Regular Paper

Ma, D., Ye, J.M., Zhang, Y.R. (2018), "Can Firm Exploit Economic Gains from Eco-innovation? An Empirical Investigation of Listed Companies in China", *Transformations in Business & Economics*, Vol. 17, No 2 (44), pp.33-53.

---------TRANSFORMATIONS IN --------
BUSINESS & ECONOMICS

CAN FIRM EXPLOIT ECONOMIC GAINSFROM ECO-INNOVATION? AN EMPIRICAL INVESTIGATIONOF LISTED COMPANIESIN CHINA[1]

[1]Ding Ma
School of Economics,
Wuhan University of Technology, Wuhan
Hubei 430070
People's Republic of China
E-mail: mading@whut.edu.cn

[2]Jian-mu Ye
School of Economics,
Wuhan University of Technology, Wuhan
Hubei 430070
People's Republic of China
E-mail: jianmuye@126.com

[3]Ya-rui Zhang
School of Management,
Hubei University of Arts and Science Xiangfan
Hubei 441053
People's Republic of China
E-mail: zhangmisue@hotmail.com

[1]**Ding Ma**, PhD, is currently working in School of Economics, Wuhan University of Technology. She obtained her doctor's degree from Wuhan University of Technology, China. Her research interests focus on industrial economics and eco-innovation.

[2]**Jian-mu Ye**, PhD, is currently working in School of Management, Wuhan University of Technology, He obtained his doctor's degree from Wuhan University of Technology, China. His research interests focus on innovation management.

[3]**Ya-rui Zhang**, PhD, is currently working in School of Management, Hubei University of Arts and Science. She obtained her doctor's degree from Wuhan University of Technology, China. Her research interests focus on industrial economics and R&D alliance.

Received: March, 2017
1st Revision: May, 2017
2nd Revision: August, 2017
Accepted: October, 2017

ABSTRACT*. Based on a sample of listed companies in China from 2010 to 2016, this paper examines the types of rewarding eco-innovation, earning cycle, and contingency factors in the link between eco-innovation and profitability. Propensity score matching method indicates that eco-innovations can have positive impacts on firm profitability with a delay of about two years. Demand-side factors, which are represented by green procurement and advertising intensity and supply-side factors delegated by regulation intensity and subsidy, will positively moderate the eco-product innovation/profitability link. The only significant moderator for eco-process innovation/profitability association is subsidy.

[1]**Acknowledgment**: This study was supported by the National Social Science Fund of China (Grant No. 17BJL031).

Panel regressions results further show that market expansion is more pronounced in the eco-product innovation firms endowed with green procurement orders or with high advertising intensity. These findings suggest that demand-side policies can emphasize on optimizing green purchasing mechanism and inducing greater green promotion, whereas supply-side policies can highlight formulating reasonable levels of environmental regulation intensity and differential subsidies.

KEYWORDS: eco-innovation, profitability, moderating effect, propensity score matching, China.

JEL classification: O31, O53, P28.

Introduction

In recent years, environmental issues and sustainable development have drawn increasing attention worldwide, particularly in China who is striding ahead in her economic transition and industry upgrade. The congruence of environment and economy not only matters for national well-being but also determines the competition position of China internationally. Firms are the main drivers in decoupling environmental pressure and economic growth because the lion's share of environmental pollution comes from industrial production and operation. Consequently, these firms are under great regulation pressure and public scrutiny (Cheng *et al*., 2014; Ghisetti, Rennings, 2014). More importantly, firms pursuing efficiency, market share, and sustainable competitiveness tend to tune their economic activity to the "triple bottom line" (Elkington, 1998). Eco-innovation, which refers to technological and non-technological innovation with high ecological efficiency, renders an effective way in achieving "win-win" outcome of environment and economy (Peng, Huang, 2013). Given the paramount significance of eco-innovation in ecology-oriented transformation and national strength promotion, China seems a laggard in developing environmentally friendly manufacturing and operating with the bulk of firms barely meeting the requirements of mandatory regulation (Chen *et al*., 2015). Despite the hindering influence from lack of economic incentive policies, lax regulation enforcement, and inhibitive R&D and capital investment (Zeng *et al*., 2011), the root cause lies in lack of economic incentive. Enterprises with the goals of profit-maximizing have insufficient cognition on economic benefit deriving from eco-innovation, which discourages them from addressing environmental constraints innovatively. Whether firms are sufficiently financially rewarded or even achieve over-compliance gains from eco-innovation? This question of theoretical and practical significance constitutes the research starting point of this study.

Numerous studies have explored the link between eco-innovation and economic performance. Some studies suggested that eco-innovation can improve enterprise efficiency and productivity, stakeholder relations, and corporate reputation (Cheng, Shiu, 2012), and facilitate differentiation and market segmentation (Sarkar, 2013). Scholars further argued that the positive effect of eco-innovation is influenced by the degree of environmental business integration (Ghisetti, Rennings, 2014) and types of innovation (Dong *et al*., 2014, Doran, Ryan, 2016). On the contrary, other scholars claimed that the highly systematic and complex attributes of eco-innovation bring great challenge to compatibility of current technology system and technology infrastructure, leading to high upfront investments or sunk cost and subsequently negative effect on firm profitability (Carrillo-Hermosilla *et al*., 2009; Frank, Wagner, 2009). The inconsistent conclusions can not only be explained by the differences in research contexts and the metrics of eco-innovation and performance (Ghisetti, Rennings, 2014), but can also be attributed to the ignorance of contingency factor, namely, the potential moderator between eco-innovation and economic performance (Frank, Wagner, 2009). The existence of heterogeneity in economic gains of firms from eco-innovation, especially the roles of innovation demand- and supply-side policies play in the economy/environment link remain unexplored. Thus, available studies offer limited reference to the evaluation of policy effectiveness in industrial ecological transformation.

Given the literature gap, we propose that eco-innovation in the form of eco-product or eco-process influences firm-level economic performance and that demand- and supply-side innovation moderators affect influencing directions and mechanisms. To corroborate the hypotheses, this study measures the net effect of eco-product and eco-process innovations by combining the selection bias-controlled method propensity score matching (PSM) with panel regression. The combined methods aim to identify the moderating direction and influencing mechanism of demand- and supply-side factors in the link between eco-innovation and economic performance. This method could shed light on the question of under what circumstances could a firm lead to a “win-win” situation and offer implications in government stimulation of eco-innovation.

The rest of this study is organized as follows. Section 1 presents a theoretical framework and hypothesis development regarding eco-innovation/profitability link, demand- and supply-side moderators, and economic benefit utilization mechanisms. Section 2 presents the rationale of PSM. Section 3 presents sample selection, variable description, and sample matching effectiveness. Section 4 describes the results pertaining to treatment effect, moderation effects of demand- and supply-side factors, and the interaction analysis of moderators and value appropriation mechanisms. This section further gives a discussion to explain the significant outcome of green procurement, advertising and regulation and the insignificant outcome of subsidy. Finally, the conclusions and main contributions, as well as limitations, are summarized in conclusion section.

1. Literature review

1.1 Eco-Innovation and Profitability

Ever since Porter and Van der Linde (1995) challenged conventional wisdom and initiated a debate on the seemingly exclusive economic/environmental goals, abundant studies have emerged with various econometric strategies and model specifications, which have led to no consensus regarding the economic implications of corporate environmental strategies (Qi *et al*., 2012; Busch, Hoffmann, 2011). Given the inherent model misspecification issues in these environmental/economic link analyses (Elsayed, Paton, 2005), Telle (2006) suggested that research focus should divert from validating a presence of positive economic outcome to when is it beneficial to be an environmental prospector and who benefits from becoming one. To investigate this research focus in the context of eco-innovation/competitiveness debate, a priori differentiation of eco-innovation types is of importance in that eco-innovation typologies involving varying degrees of environmental commitment and objectives will differ in their consequent economic outcomes (Ghisetti, Rennings, 2014). Eco-product and eco-process innovations may represent the most common categorization of eco-innovation because these two typologies correspond to the overlap regarding the classification of eco-innovation in the current literature and stand for the major aspects of environmental activities within an organization (Cheng *et al*., 2014). Although convergent in the aim of pollution abatement and resource efficiency, eco-product innovation differs from eco-process innovation. Literally, eco-product innovation aims to resolve environmental impact through toxic and material reduction in products, improved energy consumption and emission in usage, and prolonged usage and recycle schemes for obsolete products (Kammerer, 2009; Demirel, Kesidou, 2011). In comparison with the life cycle approach of eco-product innovation, eco-process innovation specifically addresses environment impact during manufacturing, ranging from reduction in the unit cost of production and pollution emission to improvement in tacit environmental performance, e.g., resource utilization and pollution prevention (Cheng *et al*., 2014; Dong *et al*., 2014). The current literature has acknowledged the positive effects of both innovation types on the economic performance of firms. Doran and Ryan (2016) based the sample on Irish manufactures to infer that CO2 emission reduction technology and resource reuse would have a positive impact on productivity. Brasil *et al*. (2016) analyzed a sample of Brazilian textile enterprises and claimed that eco-product innovation is positively related to economic performance and partially mediates the effect of eco-process innovation on economic performance. This study substantiated the work of Cheng *et al*. (2014) on manufactures in Taiwan. Overall, eco-product and eco-process innovations can lead to resource efficiency enhancement, compliance cost reduction, and environmental reputation enhancement (Hart, Dowell, 2011).

