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Do firms benefit from undertaking and combining Eco-innovations? An analysis on European SMEs.

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Abstract

As environmental challenges have become more apparent, there has been considerable pressure in pushing the economy to pursue eco-innovation. The success of eco-innovation is arguably dependent on business awareness in understanding the cruciality of eco-innovation. Although eco-innovation indeed promotes environmental performance, it is uncertain whether firms would benefit from implementing green practices. Therefore, the purpose of this paper is to provide a concrete understanding of whether different eco-innovations (eco-product, eco-process, and eco-organization) can positively benefit the firms' performance in terms of a higher level of turnover. It also explores whether the combination of these eco-innovative activities has positive complementary effects on firms' performance. By performing ordinal logistic regression with 4420 firms across 24 European countries, this paper finds that firms that undertake eco-process and eco-organizational innovations are more likely to have higher levels of turnover. Moreover, a pairwise super modularity test between two types of eco-innovation, while the state of the third type is kept constant, shows no statistical evidence to support the existence of complementarities in all different combinations of eco-innovations. Hence, this study discovers partial support to motivate firms towards sustainable innovations. It also advances research on sustainable innovation by being among the first ones to explore the complementarities between different types of eco-innovations.

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Table of Abbreviation

C

COSME	Competitiveness of Enterprises and Small and Medium-sized Enterprises
CSR	Corporate Social Responsibility

E

EPV	Event Per Variable
EOP	End-of-Pipe
ESIF	European Structural and Investment Fund
EU	European Union

I

IT	Information Technology
IV	Instrumental Variable

O

OLS	Ordinary Least Square

R

REACH	Registration, Evaluation, Authorization, and Restriction of Chemicals

S

SEM	Structural Equation Model
SMEs	Small and Medium Enterprises

V

VIF	Variance Inflation Factor

1. Introduction

While economic development brings prosperity and a higher standard of living, it naturally causes an environmental crisis (Bascom, 2016). Ever since the Industrial Revolution, global warming has become more apparent with an escalating emission of greenhouse gases in the atmosphere. As environmental degradation like natural disasters, climate change, and global warming are becoming more evident (Starčević, Mijoč, & Zrnić, 2017), OECD (2019) suggests that these environmental issues pose a tremendous pressure in turning the economy towards a sustainable one. European Commission (n.d.-a) claims that eco-innovation is vital for achieving sustainable development goals. By implementing more responsible and efficient use of natural resources, enriching nature's resilience, and switching to sustainable production modes through eco-innovation, one will significantly reduce environmental impacts. Economic prosperity and well-being can also be achieved by implementing these "green and clean" activities. European Commission (2021) claims that environmental innovation is fundamental and essential in driving the future of the European economy. As demand for resource efficiency and renewable energy is predicted to be continuously increasing in the coming years, there is an excellent opportunity for eco-innovation in generating sustainable employment and fostering economic growth. Indeed, the green industry in Europe appears as one of the industries to perform well after the 2008 financial crisis and has flourished by over 50% between 2000 and 2011 (European Economic Area, 2020). Despite the growth of eco-industries in Europe, business owners remain curious whether adopting eco-innovations will indeed be financially beneficial or not. While eco-innovations certainly benefit the environment, it is uncertain if firms would also benefit from such activities. As a result, this study aims to discover an understanding of heterogeneity in eco-innovations and their potential contribution to the firms that eventually contribute to the economy and society.

Although "clean and green" innovative activities certainly reduce environmental issues, it is unclear whether firms would benefit from such actions. Existing literature has provided ambiguous results on the relationship between eco-innovation and business performance, ranging from positive (Lee & Min, 2015; Ryszko, 2016; Bigliardi et al. 2012; Weng et al., 2015) to negative (Cainelli et al., 2011; Wagner et al., 2002; Marin & Lotti, 2017; Madaleno et al., 2020) as well as neutral (Earnhart & Lizal, 2007; Trumpp & Guenthe, 2017). Such ambiguous results can make firms skeptical in their decision to perform eco-innovations. On the one hand, undertaking eco-innovations can improve competitive advantage by accumulating valuable green resources and capabilities (Ar, 2012; Porter & Van der Linde, 1995).

Other mechanisms like improving production efficiency (Lee & Min, 2015; Hojnik & Ruzzier, 2016a), fulfilling customers' green pressures and expectations (Bigliardi et al., 2012), and justifying higher costs through price premium also create business opportunities to perform eco-innovations (Ambec & Lanoie, 2008). On the other hand, eco-innovations can lower business performance because of the lack of expertise (Hockerts & Wüstenhagen, 2010), financial constraints (Marin & Lotti, 2017; Madaleno et al., 2020), and high investment risk (Cainelli et al., 2011). The neutral relationship may be explained by the two interplay effects that are occurring. Since there is a lack of concrete understanding of whether eco-innovation is positively beneficial to the firms, firms are not fully convinced to adopt green practices. They may also continue to follow the traditional innovative technologies due to lock-in and path-dependency, which is detrimental to both the environment and the economy in the long run. In terms of environmental damage, traditional innovative technologies, such as fossil fuels, have caused extensive damage to the environment. By emitting several air pollutants, non-green technologies lead to ozone depletion, climate change, global warming, and depletion of non-renewable resources. Thus, eco-innovations are perceived as green solutions against such environmental challenges. Additionally, eco-innovations also contribute towards sustainable economic growth. They create both green business and job opportunities, which is the key to the transition to the green economy. Eco-innovations will protect the environment and contribute to the economy without hampering the future generation.

Moreover, these studies mainly focus on the direct relationship between eco-innovation and performance but neglect the complementarity aspect between different types of eco-innovation. Complementarity occurs when the benefits of combining more than one strategy exceed the total benefits when undertaking each strategy separately (Milgrom & Roberts, 1990). Given that there is an imprecise understanding of eco-innovation, it is worthwhile to perform empirical analysis to investigate this relationship. This research will also examine the complementarities between different types of eco-innovation (eco-product, eco-process, and eco-organization) to examine whether the combination of different eco-innovative activities has different effects on a firm's performance. A firm's performance refers to financial performance, emphasizing profitability and competitiveness in terms of turnover. Although the complementarity among eco-innovations may not differ from the complementarity among other innovations, it is impossible to conclude that it is equivalent without formal empirical research. Unlike standard innovation, environmental innovation is often seen as an additional burden to the firm regarding higher costs and threats to their competitive advantage (King & Lenox, 2001; Hockerts & Wüstenhagen, 2010). Therefore, by studying this relationship separately, it is possible to gain insights into whether firms can simultaneously handle different eco-innovations, or it would be best to solely focus on each type of eco-innovation to maximize firms' performance. Given the aforementioned theories and studies that directed to the cruciality of eco-innovation towards the economy as well as the environment, this paper aims to answer the following research question:

"What are the effects of product, process and organizational eco-innovation and their combination on firms' performance?"

This study aims to better understand an understudied stream of literature and shed light on the complementarity effect of adopting different combinations of eco-innovation. Furthermore, the empirical analysis will be emphasized on SMEs. While SMEs are the backbone of the European economy in terms of their contribution to economic growth and employment, previous literature on eco-innovation has given scarce attention to SMEs. By performing ordinal logistic regression with 4420 SMEs across 24 European countries under Flash Eurobarometer 315 'Attitudes of European Entrepreneurs Towards Eco-innovation', this research aims to understand whether firms undertake eco-product, eco-process, and eco-organizational innovations are more likely to perform better (in terms of higher turnover). By conditioning to the presence/absence of the third form of eco-innovation, a pairwise super modularity test between two types of eco-innovation will also be performed to test complementarity.

This study also contributes to the existing literature in several ways. Firstly, this research will provide insights into whether eco-innovative activities are beneficial to the firm's performance. As previous studies discover contradictory results, it is incredibly vital to examine this relationship to appropriately motivate firms towards sustainable business and overcome the fear against the burden of environmentally friendly innovations. More importantly, while there are extensive studies on complementarities between different types of standard innovation, there is insufficient formal statistical evidence that complementarities also exist in the context of eco-innovation. This is particularly important as eco-innovation is more vital in stimulating a firm's performance than non-eco-innovation (Gilli, Mancinelli & Mazzanti, 2014). By understanding complementarity between different eco-innovations, this study fills a salient gap in the existing literature to understand if firms would benefit from complementing one eco-innovation with another. Lastly, as environmental issues become increasingly prominent, researches on eco-innovations are highly relevant and essential in contemporary literature.

Moreover, this research is also socially relevant for firms as well as policymakers. As it is expected that eco-innovation will contribute positively to performance, this research aims to provide firms with novel knowledge regarding the most profitable combination of different types of eco-innovations. This will further motivate and incentivize businesses towards eco-innovation to improve overall competitiveness. From a public policy point of view, governmental policies can assist firms in achieving their eco-innovation goals. Although it is important and relevant to promote all types of eco-innovations, the existing public policy neglects some types of eco-innovation while paying attention to the other types. Since all kinds of eco-innovations deserve attention and encouragement, policymakers are encouraged to promote and support all types of eco-innovations to stimulate business performance. For example, Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH) aims at restricting the production and use of chemical substances due to their hazardous impact on the environment and society. However, this policy can be more effective once it includes building organizational cohesion against chemical usage. OECD (2011) proposes that non-technological innovation also matters as eco-product relies heavily on a business model and appropriate organization. Another relevant example of public policy that neglects eco-organizational innovation is the EU public procurement and eco-labeling. EU eco-label is widely recognized across Europe with more than eco-labeled 72,000 products and services (European Commission, n.d.-a), but it only labels green products or green productions. Eco-labels will be more fruitful with the inclusion of eco-organization as it promoted every type of eco-innovation that is beneficial to the firms. Finally, the benefits from eco-innovation can be eclipsed by financial constraints and business uncertainty. Therefore, policies to overcome eco-innovation barriers and obstacles like the Programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME) and European Structural and Investment Fund (ESIF) are crucial. Governmental support can significantly contribute to firms' decisions to innovate environmentally.

The rest of the research paper is organized as follows: Section 2 provides the definition and types of eco-innovation. A rich understanding of eco-innovation is crucial in developing the hypotheses in Section 3 and 4, which convey the relationship between eco-innovations and business performance and complementarities in different types of eco-innovation, respectively. The data and methodology of statistical analysis are described in Section 5, and the empirical evidence is provided under Results. The last section summarizes the paper, discusses its implications and limitations, and suggests a direction for future research.

2. Eco-innovation

This research defines eco-innovation as an innovation that reduces environmental harm in the form of ecological impact and natural resource usage while creating business opportunities in line with the European Commission (n.d.-b). Eco-innovation is categorized into eco-product, eco-process, and eco-organizational innovations because it is more dominantly used in the literature (Horbach, 2008; Triguero et al., 2013). Product and process eco-innovations are also referred to as technological eco-innovations (Kemp & Arundel, 1998; Boonstra & Vink, 1996). This study will also use eco-innovation interchangeably with environmental innovation, green innovation, eco-friendly innovation, eco-technologies, and green technologies. Figure 2 presents the framework of three types of innovation as follow:

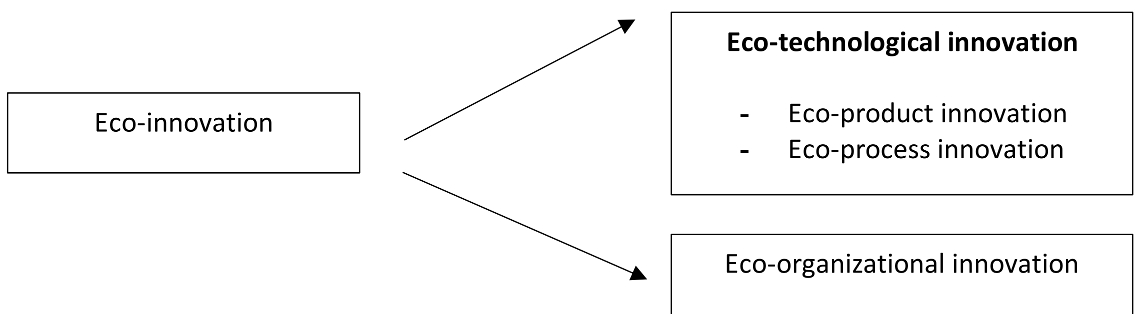

Figure 2. Types of eco-innovation

Eco-product innovation refers to products or services that are newly introduced to the market or are significantly improved to reduce their environmental impact (Pujari et al., 2004; Pujari, 2006). The reduction of environmental impact stems from the use of eco-products. Examples of such innovations include electric vehicles and biodegradable materials, which ultimately reduce greenhouse gas emissions and plastic wastes, respectively. Eco-process innovation depicts introducing a new production method or improving an existing one to contribute to environmental sustainability (Rennings, 2000; Negny et al., 2012). Green innovative production involves switching from improper material use, material waste, and dangerous emission and pollution to cleaner production with sustainable design, renewable energy, and responsible material use (Carrillo-Hermosilla, del González & Könnölä, 2009). Examples of eco-process innovation are end-of-pipe and cleaner production technology. While end-of-pipe technology adds green measures to the production process, cleaner production technologies target environmental issues, resource use, and pollution at their source. Finally, eco-organizational innovation is a development in a management system that assists eco-friendly transformations. Cruz et al. (2006) deduce that green organizational practices are beneficial in reducing costs related to administration and transaction and enhancing workplace satisfaction. Moreover, environmental organizational innovation also promotes green jobs and green management activities that explicitly aim to reduce environmental impact. Creating responsibilities for dealing with material use issues, energy, water, and waste can be seen as an example of eco-organizational innovation.

