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A Study on the Determinants of Eco-Innovation of Korean Manufacturing Firms

Cheon Yu and Yun Seop Hwang *

1 Trade Research Institute, Kyung Hee University, Seoul 02447, Korea; cheon.yu@khu.ac.kr
2 Department of International Business and Trade, Kyung Hee University, Seoul 02447, Korea; rusiahys@khu.ac.kr
* Correspondence: rusiahys@khu.ac.kr;

Abstract: The move to a low carbon economy is very important for enhancing international competitiveness. The eco-innovation is the critical factor of the green paradigm. This study is designed to investigate deeply the determinants of eco-innovation of manufacturing firms in Korea by suggesting anticipated regulations, self-regulations, and industry-specific characteristics as external factors and open information sources as internal factors. The data used in the analysis is 1,946 sample firms from Korean Innovation Survey 2010 based on the Oslo Manual. Using the multi-variate probit analysis and the zero-inflated negative binomial (ZINB) regression analysis, we have found out that the anticipated regulations and self-regulations have significant influences both on eco-process innovation and eco-product innovation, while industrial characteristics have no effects. The empirical results also show that the breadth of information sources has a positive effect on businesses in implementing eco-innovations. Our findings show that the Korean government should provide a good platform where firms can better understand the future trends of environmental policies, particularly policies on anticipated and self-regulations. At the same time, Korean firms should establish a voluntary system to control environmental activities so that they can improve eco-innovations through integrating external information.

Keywords: eco-innovation; anticipated regulation; self-regulation; industry-specific characteristics; information sourcing openness; multivariate probit model; zero inflated negative binomial model

1. Introduction

As the Paris Convention concludes, greenhouse gas reductions are becoming a global obligation, and eco-innovation pressures are increasing for firms. Since securing low-carbon capabilities of firms is a very important factor in strengthening international competitiveness, governments in each country are encouraging firms' eco-innovation through not only regulation but also support [1]. The transition to a low-carbon economy is a big challenge for highly carbon-dependent manufacturing companies. Large-scale investment is needed in new facilities and technology development, and it is difficult to create competitive advantage with existing technologies, production methods and products due to changes in consumer awareness and preference [2]. Many studies have been conducted on the factors that determine the eco-innovation of firms.

Previous studies on the determinants of eco-innovation have been limited in geographically and scholarly concerns. From the geographical point of view, much of the research is focused largely on the developed countries such as Germany [3], Britain [4], Spain [5], and overall European countries [6]. Asian countries, such as China [7] and Taiwan [8], have recently been studied, but there is little research conducted on Korea.

From the scholarly concerns, firm size, industry characteristics, and market pressure are typical and most discussed determinants of eco-innovation. However, in order to more efficiently estimate the factors that determine the eco-innovation of firms, it is necessary to consider self-regulation activities, industry-specific factors, anticipated-regulations, and information sourcing openness.

Information sourcing openness is newly suggested for eco-innovation. This is related to open innovation framework [9] and sheds new light on that firm's effort for open information encourages eco-innovation and consequently it endows the competitiveness of a firm. Although some of the mentioned determinants have been suggested by a few studies [3], they lack an explanation of logic and causation for eco-innovation activities of firms.

The purpose of this study is to identify the determinants of eco-innovations of Korean manufacturing firms. Compared to previous research, we concentrate more on the factors that have not been scrupulously treated before. Anticipated-regulations, self-regulations, and industry-specific characteristics are introduced as external determinants, and information sourcing openness is introduced as an internal determinant with logic and causation derived from various theories. These variables, together with regulatory pull/push and market pull, also play an important role in determining eco-innovation activities of a firm. More importantly, if the determinants proved to be powerful driving forces of eco-innovation, then it contributes to fill the research gap between general innovation and eco-innovation. Besides, Korean manufacturing firms' characteristics can be shown and compare our results with those of previous research done in other countries.

The remainder of the paper is organized as follows: Section 2 reviews the relevant literature and the hypotheses are proposed. Section 3 the research model and estimation method is presented. Section 4 illustrates the empirical and measurement results. Section 5 provides the conclusions and implications and the future research direction.

2. Literature review and Hypotheses

2.1 Concepts of Eco-innovation

Eco-innovation is not limited to innovations in products, processes, marketing methods, and organizational methods, but also includes innovations in social and institutional structures [10]. Most of researches, however, focus on products and processes related innovation activities of firms and are so in eco-innovation researches. According to Negny et al. [11], eco-process innovation is defined as a newly-introduced elements on the production process of eco-friendly products. And eco-product innovation is defined as an introduction of new or ground-breaking eco-friendly products. These two types of eco-innovations will be treated as dependent variables in representing eco-innovation outcomes. Eco-process innovation is measured in terms of consumed material per output unit in the process, emitted carbon-dioxide, contaminated material, reduction of harmful and wasted material and water, and recycle of material. Eco-product innovation is measured in terms of energy consumption reduction from using concerned products, reduction of water and air pollutants, and improvement of recyclability after use. In the research eco-process and product innovations are separately discussed and measured on Korean manufacturing firms.

2.2 Determinants of eco-innovation and its effect on performance

Scholars discussed about the determinants of eco-innovation in various ways. Horbach [12] grouped them into supply, demand, and environmental policy, and Horbach et al. [3] grouped into regulation (Pull/Push), market factors (Pull), technological factors (Push), and firm-specific factors. Cai and Zhou [7] divided the determinants into internal drivers such as technological capability, organizational capability, and CSR, and external drivers such as regulation, customers, and competition, and took integrating capability as an mediating variable and then analyzed the relationship with eco-innovation. Following Cai and Zhou [7], in our study, external and internal factors are analyzed. The external factors include anticipated regulations, self-regulations, industry-specific factors and other control variables. In dealing with internal factors, the focus is placed on external information openness, and other factors (technology, organizational capability, etc.) are used as control variables.

Contingency theory explains the mechanism of the influence of outer circumstances on firm's internal organization activities and decision making. It seems adequate for explaining the influence of anticipated regulation, self-regulation, and industry-specific factors on eco-innovation performance. One of the issues we are interested in is whether the regulation, including anticipated and self, has some influence on corporate eco-innovation activity. From the view point of contingency theory, anticipated- and self-regulation is outside circumstances which have direct effect on firm activity. Traditionally scholars insisted that regulations have negative influence on corporate innovation activities and its performance [13]. Contrary to this view, Porter and van der Linde [14] argued that companies would carry out more innovations to prevent environmental pollution under stricter future regulations. Industry specific factors also are external environment that has direct influence on firm activities. In this paper, we focus on energy consumption of an industry which consequently incurs more regulation of the industry.