Moreover, the current literature has proposed that a delay exists in obtaining rewards from eco-innovation. Jansson (2011) claimed that the success of eco-innovation depends on industry foundation, social norms, and consumer perception, that is, the evolution of social arrangement and institutional support structure. Hart and Ahuja (1996) empirically found that it takes time for environmental performance to materialize in financial performance as considerable exterior and interior reorganization and restructuring are required in place. Amores-Salvadó *et al*. (2014) analyzed a sample of 157 Spanish metal firms and concluded that eco-product innovation requires two years to positively influence operating performance. Accordingly, we propose the following hypotheses:

H1a: *Firm profitability can be enhanced by eco-product innovation with a lag.*

H1b: *Firm profitability can be enhanced by eco-process innovation with a lag.*

1.2 Demand-Side Moderators for Eco-Innovation

Innovation demand side is reflected in market demand, which undoubtedly plays an important role in deriving rewards from eco-innovation (Lin *et al*., 2013). However, no necessary link exists between market demand and economic gains because firms may undertake the minimum investment in eco-innovation to heighten legitimation and green image or because information asymmetry within environmental initiatives deters any potential value exploitation (Doran, Ryan, 2012). Government green procurement and advertising are two effective solutions to address stimulation and information asymmetry problems, respectively. Government green procurement refers to the priority of government purchase in products with smaller environmental impacts, thus exhibiting potential gains of eco-friendly technologies to other stakeholders and consequently leading to demonstration effect and wider commercialization (Brammer, Walker, 2011). Such measure can generate demand capacity from intermediate and final customers for sustainable products and services (Testa *et al*., 2011).

Chen (2008) argued that effective development of eco-innovation capabilities should be coupled with the construction and diffusion of good green corporate image to strengthen environmental legitimacy and economic return. Communication and promotion are effective tools in reinforcing green image of a firm because these tools reduce consumer distrust and consequently increase market share and profits (Amores-Salvadó *et al*., 2014). Wagner (2010) claimed that advertising serves the function of differentiation manifesting in information dissemination and signaling and confirmed empirically that advertising intensity positively moderates the relationship between sustainability management and financial performance.

Demand side moderators may exert varying degrees of influence on the two typologies of eco-innovation. Eco-product innovation renders direct benefits to consumers from resource conservation during usage and improved disposal value during recycling and reusing stages. The latter type emphasizes resource conservation and waste minimization in manufacturing process, which lead to less straightforward advantage to the image of a firm (Chen *et al*., 2006). Therefore, to the market, eco-process innovation is not as visible as eco-product innovation. Although cost savings from eco-process innovation results in the lowering of product price, the effect can still be obscure in the perception of consumers. Therefore, we propose the following hypotheses:

H2a: *Government green procurement can positively moderate eco-product innovation/profitability link but exert no influence on eco-process innovation/profitability link.*

H2b: *Advertising intensity can positively moderate eco-product innovation/profitability link but exert no influence on eco-process innovation/profitability link.*

1.3 Supply-Side Moderators for Eco-Innovation

Despite the common drivers in terms of technological and organizational capabilities (Kesidou, Demirel, 2012), eco-process innovation is different from eco-product innovation in the relative consideration of regulation instruments (Cleff, Rennings, 1999). Ghisetti and Rennings (2014) contended that factors that drive eco-innovation would affect economic outcome; thus, a set of regulatory instruments would exert varying impacts on firm profitability gains aside from market demand. In terms of command and control regulation, Hart and Ahuja (1996) demonstrated empirically that firms with the highest emission levels gain most from pollution prevention and emission reduction, indicating a subtle link between regulation intensity and firm economic outcome. The rationale is that “dirty firms,” which are heavily regulated, are most likely to benefit from the reduction in regulation cost, e.g., liability costs, fines, and litigation. Testa *et al*. (2011) demonstrated that direct regulation has a strong effect on innovation, intangible benefits, and business performance in the building and construction sector of EU region.

Another regulatory strategy frequently applied to stimulate corporate environmental management is subsidy. Subsidy in the forms of accelerated depreciation of fixed assets, tax breaks of imported equipment, incentives, and technical assistance (Dong *et al*., 2014), is a major policy instrument that supports sustainable development in China (Shen, Luo, 2015). Given that subsidy is normally applied in the circumstance of market failure to pursue social objectives, Ghisetti and Rennings (2014) argued that eco-innovation in response to financial incentives is not profitable on its own and substantiated it with the negative moderation effect of government grant on the link between externality reducing eco-innovation and profitability.

Generally, prescriptive regulation, including restrictive policies (e.g., technical standards, effluent policy, and admittance), if designed well and enforced stringently, will motivate firms in seeking improved process or method to offset the compliance cost and appropriate innovation benefits. Meanwhile, subsidy, being necessary for the launching of environmental practice with explicit social good and large outlays, may not induce profitable eco-innovation in the first place. This is especially the case for eco-process innovation, as subsidy mainly pays for the externality reducing eco-innovations such as end-of-pipe equipment procurement (Ghisetti, Rennings, 2014). Hence, we hypothesize the following:

H2c: *Regulation intensity can positively moderate the relationship in eco-product innovation/profitability and eco-process innovation/profitability link.*

H2d: *Subsidy exerts no impact on the eco-product innovation/profitability and eco-process innovation/profitability link.*

1.4 Value Appropriation Mechanisms

Hart (1995) proposed the natural-resource-based view that firms adopting pollution prevention or product stewardship would accumulate key resources, such as efficiency improvement and shareholder integration, and subsequently competitive advantage in cost leadership and preempt competition. This claim sheds light on the two mechanisms through which firms acquire innovation profits, namely, productivity improvement and market expansion. For the former mechanism, Porter and Van der Linde (1995) theorized that pollution represents economic waste or incomplete utilization of resources with which reduction could mean enhanced productivity. Long *et al*. (2015) empirically supported the positive association between productivity and eco-efficiency based on evidence from cement industry manufacturers. The latter mechanism mainly stems from product differentiation through embedding environmental concepts into design and packaging, leading to new market segments and enhanced firm image (Hart, Dowell, 2011). Given the different focuses of the two types of eco-innovation in manufacturing and product, the two mechanisms vary in the means concerning the exploitation of economic benefits. Thus, we hypothesize the following:

H3a: *Productivity improvement and market expansion correspond to the main mechanism for rewarding from eco-process innovation and eco-product innovation, respectively.*

The interaction of moderators and mechanism proxies should also be considered, because the outcome can indicate whether the efforts on behalf of demand- or supply-side can effectively induce the actual growth manifesting in market expansion or efficiency improvement (Cheng *et al*., 2014). Thus, we propose the following:

H3b: *Market expansion mechanism is more pronounced given a higher level of innovation demand-side moderators.*

H3c: *Productivity enhancement mechanism is more pronounced given a higher level of innovation supply-side moderators.*

2. Methodology

The current work aims to measure the net effect of eco-innovation, namely, the average treatment effect on the treated (ATT), which can be expressed as

$$ATT = E[Y_{i1} \mid D_i = 1] - E[Y_{i0} \mid D_i = 1] \quad (1)$$

where D denotes eco-innovation indicator. $Y_{i1} \mid D_i = 1$ and $Y_{i0} \mid D_i = 1$ represent the profitability of eco-innovation firms and counterfactuals, respectively. Counterfactual is the hypothetical profitability of eco-innovation firm supposing that it does not implement eco-innovation. Since $Y_{i0} \mid D_i = 1$ could not be observed, it is necessary to consider whether eco-innovation practice has randomness. When eco-innovation is random, ATT can be obtained by comparing the averages between innovation-implementing and non-implementing firms. When the implementation of eco-innovation is related to a series of factors, the comparison of the averages will result in selection bias. Therefore, PSM is applied to identify the control sample against eco-innovation firm sample to simulate the random experiment. One of the underlying conditions of PSM is conditional independence assumption, which requires profitability to be independent of indicator variable D after controlling the effects of co-variates X . This relation can be expressed as

$$ATT = E[Y_{i1} \mid D_i = 1, X_i] - E[Y_{i0} \mid D_i = 1, X_i] \qquad (2)$$

where X is the multidimensional vector of the common characteristics between innovation-implementing firms and control sample. To address the multidimensionality of X , the eco-innovation propensity score $p(X_i)$ controlling X is used as the selection basis of the control sample. This step ensures that eco-innovation participation is the only ex-ante difference between the eco-innovation and control groups, thereby meeting the condition of common support assumption underlying PSM. ATT can be described as follows:

$$ATT = E[Y_{i1} \mid D_i = 1, p(X_i)] - E[Y_{i0} \mid D_i = 0, p(X_i)] \qquad (3)$$