Although eco-innovation is described to create business opportunities and reduce environmental harm, which is beneficial to the economy, society, and environment, firms may not be obliged to sustainable behavior. Pacheco et al. (2010) describe this situation as "Green Prison". Entrepreneurs are typically compelled to unsustainable innovations as sustainable behavior is being punished rather than rewarded in higher costs and lower competitive advantage. Therefore, there is no incentive for firms to implement green practices. Furthermore, Pacheco et al. (2010) also use prisoner's dilemma to show the situation of green prison. Even though sustainable practices may bring in collective benefits at the industry level, such expensive eco-friendly activities are disadvantageous. The costs are not distributed to competitors (McWhinnie, 2009; Carraro & Fragnelli, 2004). Since firms are subject to green prison, there is a low incentive to switch from unsustainable to sustainable innovations. By examining the relationship between eco-innovations and a firm's financial performance, this research will investigate if there are incentives to environmentally innovate and how complementary eco-innovations can solve exit from green prison.

3. Eco-innovation and Firm’s Performance

There is limited understanding of how eco-innovations contribute to firms’ performance. In order to investigate this long-debated question, it is important to understand how firms’ performance is defined clearly. Business performance can be measured in both financial and non-financial (customers, learning and growth, and internal processes) context (Kaplan & Norton, 1996). Although both financial and non-financial indicators are significant in defining business performance (Lebans & Euske, 2006), non-financial performance is difficult to measure, which results in a lack of statistical reliability. This study will use a financial indicator, emphasizing profitability and competitiveness in terms of turnover as a performance measure.

The existing studies on technological eco-innovations (eco-product and eco-process) and firms’ performance are diverse and inconclusive. Horváthová (2010) performs a meta-analysis of 64 empirical studies that are available between 1978 and 2008. He discovers that 55%, 15%, and 30% of studies find a positive, negative, and non-significant effect of environmental performance on a firm's performance, respectively. Table A1 in Appendix A summarizes the diverse relationship between different types of eco-innovation and firms' performance. Some studies find a negative association between eco-innovations and firms' performance (Cainelli et al., 2011; Wagner et al., 2002; Marin & Lotti, 2017; Madaleno et al., 2020) which can be explained by the additional effort requirements when adopting eco-innovations. This is because the sustainable raw material is relatively more expensive (Mao & Wang, 2019) and may require additional onsite costs (King & Lenox, 2001), resulting in higher prices in implementing eco-innovation. In line with this argument, Madaleno et al. (2020) discover a lower turnover and employment growth associated with implementing eco-product and eco-process innovation in 13 different European Union countries. Furthermore, eco-product and eco-process may cannibalize the market share of current offerings or deteriorate previous investment into unsustainable production processes (Hockerts & Wüstenhagen, 2010). Cainelli et al. (2011) use early mover disadvantages in non-mature green markets to explain a negative link between environmental motivations and business performance regarding employment and turnover growth in the short run. The shortcoming in non-mature markets is defined by the inability of early movers to fully grasp the benefits of eco-innovation and weakness in the early stages of some service divisions. In paper manufacturing firms, Wagner et al. (2002) also discover a uniformly negative relationship between environmental and economic performance. The findings are based upon the traditionalist view that a firm's optimal level of green activities is smaller than the socially optimal level. Thus, eco-innovation is highly unlikely to generate competitive advantages because it is induced by stringent regulations which aim to maximize societal benefits. Similarly, Marin and Lotti (2017) argue that the firms do not fully appropriate the environmental benefit from eco-innovation. Thus, the productivity losses from green practices that cannot be fully recovered reveal a lower return relative to other innovations among Italian manufacturing firms. Eventually, firms will be less willing to devote their resources to environmental innovations and adopt other profitable projects. In addition, Driessen et al. (2013) also found a negative association between eco-friendly product innovation and a firm's financial performance regarding profitability, sales, and market share. They argue that market demand for green products and services is majorly embedded in green niches. Unfortunately, these green niches are still immature, which results in relatively low green demand.

On the other hand, the positive relationship between eco-innovation and business performance is recognized by many studies. Green innovation is considered as a company's strategic weapon. By implementing green innovation, firms can fulfill regulatory and environmental requirements and simultaneously improve their capabilities and performance. Weng et al. (2015) perform a statistical analysis of five eco-product and seven eco-process innovation variables on business performance. Green product and process innovation are associated with increased market share, sales, and profitability of Taiwanese firms. Similarly, Lee and Min (2015) found a positive association between green research and development (R&D) and financial performance in Japanese firms. They argue that green R&D develops a long-term sustainability commitment that improves internal resources and capabilities to reduce costs and environmental impacts. Hojnik and Ruzzier (2016) also show an improvement in the company's profitability, growth, and competitive benefits in succeeding in the ecological production process. The positive association is driven by early mover advantage in creating green competitive capability. In the framework of Turkish manufacturing firms, green product innovation significantly promotes a firm's performance and competitive capability (Ar, 2012). Ryszko (2016) also found that technological eco-innovation reduces environmental impacts and improves business performance among Polish firms. The importance lies within firms' effort to effectively use their green capabilities from technological eco-innovations that enhance and sustain firms' performance. Building upon the theory of early mover advantage by Porter and Van der Linde (1995), firms that adopt environmental practices earlier can establish a competitive advantage and capture green market demand before their competitors. In addition, there has been a shift in demand towards sustainable development in recent years following a more evident environmental issue. Eco-product and eco-process innovation are great ways to avoid additional environmental and regulations costs, such as pollution tax (Tuttle & Heap, 2008). Bigliardi et al. (2012) deduce that customer pressure and expectations play a vital role in determining a company's eco-innovation direction. Although eco-innovations may involve extra costs, Ambec and Lanoie (2008) suggest that transferring additional costs from eco-innovations in the form of green product and services premium can be enormously advantageous in meeting customer expectations whilst fostering the company's financial performance. Firms that adopt eco-product and eco-process innovation will, therefore, attract these niche markets of green customers more profitably.

Some studies discovered that eco-innovation neither improves nor undermines firms' financial success (Earnhart & Lizal, 2007; Trumpp & Guenthe, 2017). The two opposing effects explain it. Firms that do not perform eco-innovation will have lower costs and lower prices as they do not have to invest in expensive eco-technology costs (McWilliams & Siegel, 2001). However, firms that perform eco-innovations can transfer additional charges as price premiums to the eager customers. Besides, there are high risks from new eco-innovations. Eco-innovation may allow firms to capture the new green market demand and create an early mover advantage (Porter & Van der Linde, 1995; Bigliardi et al., 2012). Nevertheless, non-mature emerging green markets may lead to early mover disadvantages (Cainelli et al., 2011).

The ambiguity in existing empirical research implies an inadequate understanding of eco-innovation and firm performance relationships. Studies on eco-innovation and firm's performance summarized in Table A1 are mainly restricted by data availability, limiting them to study the three types of eco-innovations altogether. Technological eco-innovations like eco-product and eco-process are empirically tested more compared to eco-organizational innovation (Cainelli et al., 2011; Wagner et al., 2002; Weng et al., 2015). Previous studies predominantly use Structural Equation Modeling (SEM) and Ordinary Least Square (OLS) regression as the methodologies of statistical analysis. Moreover, it is impossible to generalize the findings due to country- and industry-specific assumptions (Cheng et al., 2014; Ar, 2012; Ryszko, 2016; Lee & Min, 2015). Focusing on a small geographical area can also diminish the study's statistical power because of the small sample size. The dynamics are complex as a unique research setting can influence the results significantly. Some performance measures, like turnover, can be influenced by eco-innovations, while other measures can have a negative or insignificant impact.

Considering the above argumentation and the academic relevance of this relationship claimed by previous studies, this study argues a win-win situation for the environment and firms in adopting eco-product and eco-process innovations. This can be explained by improved resources and capabilities (Lee & Min, 2015; Ar, 2012), early mover advantage (Hojnik & Ruzzier, 2016; Ryszko, 2016), ability to fulfill environmental and regulatory pressure (Tuttle & Heap, 2008), ability to meet customers' green expectations (Bigliardi et al., 2012), and green price premium (Ambec & Lanoie, 2008). Empirical evidence also confirms that benefits from technological eco-innovations can outweigh their costs (Andries & Stephan, 2019). Consequently, it is proposed that a firm's performance (measured by turnover) can be improved by technological eco-innovations (including eco-product and eco-process).

Hypothesis 1a: Firm's eco-product innovation is positively related to its business performance

Hypothesis 1b: Firm's eco-process innovation is positively related to its business performance

Eco-organizational innovation can also influence financial success. It refers to an innovative change in a management system that aligns companies' specific goals with sustainable development goals. Eco-organizational innovation represents eco-capabilities associated with administration, activities, infrastructure, and technologies that are environmentally friendly. These eco-capabilities facilitate the improvement in the entire corporate culture through green experiences and information, which develops the innovative design, speed, and flexibility (Díaz-García, González-Moreno & Sáez-Martínez 2015). Cheng et al. (2014) describe eco-organizational innovation as a continuous managerial engagement in improving the entire organizational ecological initiative. Examples of eco-organizational innovation are reshaping organizations towards responsible material use, energy and water, waste management, and eco-friendly instruments. As environmental degradation like natural disasters, climate change, and global warming are becoming more noticeable (Starčević, Mijoč, & Zrnić, 2017), organizational innovation will allow firms to adapt to new markets and change technology more efficiently (Lawrence, 1969).

Several studies have found that eco-organization can affect a firm's performance positively (Ch'ng et al. (2021; Cheng, 2014; Doran & Ryan, 2011; Przychodzen & Przychodzen, 2015). First, Ch'ng et al. (2021) claim that eco-organizational innovation leads to development in a management system that subsequently enhances economic performance in the context of Malaysian firms. They explain this with respect to the resource-based theory, which features the importance of the resources and capabilities in determining the firm's success. Eco-organizational innovation is the firms' unique and valuable capabilities to improve resource and energy usage, reduce operation costs, and prosper competitive advantage (Liao, 2018). This is also consistent with Cheng et al. (2014), who found that business performance is positively and significantly influenced by the three types of eco-innovation, with eco-organization having the most substantial effect. Eco-organizational capabilities, resources, technologies, and knowledge play a significant role in benefiting organizations. Adopting organizational innovation will constitute an unrivaled mechanism that protects profit margins and consistency, positively affecting a firm's performance as it facilitates appropriation and prevents imitation (Dong et al., 2014; Teece, 1986).

Moreover, when performing eco-organizational innovation, firms can consider other motives that are beyond profit-seeking. This allows firms to broaden their perspective, which expands their business opportunities from sustainable innovation. Hoogendoorn et al. (2020) argue that these other-regarding motives can substantially influence a firm's opportunity identification, exploitation, and incentive to innovation. Given that pursuing eco-innovation broadens organizational awareness, firms will understand environmental issues more effectively and adjust their behavior to persist in the changing market more efficiently.

The relevance of environmental issues may also raise attention towards eco-technologies and sustainable products and services in which eco-organization will play a crucial role in promoting green practices. More stringent environmental regulations and codes of practice also require firms to turn greener at the organizational level to meet the environmental standard without sacrificing their business performance

(Tuttle & Heap, 2008). Furthermore, Vidaver-Cohen and Brønn (2015) suggest that a company's reputation can significantly drive business performance. In the context of eco-organizational innovation, green practices through Corporate Social Responsibility (CSR) campaigns help portray companies' green initiative and position in the market. This consequently promotes firms' eco-friendly reputation and financial performance. Besides, Tuttle and Heap (2008) also propose that a sustainable organization will experience an increase in productivity through higher shareholder value, customer and employee loyalty, along long-term financial growth. Thus, eco-organization can enhance its reputation and promote its productivity, which optimistically fosters business performance. Lastly, as mentioned above, eco-organization implies innovative design, speed, and flexibility that functions as companies' competitive advantage. To gain a better understanding of this concept, this research brings an example of a company, Shell. Shell is a multinational oil and gas company that adapted its business strategy to more sustainable activities by providing more and cleaner energy solutions. While being one of the most pollutant corporations globally, the company's innovative design, speed, and flexibility in following the 'green model' allow it to adapt to environmental change and remain sustainably competitive in the market (Guo & Munteanu, 2011). Following empirical studies (Lin & Chen, 2007; Cheng et al., 2014; Armbruster et al., 2008; Ch'ng et al., 2021) that discover a mechanism in driving the positive association between both standard and environmental innovation in stimulating a firm's financial performance, the hypothesis is formulated accordingly. Figure 3 represents the conceptual framework of business performance and different types of eco-innovations.