2.2.1 External determinants of eco-innovation

Anticipated regulation

Preemptive responses for anticipated regulations can save costs that are possibly incurred in the future, by applying the technologies related to the anticipated future regulations in advance to their production processes and products [15]. The firms that succeeded in innovation beforehand can prevent their current or potential competitors from easily entering the market by utilizing their own competitive superiority, for example, by setting the environmental regulation standards in the industry [16]. Although there still exist organizational coordination problems [17], a company will collect information about the anticipated regulations and take strategic actions if it is aware of these advantages.

Recent empirical results have proved that anticipated regulations spur eco-innovation [3,18]. The path of its impact can be explained by two ways. One is firm's recognition path. If a firm anticipates that there will be new regulations in the future and recognizes them as threat, it will take various actions in response to the regulations. They can reset its strategic direction and make new frames according to new conditions [19]. The second path is from learning effect of late-movers. The first-movers' response to the regulation can encourage late-movers' participation in eco-innovation activities. Under some circumstances late-movers can respond more actively than first-movers [20]. Through these two paths the anticipated regulation can accelerate the eco-innovation activities. Furthermore, first-movers' response to the regulation will encourage late-movers' participation, so late-movers can respond more actively than first-movers [20].

The Korean government has introduced various ways such as public hearing or prior notice system to help companies adapt to new regulations. As a member of the Paris Convention in 2016, Korea has an obligation to largely reduce its CO_2 emissions. Under these circumstances, firms make endeavors to come up with sustainable and active measures to respond to anticipated regulations. Based on the discussion above, we propose the following hypothesis.

H1. The anticipated regulations will positively affect Korean firms' eco-innovation performance.

Self-regulations

Another external factor that influences eco-innovation is self-regulations within industry. Regulations are generally imposed by the government. On the contrary, the stakeholders, as themselves are the object of regulation, regulate their own activities and advancing information technologies also encourage self-regulation. Advanced information technologies, however, also encourage self-regulation, leading stakeholders to autonomously control their practices. Self-regulation includes establishing financial exchanges, licensing professionals, setting safety standards, controlling entertainment content, advertising restrictions, and voluntarily reducing pollution, etc. [21], which will continuously change along with the development of technology and society.

Self-regulations are formed under the following conditions — 1) when there is market failure, 2) when it is hard to adjust the market failure or the failure accompanies huge costs, and 3) when self-regulations are more efficient than public (governmental) regulations [22,23]. Among these conditions, the third one is relevant to benefit-costs and differences between public regulations and self-regulations. Ogus [23] explains that self-regulation is advantageous from the following perspectives: First, self-regulation agencies have many experts and experiences of technological innovation trials in certain areas. They can also establish standards with less information costs, so firms under self-regulation have greater innovation potential; Secondly, companies can reduce costs in monitoring and enforcement through creating reliability among stakeholders. Lastly, relatively less formal nature of self-regulation enables lower costs for enforcement and standard revision.

Self-regulation has both positive and negative effects. From the legislative view, self-regulation is a type of contemporary 'corporatism' which is empowered not ty the formal institutional process, but by the informal interest groups. Such groups have the potential to abuse the power or tendency to administer not in right way. Potential abuse/misuse of the power, in virtual, is activated when the third parties experience with negative effect [22]. Furthermore, self-regulation related groups are tend to be very generous to illegal actions of the group members [24]. Rent-seeking hypothesis explains that the establishment of self-regulation agency, by itself, hinders or making barriers in voluntary establishment of self-regulate organizations. Since established self-regulation agency feels that it owns vested rights in this field and does not want to share the rights with other interest groups. This situation itself creates the inefficiency.

This gives important implications to both the government and firms. If it is more efficient for firms to do voluntary environmental regulations, there is no reason for the government to set rules on the industry while incurring social costs. Self-regulation is also beneficial because unintended negative effects caused by government regulations will not be a problem anymore. Voluntary regulation also enables firms to reduce burden from forceful government regulations, boost environmental competitiveness, and appeal to the market more effectively with their environmentally responsible behaviors [25].

It can be expected that firms can benefit from self-regulation thanks to regulatory flexibility, preemption of existing regulations, and improved anticipation of future regulations. Firms are also expected to actively engage in eco-innovation and achieve better performance. In Korea, corporate social responsibility (CSR) is regarded very important for firms, and eco-friendly corporate image is a valuable asset for corporate performance. Based on the discussion so far, the following hypothesis can be established:

H2. Self-regulations will positively affect Korean firms' eco-innovation performance.

Industry-specific factors

Most eco-innovation related research empirically analyzed the determinants of eco-innovation activities of firms [6]. However, few studies considered industry-specific characteristics, which can also influence eco-innovation activities. According to Horbach [12], high energy-consuming industries, such as automobile and machinery, show a positive relationship with eco-innovation, but industries which consume less amounts of energy do not show any significant relationship. Machiba [26] chooses three sectors such as the automotive and transport industry, the iron and steel industry, and the electronics industry as examples and analyze the application of eco-innovation. And the result indicates that eco-innovations in these industries are more active because energy-intensive industries are more likely to pursue eco-innovation to increase energy efficiency.

Regarding industry-specific factors, few studies regarded these factors as the determinants of eco-innovation. Most Korean studies about the relationship between industry-specific factors and eco-innovation assert that there is a positive relationship between them. When treating climate change issues, energy consumption of an industry is most widely used as a proxy for industry-specific factors. In this paper, we expect that energy consumption of an industry has a positive relationship with eco-innovation activities of Korean manufacturing firms.

H3. Energy consumption as an industry-specific factor will positively affect Korean firms' eco-innovation performance.

2.2.2 Internal determinants of eco-innovation

Information sourcing openness for eco-innovation

Chesbrough [9] argued that innovation outcomes can improve through greater openness to obtaining and using external information. When a firm becomes more open to the use of external information, it can achieve eco-innovation and higher performance. Firms should not only become more open to external information, but also consider the importance of such information. Companies with more sources of gathering helpful and important information can have more opportunities to achieve higher performance. De Marchi and Grandineti [27] argued that the information obtained from external partners such as research institutions, colleges, or competitor firms is more important to eco-innovation than to other types of innovations.

Laursen and Salter [28] categorized external information collected for innovation activities in terms of breadth and depth. For the breadth of sourcing, Ghisetti et al. [29] suggested two reasons why firms need a broader source of external information. Firstly, it is difficult to respond to various changes only with their own internal resources and capabilities, especially under the global climate change situation. Secondly, eco-innovation requires a huge volume of information in achieving multiple objects, not only improving the productivity and quality of common innovation but also reaching environmental targets. Rennings and Rammer [30] proved that the German firms use relatively more diverse sources of information to obtain innovative outcomes, and Horbach et al. [31] argued that eco-innovation needs more external information sources.