The propensity score $p(X_i)$ can be estimated by the logit model following the existent literature (Lian *et al.*, 2011) and operationalized as follows:

$$p(X_i) = \Pr(D_i = 1 \mid X_i) = \frac{\exp(\beta X_i)}{1 + \exp(\beta X_i)} \qquad (4)$$

Therefore, PSM converts the multidimensional eigenvector ex-ante eco-innovation propensity score though logit regression. In comparison with the matching method based on industry and year in similar studies (Clarkson *et al.*, 2011), PSM not only avoids the specification of functional form and error term distribution but also extends match dimensions. According to the literature, the drivers of eco-innovation are comprised of firm intrinsic factors, market pull, technology push, and regulation (Kesidou, Demirel, 2012). In the same vein with the current studies, firm size (SIZE), ownership (STATE), profitability (MARGIN), and environmental management capability (ISO) are used in the present work to proxy firm intrinsic factors. Industry competition Herfindahl index (HHI) and government green procurement (GREENP) are used to proxy market pull. Technology pull is delegated by RD dummy (RD). Regulation stringency (REGU) and subsidy (SUB) represent regulation instruments. Moreover, industry effect is controlled by industry dummy (INDUS_D). The logit model is expressed as

$$\begin{aligned} \Pr(D_i = 1 \mid X_i) &= \beta_0 + \beta_1 SIZE + \beta_2 STATE + \beta_3 MARGIN + \beta_4 ISO + \beta_5 HHI \\ &+ \beta_6 GREENP + \beta_7 RD + \beta_8 REGU + \beta_9 SUB + \beta_{10} INDUS\_D + \varepsilon_{it} \end{aligned} \qquad (5)$$

Given that $p(X_i)$ is a continuous variable, locating the control firm with exactly the same propensity score is difficult. The general practice is to apply certain matching method with which the options include nearest neighbor matching, Kernel matching, and caliper matching. The nearest neighbor matching is based on the following expression:

$$C(i) = \min_j \| p_i - p_j \| \qquad (6)$$

where $C(i)$ denotes the control sample; and p_i and p_j are the propensity scores of the eco-innovation and control group, respectively. Caliper matching differs from the nearest neighbor matching in terms of searching radius and is described as follows:

$$C(i) = \left\{ \| p_i - p_j \| < r \right\} \qquad (7)$$

where r is the pre-determined positive real number. Based on the study of Hottenrott and Lopes-Bento (2014), caliber matching is applied in the present work to reduce the bias from matching above a certain distance and avoid the creation of fictitious unit as Kernel matching does.

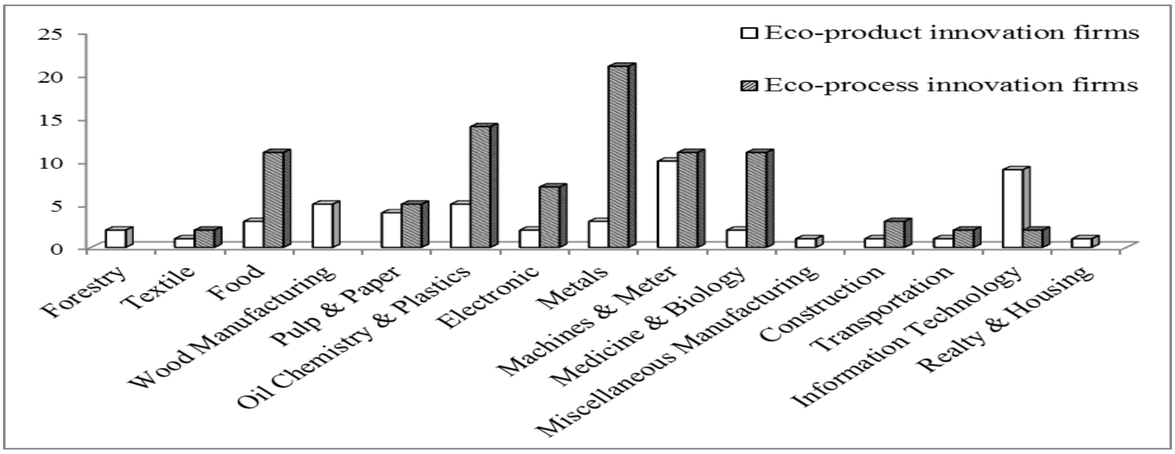
3. Empirical Data and Analysis

3.1 Sample selection

The identification of eco-innovation firm is a preliminary step in our study. A total of 104 listed firms with eco-label and 160 listed firms with cleaner production accreditation were selected to represent eco-product innovation firms and eco-process innovation firms, respectively. Sample firms are all selected from China's two main board markets between 2012 and 2013. Particularly, we identified the two types of listed companies from the official websites of China Ministry of Environmental Protection and China Cleaner Production Center through retrieval of every firm in the eco-label and cleaner production accreditation databases. The former database offers detailed information about the range of products with extraordinary environmental features based on the criteria that the product has reduced waste and toxic elements and enhanced resource efficiency throughout the entire life cycle relative to conventional products. This measure coincides with the definition of eco-product innovation. Lin *et al*. (2014) applied eco-label certification to proxy for eco-product innovation in China. Meanwhile, the latter database provides information on the output of qualified cleaner production of firms, industry, and auditing agencies with a focus on corporate production management and pollutant emission control (Diao *et al*., 2009). Cleaner production, which refers to a range of environmental friendly innovations and especially contamination prevention in China's context, can be applied as a valid measure of eco-process innovation (Zeng *et al*., 2011).

Sample selection is based on the following considerations. First, listed companies are not only financially advantageous compared with non-listed ones given the prevalence of "soft budget" in China (Fan *et al*., 2013), but are also subject to greater pressure to maintain legitimacy due to their visibility and high environmental default costs in the stock market and firm reputation (Lin *et al*., 2014). Thus, such firms have greater capability and motivation to conduct eco-innovation. Non-listed companies, which are short of finance and resources, will struggle to meet regulation and may not exhibit much variation toward environmental management practices (Lin *et al*., 2014). Furthermore, comprehensiveness and validity of financial report disclosure of listed companies can enhance the creditability of the results. Second, current studies have generally applied survey data to measure eco-innovation (Cheng *et al*., 2014; Wong, 2013). Berrone *et al*. (2013) indicated that survey data could not elaborate complex and comprehensive environmental technologies and that questionnaire response could be seriously biased because respondents tend to present a socially desirable image of the firm. Therefore, we selected objective official disclosure to identify eco-innovation sample.

For sample filtering, we removed the firms with listing year later than 2011 to keep sufficient firm year observations to evaluate post-innovation performance and rule out the effect of IPO window dressing. We eliminated ST/*ST firms due to their abnormal financial conditions. We further excluded firms in the industries without any eco-innovation firms to facilitate matching accuracy. Eventually, we had 139 firms in our treatment group that adopt eco-innovation in 2012 and 2013, among which 89 firm adopted eco-process innovation and the remaining 50 firms engaged in eco-product innovation. For the control group, we had 652 firms that could match firms in the treatment group.



Source: China Stock Market and Accounting Research (CSMAR) database developed by Shenzhen GTA Information Technology Company, website: http://www.gtarsc.com/Home

Figure 1. **Industry Distribution for the Sample of 139 Eco-innovation Firms**

Figure 1 presents an industry frequency distribution of the eco-innovation firms. The bar chart shows that eco-process and eco-product innovation firms have the greatest number of firms in metals and machine and meter industries, respectively, and similar distribution weights in pulp and paper, machine and meter, and transportation industries. Therefore, eco-product and eco-process innovations have significant variances in industry distribution.