H1c: Firm's eco-organizational innovation is positively related to its business performance

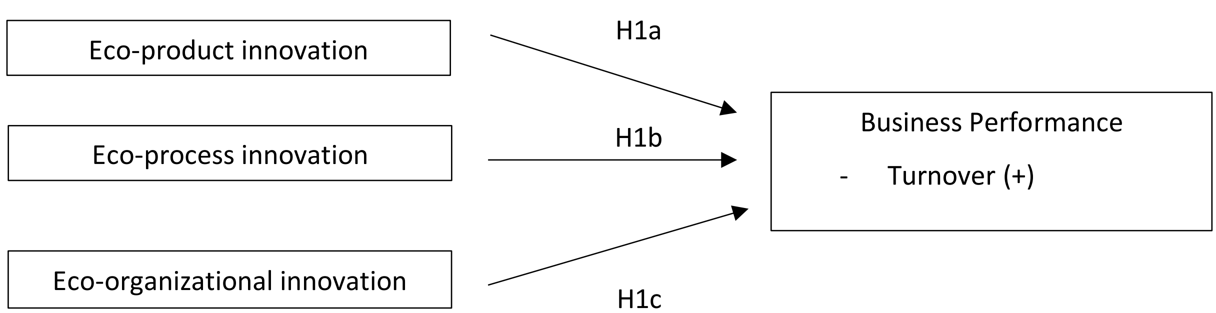

Figure 3 Relationship Eco-innovations and Business Performance

4. Complementarity of Eco-innovations

Although existing literature on different eco-innovation and business performance is rich and extensively researched (Appendix A), they do not address whether these forms of eco-innovation complement one another. Besides, studies on the complementarity of standard innovation have only gained academic attention in the recent decade (Schiederig, Tietze & Herstatt, 2012). To investigate the complementarity between different eco-innovation strategies to maximize a firm's performance, it is crucial to understand the meaning of complementarity.

In economics, the term "complementarity" has diverse meanings. This research defines complementarity as consistent with the definition derived by Milgrom and Roberts (1990). Complementarity occurs when the benefits of combining more than one strategy exceed the total benefits when undertaking each strategy separately. When the activities complement each other, they shall be able to execute independently and simultaneously. In terms of eco-innovation, product and process eco-innovation are considered as complementary strategies if the benefits from combining these two innovations exceed the sum of the benefits if they are being executed separately. Moreover, two activities cannot be considered complements if they cannot be adopted together, which means that adopting one type of eco-innovation must not preclude the firm from adopting another activity. Golovko and Valentini (2011) used this concept of complementary to explore the complementarity between innovation and export for SMEs' growth. Similarly, Schmiedeberg (2008) uses this concept to test the complementarity of internal and external R&D activities among German manufacturing firms. Doran (2012) also investigates whether different forms of standard innovation complement each other by using an Irish dataset based on the same concept of complementarity.

In innovation literature, complementarity can be understood by two approaches- complementarities-in-use and complementarities-in-performance (Ballot et al., 2015). While the first approach aims to provide a link between types of innovation, the second approach tries to investigate the impact of implementing the combination of both innovation activities on a firm's performance. For this study, the emphasis will be on complementarities-in-performance on eco-innovations. Therefore, this study will explore the complementarity between two types of eco-innovation, keeping the third eco-innovation constant. First, the complementarity between eco-product and eco-process will be discussed, followed by the complementarity between eco-organization and eco-product and eco-organization and eco-process innovations.

The complementarity in eco-product and eco-process innovations can be explained by technological novelty, productivity gains, and improve product performance when both eco-innovations are performed jointly (Evangelista & Vezzani, 2010). On the one hand, eco-product innovation can enhance ecological knowledge and improve eco-friendly product performance. On the other hand, eco-process innovation allows firms to overcome environmental and regulatory pressure. Efficient material use, recycling, and reusing schemes also promote production efficiency. Hence, both eco-product and eco-process innovation will encourage competitiveness and technological diffusion, enhancing firms' financial success. The technological and productivity gains have already been discovered in the complementarity of standard technological innovations. Capon et al. (1992) claim that complementarity in standard product and process innovation encourages higher return in capital. Even though formal tests for complementarities were not carried out by Evangelista and Vezzani (2010), they noticed higher growth when combining product and process eco-innovation in Italian firms compared to implementing one type of innovation solely. Product innovation fosters technological novelty and product performance, and process innovation fosters efficiency and productivity gains. The combination of technological novelty, product performance, efficiency, and productivity gains are the sources of competitiveness that mutually stimulate sales growth. This indirectly signals complementarity between different types of innovation. In French and UK manufacturing firms, Ballot et al. (2015) formally test for complementarities between the three innovation types. Using pairwise relation, product and process innovations are a complementary strategy among UK firms only when keeping the third form, organizational innovation, constant. Therefore, it is possible to believe that technological novelty, product performance, efficiency, and productivity also exist when complementary eco-product and eco-process innovations are performed jointly.

Moreover, there is an additional economic value from combining eco-product and eco-process innovative activities and practices. Undertaking one type of technological eco-innovation may strengthen the benefits from the other kind. For instance, eco-product innovation is driven by market demand for sustainable products and services, but this may also pose requirements on production processes that reinforce eco-process innovation. Likewise, eco-process innovation may be driven by cost-savings strategy induced by environmental legislation, but it may also lead to new ideas and opportunities for sustainable products and services. In this way, firms can use specialized green knowledge and capabilities from both eco-product and eco-process to enhance their performance. Studies (Pisano &Wheelwright, 1995; Milgrom & Roberts, 1990) conducted on standard innovations have already shown that firms can create a strong relationship between product and process innovation. This will increase the ease of launching and commercializing a new product, creating new product and process development opportunities, and improving production costs. Milgrom and Roberts (1990) also discover that combining different innovations is no accident. It is the firm's profit-maximizing intention to exploit the advantages from complementarities. Firms in the modern economy are managed and structured concerning customers, suppliers, and employees. Flexible and specialized qualities from product and process innovations allow firms to achieve complementary benefits between the coordinated system. Therefore, it is likely that complementing eco-product and eco-process innovations will also create additional economic value, building upon strong relationship between two eco-innovations that improve flexibility and create new opportunities from green coordination.

Eco-product and eco-process also generate green synergistic gains and capabilities that mutually promote firms' performance. Investing in environmental R&D also promotes the company's knowledge capital, which enhances eco-innovative capabilities that benefit performance in the long term (Horbach, 2008; Hansen et al., 2002). New green production builds new routines, creates expertise, and increases absorptive capacity. While green market demand provides the opportunity and motivation to produce eco-friendly products and services, process eco-innovation can extend the technological frontier and increase the familiarity with environmentally related issues, which reduces overall eco-innovation uncertainty. Schumpter (1934) has already claimed the interrelatedness between product and process innovations as a source of complementarity when considering standard innovation. Introducing one type of innovation may necessitate the introduction of another (Freeman & Soete,1997; Mohnen & Roller, 2005; Swann, 2014; Martinez-Ros & Labeaga, 2009). As the two innovations promote one another, applying both together will positively impact performance due to benefits concerning synergistic gains and technological capabilities. Hence, it is possible to conclude that synergies and capacities also exist when combining eco-product and eco-process innovations that are interrelated.

Building upon the complementarity evidence of product and process in standard innovation, this research proposes a similar relationship in the framework of environmental innovation. Eco-product and eco-process innovation are expected to promote firms' performance mutually. Identical to standard innovation, combining the two green technological innovation strategies will enhance firms' capabilities, competencies, and expertise in performing environmentally friendly activities. Adopting both innovations simultaneously will enforce mechanisms and synergies that facilitate companies' success. Yet, the link between eco-product and eco-process complementarity may be intuitive due to a limited number of empirical studies on eco-innovation complementarity. It is desirable and essential to test this relationship empirically. Consequently, the hypothesis is formulated as follows:

Hypothesis 2: eco-product and eco-process innovations are complementary strategies for firm's performance

The complementarities in eco-innovations do not lie between eco-product and eco-process innovations only. Eco-organizational innovation also favorably contributes to firms' performance in combining eco-product and eco-process innovations (Cheng et al., 2014). By implementing eco-organizational innovation, firms are equipped with the necessary infrastructure and eco-knowledge to support sustainable manufacturing processes and the introduction of new eco-products to the market. Eco-organization is beneficial in creating better intra organizational coordination and cooperation. This creates mechanisms to promote a more effective eco-green management system. Studies (Sapprasert & Clausen, 2012; Damanpour, Walker & Avellaneda, 2009) conducted on standard innovations have already shown that benefits from reorganization can be better exploited by integrating organizational innovation with technological innovations. They propose that the renewal of organizational structure, strategy, and administration that occurs when implementing organizational innovation helps in enriching the other types of innovation, which subsequently facilitates firms' financial achievements. Therefore, it is likely that eco-organization in combination with eco-product and eco-process will also promote firms' performance through organizational structure, strategy, and administration renewal.

By performing eco-organizational and eco-product and eco-organizational and eco-process innovations simultaneously, firms can generate additional benefits in environmentally efficient infrastructure, technologies, administrative support, and enterprises' structure and activities. These benefits are recognized as synergistic gains from green organizational coherence. Specifically, Cheng et al. (2014) propose that eco-organizational innovation favorably contributes to business performance in combination with eco-product and eco-process innovations. Teece (1986) has already claimed the importance of organizational coherence in complementarity benefits when considering standard innovation. Organizational coherence is regarded as a "valuable and rare complementary asset" that is critical in ensuring the benefits of complementarity with technological innovations. Combining organizational and technological innovation is essential to preclude imitation and enable appropriation. Hence, it is possible to believe that organizational coherence also exists as a "valuable and rare complementary asset" in the context of complementary organizational and technological eco-innovations.

The complementarities of eco-organizational and eco-product and eco-process are also explained by the ability to adapt better to the new market and changing technology. Organizational developments such as efficient material use, recycling and reusing schemes, and sustainable management can enormously promote eco-product and eco-process innovations to benefit business performance (Cecere et al., 2014). This is because such green organizational developments derive from complex interactions between the organization, employees, and other stakeholders that subsequently create sustainable knowledge, capabilities, coordination, and attention necessary to facilitate product durability and transform organizational processes. Moreover, formal eco-organizational campaigns that aim to reduce environmental degradation and fulfilling customer's green expectations also broaden the firm's perspective on eco-friendly practices, which correspondingly facilitates other technological eco-innovations. Some examples are "Strategic Environmental Management," "Environmental Management Systems," and "Environmentally Conscious Manufacturing". Organizational flexibility has already been discovered in the complementarity of standard technological innovations (Lawrence, 1969). The capabilities to adapt to changing customers and technical opportunities are crucial in developing new products and processes. Carboni and Russo (2018) argue that complementary capabilities or assets related to production, commercialization, and organization are required in implementing innovative activities. The ability to adapt to changing customer demand, apply a viable business model, and develop new products and production methods facilitates successful innovations. Thus, it is possible to conclude that adapting better to new markets and changing technology also play a significant role in eco-innovation complementarities.

Lastly, according to the evolutionary approach, firms are subject to lock-in and path-dependency, limiting firms from exploring sustainable innovation. By undertaking eco-organizational innovation and eco-product and eco-process innovations, firms can broaden opportunity identification and increase the incentive to innovate to eco-innovate efficiency by developing coordinated cognition, learning, and creativity. Becker et al. (2005) have already claimed that individuals will use routines and competencies to economize the cognitive resources and offset their bounded rationality in the context of standard eco-innovations. They argue that firms' performance depends on introducing a new product or improving the production process. By creating innovative routines, firms can benefit from synchronized utilization of resources which promotes cognition, learning, and creativity. Therefore, it is likely that complementing eco-organization and eco-product and eco-organization and eco-process innovations will also create synchronized routines that shape a strong relationship between eco-innovations that improve environmental cognition, learning, and creativity.

The complementarities of organizational and technological innovations are verified empirically. Polde et al. (2010) find positive effects of product and process innovation when combined with an organizational innovation that suggests complementarities. Similarly, Mothe and Thi (2010) also stress that organizational innovation plays a crucial role in enhancing firm performance as it increases the likelihood of introducing new or improved products and services. While Hervás Oliver et al. (2012) insist that organizational and process innovations are interrelated, Walker (2008) finds evidence in the setting of product innovation. Organizational innovation also plays a crucial role in determining innovative activity among UK firms (Battisti & Stoneman, 2010). This is supported by the finding of Damanpour and Aravind (2012), which propose that adoption of a single innovation type is insufficient for firms to fully take advantage of innovation benefits. By combining technological and organizational innovation, firms are more likely to perform better. Borrowing from the general innovation literature, the same relationships are proposed to exist in the context of eco-innovation. Namely, eco-organizational innovations can complement eco-process as well as eco-product innovations in promoting a firm's performance. Figure 4 provides the conceptual framework of complementarity in eco-innovations on performance.

Hypothesis 3: eco-organizational and eco-product innovations are complementary strategies for firm's performance

Hypothesis 4: eco-organizational and eco-process innovations are complementary strategies for firm's performance

5. Data and Methodology

5.1 Data Source

The relationship between different types of eco-innovation (eco-product, eco-process, and eco-organization) and a firm's performance is examined using the data from European Commission: Flash Eurobarometer 315 'Attitudes of European Entrepreneurs Towards Eco-innovation'. The Gallup Organization Hungary conducted the survey on behalf of the Directorate-General for the Environment of the European Commission to investigate the entrepreneurial behavior, attitudes, and expectations towards the development and uptake of eco-innovation. The survey also specifically defines eco-innovation as "the introduction of any new or significantly improved product (good or service), process, organizational change or marketing solution that reduces the use of natural resources (including materials, energy, water, and land) and decreases the release of harmful substances across the whole life-cycle". Telephone interviews with 5,222 managers of SMEs were collected in 27 European Union member states between 24 January and 1 February 2011. The companies were randomly selected for interviews using local statistical data sources by national institutes. This study excludes observations with missing values to limit the possible errors in statistical analysis. Countries with relatively small sample sizes like Cyprus, Luxembourg, and Malta will also be eliminated from the analysis due to the high sensitivity to the margin of error. The small sample size mainly refers to an average of 50 observations compared to a target number of interviews of 200 in other countries. This finally leads to a total of 4,420 SMEs for empirical analysis.