Meanwhile, firms need more professional and in-depth information guides in order to carry out innovative activities. In this study, we use the importance of information, instead of using the concept of depth. It seems that importance is similar to depth in that it is understood as usefulness and sincerity of outsourced information. However, the importance evaluates the importance level of external information to the firm, while the depth of information evaluates the degree of specialty and cooperation of partner companies. Resource-based view (hereinafter referred to as RBV) insists that the way a firm keeps its competitive advantage depends on the uniqueness, rarity, and worthiness of its resources, and on whether it is difficult to imitate its resources or not [32]. Capabilities based on accumulated information can be one of the key resources that cannot be easily imitated by competitors. The complexity and rapid changes of the recent external circumstances urge firms to gather important information from outside as well as inside the organization [9].

It is expected that a company will be more likely to achieve innovation, including eco-innovation, when it acquires greater amount of important information from various external sources. Korean firms are making efforts to strengthen their competitiveness by introducing information from various external sources. In a study on the effects of external information search on the Korean ICT sector, Hwang and Lee [33] found that external information search is relevant to incremental innovation and productivity. From the point of supply chain management, Woo et al. [34] investigated communication capability and external green integration for the financial and green performance of construction providers in Korea. Their results show that the greater capability a firm shows in sharing information with other organizations, the more likely it is for the firm to acquire superior positions in taking environmentally cooperative actions, in making green cost reduction, and in securing higher competitiveness. It means that the efforts to get valuable information from external organizations can lead to better performance of Korean manufacturing firms. According to these discussions, the following hypotheses are proposed.

H4. Information sourcing openness have a positive influence on eco-innovation performance of Korean manufacturing firms.

H4a. When information sourcing becomes broader, the performances of eco-innovation by Korean manufacturing firms increase.

H4b. When information sourcing is more important to receiving firms, the performances of eco-innovation by Korean firms increase.

2.2.3. Control variables

This study sets the control variables as follows. The control variables as external factors are market pull, regulatory pull and push. Following the demand pull hypothesis, the market demands or needs promote technological innovations [35,36]. Firms prefer to take competitive advantages through eco-innovation as they are aware of the market demands for eco-friendly goods triggered by the need for energy saving and environmental preservation [18,37-39]. Regulatory push and pull are also important influential factors for eco-innovation. There is a conventional view that governmental mandatory regulations (regulatory push) hamper economic growth by aggravating cost loads [13,40-42]. On this account, firms try to avoid cost increase and reduce innovative actions which require capital expenditure. Conversely, there are also cases where the government's environmental regulation is an important factor in driving firms to pursue eco-innovation [3,43]. Stricter regulations drive firms to lead innovations to reduce environmental pollutants, which enable profits to exceed costs [14]. On the other hand, Governmental supporting policies (regulation pull factor) have a positive influence on firms' eco-innovation [12,44,45].

The control variables as internal factors are innovative capability, technology push, firm size and age. Eco-innovation requires more professional knowledge compared to general innovation [46,47]. It means that general innovation capability is necessary in successfully accomplishing eco-innovation. General innovation capability includes technological innovation capability for products and processes and non-technological innovative capability for markets and organizations. Generally, higher general innovation capability leads to higher outcomes of eco-innovation. Technology push like R&D investment is also important determinants for eco-innovation. Firms' investments into R&D produce new technological information and promote technological innovation by strengthening internal capability of assimilation and exploitation [48]. R&D investment refers to technological and absorbing capabilities, a determinant of internal technological level of a firm [49]. It is also true for eco-innovation [12].

3. Research Model and Data

3.1 Research Model

The research model of this study is presented in <Figure 1>. The dependent variables are divided into eco-process innovation and eco-product innovation. Eco-process innovation consists of six items and eco-product innovation consists of three items. Whether eco-innovation is executed or not is analyzed by using the binary dependent variables, and the sum of all areas, from 0 to 9, is used as the aggregated variable for eco-innovation performance.

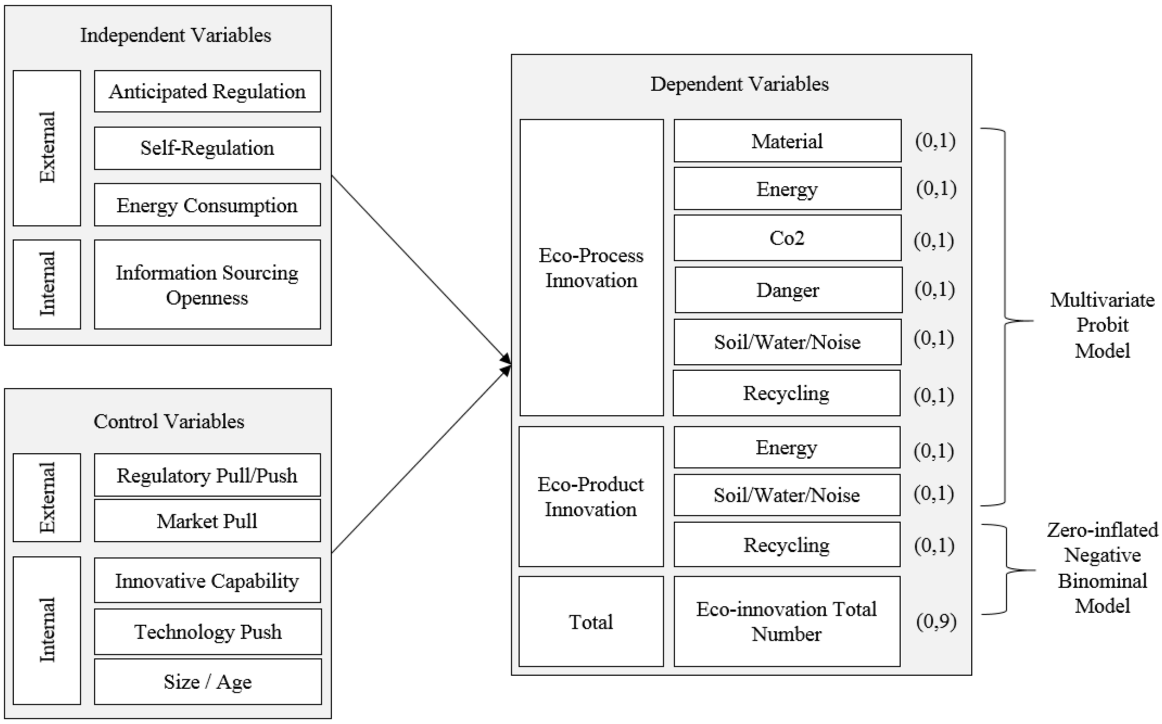

Figure 1. Research Model

3.2 Definition of the data and the variables

The data used in this study is "Korean Innovation Survey 2010: Manufacturing sector." The statistics come from Science and Technology Policy Institute (STEPI)'s investigation into firms' innovation activities from 2007-2009 based on the Oslo Manual developed by OECD and Eurostat Community Innovation Survey (CIS). The survey is approved by Statistics Korea (KOSTAT) and recognized to have high reliability, validity, and international comparability. The size of the population is 41,485, and the samples of 3,925 firms were selected by using the stratified sampling method, and 1,964 firms remained after the deletion of missing data. The definitions of the variables are summarized in <Table 1>.