3.2 Variable Description

In logit regression, we used variables of SIZE, STATE, MARGIN, ISO, HHI, GREENP, RD, REGU, and SUB from 2010 to 2013. With regard to profitability, we used ROE from 2013 to 2016 to measure the profitability effect, following Hart and Ahuja (1996). Furthermore, to identify the possible avenues through which eco-product and eco-process innovations exert influence over firm performance, we used sales growth (SG) and total factor productivity (TFP) to test market expansion, as well as productivity enhancing effects. For moderating variables, we used advertising intensity (ADVER) in addition to REGU, SUB, and GREENP. *Table 1* presents measures and data sources of the variables.

Table 1. Variable description and data sources

Variable	Description	Source
SIZE	Natural logarithm value of total sales	a
STATE	Dummy variable that equals to 1 if a firm is state-owned and 0 otherwise	a
MARGIN	Operating profit divided by sale revenue	a
ISO	ISO14001 certification dummy	b
HHI	Industry competition Herfindahl index calculated by $\sum\left(MS_i/\sum MS_i\right)^2$, where MS_i is firm i's sale revenue	a
GREENP	Industries green procurement dummy	c
RD	R&D dummy	d
REGU	Output weighted "industry three waste" emissions target hitting ratios calculated by $\sum\left(\frac{E_{ij}}{\sum E_{ij}}\Big/\frac{O_i}{\sum O_i}\right)\times TH_j$, E_{ij} and $\sum E_{ij}$ are industry i's and nation's gross emission in waste material j, O_i and $\sum O_i$ are industry i's and nation's gross output, TH_j denotes industry's waste water target hitting, sulfur dioxide removal, and solid waste multipurpose use ratios	e
SUB	Logarithm of government subsidy	d
ADVER	Advertising intensity calculated by sale revenue divided by sale expense	a
ROE	Return on equity defined as shareholders' value divided by pre-tax profit	a
SG	The growth rate of sale revenue	a
TFP	Semi-parametric Levisohn-Petrin estimation	a

*Source:*a denotes CSMAR database; b is Certification and Accreditation Administration of China, website: http://www.cnca.gov.cn/; c is Product Database from the Union of Green Purchasing Network in China, website: http://www.cgpn.org/; d is footnotes to financial statement of the listed firms in CSMAR database; e stands for China Statistical Yearbook and China Environment Statistical Yearbook.

3.3 Sample Matching

We first conducted a univariate analysis to test whether endogeneity exists in the eco-innovation strategy of a firm. *Table 2* shows descriptive statistics. It could be inferred from t-test that eco-innovation firms differ significantly from control sample firms in all the selected exploratory variables, implying the necessity of applying PSM to address selection bias in the estimation of treatment effects. On average, both types of eco-innovation firms have larger size (SIZE) and ISO14001 certification proportion (ISO), invest more in R&D (RD), receive more from government subsidy (SUB), experience greater regulation pressure (REGU), but have lower profitability (MARGIN). Moreover, several dimensions exist along which two innovation categories differ. Relative to eco-process innovation firms, eco-product innovation firms have less proportion in state ownership (STATE) and ISO14001 accreditation (ISO), access to more government green procurement (GREENP), and subject to higher concentrated product market (HHI). These results indicate that eco-product innovation, which tends to be implemented in private firms within higher concentrated industry, is more dependent on market expansion while relying less on the environmental management system compared with eco-process innovation.

Table 2. Descriptive statistics for the determinant variables of eco-innovation

Variables	SIZE	STATE	MARGIN	ISO	HHI	GREENP	RD	REGU	SUB
Control	21.22	0.51	0.11	0.09	0.17	0.42	0.61	0.98	1.83
Eco-product	22.32	0.38	0.76	0.15	0.32	0.51	0.70	1.56	2.33
Eco-process	20.69	0.75	0.07	0.19	0.22	0.19	0.75	2.01	2.56
t_a	9.37***	-4.07***	-3.01	-1.46	16.78***	3.79***	1.89	2.37	5.28***
t_b	6.40***	1.82	-4.27***	4.87***	-0.45	-7.25***	5.06***	7.26***	6.27***
t_c	2.20	-2.88***	-1.04	-0.56	8.78***	7.09***	-0.84	-0.67	-0.01

Notes: : t_a, t_b, and t_c denote t-tests for differences in mean values between eco-product sample and control sample, eco-process sample and control sample, and eco-product sample and eco-process sample, respectively. ***p<0.01, ** p<0.05, *p<0.1.

Source: own calculations.

Table 3. Logistic regression results for eco-product &process innovations

Variables	Eco-product innovation			Eco-process innovation		
	M1	M2	M3	M4	M5	M6
RD		0.206	0.221	0.317	0.394	0.388
		(0.80)	(0.85)	(1.32)	(1.62)	(1.60)
ISO	1.504***	1.510***	1.494***	2.494***	2.514***	2.506***
	(6.65)	(6.67)	(6.57)	(11.32)	(11.40)	(11.35)
REGU	0.112***	0.104***	0.107***	0.056*	0.054*	0.073**
	(2.83)	(2.63)	(2.72)	(1.85)	(1.74)	(2.46)
SUB	0.226**			0.285***	0.321***	0.323***
	(1.99)			(2.36)	(2.96)	(2.97)
GREENP	0.743***	0.818***	0.701***		-0.770*	-0.787***
	(3.01)	(3.32)	(2.84)		（-3.03）	(-3.09)
HHI	4.989***	4.785***	4.751***		-0.462	
	(7.86)	(7.79)	(7.64)		（-0.46）	
MARGIN	2.146**	1.749*	1.720*	-1.196	-1.164	-1.214
	(2.17)	(1.82)	(1.70)	(-1.14)	（-1.13）	(-1.17)
SIZE	0.552***	0.572***	0.633***	0.351***	0.328***	0.342***
	(6.92)	(7.21)	(7.71)	(4.47)	(4.28)	(4.34)
STATE			-0.755***	-0.152		-0.195
			(-3.12)	(-0.70)		(-0.90)
INDUS_D	Yes	Yes	Yes	Yes	Yes	Yes
_CONS	-17.62***	-17.60***	-18.62***	-12.11***	-11.63***	-11.90***
	(-9.76)	(-9.72)	(-9.99)	(-7.13)	（-6.93）	(-6.95)
Pseudo-R^2	0.216	0.212	0.223	0.234	0.244	0.244
AUC	0.844	0.847	0.859	0.854	0.857	0.858
N	3450	3450	3450	3671	3671	3671

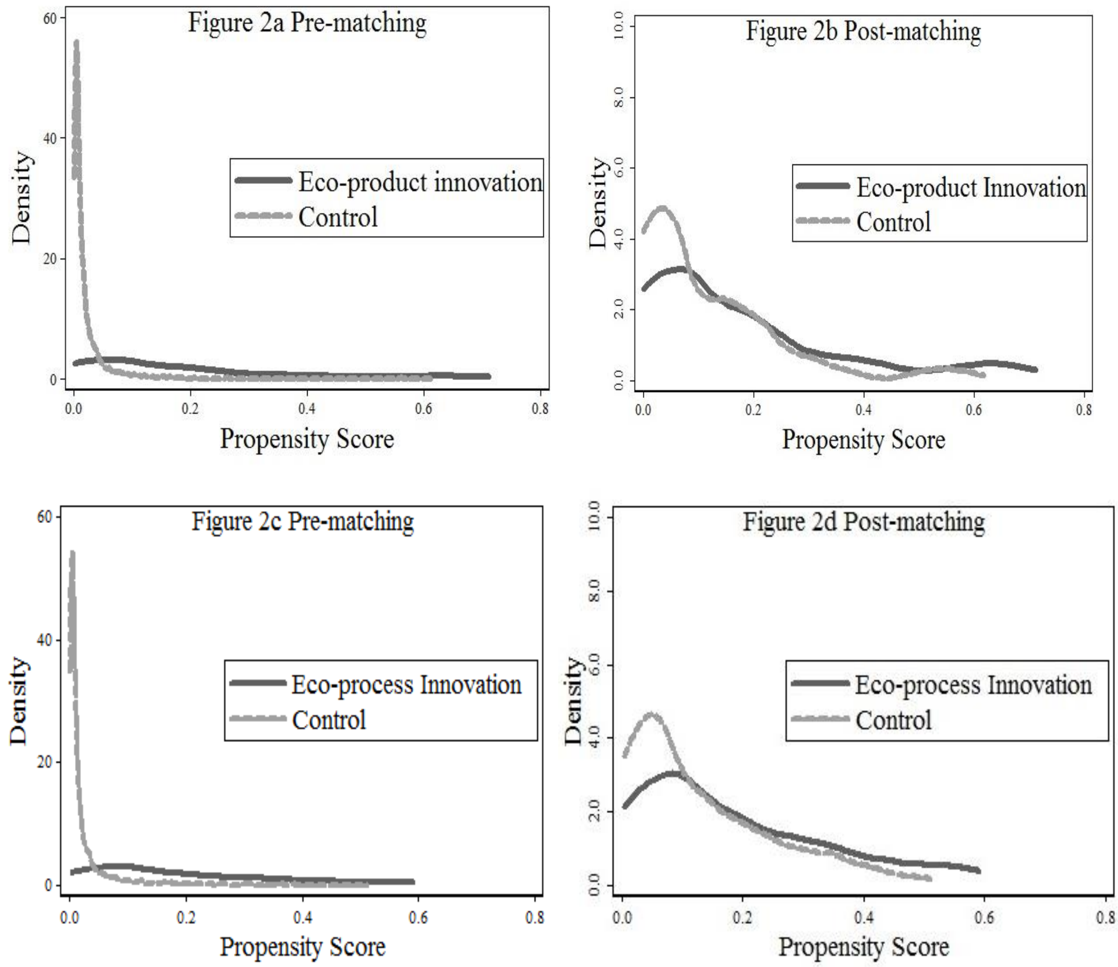
Notes: t-values are presented in the parentheses and AUC denotes the area under the Receiver Operating Characteristics (ROC) curve.***p<0.01, ** p<0.05, *p<0.1.