5.2 Dependent Variables

To measure the contribution of eco-innovation to performance, the annual turnover is considered as a proxy to business financial performance. The relevant question in the questionnaire for turnover is "What is the annual turnover of your company?". This is an ordered categorical variable with three categories ranging from below 2 million euro, 2-10 million euro, to more than 10 million euros. Although it is preferable to use change in turnover as the dependent variable, the variable does not fulfill the proportional odds assumption. To avoid unbiased estimates of ordinal logistic regressions, the annual turnover is considered as a proxy of performance. Given that this study focuses on SMEs, the annual turnover is deemed to represent SMEs' performance. For example, this study only compared the annual turnover within SMEs and not comparing 2-million-euro SMEs to a 10-million-euro large organization anyway.

5.3 Independent Variables

5.3.1 Types of Eco-innovation

The independent variables are given by the three types of eco-innovation - eco-product, eco-process, and eco-organization. These are binary variables that take a value of 1 if the firm introduced the specific type of eco-innovation and 0 otherwise. Firms were the following question: *"During the past 24 months have you introduced the following eco-innovation?".* Eco-innovation is categorized by eco-product, eco-process, and eco-organizational innovations. They refer to "*new or significantly improved eco-innovative*" product or service, production process, and organizational innovation.

5.3.2 Types of Firm by eco-innovation

To examine the complementarities between different types of eco-innovation on firms' performance, this study will perform super modularity test. It tests complementarity under the condition: the benefits from combining two eco-innovation activities should exceed the sum of the benefits if they are being executed separately. By what means complementarity test is executed will be discussed more extensively in subsection 5.6.2 as part of methodology of analysis. Consequently, firms will have to be grouped according to different combinations of eco-innovation strategies to perform complementarity test. This is a categorical variable with eight categories, as given in Table 5.1.

5.4 Control Variables

5.4.1 Firm Size

As firm size also determines both financial performance and the firm's attitudes towards innovative environmental activities, it is included as a control variable. Doğan (2013), along with Lee (2009), discovers that firm size positively influences a firm's financial performance. In addition, firm size also explains the spurious relationship between corporate social performance and firm financial performance. Small companies also face more difficulties applying eco-innovation (Hojnik & Ruzzier, 2016b; Triguero et al., 2013). Hence, it is necessary to control firm size to avoid possible omitted variable bias. Firm size is a binary variable, estimated by asking the firms, "How many employees does your company have?". Firms are categorized as small and medium-sized enterprises with 10 to 49 employees and 50 to 249 employees.

5.1.1 Main Activities

There is a reason to assume that the business sector influences both propensities to eco-innovation and business performance. Cheng et al. (2014) specify that the development of eco-innovation is subject to specific industry practices. More resource-intensive and tangible industries like construction or manufacturing are more likely to engage in environmental practices as they largely contribute to environmental damage (Hoogendoorn et al., 2015).

Table 5.1 Combination of Eco-innovation

Type of eco-innovation	Firms' eco-innovation combination	Eco-product	Eco-process	Eco-organization
0,0,0	Firms that perform **no** eco-innovation [ref]			
1,0,0	Firms that perform **only** eco-product innovation	*		
0,1,0	Firms that perform **only** eco-process innovation		*	
1,1,0	Firms that perform **both** eco-product and eco-process innovation	*	*	
0,0,1	Firms that perform **only** eco-organizational innovation			*
1,0,1	Firms that perform **both** eco-organizational and eco-product innovation	*		*
0,1,1	Firms that perform **both** eco-organizational and eco-process innovation		*	*
1,1,1	Firms that perform **all** three types of eco-innovation	*	*	*

[ref] refers to a reference variable

On the other hand, the financial service and retail sectors have lesser impacts on the environment and subsequently lower eco-innovation engagement opportunities. Cheng et al. (2014) also argue that Taiwanese IT manufacturers first focus on organizational innovation to distribute new eco-knowledge within the firm following by environmental product and process innovations. Different environmental harm levels per industry also provide a strong link between environmental corporate social responsibility and the industry sector (Ndemanga & Koffi, 2009). Accordingly, industry-fixed effects will also be included to control observed and unobserved average differences across industries. Main activities represent industry: Agriculture and fishing, Construction, Water supply, Manufacturing, and Food services.

5.1.2 Country

Country-specific dummies will also be included as control variables. Given that individual environmental policies and regulations drive different countries, the extent and variety of eco-innovation may also differ per country. Triguero et al. (2013) also claim that differences that arise across countries are difficult to disentangle. As a consequence, country-specific influences of EU-27 countries (excluding Cyprus, Luxembourg, and Malta) are being controlled in this model. Table 5.2 presents different types of eco-innovation by country. The majority of firms are not involved in green innovation. The highest percentage of eco-product, eco-process, and eco-organizational innovation implementation is 32%, 44%, and 35% in Italy, Poland, and Portugal, respectively.

5.1 Descriptive Statistics

The descriptive statistics in Table 5.3 provide the exact definition of variables that are used for analysis in this study. Percentages of firms that belong to each category are given in the last column. When looking at three types of eco-innovation, there are only 23.9%, 29.45%, and 22.66% of firms that undertake eco-product, eco-process, and eco-organizational innovation. The majority of firms are still skeptical towards innovative environmental practices. The majority of firms are small-sized enterprises (79.09%) and focus mainly on manufacturing activities (53.14%).

Table 5.2 Types of Eco-innovation by Country

Country	Observations	Eco-product		Eco-process		Eco-organizational	
		No = 0	Yes = 1	No = 0	Yes = 1	No = 0	Yes = 1
France	250	79%	21%	80%	20%	81%	19%
Belgium	201	79%	21%	74%	26%	78%	22%
The Netherlands	200	78%	22%	65%	35%	70%	30%
Germany	250	75%	25%	73%	27%	78%	22%
Italy	251	68%	32%	71%	29%	79%	21%
Denmark	201	79%	21%	73%	27%	85%	15%
Ireland	200	74%	26%	65%	35%	72%	28%
United Kingdom	251	73%	27%	70%	30%	80%	20%
Greece	201	69%	31%	63%	37%	72%	28%
Spain	250	78%	22%	66%	34%	69%	31%
Portugal	201	68%	32%	62%	38%	65%	35%
Finland	205	80%	20%	72%	28%	93%	7%
Sweden	200	78%	22%	68%	32%	81%	19%
Austria	200	71%	29%	70%	30%	79%	21%
Czech Republic	200	79%	21%	75%	25%	79%	21%
Estonia	200	86%	14%	74%	26%	79%	21%
Hungary	202	87%	13%	81%	19%	86%	14%
Latvia	202	78%	22%	73%	28%	79%	21%
Lithuania	202	77%	23%	79%	21%	85%	15%
Poland	200	74%	26%	56%	44%	66%	34%
Slovakia	200	78%	22%	73%	27%	75%	25%
Slovenia	200	74%	26%	68%	32%	80%	20%
Bulgaria	204	81%	19%	74%	26%	74%	26%
Romania	200	71%	29%	67%	33%	72%	28%
Total	5,071	76%	24%	71%	29%	77%	23%

Source: Flash Eurobarometer 315 ‘Attitudes of European Entrepreneurs Towards Eco-innovation' Survey

Table 5.3 Descriptive Statistics

Variables	Categories	Frequency	Percentage
Dependent Variables			
Turnover	Up to 2 million euro	2,435	52.81
	2-10 million euro	1,591	34.50
	10 million euro and over	585	12.69
Independent Variable			
Eco-innovation			
Eco-product	1 if introduce new or significantly improved eco-innovative product or service	1,170	23.60
	0 otherwise	3,787	76.40
Eco-process	1 if introduce new or significantly improved eco-innovative production process or method	1,453	29.39
	0 otherwise	3,491	70.61
Eco-organizational	1 if introduce new or significantly improved eco-innovative organizational innovation	1,107	22.52
	0 otherwise	3,808	77.48
Complementarity	Firm that perform **no** eco-innovation	2,716	56.35
	Firm that perform **only** eco-product innovation	336	6.97
	Firm that perform **only** eco-process innovation	437	9.07
	Firm that perform **both** eco-product and eco-process innovation	260	5.39
	Firm that perform **only** eco-organizational innovation	267	5.54
	Firm that perform **both** eco-organizational and eco-product innovation	109	2.26
	Firm that perform **both** eco-organizational and eco-process innovation	293	6.08
	Firm that perform **all** three types of eco-innovation	402	8.34
Control Variables			
Firm size	Small [ref]	4,008	79.04
	Medium	1,063	20.96
Main Activities	Agriculture and fishing [ref]	426	8.40
	Construction	1,422	28.04
	Water supply	166	3.27
	Manufacturing	2,720	53.64
	Food services	337	6.65

[ref] refers to a reference category

Source: Flash Eurobarometer 315 ‘Attitudes of European Entrepreneurs Towards Eco-innovation' Survey

5.2 Methodology

An ordinal logistic regression model is chosen for empirical analysis following the ordered and categorical characteristics of dependent variables. Eco-product, eco-process, and eco-organizational innovation are selected as potential explanatory variables. Control variables in Section 5.4 will be included to limit statistical bias.

Assumptions of the ordinal logistic regression are verified to ensure unbiased estimates. Due to the dependent variable's ordered categorical nature, ordinal logistic model regression is appropriate for statistical analysis. Besides, large sample size is typically required. The rule of event per variable (EPV) of 50, given by n = 100 + 50i, calculates the critical minimum sample size (Bujang, Sa'at & Bakar, 2018), and i denotes the total number of independent and control variables. As this research aims to provide answers to two types of relationships, eco-innovation, and performance, as well as complementarities in eco-innovation on performance, the minimum sample size will be calculated separately. On the one hand, the minimum required sample size to examine the direct relationship between eco-innovation and firms' performance is given by 400 as three independent variables (three types of eco-innovations) along with three control variables are proposed. On the other hand, the minimum required sample size to test complementarities between different types of eco-innovation is 300, given that there is one independent (complement) and three control variables. The second relationship requires a distinct form of the independent variable that categorize eco-innovation into distinct combination of eco-innovations which has been discussed extensively subsection 5.3.2. Therefore, 4,420 observations in the model specify a large enough sample size.

Multicollinearity refers to the relationship between multiple independent variables that are highly associated with each other. Such high correlation may erode the true statistical power of the variable of interest. Therefore, minor or insignificant multicollinearity is also required in ordinal logistic regression. The correlation matrix and Variance Inflation Factor (VIF) in Appendix B and Appendix C suggest no severe multicollinearity issues. Farrar and Glauber (1967) suggest that the rule of thumb that if the correlation coefficient exceeds 0.8 in absolute terms, there is an indication of severe multicollinearity. The correlation coefficient between eco-process and eco-organizational has the highest value of 0.4257, revealing no sign of serious multicollinearity. Variance Inflation Test (VIF) is also executed to check the sign of multicollinearity. According to the rule of thumb, a VIF value greater than 10 suggests severe multicollinearity (Yoo et al., 2014). As Appendix C shows, no VIF values are above 10. There is no sign of a multicollinearity issue.

Lastly, proportional odds or parallel regression assumption assumes that the effects of independent variables are consistent or proportional across the different thresholds of dependent variables. Proportional odds assumption is verified by performing a Brant test Appendix D. Since a significant test statistic provides evidence that the parallel regression assumption has been violated, Table D shows none of the significant test statistics, which proposes no violation to proportional odds assumption.

5.2.1 Performance

In order to assess the positive link between eco-product, eco-process, and eco-organizational innovation and business performance, ordinal logistic regression is performed. Firm size, main activities, and country are also included as control variables, as they may influence business performance. The ordered logistic regression on performance is demonstrated as follow in Eq.1 below:

$$Performance^{*} = \beta_1(Eco - product) + \beta_2(Eco - process) + \beta_3(Eco - organizational) + \beta_4 Firm\ Size + \beta_5 Main\ Activities + \beta_6\ Country\ Dummies + \varepsilon_i$$

Eq 1

Where ε_i is an error term that follows a logistic distribution, and $Performance$ is generated by the latent variable$Performance^{*}$. $Performance^{*}$ represents $Turnover^{*}$ which takes a value between below 2 million euro, 2-10 million euro, and over 10 million euro. $Eco - product$, $Eco - process$, and $Eco - oragnizational$ refers to the dummy variables of the three types of eco-innovation. $Firm\ Size$, $Main\ Activities$, and $Country\ Dummies$ included as control variables in the model.