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Table 1. Definition of Variables

Variables		Label	Definition	Type
Independent variables	Anti-Regulation	Anti-Regu	The future predicted environmental regulations or taxes	Binary
	Self-regulation	Self-Regu	Voluntary conventions or agreements within the industry	Binary
	Energy Consumption	Eng-Cons	Within an industry, the averaged energy consumption of the belonged firms	Log
	Information Sourcing Openness	Breadth	The number of used information sources	0~12
		Importance	Averaged degree of information use(=sum of importance of used information/the number of used sources)	0~5
Control variables	Regulatory Pull/Push	Pre-Regu	Existing environmental regulations or taxes	Binary
		Subsidy	Using subsidiaries from the government or financial benefits related to eco-innovation	Binary
	Market Pull	Mkt-Pull	Market demands for eco-innovation from the current or future consumers	Binary
	Innovation Capability	Inno-Capa	The number of innovations on products, processes, organizations, and marketing	0~4
	Technology Push	In-R&D	% of internal R&D expense to sales volumes 2007~2009	Log
		Ex-R&D	% of external R&D expense to sales volumes 2007~2009	Log
	Size		Log (The number of full-time employees in 2007)	Log
	Age		The age of the firm (=2014-the founded year)	count
Dependent	Eco-Process Innovation	D1	Reduction of material consumption per output unit	Binary
		D2	Reduction of energy consumption per output unit	Binary
		D3	Reduction of CO2 emissions	Binary
		D4	Replacing polluting or harm matters	Binary
		D5	Reduction of soil, water, noise, and air pollutants	Binary
		D6	Recycling wastes, water, and materials	Binary
	Eco-Product Innovation	D7	Reduction of energy consumption	Binary
		D8	Reduction of soil, water, noise, and air pollutants	Binary
		D9	Improving recyclability after product use	Binary
	Total Number	D10	(1)+(2)+(3)+(4)+(5)+(6)+(7)+(8)+(9)	0~9

3.3 Analysis Model

As mentioned before, there are two special kinds of dependent variables in our research model. One is binary (0, 1) variable, and another is count variable. The former is on whether a firm engages in eco-innovative actions, including six eco-process innovative actions and three eco-product innovative actions. The latter is the overall number (count number) of the innovative actions.

Considering the special data types, we estimate multivariate probit models addressing the nine innovative actions at the same time. In our research, the dependent variables will be 0 if the firm does not engage in eco-innovative action, and will be 1 if the firm engages in eco-innovative action. And the multivariate probit model is a generalization of the probit model used to estimate several correlated binary outcomes jointly. In this research, the multivariate probit model allows a simultaneous estimation of the nine types of eco-innovation. The existing evidence about the likelihood of complementarities between different types of innovative activity makes us consider that unobserved firms' characteristics may jointly influence the nine types of eco-innovation [50]. If these correlations were neglected, parameter estimates would be biased and inconsistent. The multivariate probit models can be written as:

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$$y_{im}^{*} = \beta_{imo} + \beta_{im1}x_1 + \beta_{im2}x_2 + \cdots + \beta_{imp}x_p + \varepsilon_{im}$$
$$y_{im} = 1 \; if \; y_{im}^{*} > 0 \; and \; 0 \; otherwise.$$

Where i represents individual firms; y_{im} are nine binary eco-innovation dependent variables (m= 1, 2, …, 9); x_p are indepent variables and control variables (p= 1, 2, …, 12); and ε_{im} are error terms distributed as multivariate normal, each with a mean of zero, and variance-covariance matrix V, where V has values of 1 on the leading diagonal and correlations $\rho_{jk} = \rho_{kj}$ as off-diagonal elements. Also, we estimate the zero-inflated negative binomial regression model for the overall number of eco-innovation activities. There are two basic methods for modeling count variables with excessive zeros, zero-inflated poison (ZIP) regression and ZINB regression. There is an issue that should be considered when using Poisson models which are a Poisson distribution and constrain the variance to be equal to the sample mean. This is a problem in our case given that the sample is much skewed. In contrast, ZIP does not have this constraint. By testing, we ultimately estimate zero-inflated negative binomial models in recognition of the high number of "zero" responses in the dependent variables. According to Table 2, the ZINB is preferred over ZIP. Thus, ZINB models are used to estimate the determinants of the total number of eco-innovations.

Table 2. Tests and Fit Statistics

ZIP	BIC= -7962.343	AIC=	3.425	Prefer	Over	Evidence
vs. ZINB	BIC= -8053.391	dif=	91.048	ZINB	ZIP	Very strong
	AIC= 3.375	dif=	0.050	ZINB	ZIP	
	LRX2= 98.622	prob=	0.000	ZINB	ZIP	p=0.000

The ZINB regression model assumes that there are two distinct data generation processes. The results of a Bernoulli trial are used to determine which of the two processes. For observation i, with probability π_i, the only possible response of the first process is zero counts, and with the probability of (1 - π_i), the response of the second process is governed by a negative binomial with mean μ_i. The zero counts are generated from both the first and second processes, where a probability is estimated for whether zero counts are from the first or the second process. The overall probability of zero counts is the combined probability of zeros from the two processes. A ZINB model for response Y_i can be written as:

$$\begin{cases} P(Y_i = 0) = \pi_i + (1-\pi_i)\cdot\left(\dfrac{k}{\mu_i + k}\right)^k \\ P(Y_i = n) = (1-\pi_i)\cdot\dfrac{\Gamma(Y_i + k)}{\Gamma(k)\Gamma(Y_i + 1)}\cdot\left(\dfrac{k}{\mu_i + k}\right)^k\cdot\left(1-\dfrac{k}{\mu_i + k}\right)^{Y_i} \end{cases}$$

Where k is the over dispersion parameter; Γ is the gamma distribution, and n is a natural number larger than 0. We can model π_i and μ_i as a function of a set of explanatory variables. For π_i, it is common to use a logistic regression with a logit link function, as it describes a binomial process:

$$logit(\pi_i) = e^{\alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n}$$

Where α is the intercept, $\beta_1 \; \ldots \; \beta_n$ are the model parameters to estimate, and $X_1 \; \ldots \; X_n$ are a set of independent variables. We can also model the dependence of μ_i on a different (or same) set of explanatory variables with the aid of a log link function:

$$log(\mu_i) = \lambda + \delta_1 Z_1 + \delta_2 Z_2 + \cdots + \delta_n Z_n$$

Where λ is the intercept, $\delta_1 \ldots \boldsymbol{\delta_n}$ are the model parameters to estimate, and $z_1 \ldots z_n$ are a set of independent variables.

4. Results of the Empirical Analyses

<Table 3> shows the results of multivariate probit models, which analyzed the effects of determinate factors on the nine types of eco-innovation of the 1,964 manufacturing firms in Korea. The corresponding Wald tests analyzing the explanatory power of the entire model indicate that the null hypothesis that all parameters of the explanatory variables are zero can be clearly rejected at all common levels of significance for all probit models. The last column in the <table 3> reports the determinants on the extent to which firms engage in eco-innovation which can be seen as outcome of eco-innovation.

