007). However, environmental innovations are hardly taken into account in this research context. Exceptions are, e.g., McWilliams and Siegel (2000) and papers extending this study (e.g. Hull and Rothenberg 2008). Reif and Rexhäuser (Chap. 8) focus on the neglected link between CSR and environmental innovation. They specifically analyze the complementarity of CSR and environmental innovation, which would indicate a higher financial performance when both measures are introduced together. Based on a worldwide panel dataset, they confirm that environmental R&D and CSR measured by the participation in the Global Reporting Initiative (GRI) are complementary. However, the authors also stress that for other types of CSR measures the link to environmental innovations might have a different effect. The results in this context raise the question of the historical development of CSR activities and environmental innovation. Wagner and colleagues (Chap. 9) investigate this question by using a recent survey dataset of German and UK manufacturing firms including the years 2001–2016. On the aggregate level, they show an increase in the usage of environmental measures and EMS certification. However, by differentiating large and small firms, the analysis reveals that the former prefer ISO 14001 certification, while for the latter EMAS gains importance. Especially this result calls for a distinction between large and small enterprises in research but also informs policy makers and practitioners that firms should adapt their strategy depending on their size.

Focusing on specific industries to get more detailed insights constitutes another step forward in eco-innovation research. Regulation might differ not only from country to country but also by industry. Empirical research has mainly focused on the manufacturing sector. A further distinction within this sector is necessary to gain more knowledge on the specific circumstances of eco-innovation in sub-sectors. Smith and Crotty (2008) particularly investigate the impact of the EU 'End of Life Vehicles Directive (ELVD)' on the UK automotive sector. Their results show a rather low influence of this directive on product innovation. The authors call for more restrictive regulations to promote product innovation. Also Schleich and Walz (Chap. 10) contribute to this new research line by focusing on wind power. They observe how innovation and support policies influence the exports of wind power in a panel of twelve OECD countries. In their analysis, they differentiate between innovation input and output. They find a positive relation of wind power exports to both innovation measures and to supportive policies, but the effects of feed-in tariffs do not seem to differ from the effects of other support policies. Besides the

importance to observe sub-sectors more specifically, this study also demonstrates the relevance of accounting for international interrelation.

In connection with that, another recent line in eco-innovation research is to account for policy mixes rather than a single policy [see Flanagan et al. (2011) and Rogge and Reichardt (2016) for a discussion on the term policy mix]. Normally, if a new policy is implemented other policies are already in place. These policies might interact with each other. Thus, focusing only on the effect of one specific policy could lead to wrong conclusions. This topic has been raised in the context of innovation policies for example by the OECD (2010). Especially innovation policy is characterized by different combined policy instruments (see e.g. Borrás and Edquist 2013; Magro and Wilson 2013) and becomes more pronounced within the attempts of achieving sustainable transitions, such as the transition to low-carbon energy systems (Rogge et al. 2017). For this purpose, further developments in existing datasets and setting up new data are necessary. Rogge and Schleich (Chap. 11) contribute to this young research field. The authors have specifically developed a policy mix module which they have incorporated into a standard company innovation survey based on the CIS to analyze renewable energy innovation in Germany. In their analysis the authors focus on the role of the interaction of multiple instruments and the role of instrument design features for innovation in renewable power generation technologies. This new attempt to observe the effects of policy mixes is informative for policy makers as well as researchers and therefore sets future research trends.

Another step in the direction of focusing on a specific industry and the generation of new data is the usage of case studies. Especially for those industries in which the supply chain across countries and several production steps makes it difficult to track eco-innovation and sustainability efforts, case studies are an important research tool. The fashion industry is an example for a sector with complex supply chains and additionally high usage of natural resources (see e.g. de Brito et al. 2008). Cleff et al. (Chap. 12) provide a case study, conducting a structured interview with ten participants. In general, the three participating fashion companies and the seven sustainability experts confirm that measures to increase resource efficiency are being implemented but only slowly. Moreover, they stress the importance of awareness on all levels—government, business and consumers—to make progress in sustainability issues. Cleff et al. conclude that especially eco-innovations are required to pave the way for a more sustainable fashion industry.

Incorporating dynamics has been a further expansion of eco-innovation research in recent years. Innovations in general follow paths. These path dependencies are especially interesting for sustainable transition and therefore also for the related eco- und sustainable innovations. There the consideration of interacting different levels is important for the conceptualization of research analyses. Walz (Chap. 13) provides such a concept by combining a technological innovation system with a multi-level perspective approach (see Markard and Truffer 2008 for a review on the usage of both concepts), which allows him to analyze the dynamics in the innovation process. Based on this methodology, he conducts a case study for the Chinese wind energy

industry, which is an example for a sector characterized by different phases of innovation.

This short overview covers the different perspectives on 'New Developments in Eco-Innovation Research' taken by the following chapters. The historical view on eco-innovations shows us the development of the still young research field and particularly the boom in the last decade (Chap. 2). The reviews on the current state of the art in eco-innovation demonstrate the influence of political agenda setting in this context and show the ways forward with the main focus on regulation effects (Chaps. 3, 4, and 5). The contributions of current empirical research (Chaps. 6, 7, 8, 9, 10, 11, 12, and 13) reveal the new developments in eco-innovation research concerning research targets like sustainability, the focus on specific industries, the generation of new databases and the consideration of interaction effects. Altogether, it should provide practitioners, policy makers and researchers with the necessary information to further develop future strategies in eco-innovation in particular in the context of sustainable transition.

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