5.2.2 Complementarity

In order to assess whether eco-product and eco-process, eco-organization and eco-product, and eco-organization and eco-process innovations are complementary strategies, ordinal logistic regression will be performed while having business performance as dependent variable and types of firms by combinations of eco-innovative activities in subsection 5.3.2 as independent variables. The coefficient for the firms that perform both eco-product and eco-process, both eco-organizational and eco-product, and both eco-organizational and eco-process innovations, are expected to be positive and significantly related to firms' performance compared to the coefficients for the firms that do not perform eco-innovation at all as a precondition to support complementarity.

Finally, Chi-square test (χ2) will be performed to formally test complementarity known as super modularity test, as suggested by Milgrom and Roberts (1990). It is a pairwise test that will be performed to test the complementarity between two types of eco-innovations while keeping the third form at a constant state. The complementarity test between eco-product and eco-process innovations will be tested in the absence of the eco-organizational innovation and the presence of it separately. Similarly, the complementarity test between eco-organizational and eco-product innovations and between eco-organizational and eco-process innovations will also be tested in the absence/presence of the eco-process and eco-product innovations, respectively. More precisely, the benefits in terms of firms' performance when undertaking two eco-innovations simultaneously should be significantly higher than the combination of benefits that firms achieve when undertaking each eco-innovation separately.

Following the combination of eco-innovation in Table 5.1, eco-product and eco-process complement each other under the following conditions:

- [Performance (1 , 1 , 0) - Performance (1 , 0 , 0)] > [Performance (0 , 1, 0) - Performance (0 , 0, 0)] in absence of eco-organizational innovation
- [Performance (1 , 1 , 1) - Performance (1 , 0 , 1)] > [Performance (0 , 1, 1) - Performance (0 , 0, 1)] in presence of eco-organizational innovation

Similarly, the complementarity between eco-organization and eco-product is subject to the following conditions:

- [Performance (1 , 0 , 1) - Performance (0 , 0 , 1)] > [Performance (1 , 0, 0) - Performance (0 , 0, 0)] in absence of eco-process innovation
- [Performance (1 , 1 , 1) - Performance (0 , 1 , 1)] > [Performance (1 , 1, 0) - Performance (0 , 1, 0)] in presence of eco-process innovation

Finally, eco-organization and eco-process depicts complementarity if:

- [Performance (0 , 1 , 1) - Performance (0 , 0 , 1)] > [Performance (0 , 1, 0) - Performance (0 , 0, 0)] in absence of eco-product innovation

- [Performance (1 , 1 , 1) - Performance (1 , 0 , 1)] > [Performance (1 , 1, 0) - Performance (1 , 0, 0)] in presence of eco-product innovation

Since whether the firm performs eco-organizational innovation or not affects its performance, this study considers a constant state for organizational innovation to observe the complementarity between eco-product and eco-process innovations. Conditional to the absence and presence of eco-organization, the performance benefits from combining eco-product and eco-process innovation should exceed the sum of benefits from undertaking either eco-product or eco-process innovation. In order to ensure that changes of the third eco-innovation do not influence all complementarity tests in the other type of eco-innovation, the third type of innovation should be considered constant to test the complementarity between the other two pairs of complementarities. Eq. 2 portrays the estimated equation for complementarity between the three types of eco-innovation.

$$Performance^* = \beta_1(\boldsymbol{only}\ eco-product) + \beta_2(\boldsymbol{only}\ eco-process) + \beta_3(\boldsymbol{both}\ eco-product\&eco-process) + \beta_4(\boldsymbol{only}\ eco-organization) + \beta_5(\boldsymbol{both}\ eco-organization\&eco-product) + \beta_6(\boldsymbol{both}\ eco-organization\&eco-process) + \beta_7(\boldsymbol{all}\ eco-innovation) + \beta_8 Firm\ Size + \beta_9 Main\ Activities + \beta_{10}\ Country\ Dummies + \varepsilon_i$$

Eq.2

Where ε_i is an error term that follows a logistic distribution and $Performance$ is generated by the latent variable $Performance^*$. $Performance^*$ represents $Turnover^*$. $\boldsymbol{only}\ eco-product$, $\boldsymbol{only}\ eco-process$, $\boldsymbol{both}\ eco-product\&eco-process$, $\boldsymbol{only}\ eco-organization$, $\boldsymbol{both}\ eco-organization\&eco-product$, $\boldsymbol{both}\ eco-organization\&eco-process$ and $\boldsymbol{all}\ eco-innovation$ refers to different combination of eco-innovations that firm undertake having $No\ eco-innovation$ as reference category.

6. Results

6.1 Direct Relationship

The result of ordinal logistic regression of different eco-innovation types (eco-product, eco-process, and eco-organization) on business performance is given in Table 6.1. Since eco-innovation states are dummy variables, the results are interpreted in terms of firms that undertake a specific type of eco-innovation relative to those who did not undertake eco-innovation by having everything else constant (ceteris paribus). Additionally, logistic regression is given in two models in columns 2 and 3 of Table 6.1. Model 1 is performed with control variables only, and Model 2, including both independent and control variables. The benefits of running two models lie in its ability to compare the predictability of eco-innovations. When comparing Model 1 and 2, the inclusion of eco-innovations increases pseudo R-squares from 0.223 to 0.226. Although the model's predictability rises with the inclusion of eco-innovation, this difference is noticeably minor, suggesting that turnover is not significantly explained by eco-innovation. According to Table 6.1, it is also noticeable that firm size positively influences firm financial performance. When keeping other variables fixed, medium-sized firms are more likely to higher turnover compared to small-sized firms at a 1% significance level. Moreover, when looking at primary activities, firms that operate in different sectors have a different impact on turnover. Agriculture and fishing, construction, and water supply are not significantly different in influencing turnover. The manufacturing sector has significantly higher probabilities, and the food services industry has lower probabilities than agriculture and fishing in having a higher turnover.

6.1.1 Hypothesis 1a

According to column 3 in Table 6.1, firms that implement eco-product innovation have higher probabilities of having a turnover of over 10 million euros compared to firms that do not implement eco-product innovation, ceteris paribus. However, the positive relationship is not statistically significant at a 5% significance level. This suggests a rejection of Hypothesis 1a. When keeping other eco-innovations constant, firms that perform eco-product innovation do not significantly experience an increase in turnover. Since the coefficient of ordinal logit regression output only suggests the sign and statistical significance of being the top categories of performance variables, turnover, the marginal effect is calculated for each turnover category (Table E1, Appendix E) to gain better interpretation. Keeping other variables constant, engaging in eco-product innovation compared to not doing so decreases the likelihood of having turnover up to 2 million euros by 1.7 percentage points. Eco-product innovation also increases the likelihood of higher turnover categories of between 2 and 10 million euros and more than 10 million euros by 1.3 and 0.4 percentage points, respectively. However, the result on turnover is statistically insignificant at a 5% significance level. Therefore, the results suggest that eco-product innovation has no significant impact on turnover.

6.1.2 Hypothesis 1b

Similarly, the relationship between eco-process innovation and turnover is executed. Second row of Table 6.1 suggests a significant and positive association between eco-process innovation and business performance. Keeping other variables fixed, compared to non-eco-process innovative firms, firms that undertake eco-process innovation have higher probabilities of being in the top category of having turnover (more than 50 million euros). This effect is statistically significant at a 1% significance level. For a deeper interpretation of results, the marginal effect is given in Table E1, Appendix E. On average, undertaking eco-process innovation relative to not taking eco-process innovation decreases the probabilities of having turnover up to 2 million euros by 5.8 percentage point at a 1% significance level, ceteris paribus. Introducing a new or significantly improved eco-friendly production process increases the likelihood of having turnover between 2 and 10 million euros and more than 10 million euros by 4.4 and 1.4 percentage points, respectively. The regression result supports Hypothesis 1b, that eco-process innovation is positively related to a firm's performance in the context of turnover.

6.1.3 Hypothesis 1c

Lastly, the relationship between eco-organizational innovation and business performance is also portrayed in Table 6.1. Compared to firms that did not undertake eco-organizational innovation, firms that implement eco-organizational innovation have significantly higher probabilities of being the top categories of performance variables for turnover at 5% significance level, ceteris paribus. Therefore, the positive coefficient suggests a positive association between eco-organization and a firm's performance when keeping other types of eco-innovation constant, which supports Hypothesis 1c. The marginal effect in Table E1, Appendix E shows the precise impact of eco-organization on performance. On average, keeping other variables fixed on average, undertaking eco-organizational innovation compared to not taking eco-organizational innovation decreases the probabilities of having turnover up to 2 million euros by 5.6 percentage points. This suggests that taking eco-organizational strategy reduces the likelihood of being in the lowest category of turnover. Eco-organizational innovation also increases the likelihood of having turnover between 2 and 10 million euros by 4.3 percentage points when keeping other eco-innovations constant. When considering the highest turnover category, firms that perform eco-organizational innovation have higher probabilities of having turnover of more than 10 million euros by 1.3 percentage points relative to performing no eco-organizational innovation, ceteris paribus. This effect is statistically significant at a 1% significance level.

Table 6.1 Ordinal Logistic Regression on Eco-innovation and Business Performance

	Turnover	
	Model 1	Model 2
Eco-product		0.067
		(0.081)
Eco-process		0.232***
		(0.078)
Eco-organizational		0.223**
		(0.087)
Firm Size		
Small [ref]		
Medium	2.776***	2.739***
	(0.091)	(0.091)
Main Activities		
Agriculture and fishing [ref]		
Construction	-0.118	-0.074
	(0.135)	(0.136)
Water supply	0.196	0.218
	(0.214)	(0.213)
Manufacturing	0.228*	0.259**
	(0.127)	(0.128)
Food services	-1.148***	-1.127***
	(0.199)	(0.201)
Country Fixed Effects	Yes	Yes
τ_1	-0.151	-0.030
	(0.173)	(0.176)
τ_2	2.480***	2.617***
	(0.183)	(0.186)
No. of Observations	4420	4420
Pseudo R-square	0.223	0.226

Standard errors in parentheses

* p<.10, ** p<.05, *** p<.01

[ref] refers to a reference category

6.2 Complementary Relationship

To test the complementarity, this research will assess two conditions. First, a prerequisite to support complementarity requires the positive and significant coefficient of variable firms that perform both types of eco-innovation. Second, a formal super modularity test is executed through a chi-square test. The tests are performed pairwise conditional to the presence and absence of the third eco-innovation. This requires positive and significant chi-square test statistics to confirm the existence of complementarity. It indicates that benefits from combining two eco-innovations exceed the sum of the benefits if they are being executed separately.

The results regarding the complementarities between eco-product and eco-process, between eco-organizational and eco-product, and between eco-organizational and eco-process innovations are verified by the results of ordered logit regression in Table 6.2. The regression outputs are given in two separate models. When comparing Model 1 and 2, incorporating eco-innovation increase pseudo R-square from 0.223 to 0.227, showing that the model predicts the outcome better. Nevertheless, the increase in the model's explanatory power is considerably small. It proposes that eco-innovations do not significantly explain turnover. It is also noticeable that firm size does plays a substantial role in determining the likelihood of increasing turnover. As expected, medium-sized firms have a higher probability of having higher turnover than small-sized firms when keeping other variables constant. In addition, firms that operate in manufacturing are more likely to have higher turnover than agriculture and fishing. Conversely, firms that operate in food services have a lower probability of experiencing higher turnover. Other sectors like construction and water supply have no significant difference in turnover relative to the agriculture and fishing sector. Main activities allow this research to account for observed and unobserved heterogeneity.

6.2.1 Hypothesis 2

To investigate the precondition of complementarity, ordered logit regression is executed. Firms that perform no eco-innovation are dropped out of the regression as a reference variable because of the categorical nature of the independent variable. According to Table 6.2, firms that undertake both eco-product and eco-process innovation have higher probabilities of being in the top category of having turnover higher than 10 million euros compared to firms that do not perform any eco-innovation, ceteris paribus. This effect is significant at a 5% significance level. This justifies the precondition of complementarity between eco-product and eco-process innovations. As the coefficient of ordered logit regression only denotes the sign and significance level of taking both eco-product and eco-process innovation together on performance, the marginal effect is provided in Table E2, Appendix E for a richer understanding. Compared to firms that perform no eco-innovations, performing both eco-product and eco-process innovations decreases the probabilities of having turnover up to 2 million euros by 7.7 percentage points, ceteris paribus. Undertaking both eco-product and eco-process also increases the likelihood of having turnover between 2 and 10 million euros and more than 10 million euros by 6.0 and 1.7 percentage points when keeping other combinations of eco-innovations constant, respectively. Furthermore, the second condition to verify complementarities is performed by a formal super modularity test, keeping the third form constant. Eco-product and eco-process innovations are complementary strategies if:

- [Turnover (1, 1, 1) - Turnover (1, 0, 1)] > [Turnover (0, 1, 1) - Turnover (0, 0, 1)] in presence of eco-organizational innovation
- [Turnover (1, 1, 0) - Turnover (1, 0, 0)] > [Turnover (0, 1, 0) - Turnover (0, 0, 0)] in absence of eco-organizational innovation

The chi-square test is performed to scrutinize the super modularity conditions above formally. Positive and significant chi-square test statistics suggest the existence of complementarity between eco-product and eco-process by meeting the super modularity conditions above. Table 6.3 confirms chi-square test statistics of 0.48 and 1.39 in the presence and absence of eco-organizational innovation, respectively. Although results provide positive chi-square test statistics, they are non-significant values at a 5% significance level, which leads to a rejection of Hypothesis 2. Hence, it is impossible to conclude that eco-product and eco-process innovation complement each other in promoting turnover.