4.1. The Results of Empirical Analyses of external factors

Among the external factors, the future anticipated regulations have positive influences on eco-process and eco-product innovation at the 1% significant level. Also for the eco-innovation outcome performance by how many kinds of innovation activities are enacted, there is a significant positive influence. Therefore, the hypothesis 1 is supported. This result shows that firms make efforts to win competitive superiority by differentiating their products and cutting down expenses by implementing environment-related innovation activities preemptively in response to the future predicted regulations [15, 16]. It means that the argument by Porter and Van der Linder [14] can also apply to Korea. Also in Khanna et al. [46], current and anticipated regulatory pressures, as proxied by penalties, inspections, hazardous air pollutants and non-attainment have a statistically positive impact on an adoption of a new pollution prevention measure. But, due to data limitation, it is difficult to figure out whether companies regard future predicted regulations as an opportunity or a threat.

Not only the governmental regulations, but also firms' voluntarily engaged conventions (self-regulation) have influence on their eco-innovation activities. According to the results of analyses, firms which are voluntarily engaged in conventions show higher possibilities of innovation in all activities which belong to eco-process and eco-product innovations. Such firms also have higher numbers of eco-innovation activities than others. From this result, hypothesis 2 is adopted. It means that, as in the argument of Nash and Ehrenfeld [51], eco-innovation activities are also realized under non-public control in Korea, and that voluntarily engaging firms are more likely to use eco-innovation than non-voluntary firms. Despite the vulnerability of voluntary conventions being loosely operated compared to the government regulations without explicit punishment on free-ride or opportunistic behaviors, voluntary conventions promote eco-innovations of Korean firms.

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Table 3. Determinants of Eco-innovation by different environmental types & Total Number of Eco-innovation

Number of obs = 1946 Wald chi2 (117) = 2125.87 Prob > chi2 = 0.000 Log likelihood = -6014.5327			Eco-Process Innovation					
			D1 Material	D2 Energy	D3 CO2	D4 Danger	D5 Soil/Water/ Noise	D6 Recycling
Independent variables	External	Anti-Regu	0.7583*** (9.44)	0.9308*** (11.73)	0.8141*** (10.17)	0.9138*** (11.43)	0.7982*** (10.20)	0.7374*** (9.22)
		Self-Regu	0.7230*** (8.39)	0.8251*** (9.83)	0.8399*** (9.81)	0.6958*** (8.02)	0.7872*** (9.19)	0.9280*** (10.85)
		Eng-Cons	0.0188 (0.88)	0.0363* (1.73)	0.0549** (2.57)	0.0029 (0.14)	0.0543*** (2.63)	0.0750*** (3.66)
	Internal	Breadth	0.0287** (2.30)	0.0232* (1.92)	0.0181 (1.45)	0.0129 (1.06)	0.0198 (1.64)	-0.0068 (-0.58)
		Importance	0.0880* (1.68)	0.0653 (1.28)	0.0272 (0.52)	0.0380 (0.75)	-0.0312 (-0.62)	-0.0020 (-0.04)
Control variables	External	Pre-Regu	0.6855*** (7.69)	0.6268*** (7.18)	0.6615*** (7.48)	1.0226*** (11.51)	1.0763*** (12.51)	1.0579*** (12.04)
		Subsidy	0.7103*** (5.30)	0.6787*** (5.20)	0.6907*** (5.08)	0.7343*** (5.18)	0.7590*** (5.59)	0.8178*** (5.78)
		Mkt-Pull	1.1900*** (15.82)	1.1461*** (15.63)	1.0380*** (13.72)	1.0793*** (14.57)	1.0554*** (14.23)	1.1152*** (15.44)
	Internal	Inno-Capa	0.1523*** (3.91)	0.0908** (2.43)	0.0973** (2.51)	0.2085*** (5.48)	0.0968** (2.58)	0.1287*** (3.50)
		In-R&D	-0.1199 (-1.04)	-0.0023 (-0.02)	-0.0554 (-0.49)	-0.1452 (-1.23)	-0.1497 (-1.32)	-0.3538*** (-2.95)
		Ex-R&D	0.1294 (0.43)	0.0309 (0.11)	-0.0637 (-0.20)	0.3998 (1.28)	0.0138 (0.05)	0.1461 (0.50)
		Size	0.0405 (1.21)	0.0198 (0.61)	0.1088*** (3.30)	0.0225 (0.68)	-0.0016 (-0.05)	0.0087 (0.27)
		Age	0.0005 (0.16)	0.0068** (2.37)	-0.0019 (-0.63)	0.0027 (0.91)	0.0085*** (2.97)	0.0021 (0.75)
		_cons	-2.7555*** (-3.94)	-2.4701*** (-3.66)	-2.9788*** (-4.04)	-1.9467*** (-2.73)	-2.5577*** (-3.72)	-2.2967*** (0.6741)

Note. Standard deviation in parenthesis. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

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Table 3. Determinants of Eco-innovation by different environmental types & Total Number of Eco-innovation (continued)

Number of obs = 1946 Wald chi2 (117) = 2125.87 Prob > chi2 = 0.000 Log likelihood = -6014.5327			Eco-Product Innovation			Total Number Negative Binomial Regression Part (>0 eco-innovation)
			D7 Energy	D8 Soil/Water /Noise	D9 Recycling	Number of obs = 1946 Nonzero obs = 1081 Zero obs = 865 LR chi2 (13) = 946.36 Prob > chi2 = 0.000 Inflation model = logit Log likelihood = -3361.498
Independent variables	External	Anti-Regu	0.5214*** (6.52)	0.645*** (8.40)	0.5274*** (6.75)	0.8968*** (14.14)
		Self-Regu	0.8705*** (10.34)	0.7181*** (8.53)	0.7931*** (9.70)	0.9503*** (13.60)
		Eng-Cons	-0.0029 (-0.14)	0.0270 (1.30)	-0.0119 (-0.58)	0.0320** (2.04)
	Internal	Breadth	0.0213* (1.80)	0.0245** (1.97)	0.0313*** (2.62)	0.0212** (2.35)
		Importance	-0.0522 (-1.06)	0.0543 (1.06)	0.0168 (0.34)	0.0291 (0.78)
Control variables	External	Pre-Regu	0.6239*** (7.22)	0.7478*** (8.54)	0.7016*** (8.17)	1.0457*** (14.61)
		Subsidy	0.7125*** (5.13)	0.6853*** (5.06)	0.4359*** (3.23)	0.8006*** (7.47)
		Mkt-Pull	1.2471*** (17.39)	1.1636*** (15.43)	1.0428*** (14.63)	1.3937*** (23.52)
	Internal	Inno-Capa	0.1468*** (4.00)	0.1404*** (3.63)	0.1164*** (3.18)	0.1611*** (5.67)
		In-R&D	-0.1359 (-1.21)	-0.1329 (-1.10)	-0.3950*** (-3.14)	-0.2145** (-2.43)
		Ex-R&D	0.1907 (0.65)	0.4419 (1.51)	-0.3264 (-1.00)	0.1140 (0.49)
		Size	0.0629* (1.94)	0.0450 (0.46)	-0.0777** (-2.45)	-0.0014 (-0.06)
		Age	-0.0033 (-1.14)	0.0004 (0.15)	0.0016 (0.54)	0.0019 (0.85)
		_cons	-1.955*** (-2.91)	-1.9133*** (-2.84)	-3.4034*** (-4.58)	-1.4686 (-2.77)
Inflated (Probit Selection Part) _cons						-18.8153 (-0.04)
/lnalpha						-0.4044*** (-6.10)
alpha						0.6674