Source: own calculations.

Furthermore, we estimated logit models of both types of eco-innovation with various specifications and presented the results in *Table 3*. We incorporated industry dummies in all the models in *Table 3* to control for industry effects. In line with previous literature, the propensity of eco-product and eco-process innovations are significantly positively related to environmental management system (ISO), government regulation intensity (REGU), economic incentive schemes (SUB), and firm size (SIZE) (Kesidou, Demirel, 2012; Lin *et al*., 2014). The coefficients on RD are positive as predicted (Horbach *et al*., 2012). But the coefficients are insignificant in every model due to fragmentary data pertaining to RD. Firm profitability (MARGIN) exerts positive effect on eco-product innovation but has insignificant effect on eco-process innovation. Hence, the firm with adequate financial resources may have the capabilities to develop long-term competence and allocate sufficient funds to ecological initiatives (Lin *et al*., 2014). Moreover, the propensity to implement both typologies of eco-innovation is lower in state-owned firms relative to other firms. As state ownership brings favorable credit loans, tax redemptions, fiscal subsidies, and regulation lenience to the listed companies, these measures can disincentive firms from resolving environmental issues proactively (Lin *et al*., 2014). Green procurement (GREENP) and industry competition (HHI) influence the probabilities of the two types of innovations in the opposite directions. GREENP is positively correlated with eco-product innovation while negatively related to eco-process innovation; hence, a firm makes exclusive strategies on eco-process or eco-product innovations given the anticipated market augmentation and limited resources. HHI exhibits similar direction to green procurement, albeit with declining significance on eco-process innovation; thus, eco-product innovation is driven by the motive to utilize higher profitability potential in highly concentrated industries (i.e., monopolistic markets) (Ghisetti, Rennings, 2014). These findings substantiate the finding of Cleff and Rennings (1999) in that eco-product innovation is determined significantly by strategic market behaviors, whereas eco-process innovation is driven more by regulation policy.

Since matching metric is propensity score derived from Logit models, it is crucial that we obtain acceptable goodness of fit to guarantee a valid matching. The commonly adopted indices for the diagnosis of dichotomous dependent variables models are pseudo-R2 and the area under the ROC curve (AUC). Pseudo-R2 refers to the ratio of the actual increment of log likelihood function to the maximum increment. AUC measures the area under the ROC curve with correct discrimination rate as the y-axis versus false discrimination rate as the x-axis. The pseudo-R2s in all the specifications range from 0.216 to 0.244 which are comparable to those reported in the eco-innovation determinant studies like Cleff and Rennings (1999) and Kesidou and Demirel (2012). AUC values are all above the suggested value of 0.8, indicating good model discrimination (Lian *et al*., 2011). By combining pseudo-R2 and AUC value, we selected M3 and M6 as the basic specifications for eco-product and eco-process innovation determination models, respectively, upon which we will calculate propensity scores for each firm.

Two prerequisites must be met to ensure validity of sample matching. The first condition is common support assumption, which requires the propensity score distribution of the treatment group and control group to overlap on the whole. We generated kernel density functions of both typologies of eco-innovation against its control sample based on pre- and post-matching propensity scores (figures 2a–2d). From *Figure* 2a and *Figure* 2c, eco-product and eco-process innovation groups exhibit significant differences from control groups either in the highest frequency or the entire propensity level. After applying the nearest neighbor matching approach, the kernel density functions of both categories of eco-innovation display a lot closer with their control groups (*Figure* 2b and *Figure* 2d). For the second prerequisite (i.e., balancing assumption), the t-statistics in *Table 4* indicate that all our covariates are well balanced because no significant differences exist in variable means (Hottenrott, Lopes-Bento, 2014).



Source: author's own results.

Figure 2. **Pre- and Post-Matching Kernel Density Estimations of Propensity Scores**

Table 4. Balancing test of matching covariates

Variables	Eco-product N=50	Control N=232	t-statistics	Eco-process N=89	Control N=266	t-statistics
	Mean	mean		mean	mean	
Margin	0.086	0.089	-0.16	0.062	0.063	-0.07
SIZE	22.437	22.315	0.56	22.08	22.108	-0.15
ISO	0.538	0.534	0.05	0.748	0.768	-0.35
REGU	1.463	1.464	-0.00	2.152	1.918	0.50
GREENP	0.505	0.530	-0.34	0.193	0.227	-0.63
STATE	0.495	0.491	0.05	0.622	0.577	0.70
RD	0.742	0.759	-0.28	0.782	0.790	-0.16
HHI	0.254	0.261	-0.24			
SUB				2.459	2.425	0.28

Source: own calculations.

4. Results and Discussion

4.1 Result Analysis

H1a to **H1d** predict that eco-product and eco-process innovations will exert positive impact on firm profitability with a lag. To test these hypotheses, we examined the average treatment effects on the treated (ATT) for our outcome measure ROE subsequent to accreditation year. The statistics are shown in *Table 5* with the comparisons of the eco-product innovation/control group matched pairs in Panel A and the comparisons of eco-process innovation/control group matched pairs in Panel B, respectively.

Table 5. Average treatment effect on the treated (ATTs) based on the metric of ROE

Panel A: ATTs for Eco-product Innovation versus Control Group					
Sample	2013	2014	2015	2016	overall
Eco-product	0.156	0.108	0.104	0.136	0.131
Control	0.122	0.098	0.095	0.093	0.107
Unmatched difference	0.036*** (2.72)	0.030** (2.32)	0.012 (0.91)	0.046*** (3.51)	0.029*** (4.47)
ATT	0.034 (1.62)	0.009 (0.46)	0.010 (0.40)	0.043** (1.99)	0.024** (2.37)
Panel B: ATTs for Eco-process Innovation versus Control Group					
Eco-process	0.111	0.086	0.060	0.068	0.069
Control	0.091	0.081	0.055	0.0225	0.070
Unmatched difference	0.008 (0.59)	-0.010 (-1.12)	-0.034*** (-3.47)	-0.006 (-0.66)	-0.018*** (-3.58)
ATT	0.196 (1.14)	0.006 (0.48)	0.005 (0.39)	0.025** (1.99)	-0.000 (-0.08)

Notes: *** p<0.01, ** p<0.05, *p<0.1.T-values are presented in the parentheses.

Source: own calculations.

As can be seen from Panel A, the eco-product firms appear to experience greater improvements in ROE relative to their matched firms only until 2016 while exhibiting minor ROE increase at insignificant levels in other years. This is in line with that of Hart and Ahuja (1996), in which they asserted that it takes two years before financial performance could be positively affected by environmental proactive strategies. The significant mean differences in ROE between unmatched pairs indicate that we will overestimate the economic outcome of eco-product innovation in the absence of matching. Panel B in *Table 5* suggests an analogous but weaker pattern pertinent to the eco-process/control group pairs because the overall ATTs on ROE are significantly positive for eco-product innovation firms but insignificant for eco-process innovation firms. This result is probably due to the mixed results of different eco-process innovation types, i.e., whether it is a cleaner production measures or add-on measures. With the distinguished objectives to reduce negative externalities and improve productivity, these two types of innovation will have opposite economic implications (Ghisetti, Rennings, 2014). Another minor difference is the unmatched differences of ROE, which is opposite to the direction reported in eco-product innovation/control group comparison. The result is indicative of downward effects of eco-process innovation if we do not control for selection bias. Overall, our treatment analysis suggests that eco-product and eco-process innovations will lead to lagging profitability gains with the former one displaying a stronger pattern. This outcome validates **H1a** and **H1b**.