6.2.2 Hypothesis 3

The complementarity regression outcomes between eco-organizational and eco-product innovations are given in Table 6.2. Firms that perform both eco-organizational and eco-product innovations have a higher likelihood of having a turnover of more than 10 million euros relative to firms that perform no eco-innovations, ceteris paribus. This is significant at the 10% significance level. It is noticeable that firms that perform only eco-organizational and only eco-product innovation are also more likely to be in the top category of turnover than firms that neither eco-organizational nor eco-product innovate. The positive and significant coefficient of firms that perform both eco-organizational and eco-product innovation fulfills complementarity precondition. Table E2, Appendix E provides the marginal effect for a more profound understanding. Undertaking both eco-organizational and eco-product innovations decrease the probabilities of having turnover up to 2 million euros by 8.1 percentage points, ceteris paribus. Implementing both eco-organizational and eco-product innovations also increases the likelihood of higher turnover categories of between 2 and 10 million euros and more than 10 million euros by 6.3 and 1.8

percentage points, respectively. The effects are significant at 10% significance for turnover up to 2 million euros and between 2 and 10 million euros, but not significant for turnover beyond 10 million euros. Formal complementarity tests are performed, and eco-organizational and eco-product innovation are complementary strategies if:

- [Turnover (1, 1, 1) - Turnover (0, 1, 1)] > [Turnover (1, 1, 0) - Turnover (0, 1, 0)] in presence of eco-process innovation
- [Turnover (1, 0, 1) - Turnover (0, 0, 1)] > [Turnover (1, 0, 0) - Turnover (0, 0, 0)] in absence of eco-process innovation

Similar to the complementarity test between eco-product and eco-process innovations, the chi-square test is performed to formally scrutinize the abovementioned conditions. Positive and significant chi-square test statistics show that benefits from combining eco-product and eco-process two innovations exceed the sum of the benefits if they are being executed separately. In other words, it suggests the presence of complementarity between eco-organizational and eco-product innovations. The formal complementarity test results are given in Table 6.3. Chi-square test statistics are 0.49 and 1.09 in the presence and absence of eco-process innovation, respectively. Accordingly, eco-organization and eco-product cannot be established as a complementary strategy in promoting turnover, which proposes a rejection to Hypothesis 3.

5.1.1 Hypothesis 4

Table 6.2 shows that firms that perform both eco-organizational and eco-process positively and significantly relate to turnover at a 1% significance level, ceteris paribus. This suggests positive signs of combining both eco-innovative strategies in promoting a firm's performance, verifying the precondition of complementarity. The marginal effects in Table E2, Appendix E demonstrates that, on average, undertaking eco-organizational and eco-process together decreases the probabilities of being the lowest categories of turnover (up to 2 million euros) by 9.8 percentage points at a 1% significance level. Undertaking both eco-organizational and eco-process increases the likelihood of having turnover between 2 and 10 million euros and more than 10 million euros by 7.6 and 2.3 percentage points when keeping other combinations of eco-innovations constant, respectively. Therefore, firms that implement both eco-organizational and eco-process innovation are more likely to perform better in terms of turnover. In addition, a complementarity test is performed under the condition:

- [Turnover (1, 1, 1) - Turnover (1, 0, 1)] > [Turnover (1, 1, 0) - Turnover (1, 0, 0)] in presence of eco-product innovation

- [Turnover (0, 1, 1) - Turnover (0, 0, 1)] > [Turnover (0, 1, 0) - Turnover (0, 0, 0)] in absence of eco-product innovation

Similar to the previous complementarity tests, the chi-square test is performed to verify the existence of complementarities. According to the super modularity test in Table 6.3, chi-square test statistics suggest statistical evidence of complementarities between eco-organizational and eco-process innovations in improving turnover in the absence of eco-product innovation. The resulting chi-square test statistic is 3.84 with a p-value of 0.05. Hence, it is statistical significance at a 10% significance level. However, when performing the complementarity test in eco-product innovation, chi-square test statistics is 0.01, which is statistically insignificant. Thus, Hypothesis 4 is partially supported as combining eco-organizational and eco-process innovations mutually reinforce each other only in the context of turnover when keeping eco-product innovation absent.

6.3 Robustness Checks

A robustness check is performed in Appendix F to ensure the quality of regression models performed above. This is done by altering the dependent variables using change in turnover as a proxy for business performance. The related question from the questionnaire for change in turnover is "Has your company's annual turnover decreased, remained unchanged, or increased over the past two years?" and the possible answers are increased, remain unchanged, and decrease. Ordinal logit regression is performed to test the relationship between different types of eco-innovation and business performance, and their complementarities using these different measurements of performance. The results in Table F1, Appendix F, are in accordance with Table 6.1 in terms of sign and significance level. Only eco-process and eco-organizational innovative firms are more likely to experience increased turnover. Eco-product innovation remained insignificantly related to the firms' performance at a 10% significance level. When looking at complementarity in Table F2 in Appendix F, undertaking two eco-innovative strategies is positively related to the increased turnover compared to not taking both types of eco-innovations. In addition, robustness checks on the super modularity test are given in Table F3, Appendix F. The results are similar to Table 6.3, suggesting a positive chi-square test statistic but statistically insignificant at a 5% significance level. Therefore, eco-process, eco-process, and eco-organizational cannot be considered complementary strategies in stimulating turnover. Given that the results are different expected hypotheses, further research on complementarities of eco-innovation using various performance measures and different samples will be tremendously favorable for both firms and policymakers.

Table 6.2 Ordinal Logistic Regression on Eco-innovation Complementarities

	Turnover	
	Model 1	Model 2
Complement		
Firm that perform **no** eco-innovation [ref]		
Firm that perform **only** eco-product innovation		0.174
		(0.122)
Firm that perform **only** eco-process innovation		0.379***
		(0.108)
Firm that perform **both** eco-product and eco-process innovation		0.310**
		(0.140)
Firm that perform **only** eco-organizational innovation		0.434***
		(0.149)
Firm that perform **both** eco-organizational and eco-product innovation		0.327*
		(0.198)
Firm that perform **both** eco-organizational and eco-process innovation		0.395***
		(0.129)
Firm that perform **all** three types of eco-innovation		0.492***
		(0.131)
Firm Size		
Small [ref]		
Medium	2.776***	2.742***
	(0.091)	(0.091)
Main Activities		
Agriculture and fishing [ref]		
Construction	-0.118	-0.068
	(0.135)	(0.137)
Water supply	0.196	0.224
	(0.214)	(0.213)
Manufacturing	0.228*	0.261**
	(0.127)	(0.128)
Food services	-1.148***	-1.116***
	(0.199)	(0.201)
Country Fixed Effects	Yes	Yes
τ_1	-0.151	-0.001
	(0.173)	(0.177)
τ_2	2.480***	2.648***
	(0.183)	(0.188)
No. of Observations	4420	4420
Pseudo R-square	0.223	0.227

Standard errors in parentheses

* p<.10, ** p<.05, *** p<.01

[ref] refers to a reference category

Table 6.3 Super modularity test on Eco-innovation Complementarities

	Turnover	
	Third Form Presence	Third Form Absence
Eco-product & Eco-process	[Turnover (1, 1, 1) - Turnover (1, 0, 1)] > [Turnover (0, 1, 1) - Turnover (0, 0, 1)] χ^2 (1) = 0.48 p-value = 0.4892	[Turnover (1, 1, 0) - Turnover (1, 0, 0)] > [Turnover (0, 1, 0) - Turnover (0, 0, 0)] χ^2 (1) = 1.39 p-value = 0.2379
Eco-organization & Eco-product	[Turnover (1, 1, 1) - Turnover (0, 1, 1)] > [Turnover (1, 1, 0) - Turnover (0, 1, 0)] χ^2 (1) = 0.49 p-value = 0.4836	[Turnover (1, 0, 1) - Turnover (0, 0, 1)] > [Turnover (1, 0, 0) - Turnover (0, 0, 0)] χ^2 (1) = 1.09 p-value = 0.2958
Eco-organization & Eco-process	[Turnover (1, 1, 1) - Turnover (1, 0, 1)] > [Turnover (1, 1, 0) - Turnover (1, 0, 0)] χ^2 (1) = 0.01 p-value = 0.9205	[Turnover (0, 1, 1) - Turnover (0, 0, 1)] > [Turnover (0, 1, 0) - Turnover (0, 0, 0)] χ^2 (1) = 3.84 p-value = 0.0500

Positive and Significant χ^2 test statistics suggests complementarity

7. Discussion and Conclusion

This paper aims to understand whether eco-innovation is beneficial for SMEs and which combination of these eco-innovations would be most beneficial. Eco-product, eco-process, and eco-organization are distinguished as the three types of eco-innovation, and the benefits are recognized in terms of firms' financial performance of turnover.

7.1 Discussion of Results

This research does not find support for the hypothesis regarding eco-product innovation. While eco-product innovation is expected to be linearly and positively related to business performance, firms that undertake this type of environmental innovation are not significantly associated with the top annual turnover category. The positive but insignificant relationship suggests introducing innovative eco-products might not necessarily result in higher profits unless it leads to higher demand, especially if the new product is costlier to produce or at least the same price as the previous products. For example, a plastic bottle is cheaper than a bamboo bottle, and a plastic bag is more affordable than a cloth bag. Environmental concern is generally considered as an antecedent to eco-product consumption, but the market demand for green products and services is majorly embedded in green niches. More expensive eco-products can also be recognized as luxury goods rather than necessity goods. Moreover, while many customers are becoming concerned about eco-friendly practices, others are skeptical about the hygiene standards of eco-products. For example, biodegradable and plastic food packages are debatable regarding their ability to secure product quality and freshness during distribution and storage. Hence, the benefits from eco-product innovation are neutralized by the complexity in producing and commercializing the eco-friendly product. Despite the convincing environmental benefits, it is unclear whether eco-products are better in terms of their use and quality. Additionally, the empirical dynamics are complex. The results are highly dependent on the proxies used to measure business performance and eco-product innovation. Thus, further research is required in this area to completely disentangle the influence of eco-product innovation on different types of firm's performance.

Regarding eco-process innovation, undertaking an eco-innovative production process or method increases the likelihood of better performance, corresponding to Hypothesis 1b. The positive relationship is explained by cost-savings motives in implementing environmental process innovation. Triguero et al. (2013) found that cost-savings are solely crucial for eco-process innovation and no other types of eco-innovation. While eco-product and eco-organization are driven by market demand and technological change, eco-process innovation aims at reducing costs. Both End-of-Pipe (EOP) and cleaner technologies appear to facilitate cost-savings. Cleaner technology aims to reduce environmental harm at the source, which has higher social and cost-saving benefits. In contrast, EOP technology is also associated with regulatory pressure, which demotivates firms against environmentally harmful practices to save additional legislation costs like pollution tax and cap-and-trade programs[1]. Moreover, the positive relationship between eco-process innovation and a firm's performance can also be explained by improved competitive advantage, increased efficiency, productivity, and better product quality, which constitutes

[1] Cap-and-trade is a market-based approach by creating economic incentives to reduce pollution emission See https://www.edf.org/climate/how-cap-and-trade-works for more information

increased turnover (Chen, Lai & Wen, 2006). Similarly, Ghisetti and Rennings (2014) also argue that eco-friendly production activities strengthen companies' reputation and competitive advantage by creating positive environmental externalities in reducing energy and material usage. Therefore, eco-process innovation improves business performance through cost reduction and a strengthened competitive advantage.

The result of eco-organizational innovation is in line with Hypothesis 1c. Firms that undertake eco-organizational innovation are more likely to have higher turnover. Eco-organizational innovation is equipped with the potentials to improve management efficiency, which consequently promotes business performance. The business potentials are be noticed in terms of eco-capabilities in accumulating green experience and information (Ch'ng et al., 2021), innovative design, speed, and flexibility (Díaz-García et al., 2015), unique and valuable capabilities to improve resource and energy usage, reduce operation costs, and prosper competitive advantage (Liao, 2018), broadened opportunity identification, exploitation, and incentive to innovation (Hoogendoorn et al., 2020) and ability to meet the environmental standard without sacrificing their business performance (Tuttle & Heap, 2008). Therefore, green business reorganization creates a positive impact on the environment, and it is also advantageous to firms in promoting business performance.