Note. Standard deviation in parenthesis. * p < 0.10; **p < 0.05; ***p < 0.01.

Regarding industry-specific factors, there are interesting results. Industry-specific factors positively influence eco-process innovations, but influence eco-product innovations insignificantly. Among eco-process innovations, when average energy consumption in an industry is higher, possibility of innovation is higher in areas including (2) reducing energy consumption per output unit, (3) reducing carbon dioxide emission, (5) reducing soil, water, noise, and air pollution, and (6) recycling of wastes, water, and materials. This means that firms in a high energy consumption industry are focusing more on the benefit from cutting down their energy consumption rather than consumers' energy consumption in product use. Also in manufacturing processes, they concentrate more on the innovative actions which bring reduction outcomes in a relatively short period of time. But in the processes which need investment and research for a relatively longer period of time, such as replacement of pollutants or harm matters, innovative actions are less likely to happen at least in short term. Industry-specific factors have influences on eco-innovation possibilities of companies, but not on eco-innovation outcomes.

4.2. The Results of Empirical Analyses of Internal Factors

As one of our focusing variables, let us see how openness to information affects eco-innovation. First, when the scope of obtaining information is broader and more diverse, the diversity of eco-innovation improves. This result is consistent with Laursen and Salter [28] which studied general technology innovation. Hypothesis 4-1, therefore, is supported. In Korea, as many researchers suggest, eco-innovation requires capabilities to deal with different dimensions, which can be acquired from diverse external information sources [27,29,31]. So, the firms with broader information sources can be said to get higher outcomes of eco-innovation than those with narrower sources.

Also in eco-process and eco-product innovation activities, it has a significantly positive influence on the activities of (1) material, (2) energy, and all activities in eco-product. From this result, firms obtaining information from broader and more diverse sources are more likely to take actions on eco-innovation. This result has great implications on both policy and academic study. In terms of academic study, it suggests the necessity of expense-related studies, as it is possible that more diverse sources of external information accompany higher costs in their handling and management. In terms of policy, the method to raise diversity of external information should be proposed.

The importance of openness to information has not showed any significant results in the outcomes and individual items of innovation activity, which is far from the expectations of this study. Therefore, hypothesis 4-2 is not supported. It is probably because of firms' lack of absorbing capability, which refers to firms' ability to effectively use outside information [52,53]. The value of external information depends on firms' potential absorptive capabilities [53-55]. But this result should be strengthened by empirical analyses.

4.3. The Results of Empirical Analyses of Control Factors

Regarding the results about regulatory pull/push, Korean firms show the same results as the previous studies [3,43]. The present regulations positively affect eco-innovation at 1% significance level. Also, governmental subsidiaries show the same results as the present regulations. Both regulatory push and pull have a significantly positive influence on each dimension of eco-process and eco-product innovation. The existences of the present regulations and governmental support have significantly positive relationships with all activities of eco-process and eco-product innovation. Also in the market-pull factors, higher demands on eco-friendly products have greater positive influences not only on eco-process and eco-process innovation, but also on eco-innovation outcome performance. This is consistent with the empirical research results of Kammerer [18]. Next, let us see how influential internal factors are on eco-innovation of Korean firms. First, innovation capability has a significant effect at 1% level. It means that for Korean firms, higher innovation capability promotes eco-innovation. When seeing technology push factors, internal R&D investments have significantly negative relationships with eco-innovation. The reason is that business R&D investment has a negative effect on productivity growth in short run, as Guellec and Potterie [56] argued. They presented that it takes some time for those outcomes to have relationships each other, and before they do, they can show negative relationships. In Seop et al. [57], R&D intensity has a negative relationship with firms' revenues in short run. Meanwhile, external investment is not in significant relationships.

The size of firms, which is represented by the number of employees, has a significant effect only partly on eco-innovation. Only eco-innovation activities for carbon dioxide reduction have been proportionally influenced by firm size. In eco-product innovation, the activities regarding energy use reduction have been positively influenced by the size of firms at 10% significance level, though firms' size negatively affects recycling of products. Firm's age, which represents firm's experience, has a positive relationship with the overall outcomes of eco-innovation.

5. Conclusions

This study has empirically proved the determinant factors of the eco-innovation of Korean manufacturing firms, divided into external and internal factors, mainly by using the variables that have not been much proved. Both anticipated regulations and self-regulations, which are external factors, promote eco-innovation. On the dimension of industry-specific characteristics, firms which belong to a more energy-consuming industry are more concentrated on eco-process innovation. In information sourcing openness, which is an internal factor, breadth is a factor with a more significant influence on eco-innovation than importance is. It means that the capability of a firm to make connections with diverse bodies (businesses, colleges, research institutions, etc.) and apply their information itself has an influence on its choice of eco-innovation. The three variables, anticipated regulations, self-regulations, and the breadth of information sourcing, also have significantly strong influences on firms' eco-innovation outcomes, which are represented by how frequently they engage in eco-innovation activities.

According to the empirical results, the following academic and policy implications can be provided. First, it has been already confirmed by a lot of researchers that the government's environmental regulations promote eco-innovations [14,58,59]. This study analyzes how firms react to anticipated environmental regulations imposed by the government, which has not been much addressed in previous studies. As shown in the results, firms take positive response strategies rather than passive defending actions, as anticipated regulations imply that their future competition circumstances will be different. Particularly, the argument that late comers take anticipated regulations as an opportunity to secure competitive advantages and become leading firms, and take more vigorous actions for technological innovations strengthens the validity of the results of this study [60].

When firms clearly see the direction of environmental policies, they decide on their strategies and respond to anticipated circumstantial changes. The consistency and continuation of the government's environment policies, therefore, are important. But even when firms are aware of external circumstantial changes, they cannot be immune from the problem of uncertainty. Firms are more likely to take passive actions when uncertainty is high, while they are more likely to take active actions when uncertainty is low and there is improved predictability. When it comes to activities related to eco-innovation, the predictability of future regulations can be explained by the same theory. Due to the limitations of our data, however, future studies should be conducted based on related studies.