A central question that arises from the reported positive economic outcome is whether the specific features either on half of demand- or supply-side can facilitate the utilization of economic gains. We illuminated this question by testing the moderating effects of innovation demand- and supply-side factors on ATTs. We used the variables GREENP, ADVER, REGU, and SUB to classify the entire sample. Aside from dummy variable GREENP and SUB, we used 75thand 25th percentiles as the cutoffs to generate classification dummies for the variables ADVER and REGU, respectively. The comparison of the subgroups with respect to the economics gains (ROE) of eco-innovation is shown in *Table 6*. *Table 6* shows that ATTs in the higher-level moderator groups experience greater magnitude of increase compared with those in the last columns of *Table 5* while displaying insignificance in the lower-level moderator group. This result indicates that the demand- and supply-side moderators strengthen the relationship between eco-product innovation and firm profitability. It is not the highest but the upper middle level of advertising (ADVERQ3–Q4) and regulation intensity (REGUQ3–Q4) variables serve the role of moderators, shedding light on the appropriate level in regulation and advertising in triggering greater economic benefits from eco-product innovation. This finding on eco-product innovation is coherent with Wagner (2010) and supports **H2a** and **H2b**.

Table 6. Moderating effect of demand-side and supply-side factors

Partition variables	Eco-product innovation		Eco-process innovation	
	ATT	t-statistics	ATT	t-statistics
GREENP=1	0.041***	2.66	0.014	0.69
GREENP=0	0.008	0.56	-0.014	-0.81
$ADVER_{ABOVE\ Q4}$=1	0.016	0.70	0.000	0.03
$ADVER_{Q3–Q4}$=1	0.077*	1.70	0.027	0.64
$ADVER_{Q2–Q3}$=1	0.032	1.31	-0.032	-1.64
$ADVER_{Q1–Q2}$=1	0.034	0.95	-0.063	-0.056
$REGU_{ABOVE\ Q4}$=1	-0.011	-0.55	0.008	0.30
$REGU_{Q3–Q4}$=1	0.061***	2.67	-0.031	-1.05
$REGU_{Q2–Q3=1}$	0.015	0.78	0.009	0.93
$REGU_{Q1–Q2}$=1	0.013	0.65	0.022	0.72
SUB=1	0.035***	2.82	0.042***	3.13
SUB=0	0.016	0.49	0.011	0.52

Notes: REGUQ2–Q3 = 1 is not presented because no eco-innovation observations exist in this quartile. *** p<0.01, ** p<0.05, *p<0.1.T-values are presented in the parentheses.

Source: own calculations.

In terms of eco-process innovation, the only identified moderator is SUB with a higher level of subsidy indicating greater profitability utilization. This result is contradictory with Ghisetti and Rennings (2014) who found negative effect of financial grant/eco-innovation multiplier on operating margin, arguing that eco-innovation needing financial incentives is not profitable per se. Given the paramount influence government exerts on listed companies in China, this result may imply that the government can select the most promising ones to support or the subsidy per se contributes to profitability. However, regulation intensity cannot reinforce eco-process innovation/profitability link at any level. This result implies that the lack of specific data in differentiating resource efficiency and externality-reducing typologies within eco-process innovation leads to ambiguous economic returns of eco-process innovation. In addition, the non-existing moderating effect from demand-side factors implies that potential economic gains from eco-process innovation are independent of market augmentation. Thus, **H2c** and **H2d** are rejected.

In light of the above findings, one interesting question would be to assess whether market expansion and productivity enhancement mechanism proposed by Porter and Van der Linde (1995) can explain "win-win" outcome. Applying the obtained treatment effect from the matching procedure as the dependent variables, we performed several panel data regressions to test the presence of market expansion and efficiency improvement mechanism. We regressed individual ATT_{it} on a set of control variables and mechanism proxies. To investigate the additional role of moderator variables on the mechanisms, we further introduced the interaction variables in the model. The model is expressed as:

$$ATT_{it} = \alpha + \beta MECHANISM_{it} + \phi MODERATOR_{it} + \gamma INTERACTION_{it} + \eta CONTROL_{it} + \varepsilon_{it} \quad (8)$$

where $MECHANISM_{it}$ denotes productivity enhancement and market expansion mechanism represented by total factor productivity (TFP) and sales growth (SG); $MODERATOR_{it}$ represent the demand- and supply-side factors; $INTERACTION_{it}$ denote the interaction variables of TFP, SG, and demand- and supply-side factors; $CONTROL_{it}$ include firm size (SIZE) and industry dummies; and e_{it} refers to error terms. The results are presented in *Table 7*. We kept only the models with correlations of the independent variables below 0.5, thereby avoiding biased results from multicollinearity (Clarkson *et al*., 2011). According to Hausman test, we selected random and fixed effect models for eco-product and eco-process innovation regressions, respectively.

Table 7. Panel Data Analysis of Firm-level ATTs

Variables	Eco-product			Eco-process	
ROE	M1	M2	M3	M4	M5
SG	0.111*** (0.023)	0.092*** (0.024)	0.060** (0.026)	0.037*** (0.011)	0.036*** (0.010)
TFP	0.043** (0.018)			0.069** (0.032)	0.068* (0.041)
$ADVER_{Q3\text{-}Q4}$		-0.008 (0.022)			
$SG\_ADVER_{Q3\text{-}Q4}$		0.196*** (0.059)			
GREENP			-0.028 (0.658)		
SG_GREENP			0.186*** (0.047)		
SUB					0.049 (0.073)
SUB_TFP					-0.004 (0.010)
SIZE	0.006 (0.105)	0.018** (0.008)	0.020** (0.009)	-0.087*** (0.028)	-0.084*** (0.028)
INDUS_D	Yes	Yes	Yes	Yes	Yes
N	144	144	144	271	271
R^2	0.2438	0.2931	0.3302	0.1292	0.1534
Wald chi2	46.22***	52.66***	58.35***		
F				8.95***	6.49***
Hausman	1.71	1.81	2.56	12.09***	19.956***

Notes: standard errors shown in parentheses. *** p<0.01, ** p<0.05, *p<0.1.T-values are presented in the parentheses.

Source: own calculations.

Model M1 shows that sales growth and TFP are positively related to treatment effect controlling for industry and size effect. In Models M2 and M3, the above average advertising dummy (ADVERQ3–Q4), GREENP, and the interaction terms with sales growth were introduced to M1 separately to infer whether moderating effects of GREENP and ADVERQ3–Q4 better facilitate the market expansion mechanism. The combined results of M1 to M3 indicate that additional economic returns from eco-product innovation firms relative to non-adopting ones are resulted from productivity and sales growth. In addition, the latter mechanism is especially apparent for firms with government procurement orders or higher than average advertising intensity. For eco-process firms, the two mechanisms still hold but differ from eco-product innovation firms in terms of relative importance of sales growth and TFP. TFP mechanism predominate sales growth in eco-process innovation firms while exhibiting the opposite in eco-product innovation firms. In addition, the lack of significance on interaction terms of SUB and TFP suggests that subsidy is not effective in incentivizing TFP improvement. In terms of the control variable, firm size is significantly negatively related to additional profitability gains, implying that a larger firm with higher cost to adjust or alter its current production process toward greenness will lower its financial rewards from eco-innovation. Therefore, **H3a** and **H3b** are corroborated, **H3c** is rejected.

4.2 Discussion

Based on PSM and panel regression analysis, we infer the following implications.

First, our treatment analysis suggests that eco-product and eco-process innovations will result in profitability gains with the former displaying a stronger pattern. Given that eco-product innovation can address environmental impact while simultaneously improving the product and related process, more benefits can be induced (Doran, Ryan, 2012). This finding suggests that managers should transit their mindset concerning environmental constraints, from fixating on shielding or reaching the minimal legal and regulatory standards to focusing on market opportunity and productivity increase from resolving environmental problems innovatively. In the meantime, firms should allow a longer timeline for eco-innovation payback because eco-process or eco-product innovations require time for reorganization, adaptation, and market acceptance.

Second, the positive moderating effect of government green procurement on eco-product innovation/profitability link and profit-deriving mechanism proves its effectiveness in promoting ecological modernization and the national circular economy of China. To promulgate this instrument in depth and width, China can learn from the European practice, which makes purchase decision based on how specific environmental performance metrics embedded in product and service are satisfied (Geng, Doberstein, 2008). This practice is superior to current descriptive order of approved products because it involves investigation of the eco-efficiency in the production process, thereby incubating the market for more extensive environmental innovation types, such as eco-process innovation.