The results regarding complementarity between different types of eco-innovations differ from what has been hypothesized. The precondition test of complementarity did show that firms that perform two eco-innovations are associated with a higher turnover category than not performing any eco-innovations. This implies that performing eco-innovation is nevertheless better than not performing at all. However, there is no statistical evidence that performing two eco-innovation types simultaneously will improve firms' performance. The super modularity results are statistically insignificant. The unexpected results can be explained by the focus on SMEs in this study. SMEs often work in traditional ways to avoid risks and uncertainty, which leads to a lack of commitment to innovating environmentally (Gupta & Barua, 2018). Moreover, SMEs are also characterized by several financial and non-financial barriers that prevent them from performing eco-innovation. The financial barriers include high costs for eco-innovative certifications (Hilary, 2004) and expensive eco-friendly technologies and materials (Mao & Wang, 2019; King & Lenox, 2001). Other barriers are lack of human resources, commitment, information, knowledge, and integration with the government in developing eco-innovative practices (Gupta & Barua 2018; Marin Marzucchi & Zoboli, 2015; Lin & Ho, 2008). Given that SMEs are subject to resource constraints and less committed to performing eco-innovations, there are limited resources available for synchronized utilization. The key advantages of complementing different eco-innovations often occur through the concurrent utilization of resources like qualified personnel and liquidity (Golovko & Valentini, 2011). Such resources may not be sufficient for SMEs to benefits from complementarity. Instead, SMEs may opt to focus on a particular type of eco-innovation because they are less willing or able to bear high uncertainty and fund sizable investments (European Commission, 2020). One eco-innovation strategy may come at the expense of the other because of limited firm resources. Complementarity strategy may be considered as SMEs' burden as it is beyond their capability to innovate successfully. On the other hand, the empirical analysis performed by this study consists mainly of small firms (79.09%). These firms may be in the early stages of the company's origin and growth. Unlike matured and more experienced firms that are equipped with resources and capabilities to undertake green innovations, younger firms are more vulnerable in a complex and uncertain business environment (Amores-Salvadó, Martin-de Castro, & Navas-López, 2015; Hughes & Morgan, 2007). Deeper analysis of whether stages of the business life cycle determine the magnitude of eco-innovations and their complementarity can be accomplished with the inclusion of firm age and firm size, including the observations of large firms[2]. However, this is beyond the scope of analysis of this research, leaving a possible direction for future research.

7.2 Additional Remarks

This paper observes that only a minority of firms are active in sustainable innovation. For example, only 23.90% of firms introduce new or significantly improved eco-innovative products or services, 29.45% introduce new or significantly improved eco-innovative production processes or methods, and 22.34% introduce new or significantly improved eco-innovative organizational innovation. Hence, most firms are still skeptical about the prospects of eco-innovation. This study aims to clarify this in the first hypothesis. Moreover, the majority of firms in the sample are small-sized enterprises (79.09%). This can influence the results significantly given that small firms are often young and volatile, which directs their business strategy to focus primarily on the short-term survival rather than additional societal and environmental benefits from eco-innovations (Darnall, Henriques & Sadorsky, 2010; Lin & Ho, 2010).

[2] The European Union categorizes firms with more than 250 persons and either turnover more than 50 million euros or balance sheet total of more than 43 million euros employed as large-sized firms.
See https://ec.europa.eu/growth/smes/sme-definition_en for more information.

7.3 Implications

Environmental challenges and resource constraints, including climate change, global warming, environmental degradation, and natural resource depletion, have led to increasing demand for eco-innovation (European Commission, n.d.-b; United Nations, n.d.). Hence, understanding and stimulating the emergence of eco-innovative firms is highly relevant under such environmental challenges. This study has provided empirical evidence that performing eco-product, eco-process, and eco-organizational innovation is associated with an improved business performance, which has several important practical implications. First, economic incentives exist when implementing eco-innovation. Firms do benefit in terms of increasing turnover and declining resource use. It reveals that firms are not subject to "Green Prison" by Pacheco et al. (2010) when running businesses sustainably. Instead, turning green is seen as a competitive advantage in overcoming societal pressure (Bigliardi et al., 2012), avoiding additional costs of environmental legislation (Tuttle & Heap, 2008), and meeting the rising green demands (Bigliardi et al., 2012). Managers should, therefore, consider eco-innovations in operating a business efficiently and sustainably. Second, there is room for policy interventions in raising firms' awareness regarding the advantages of implementing eco-innovations. This helps overcome information barriers that broaden firms' perspectives to understand the fundamentality and necessity of eco-innovation in improving business performance (Hoogendoorn et al., 2020), especially in the context of contemporary environmental challenges. Third, only a minority of firms are active in undertaking eco-innovation, 23.90% in eco-product, 29.45% in eco-process, and 22.34% in eco-organizational innovation. As the findings suggest that firms can potentially stimulate their business performance by performing eco-innovation, governmental supports and funds are principally crucial in encouraging firms to turn green. The European Commission (n.d.-c) continuation of existing programs like REACH, COSME, and ESIF are the driving force in accomplishing eco-innovations. Lastly, it is essential to inspire some countries to be more environmentally and economically efficient. Table 5.2 suggests that Eastern European countries (Estonia and Hungary) perform relatively less eco-product innovation, and Northern European countries (Finland and Denmark) perform relatively less eco-organization. Therefore, as mentioned earlier, the government of these countries should develop more vigorous policies to push SMEs towards sustainable innovation for their benefits and environmental improvement.

Although this study found insignificant business performance differences for firms that perform eco-innovations simultaneously or separately, the results augment sustainable innovation literature in several ways. First, as discussed in the previous subsection, one eco-innovation strategy may come at the expense of the other because when there are limited firm's resources. Given that SMEs are subject to resource constraints, SMEs may be too early and too minor to experience the advantage of complementarity. They are advised to focus on a particular eco-innovation in the early stage as they are prioritizing their mission to short-term survival rather than long-term profitability. As firms grow, they will have more resources and capabilities to implement wider eco-innovative strategies without hurting them. Nonetheless, the findings show that a combination of eco-innovation does not improve business performance. It does not imply that complementarity strategy will worsen firms' performance. Managers are anyways encouraged to perform eco-innovation as the three types of innovation are positively related to business performance. Second, the benefits from complementary eco-innovations may be overcome by tackling obstacles that SMEs are facing when undertaking eco-friendling practices. Policymakers are recommended to focus on stimulating the drivers and overcoming the barriers so that SMEs can grasp the full advantage from implementing eco-innovation. Once SMEs can overcome uncertainty in eco-innovation, they may experience positive spillovers from one eco-innovation to another.

7.4 Limitations and Future Research

As in every research, the analysis of this research paper is considered in light of its limitations. Firstly, the empirical evidence reported in this paper may be influenced by the definitions considered to define firms' performance. While it is preferable to use change in turnover as a performance measure, the variable does not fulfill the statistical assumptions of ordinal logistic regression. Therefore, future studies are encouraged to include other financial performance measures like change in turnover, Return on Assets, Return on Earnings, profitability, market share, and Tobin's Q to strengthen the findings presented herein. Moreover, the lack of observations for large firms restricts this study from providing exciting insights regarding the difference between large firms and SMEs in implementing eco-innovations and how complementarities of these eco-innovations may differ. Therefore, further conceptual and empirical research is encouraged to analyze the influence of firm size on eco-innovation complementarities.

Although it is desired to establish a causal relationship between eco-innovations and firms' performance, this study is limited from the nature of Flash Eurobarometer cross-sectional data to do so. Moreover, as the survey is exclusively based on information derived in 2011, the single time period invokes the possibility of reverse causality. Firms that perform better may be equipped with more excellent resources and capabilities to undertake eco-innovation. Although reverse causality can be addressed with the help of an instrumental variable (IV), it is an arduous process to find an appropriate IV that is endogenous and gives a reliable result within this study. Therefore, it is highly recommended to obtain time series and/or panel data for statistical analysis to overcome this concern.

Using a cross-country dataset, this research aims to overcome the generalization issues confronted by the previous studies. However, it focuses only on EU-27 countries, which comprises of developed countries in Europe. Therefore, the results cannot be generalized to developing countries in Asia and elsewhere. According to World Air Quality Index (2020), the top three most polluted countries are Bangladesh, Pakistan, and India. Future studies on eco-innovation are encouraged to consider these highly polluted countries to find instantaneous ways to encourage firms to run businesses sustainably and efficiently as environmental problems seem to be relatively more severe.

7.5 Conclusion

The environment is continuously changing, and shreds of evidence are given in massive increases in natural disasters, climate change, loss of biodiversity, depletion of natural resources, and wild animal extinction globally. With these environmental challenges, people need to be more aware and cautious about living to avoid unknown and unintentional behavior that intensifies ecological devastation. Sustainable and green practices like eco-innovation have become solutions to the future. Yet, many firms remain unprepared to transform their businesses and commit sustainably. This research has scrutinized the relationship between eco-innovations and firms' performance, including the complementarities concerning different eco-innovations, with an attempt to answer the following research question: "What are the effects of product, process, and organizational eco-innovation and their combination on firms' performance?". By executing ordinal logistic regression, it is found that all eco-innovations innovations are positively related to business performance, but only eco-process and eco-organizational innovations are significant. This shows that eco-innovation is beneficial at the firm level. It creates business opportunities to promote turnover and efficient material uses. Super modularity tests were implemented to uncover the complementarities between different pairs of eco-innovations. Unfortunately, there is no statistical evidence to support the existence of complementarities. Mostly small-sized firms in the dataset may drive the unexpected results. SMEs possess unique characteristics which make them different from large firms in undertaking eco-innovations and, hence, in their potential to benefit from the complementarities. Nevertheless, this study is not without limitations. Further research on eco-innovation complementarity is advised to determine cause-and-effect relationships by using panel data and a more sophisticated statistical methodology. Academic attention on developing countries, especially the world's largest polluted nations, would be highly relevant to both policymakers in combating environmental issues and firms operating sustainably. In summary, performing eco-innovations is advantageous to firms' performance, but whether combining different eco-innovations improves firms' performance is ambiguous. Future studies on complementarities in eco-innovation are highly recommended. It will unravel the existence of eco-innovation complementarities and the most appropriate combination of sustainable innovations strategy, which will consequently foster environmental responsibility and long-term economic prosperity.

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Appendix A

Table A1. Summary of quantitative analysis on eco-innovations and business performance

Study	Performance	Eco-innovation Type	Innovation Variable	Methodology	Sample	Results
Doran and Ryan (2011)	Turnover per worker	Product, Process, Organizational and Marketing	New or significantly improved product (good or service), process, organizational or marketing method that creates environmental benefits.	Ordinary Least Squares (OLS) regression	2,181 firms collected as part of the Irish Community Innovation Survey 2006- 08	These results imply that eco-innovation can drive performance growth faster than non-eco-innovation and the absence of innovation.
Przychodzen and Przychodzen (2015)	Return on Assets (ROA), Return on Equity (ROE) and Expected Rate of Return (ERR)	Product, Process and Organizational	Dummy variable representing eco-innovative activities of a given company if firm introduced at least one eco-innovation	OLS regression	data on Polish and Hungarian publicly traded companies from the years 2006-2003	eco-innovators were generally characterized by higher returns on assets and equity and lower earnings retention
Cheng et al. (2014)	Return on investment (ROI), sales, profit, and market share	Product, Process and Organizational	20 items were generated, including five items measuring the eco-process construct, eight items measuring the eco-product construct, and seven items measuring the eco-organizational construct.	Structural Equation Modeling (SEM)	121 samples collected from Taiwan Environmental Management Association	eco-organizational innovation has the strongest effect on business performance. Business performance is directly and indirectly affected by eco-organizational, eco-process, and eco-product innovations
Weng et al. (2015)	market share, sales, and profitability as well as company's reputation and competitive advantage	Product and Process	Five green product innovation practices were measured by the extent that new products reduced pollution and energy consumption and seven green *process* innovation practices were measured by the degree that new processes reduced pollution and energy consumption.	carbon and total amount of waste produced by a firm divided by sales	202 companies in the service and manufacturing industries in Taiwan	Green innovation practices are positively related to firm performance

(continued)

Table A1. Summary of quantitative analysis on eco-innovations and business performance *(continued)*

Study	Performance	Eco-innovation Type	Innovation Variable	Methodology	Sample	Results
Ryszko (2016)	Product quality, customer satisfaction as well as market share, profit growth, average return on sales (ROS) and average return on investment (ROI)	Product and Process	Measured by 6 items including product and process eco-innovation number, technological eco-innovation speed and technological eco-innovation quality	Structural Equation Modeling (SEM) using Partial Least Squares (PLS)	292 firms representing selected industries operating in Poland	Technological eco-innovation reduces environmental impact and improves business performance
Ar (2012)	Sales growth, market share and ROI	Product	Less polluting materials, redesigning eco-friendly packaging, recycling and use eco-labeling	Structural Equation Modeling (SEM)	140 Turkish manufacturer firms from various sectors,	green product innovation significantly positively affects both firm performance and competitive capability
Hojnik and Ruzzier (2016)	Sales growth, employment growth, ROA, ROE and ROS	Process	Low energy consumption, recycle, reuse and remanufacture, cleaner technology and reduce the use of raw materials	Structural Equation Modeling (SEM)	223 Slovenian companies.	eco-innovation is worthwhile in terms of company profitability, growth, and competitive benefits.
Lee and Min (2015)	Tobin's Q	Process	Green research and development investment as a key proxy of eco-innovation	Structural Equation Modeling (SEM)	sample of Japanese manufacturing firms during the period of 2001-2010,	green research and development (R&D) is positively related to financial performance at the firm level

(*continued*)

Table A1. Summary of quantitative analysis on eco-innovations and business performance *(continued)*