Second, apart from governmental regulations, self-regulations have a positive influence on firms' engagement in eco-innovation activities and their performance. There is a lack of concrete discussion about the mechanism through which self-regulations have such influences. In this study, negative and positive influences of self-regulations are presented, and the empirical analyses are carried out to prove them. As shown from the results, the positive relationship of self-regulation with eco-innovation suggests that self-regulations have positive effects in Korea, and firms should be induced to take voluntary actions on environment-related innovation activities by themselves through related policies. Especially, the realization of self-regulation leads to the preparation of effective methods to replace non-elastic governmental regulations [23]. From the government's perspective, self-regulations can reduce external effects from the establishment of rules and cut down the costs on persuading various interest groups. For these purposes, it is important to prepare a foundation on which sound self-regulations can be established, and the government and firms should make joint efforts to do so. Third, concrete identify of the relationship between industry-specific factors and eco-innovation. Although the results of some studies have presented that firms which belong to a high energy-consuming industry are active for eco-innovation, they might be missing a concrete influential relationship. As the result of this study shows, industry-specific factors do not have a significant influence on eco-product innovation, but have a significant influence on eco-process innovation. Particularly, it is significant in some kinds of eco-innovation, such as energy consumption reduction, carbon dioxide reduction, soil/water/noise/air pollutants reduction, and wastes/water/material recycling. It suggests that firms that consume a lot of energy practice more process-centered eco-innovation policies. Fourth, the major contribution of this study is that it has figured out that various information sources could help firms win a competitive advantage through eco-innovation. Since eco-innovation intrinsically has a complex development process and multiple purposes, using diverse external information is important [27,29]. Also, multiple dimensions such as design, user involvement, product and service, or governance should be taken into consideration in the process of eco-innovation [27]. It is also well explained in this study as it presents the positive relationship between the breadth of information sources and eco-innovation. In particular, the positive relationship with overall eco-innovation suggests that firms which want to win competitive superiority through product differentiation need to actively use external resources. Meanwhile, from firms' point of view, the importance of external information does not influence eco-innovation engagement and outcomes. It seems to have something to do with absorbing capability, though there should be related further studies in the future.

Despite the implications presented above, this study has several limitations. First, it could not fully take into consideration the temporal effect of each factor considered in the analyses on eco-innovation. In future studies, temporal research should be done on the same firms analyzed in this study. Second, since it could not figure out whether firms take predicted regulations as opportunities or threats due to the limit of data, the changes of firms' behaviors were not explained either. If more research is done on this issue, it could provide important implications on how the strategy formations, actions, and outcomes of companies will change depending on their awareness of anticipated regulations.

Author Contributions: Conceptualization: C.Y. and Y.S.H.; Formal analysis: C.Y.; Project administration: Y.S.H.; Supervision: Y.S.H.; Writing original draft: C.Y.; Writing—review and editing: Y.S.H.

Funding: This study received no external funding.

Acknowledgments: This work was supported by the Ministry of Education of Korea and the National Research Foundation of Korea (NRF-2016S1A5B6925462)

Conflicts of Interest: The authors declare no conflicts of interest.

Reference

1. Hart, S. L.; Dowell, G. Invited editorial: a natural-resource-based view of the firm: fifteen years after. *Journal of management* **2011**, 37(5), 1464-1479.
2. Porter, M. E.; Reinhardt, F.L. A strategic approach to climate. *Harvard Business Review* **2007**, 85(10), 22-26.
3. Horbach, J.; Rammer, C.; Rennings, K. Determinants of eco-innovations by type of environmental impact-The role of regulatory push/pull, technology push and market pull. *Ecological Economics* **2012**, 78, 112-122.

4. Kesidou, E.; Demirel, P. On the drivers of eco-innovations: Empirical evidence from the UK. *Research Policy* **2012**, 41, 862-870.
5. Cuerva, M.C.; Triguero-Cano, A.; Corcoles, D. Drivers of green and non-green innovation: empirical evidence in Low-Tech SMEs. *Journal of Cleaner Production* **2014**, 68, 104-113.
6. Triguero, A.; Moreno-Mondejar, L.; Davia, M.A. Drivers of different types of eco-innovation in European SMEs. *Ecological Economics* **2013**, 92, 25-33.
7. Cai, W.; Zhou, X. On the drivers of eco-innovation: empirical evidence from China. *Journal of Cleaner Production* **2014**, 79, 239-248.
8. Cheng, C.C.; Yang, C.; Sheu, C. The link between eco-innovation and business performance: a Taiwanses industry context. *Journal of Cleaner Production* **2014**, 64, 81-90.
9. Chesbrough H. The Era of Open Innovation. *MIT Sloan Management Review* **2003**, 44(3), pp. 35-41
10. Rennings, K. Redefining innovation—eco-innovation research and the contribution from ecological economics. *Ecological economics* **2000**, 32(2), 319-332.
11. Negny, S.; Belaud, J.; Robles, C.; Reyes, R.; Ferrer, B. Toward an eco-innovative method based on a better use of resources: application to chemical process preliminary design. *Journal of Cleaner Production* **2012**, 32, 101-113.
12. Horbach, J. Determinants of environmental innovation – new evidence from German panel data sources. *Research Policy* **2008**, 37, 163-173.
13. Iraldo, F.; Testa, F.; Melis, M.; Frey, M. A literature review on the links between environmental regulation and competitiveness. *Environmental Policy and Governance* **2011**, 21(3), 210-222.
14. Porter, M.E.; Van der Linde, C. Green and competitive: ending the stalemate. *Harvard Business Review* **1995**, 73 (5), 120-134.
15. Christmann, P. Effects of "best practices" of environmental management on cost advantage: The role of complementary assets. *Academy of Management Journal* **2000**, 43(4), 663-680.
16. Dean, T.J.; Brown, R.L. Pollution regulation as a barrier to new firm entry: Initial evidence and implications for future research. *Academy of Management Journal* **1995**, 38(1), 288-303.
17. Russo, M.V.; Harrison, N.S. Organizational design and environmental performance: Clues from the electronics industry. *Academy of Management Journal* **2005**, 48(4), 582-593.
18. Kammerer, D. The effects of customer benefit and regulation on environmental product innovation. Empirical evidence from appliance manufacturers in Germany. *Ecological Economics* **2009**, 68, 2285-2295.
19. Reid, E.M.; Toffel, M.W. Responding to public and private politics: Corporate disclosure of climate change strategies. *Strategic Management Journal* **2009**, 30(11), 1157-1178.
20. Cohen, P. The regulation of protein function by multisite phosphorylation–a 25 year update. *Trends in biochemical sciences* **2000**, 25(12), 596-601.
21. Maxwell, J.W.; Lyon, T.P.; Hackett, S.C. Self-Regulation and Social Welfare: The Political Economy of Corporate Environmentalism. *The Journal of Law and Economics* **2000**, 43(2), 583-618.
22. Cane, P. Self regulation and judicial review, *Civil Justice Quarterly* **1987**, 6, 324-347.
23. Ogus, A. Rethinking self-regulation. *Oxford Journal of Legal Studies* **1995**, 15(1), 97-108.
24. Scott, C.; Black, J.; Cranston, R. *Cranston's Consumers and the Law*, 3rd ed.; Cambridge University Press: Cambridge, U.K., 2000; ISBN 10 0521605970.
25. Delmas, M.A.; Terlaak, A.K. A framework for analyzing environmental voluntary agreements. *California Management Review* **2001**, 43(3), 44-63.
26. Machiba, T. Eco-innovation for enabling resource efficiency and green growth: development of an analytical framework and preliminary analysis of industry and policy practices. *International Economics and Economic Policy* **2010**, 7(2-3), 357-370.
27. De Marchi, V.; Grandinetti, R. Knowledge strategies for environmental innovations: the case of Italian manufacturing firms. *Journal of Knowledge Management* **2013**, 17(4), 569-582.
28. Laursen, K.; Salter, A. Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms. *Strategic Management Journal* **2006**, 27, 131-150.
29. Ghisetti, C.; Marzucchi, A.; Montresor, S. The open eco-innovation mode, An empirical investigation of eleven European countries. *Research Policy* **2015**, 44, 1080-1093.
30. Rennings, K.; Rammer, C. Increasing energy and resource efficiency through innovation – an explorative analysis using innovation survey data. *Czech Journal of Economics and Finance* **2009**, 59 (1), 442-459.