Third, advertising intensity can facilitate firms in obtaining desired benefits from environmental innovation initiatives; thus, eco-product innovation should be coupled with robust marketing and branding efforts (Wong, 2013). This result should be interpreted with caution given that firms in the third quartile of advertising intensity group exhibit positive ROE and sales growth rather than the highest group, which can be attributed to efficacy of advertising. Awareness and creditability constitute sound advertising (Rubik *et al.*, 2007), whereas over-marketing can convey an untruthful signal. Therefore, firms should ensure convenient access and creditability of products' green attributes (Prakash, 2002).

Fourth, regarding regulation, the significant moderation effect exhibits in the third but not the highest quartile of regulation intensity. Hence, proper regulation intensity stimulates firms to gain economic benefit from eco-product innovation, whereas the firm with the heaviest regulation will impair profitability due to additional financial resource budget diverted to environmental management. For moderation analysis and interaction effect investigation, no evidence of regulation existing at any level moderates the eco-process innovation/profitability link or intertwines with TFP to predict ATT. This result is caused by the strong association between regulation intensity and end-of-pipe technologies (Frondel *et al*., 2007), given that our dataset lacks specific information to differentiate add-on or integrative measures within eco-process innovation. The end-of-pipe technologies, which entail costly and non-productive pollution-curative equipment, will not result in productivity increase. The command-and-control regulation can be combined with other instruments to achieve desirable outcomes. For example, China can draw on the experience of OECD countries to design market-based instrument, such as car scrapping policy and tax incentives on housing insulation.

Finally, the subsidized eco-innovation firms, which outmatch control firms in profitability, do not experience comparable productivity increase, as revealed in our panel regression. This finding implies the ineffectiveness of subsidy in assisting actual growth of firms. Based on the conclusion of Jaffe *et al*. (1995) on the main obstacles countered to environmental performance, government instead of giving sum money, should arrange funds circumspectly in mitigating firm expenses in terms of searching abatement options, giving preferential credit to environmental infrastructure investments and equipment maintenance and subsidizing the switching of production resources and R&D to non-marketable output. Meanwhile, in the selection of subsidy receiver, government can subsidize poorly performing SMEs or the best environmental performing companies to generate emulative effect from rewarding the "champions" (Testa *et al*., 2011).

Conclusions

The presented results of our analysis proved the hypothesis that a two-year lagged positive link exists between eco-innovation and profitability, and innovation demand- and supply-side factors can moderate this link and interact with value appropriation mechanisms. Specifically, from the perspective of demand-side moderators, government green procurement positively moderates the eco-product innovation/profitability link and profit-deriving mechanisms. Hence, this measure effectively promotes ecological modernization and national circular economy of China. Moreover, advertising intensity can facilitate firms in obtaining desired benefits from eco-product innovation, implying that demand-side policy can induce more robust marketing and branding efforts. From the perspective of supply-side moderators, regulation intensity should be cautiously formulated because appropriate high level of regulation can stimulate innovation bonus. By contrast, high levels of regulation divert considerable firm resources and negatively affect profitability. Subsidy, albeit strengthens the eco-process innovation/profitability link, does not lead to actual firm growth. Thus, differential subsidy is advisable to take account of eco-innovation phases and subsidy receivers.

This study contributes to current literature in several perspectives. First, we juxtapose eco-process and eco-product innovations in a holistic framework to explore economic implications and factors that drive performance heterogeneity. Second, we seek to explain economic outcome heterogeneity of eco-innovation firms in terms of innovation demand-side and supply-side and identify significant moderators in the eco-innovation/profitability link. This sheds light on the construction of effective policy instruments because government may direct more inspection or support when weak association exists, presumably that such plants lack incentives to commit continuous eco-innovation. Third, our data and methodology differ from previous studies because we utilize a large dataset of listed companies rather than survey data that are restricted to certain district or industry. This will improve the credibility of eco-innovation determinant variables and economic outcome variables. Furthermore, our application of PSM in deliberately controlling for sample selection bias can better address endogeneity problem pertaining to corporate environmental strategy and filter the net effect of eco-innovation. Our study has several limitations that could be addressed in future studies. First, the accreditation year may not represent the year that innovation actually takes place. Thus, a detailed survey about the innovation-launching year of the firm is necessary. Second, listed companies may be too diversified to infer economic implication for a certain business. Although we select the firm that is accredited for its main business, this problem can still be non-negligible and entail additional information on the categorical revenue of the firm. Further research could originate from the attribute of eco-innovation itself to provide practical economic inferences. For example, eco-product innovation could further be classified according to product recoverability and energy-consuming/passive durability given that various resource commitments and consumer acceptance would certainly influence the economic prospects of firms.

References

Amores-Salvadó, J., Castro, G. M.-d., Navas-López, J.E. (2014), "Green corporate image: moderating the connection between environmental product innovation and firm performance", *Journal of Cleaner Production*, Vol. 83, pp.356-365.

Berrone, P., Andrea, F., Liliana, G., Luis, R.G.M. (2013), "Necessity as the mother of 'green' inventions: institutional pressures and environmental innovations", *Strategic Management Journal*, Vol. 34, No 8, pp.891-909.

Brammer, S., Walker, H. (2011), "Sustainable procurement in the public sector: an international comparative study", *International Journal of Operations & Production Management*, Vol. 31, No 4, pp.452-476.

Brasil, M.V.D.O., Abreu, M.C.S.D., Leocádio, A.L. (2016), "Relationship between eco-innovations and the impact on business performance: an empirical survey research on the Brazilian textile industry", *Revista De Administração*, Vol. 51, No 3, pp.276-287.

Busch, T., Hoffmann, V.H. (2011), "How hot is your bottom line? Linking carbon and financial performance", *Business & Society*, Vol. 50, No 2, pp.233-265.

Carrillo-Hermosilla, J., Rio González, P.D.R., Könnölä, T., Río González, P. (2009), *Eco-innovation: When Sustainability and Competitiveness Shake Hands*, United Kingdom: Palgrave Macmillan Press.

Chen, L., Tang, O., Feldmann, A. (2015), "Applying GRI reports for the investigation of environmental management practices and company performance in Sweden, China and India", *Journal of Cleaner Production*, Vol. 98, pp.36-46.

Chen, Y.S., Lai, S.B., Wen, C.T. (2006), "The influence of green innovation performance on corporate advantage in Taiwan", *Journal of Business Ethics*, Vol. 67, No 4, pp.331-339.

Chen, Y.S. (2008), "The driver of green innovation and green image – green core competence", *Journal of Business Ethics*, Vol. 81, No 3, pp.531-543.

Cheng, C.C., Shiu, E.C. (2012), "Validation of aproposed instrument for measuring eco-innovation: an implementation perspective", *Technovation*, Vol. 32, No 6, pp.329-344.

Cheng, C.C.J., Yang, C.l., Sheu, C. (2014), "The link between eco-innovation and business performance: a Taiwanese industry context", *Journal of Cleaner Production*, Vol. 64, pp.81-90.

Clarkson, P.M., Li, Y., Richardson, G.D., Vasvari, F.P. (2011), "Does it really pay to be green? determinants and consequences of proactive environmental strategies", *Journal of Accounting and Public Policy*, Vol. 30, No 2, pp.122-144.