Study	Performance	Eco-innovation Type	Innovation Variable	Methodology	Sample	Results
Madaleno et al. (2020)	Turnover and Employment growth	Product, Process and Organizational	Eco-innovations are measured on ten different areas of environmental impacts	Ordinary Least Square (OLS) Regression. 2 Stage Least Square (2SLS) and 3 Stage Least Square (3SLS)	63303 firms from 13 different European Union countries	environmental benefits obtained within the enterprise have negative effects over firm performance increased efforts required to firms when adopting eco-innovations
Wagner et al. (2002)	Return on sales (ROS), return on equity (ROE) and return on capital employed (ROCE)	Product and Process	Eco-innovations are measured on ten different areas of environmental impacts	Simultaneous Equation Model	Paper manufacturing firms in Germany, Italy, the Netherlands and United Kingdom between 1995 and 1997	relationship between environmental and economic performance is uniformly negative.
Cainelli et al. (2011)	Turnover and Employment growth	Product and Process	Environmental motivations like cost reduction, extending the services/product offering, extending existing or penetrating new markets, developing services with lower environmental impact/output	Probit regression	773 Italian service firms with 20 or more employees between 1993 and 1995	negative link between environmental motivations and growth in employment and turnover in the short term which result to non-significant or even negative effect on labour productivity growth
Driessen et al. (2013)	Profitability, Sales and Market Share	Product	Green new product development (NPD)	Matching	In-depth interviews with key informants as well as site visits and document research	green products generally display low financial and customer performance compared to non-green products because green niches were emerging but market demand for green products was still low

(continued)

Table A1. Summary of quantitative analysis on eco-innovations and business performance *(continued)*

Study	Performance	Eco-innovation Type	Innovation Variable	Methodology	Sample	Results
Marin and Lotti (2017)	Labour Productivity as Environmental patents per employee	Process	Environmental patents	Heckman selection model/ Tobit type II model	Unbalanced panel sample of 11,938 Italian manufacturing firms	eco-innovations exhibit a generally lower return relative to other innovations, at least in the short run
Ghisetti and Rennings (2014)	Profitability	Process	Reduce material, energy, co2 footprint, air, water, soil pollution, replace dangerous materials and recycling	Ordered Probit and Ordinary Least Square Regression	Mannheim Innovation Panel (MIP) in 2009	The adoption of an EI does not play any effect on firms' profitability.
Earnhart and Lizal (2007)	Return on Assets (ROA) and Return on Equity (ROE) and Return to Sales (ROS)	Process	Air pollutant emissions control	Fixed effects model	Panel data of Czech firms for the years 1996–1998	better pollution control neither improves nor undermines financial success
Trumpp and Guenther (2017)	Return on Assets (ROA) and the annual change in stock price plus dividends.	Process	Carbon performance and total amount of waste produced by a firm divided by sales	Ordinary Least Square (OLS) Regression	international sample of 2361 firm-years data from 2008 to 2012	empirical evidence of a non-linear (U-shaped) relationship between environmental performance and profitability as well as stock market performance

Appendix B

Table B1 Correlation Matrix (Eq.1)

	eco-product	eco-process	eco-organizational	firm size	main activities	country
eco-product	1.0000					
eco-process	0.3745	1.0000				
eco-organizational	0.3161	0.4267	1.0000			
firm size	0.0590	0.1166	0.0712	1.0000		
main activities	0.0194	0.0165	-0.0100	0.0224	1.0000	
country	-0.0200	0.0060	0.0035	0.0760	-0.0446	1.0000

Source: Flash Eurobarometer 315 'Attitudes of European Entrepreneurs Towards Eco-innovation' Survey

The correlation coefficient takes a value between 1 to -1, and the value greater than absolute 0.8 suggests severe multicollinearity

Table B2 Correlation Matrix (Eq. 2)

	complement	firm size	main activities	country
complement	1.0000			
firm size	0.1046	1.0000		
main activities	0.0032	0.0224	1.0000	
country	0.0019	0.0760	-0.0446	1.0000

Source: Flash Eurobarometer 315 'Attitudes of European Entrepreneurs Towards Eco-innovation' Survey

The correlation coefficient takes a value between 1 to -1, and the value greater than absolute 0.8 suggests severe multicollinearity

Appendix C

Table C1 Variance Inflation Factor (Eq.1)

Variable	VIF
eco-product	1.20
eco-process	1.33
eco-organizational	1.26
firm size	1.02
main activities	1.00
country	1.01
Mean VIF	1.14

Source: Flash Eurobarometer 315 ‘Attitudes of European Entrepreneurs Towards Eco-innovation' Survey

VIF greater than 10 suggests severe multicollinearity

Table C1 Variance Inflation Factor (Eq.2)

Variable	VIF
complement	1.01
firm size	1.02
main activities	1.00
country	1.01
Mean VIF	1.01

Source: Flash Eurobarometer 315 ‘Attitudes of European Entrepreneurs Towards Eco-innovation' Survey

VIF greater than 10 suggests severe multicollinearity

Appendix D

Table D Brant Test for Parallel Regression Assumption

	Turnover		
	χ^2	p-value	Degree of Freedom
Performance			
eco-product	0.06	0.810	1
eco-process	1.26	0.261	1
eco-organizational	1.36	0.244	1
Complementarity			
Firm that perform **no** eco-innovation[ref]			
Firm that perform **only** eco-product innovation	0.07	0.793	1
Firm that perform **only** eco-process innovation	0.11	0.735	1
Firm that perform **both** eco-product and eco-process innovation	1.13	0.287	1
Firm that perform **only** eco-organizational innovation	0.14	0.705	1
Firm that perform **both** eco-organizational and eco-product innovation	0.11	0.741	1
Firm that perform **both** eco-organizational and eco-process innovation	4.43	0.035	1
Firm that perform **all** three types of **eco**-innovation	3.19	0.074	1

Source: Flash Eurobarometer 315' Attitudes of European Entrepreneurs Towards Eco-innovation' Survey

Significant χ^2 test statistics suggests a violation of proportional odds assumption

[ref] refers to a reference variable

Appendix E

Table E1 Marginal Effects of Ordinal Logistic Regression on Eco-innovation and Business Performance

	Turnover		
	Up to 2 million euro	2-10 million euro	10 million euro and over
Eco-product	-0.017	0.013	0.004
	(0.020)	(0.015)	(0.005)
Eco-process	-0.058***	0.044***	0.014***
	(0.020)	(0.015)	(0.005)
Eco-organizational	-0.056**	0.043***	0.013**
	(0.022)	(0.016)	(0.005)
Firm Size			
Small [ref]			
Medium	-0.551***	0.229***	0.322***
	(0.012)	(0.013)	(0.016)
Main Activities			
Agriculture and fishing [ref]			
Construction	0.018	-0.014	-0.004
	(0.034)	(0.027)	(0.007)
Water supply	-0.054	0.042	0.013
	(0.053)	(0.040)	(0.013)
Manufacturing	-0.065**	0.049**	0.015**
	(0.032)	(0.025)	(0.007)
Food services	0.242***	-0.205***	-0.037***
	(0.040)	(0.034)	(0.007)
Country Fixed Effects	Yes	Yes	Yes
No. of Observations	4420	4420	4420

Standard errors in parentheses

* p<.10, ** p<.05, *** p<.01

[ref] refers to reference category

Table E2 Marginal Effects of Ordinal Logistic Regression on Eco-innovation Complementarities

	Turnover		
	Up to 2 million euro	2-10 million euro	10 million euro and over
Complement			
Firm that perform **no** eco-innovation [ref]			
Firm that perform **only** eco-product innovation	-0.043	0.034	0.009
	(0.030)	(0.024)	(0.007)
Firm that perform **only** eco-process innovation	-0.094***	0.073***	0.022***
	(0.027)	(0.020)	(0.007)
Firm that perform **both** eco-product and eco-process innovation	-0.077**	0.060**	0.017**
	(0.035)	(0.026)	(0.009)
Firm that perform **only** eco-organizational innovation	-0.108***	0.082***	0.026**
	(0.037)	(0.027)	(0.010)
Firm that perform **both** eco-organizational and eco-product innovation	-0.081*	0.063*	0.018
	(0.049)	(0.037)	(0.013)
Firm that perform **both** eco-organizational and eco-process innovation	-0.098***	0.076***	0.023***
	(0.032)	(0.024)	(0.009)
Firm that perform **all** three types of **eco**-innovation	-0.122***	0.093***	0.030***
	(0.032)	(0.023)	(0.009)
Firm Size			
Small [ref]			
Medium	-0.552***	0.230***	0.322***
	(0.012)	(0.013)	(0.016)

(continued)

Standard errors in parentheses

* p<.10, ** p<.05, *** p<.01

[ref] refers to reference category

Table E2 Marginal Effects of Ordinal Logistic Regression on Eco-innovation Complementarities (continued)

	Turnover		
	Up to 2 million euro	2-10 million euro	10 million euro and over
Main Activities			
Agriculture and fishing [ref]			
Construction	0.017	-0.013	-0.003
	(0.034)	(0.027)	(0.007)
Water supply	-0.056	0.043	0.013
	(0.053)	(0.040)	(0.013)
Manufacturing	-0.065**	0.050**	0.015**
	(0.032)	(0.025)	(0.007)
Food services	0.240***	-0.204***	-0.037***
	(0.040)	(0.034)	(0.007)
Country Fixed Effects	Yes	Yes	Yes
No. of Observations	4420	4420	4420

Standard errors in parentheses

* p<.10, ** p<.05, *** p<.01

[ref] refers to reference category

Appendix F

Table F1. Robustness Checks

	Turnover	
	Model 1	Model 2
Eco-product		0.079
		(0.078)
Eco-process		0.250***
		(0.076)
Eco-organizational		0.248***
		(0.080)
Firm Size		
Small [ref]		
Medium	0.276***	0.221***
	(0.073)	(0.074)
Main Activities		
Agriculture and fishing [ref]		
Construction	-0.478***	-0.444***
	(0.103)	(0.105)
Water supply	0.078	0.093
	(0.166)	(0.167)
Manufacturing	-0.291***	-0.274***
	(0.098)	(0.099)
Food services	-0.358**	-0.341**
	(0.148)	(0.149)
Country Fixed Effects	Yes	Yes
	-0.845***	-0.730***
	(0.151)	(0.153)
	0.312**	0.437***
	(0.150)	(0.153)
No. of Observations	4374	4374
Pseudo R-square	0.042	0.047

Standard errors in parentheses

* p<.10, ** p<.05, *** p<.01

[ref] refers to reference category

Table F2. Robustness Checks

	Model 1	Model 2
Complement		
Firm that perform **no** eco-innovation [ref]		
Firm that perform **only** eco-product innovation		0.173
		(0.117)
Firm that perform **only** eco-process innovation		0.328***
		(0.106)
Firm that perform **both** eco-product and eco-process innovation		0.325**
		(0.131)
Firm that perform **only** eco-organizational innovation		0.313**
		(0.126)
Firm that perform **both** eco-organizational and eco-product innovation		0.408**
		(0.198)
Firm that perform **both** eco-organizational and eco-process innovation		0.538***
		(0.133)
Firm that perform **all** three types of **eco**-innovation		0.521***
		(0.117)
Firm Size		
Small [ref]		
Medium		0.220***
		(0.074)
Main Activities		
Agriculture and fishing [ref]		
Construction	*-0.478****	-0.441***
	(0.103)	(0.105)
Water supply	0.078	0.096
	(0.166)	(0.167)
Manufacturing	-0.291***	-0.275***
	(0.098)	(0.099)
Food services	-0.358**	-0.340**
	(0.148)	(0.149)
Country Fixed Effects	Yes	Yes
τ_1	-0.845***	-0.713***
	(0.151)	(0.154)
τ_2	0.312**	0.454***
	(0.150)	(0.153)
No. of Observations	4374	4374
Pseudo R-square	0.042	0.047

Standard errors in parentheses

* p<.10, ** p<.05, *** p<.01

[ref] refers to reference category

Table F3 Super modularity test on Eco-innovation Complementarities Robustness Checks

	Turnover	
	Third Form Presence	Third Form Absence
Eco-product & Eco-process	[Turnover (1, 1, 1) - Turnover (1, 0, 1)] > [Turnover (0, 1, 1) - Turnover (0, 0, 1)] χ^2 (1) = 0.16 p-value = 0.6928	[Turnover (1, 1, 0) - Turnover (1, 0, 0)] > [Turnover (0, 1, 0) - Turnover (0, 0, 0)] χ^2 (1) = 0.80 p-value = 0.3725
Eco-organization & Eco-product	[Turnover (1, 1, 1) - Turnover (0, 1, 1)] > [Turnover (1, 1, 0) - Turnover (0, 1, 0)] χ^2 (1) = 0.00 p-value = 0.9535	[Turnover (1, 0, 1) - Turnover (0, 0, 1)] > [Turnover (1, 0, 0) - Turnover (0, 0, 0)] χ^2 (1) = 0.09 p-value = 0.7610
Eco-organization & Eco-process	[Turnover (1, 1, 1) - Turnover (1, 0, 1)] > [Turnover (1, 1, 0) - Turnover (1, 0, 0)] χ^2 (1) = 0.02 p-value = 0.8870	[Turnover (0, 1, 1) - Turnover (0, 0, 1)] > [Turnover (0, 1, 0) - Turnover (0, 0, 0)] χ^2 (1) = 0.26 Prob > chi2 = 0.6108

Positive and Significant χ^2 test statistics suggests complementarity