31. Horbach, J.; Oltra, V.; Belin, J. Determinants and specificities of eco-innovations. An econometric analysis for the French and German industry based on the Community Innovation Survey. *Industry and Innovation* **2013**, 20 (6), 523-543.
32. Penrose, E. *The theory of the Growth of the firm*, 4th ed.; Oxford University Press: NY, USA, 2009; ISBN 9780199573844.
33. Hwang, J.; Lee, Y.; External knowledge search, innovative performance and productivity in the Korean ICT sector. *Telecommunications Policy* **2010**, 34(10), 562-571.
34. Woo, Y.B.; Cho, S.; Kim, J.; Kim, B.S. Optimization-based approach for strategic design and operation of a biomass-to-hydrogen supply chain. *International Journal of Hydrogen Energy* **2016**, 41(12), 5405-5418.
35. Schmookler, J. *Invention and economic growth*. Harvard University Press. Cambridge, Mass., USA, 1996; ISBN 9780674432833.
36. Rosenberg, N. Science, invention and economic growth. *The Economic Journal* **1974**, 84, 90-108.
37. Cleff, T.; Rennings, K. Determinants of environmental product and process innovation. *European environment* **1999**, 9(5), 191-201.
38. Hicks, C.; Dietmar, R. Improving cleaner production through the application of environmental management tools in China. *J. Clean. Prod.* **2007**, 15, 395-408.
39. Pujari, D. Eco-innovation and new product development: understanding the influences on market performance. *Technovation* **2006**, 26, 76-85.
40. Gray, W.B. The cost of regulation: OSHA, EPA and the productivity slowdown, *The American Economic Review* **1987**, 77(5), 998-1006.
41. Jenkins, R., 1998. Environmental regulation and international competitiveness: a review of literature and some European evidence. Discussion Paper Series #9801. United Nations University. Institute for New Technologies: Maastricht, Netherlands, 1998.
42. Smith, J.B.; Sims, W.A. The impact of pollution charges on productivity growth in Canadian brewing. *The RAND Journal of Economics* **1985**, 16(3), 410-423.
43. Del Rio Gonzalez, P. The empirical analysis of the determinants for environmental technological change: a research agenda. *Ecological Economics* **2009**, 68, 861-878.
44. Arranz, N.; Fdez de Arroyabe, J.C. The choice of partners in R&D cooperation: An empirical analysis of Spanish firms. *Technovation* **2008**, 28 (1), 88-100.
45. Lerner, J.S.; Tetlock, P.E. Accounting for the effects of accountability. *Psychological bulletin* **1999**, 125(2), 255.
46. Khanna, M.; Deltas, G.; Harrington, D.R. Adoption of pollution prevention techniques: the role of management systems and regulatory pressures. *Environmental and Resource Economics* **2009**, 44(1), 85-106.
47. De Marchi, V. Environmental innovation and R&D cooperation: Empirical evidence from Spanish manufacturing firms. *Research Policy* **2012**, 41, 614-623.
48. Cohen, W.M.; Levinthal, D.A. Innovation and learning: the two faces of R & D. *The economic journal* **1989**, 99(397), 569-596.
49. Cohen, W.M.; Levinthal, D.A. Fortune favors the prepared firm. *Management science* **1994**, 40(2), 227-251.
50. Reichstein, T.; Salter, A. Investigating the sources of process innovation among UK manufacturing firms. *Industrial and Corporate Change* **2006**, 15(4), 653-682.
51. Nash, J.; Ehrenfeld, J. Codes of environmental management practice: Assessing their potential as a tool for change. *Annual Review of Energy and the Environment* **1997**, 22(1), 487-535.
52. Fabrizio, K.R. Absorptive capacity and the search for innovation. *Research Policy* **2009**, 38(2), 255-267.
53. Koza, M.P.; Lewin, A.Y. The co-evolution of strategic alliances. *Organization science* **1998**, 9(3), 255-264.
54. Xia, T.; Roper, S. From capability to connectivity—Absorptive capacity and exploratory alliances in biopharmaceutical firms: A US–Europe comparison. *Technovation* **2008**, 28(11), 776-785.
55. Xia, T.; Roper, S. Unpacking Open Innovation: Absorptive Capacity, Exploratory and Exploitative Openness, and the Growth of Entrepreneurial Biopharmaceutical Firms. *Journal of Small Business Management* **2016**, 54(3), 931-952.
56. Guellec, D.; De la Potterie, B.V.P. The internationalisation of technology analysed with patent data. *Research Policy* **2001**, 30(8), 1253-1266.
57. Seop, H. Y.; Min, K. H.; Sik, K. H. Industry openness, firm capacity, and performance of Korean SMEs. *Journal of Korea Trade* **2013**, 17(3), 77-105.

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58. Palmer, K.; Oates, W.E.; Portney, P.R. Tightening environmental standards: The benefit-cost or the no-cost paradigm? *The Journal of Economic Perspectives* **1995**, 9(4), 119-132.
59. Wagner, B.A. Learning and knowledge transfer in partnering: an empirical case study. *Journal of Knowledge Management* **2003**, 7(2), 97-113.
60. Sharma, S.; Pablo, A.L.; Vredenburg, H. Corporate environmental responsiveness strategies the importance of issue interpretation and organizational context. *The Journal of Applied Behavioral Science* **1999**, 35(1), 87-108.