Cleff, T., Rennings, K. (1999), "Determinants of environmental product and process innovation", *Environmental Policy and Governance*, Vol. 9, No 5, pp.191-201.
Demirel, P., Kesidou, E. (2011), "Stimulating different types of eco-innovation in the UK: government policies and firm motivations",*Ecological Economics*, Vol. 70, No 8, pp.1546-1557.
Diao, X.D., Zeng, S.X., Tam, C.M., Tam, V.W.Y. (2009), "EKC analysis for studying economic growth and environmental quality: a case study in China", *Journal of Cleaner Production*, Vol. 17, No 5, pp.541-548.
Dong, Y., Wang, X., Jin, J., Qiao, Y.B., Shi, L. (2014), "Research on effects of eco-innovation types and regulations on firms' ecological performance: empirical evidence from China", *Journal of Engineering and Technology Management*, Vol. 34, pp.78-98.
Doran, J., Ryan, G. (2012), "Regulation and firm perception, eco-innovation and firm performance", *European Journal of Innovation Management*, Vol. 15, No 4, pp.421-441.
Doran, J., Ryan, G. (2016), "The importance of the diverse drivers and types of environmental innovation for firm performance", *Business Strategy and the Environment*, Vol. 25, No 2, pp.102-119.
Elkington, J. (1998), "Partnerships from cannibals with forks: the triple bottom line of 21st century business", *Environmental Quality Management*, Vol. 8, No 1, pp.37-51.
Elsayed, K., Paton, D. (2005), "The impact of environmental performance on firm performance: static and dynamic panel data evidence", *Structural Change and Economic Dynamics*, Vol. 16, No 3, pp.395-412.
Fan, J.P.H., Huang, J., Zhu, N. (2013), "Institutions, ownership structures, and distress resolution in China", *Journal of Corporate Finance*, Vol. 23, pp.71-87.
Frank, B., Wagner, M. (2009), "Assessing the relationship between economic and ecological performance: distinguishing system levels and the role of innovation", *Ecological Economics*, Vol. 68, No 7, pp.1908-1914.
Frondel, M., Horbach, J., Rennings, K. (2007), "End-of-pipe or cleaner production? An empirical comparison of environmental innovation decisions across OECD countries", *Business Strategy and the Environment*, Vol. 16, No 8, pp.571-584.
Geng, Y., Doberstein, B. (2008), "Greening government procurement in developing countries: building capacity in China",*Journal of Environmental Management*, Vol. 88, No 4, pp.932-938.
Ghisetti, C., Rennings, K. (2014), "Environmental innovations and profitability: how does it pay to be green? An empirical analysis on the German innovation survey", *Journal of Cleaner Production*, Vol. 75, pp.106-117.
Hart, S.L. (1995), "A natural-resource-based view of the firm", *Academy of Management Review*, Vol. 20, No 4, pp.986-1014.
Hart, S.L., Ahuja, G. (1996), "Does it pay to be green? An empirical examination of the relationship between emission reduction and firm performance", *Business Strategy and the Environment*, Vol. 5, No 1, pp.30-37.
Hart, S.L., Dowell, G. (2011), "A natural-resource-based view of the firm: fifteen years after", *Journal of Management*, Vol. 37, No 5, pp.1464-1479.
Horbach, J., Rammer, C., Rennings, K. (2012), "Determinants of eco-innovations by type of environmental impact - the role of regulatory push/pull, technology push and market pull", *Ecological Economics*, Vol. 78, pp.112-122.
Hottenrott, H., Lopes-Bento, C. (2014), "(International) R&D collaboration and SMEs: the effectiveness of targeted public R&D support schemes", *Research Policy*, Vol. 43, No 6, pp.1055-1066.
Jaffe, A.B., Peterson, P.R.P., Stavins, R.N. (1995), "Environmental regulations and the competitiveness of U.S. manufacturing: what does the evidence tell us?", *Journal of Economic Literature*, Vol. 33, No 1, pp.132-163.
Jansson, J. (2011), "Consumer eco-innovation adoption: assessing attitudinal factors and perceived product characteristics", *Business Strategy and the Environment*, Vol. 20, No 3, pp.192-210.
Kammerer, D. (2009), "The effects of customer benefit and regulation on environmental product innovation: empirical evidence from appliance manufacturers in Germany", *Ecological Economics*, Vol. 68, No 8-9, pp.2285-2295.
Kesidou, E., Demirel, P. (2012), "On the drivers of eco-innovations: empirical evidence from the UK", *Research Policy*, Vol. 41, No 5, pp.862-870.
Lian, Y.J., Su, Z., Gu, Y.D. (2011), "Evaluating the effects of equity incentives using PSM: evidence from China", *Frontiers of Business Research in China*, Vol. 5, No 2, pp.266-290.
Lin, R.J., Tan, K.H., Geng, Y. (2013), "Market demand, green product innovation, and firm performance: evidence from Vietnam motorcycle industry", *Journal of Cleaner Production*, Vol. 40, pp.101-107.
Lin, H., Zeng, S.X., Ma, H.Y., Qi, G.Y., Tam, V.W.Y. (2014), "Can political capital drive corporate green innovation? lessons from China", *Journal of Cleaner Production*, Vol. 64, pp.63-72.

Long, X., Zhao, X., Cheng, F. (2015), "The comparison analysis of total factor productivity and eco-efficiency in China's cement manufactures", *Energy Policy*, Vol. 81, pp.61-66.

Peng, X.R., Huang, X. (2013), "Analysis of frontier research of influencing factors of eco-innovation and prospects for future hot research topics", *Foreign Economics & Management*, Vol. 35, No 9, pp.61-71.

Porter, M.E., Van der Linde, C. (1995), "Green and competitive: ending the stalemate", *Harvard Business Review*, Vol. 73, No 5, pp.120-134.

Prakash, A. (2002), "Green marketing, public policy and managerial strategies", *Business Strategy and the Environment*, Vol. 11, No 5, pp.285-297.

Qi, G.Y., Zeng, S.X., Li, X.D., Tam, C.M. (2012), "Role of internalization process in defining the relationship between ISO 14001 certification and corporate environmental performance", *Corporate Social Responsibility and Environmental Management*, Vol. 19, No 3, pp.129-140.

Rubik, F., Frankl, P., Pietroni, L., Scheer, D. (2007), "Eco-labelling and consumers: toward are-focus and integrated approaches", *International Journal of Innovation and Sustainable Development*, Vol. 2, No 2, pp.175-191.

Sarkar, A.N. (2013), "Promoting eco-innovations to leverage sustainable development for eco-industry and green growth", *European Journal of Sustainable Development*, Vol. 2, No 1, pp.171-224.

Shen, J.F., Luo, C. (2015), "Overall review of renewable energy subsidy policies in China-contradictions of intentions and effects",*Renewable and Sustainable Energy Reviews*, Vol. 41, pp.1478-1488.

Telle, K. (2006), "It pays to be green"-apremature conclusion?", *Environment & Resource Economics*, Vol. 35, No 3, pp.195-220.

Testa, F., Iraldo, F., Frey, M. (2011), "The effect of environmental regulation on firms' competitive performance: the case of the building and construction sector in some EU regions", *Journal of Environmental Management*, Vol. 92, No 9, pp.2136-2144.

Wagner, M. (2010), "The role of corporate sustainability performance for economic performance: a firm-level analysis of moderation effects", *Ecological Economics*, Vol. 69, No 7, pp.1553-1560.

Wong, S.K.S. (2013), "Environmental requirements, knowledge sharing and green innovation: empirical evidence from the electronics industry in China", *Business Strategy and the Environment*, Vol. 22, No 5, pp.321-338.

Zeng, S.X., Meng, X.H., Zeng, R.C., Tam, C.M., Tam, V.W.Y., Jin, T. (2011), "How environmental management driving forces affect environmental and economic performance of SMEs: a study in the northern China district", *Journal of Cleaner Production*, Vol. 19, No 13, pp.1426-1437.

AR GALIMA PASINAUDOTI EKONOMINE NAUDA IŠ EKOLOGINIŲ INOVACIJŲ? EMPIRINIS KINIJOS ĮMONIŲ TYRIMAS

Ding Ma, Jian-mu Ye, Ya-rui Zhang

SANTRAUKA

Straipsnyje nagrinėjamos ekologinių inovacijų, uždirbimo ciklo ir nenumatytų veiksnių rūšys, susijusios su ekologinėmis naujovėmis ir pelningumu. Remiamasi 2010–2016 metų Kinijos įmonių duomenimis. Tendencijos rezultatų atitikimo metodas rodo, kad ekologinės naujovės gali turėti teigiamą poveikį įmonės pelningumui, kai vėluojama apie dvejus metus. Paklausos veiksniai, kuriuos rodo žaliųjų viešųjų pirkimų ir reklamos intensyvumas, bei pasiūlos veiksniai, kuriuos lemia reguliavimo intensyvumas ir subsidijos, teigiamai sumažina ekologinio produkto inovacijų bei pelningumo sąsają. Vienintelis reikšmingas ekologinio proceso naujovių / pelningumo moderatorius yra subsidija. Grupės regresijos rezultatai patvirtina, kad ekologinių produktų inovacijų įmonėse, turinčiose ekologiškų viešųjų pirkimų užsakymų arba didelį reklamos intensyvumą, rinkos išplėtimas yra ryškesnis. Šie rezultatai rodo, kad paklausos politika gali optimizuoti žaliojo pirkimo mechanizmą ir paskatinti intensyvesnę ekologišką reklamą, kai pasiūlos politika gali formuluoti aplinkosaugos reglamentavimą ir skatinti subsidijų diferencijavimo lygį.

REIKŠMINIAI ŽODŽIAI: ekologinės naujovės, pelningumas, mažėjantis poveikis, linkę vertinti nuoseklumą, Kinija.