Carbon disclosure and corporate green innovation: Evidence from Japan

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1. Introduction

Green innovation plays a crucial role in mitigating climate change. Since companies are key players in technological development, it is vital to understand how their innovation activities interact with mandatory and voluntary motivations. The innovation effect of mandatory policy instruments such as carbon taxes and emissions trading schemes is supported by the induced innovation theory originated from Hicks (1932). Besides complying with mandatory requirements, firms also respond to climate change through voluntary disclosure of carbon information. As one type of voluntary environmental regulation, the environmental disclosure has been found to have positive effects on firms' green innovations (Xiang et al., 2020; Yin and Wang, 2018). The impact, however, could also be inverse, since innovative firms are more likely to disclose their information for their confidence, capability, and motivation (Li et al., 2018). Therefore, the likelihood and quality of disclosure could be the result of firms' innovation output. In this study, we examine the two-way causality between carbon disclosure and green innovation and tests if there is a reinforcing relationship between them. It also sheds lights on the possibility for policy instruments to direct innovations towards green technologies by promoting environmental disclosure.

2. Methodology

We construct patent and disclosure equations as follows:

$$Patent_{it} = \alpha_0 + \alpha_1 Disclosure_{it} + \alpha_2 X_{it} + \epsilon_{it} \quad (1)$$
$$Disclosure_{it} = \beta_0 + \beta_1 Patent_{it} + \beta_2 X_{it} + \eta_{it} \quad (2)$$

where $Patent_{it}$ represents the number of patent application in environmental technology by firm i in year t and $Disclosure_{it}$ represents the level of environmental information disclosure by firm i in year t. Environmental patents are identified using the codes obtained from International Patent Classification (IPC) Green Inventory. Disclosure levels of listed firms in Japan are measured by rankings from F to A provided by the Carbon Disclosure Project (CDP) which we define as an ordinal variable from 1 to 5. The vector of exogenous control variables consists financial data including the number of employees, sales, R&D expenditures, capital stock, and return on equity (ROE). All the financial variables except employees and ROE are adjusted for deflation (2015=100).

We employ a fixed-effect Poisson model and a fixed-effect ordered logit model to estimate Equation (1) and Equation (2), respectively. The estimation for each equation is conducted in two stages due to the simultaneity between innovation and disclosure. While the simultaneous equations could be more efficiently estimated as a system, we estimate equation-by-equation due to the different model specifications which could cause cross-model bias. We first instrument for green innovations (ranking) in the ranking (innovation) equation, and then use the fitted values of green innovations (ranking) as the key explanatory variable for the ranking (innovation) regression. Fitted values of rankings are predicted probabilities of being given specific scores. We employ the lagged number of patents in technology fields other than green inventories as an instrumental variable (IV) for green patents. Innovations in other technology areas are less likely to directly affect environmental disclosure except through innovations in environmentally sound technologies thus can be considered as a valid instrument. We instrument for ranking scores with the number of facilities that are not regulated by the carbon cap-and-trade program, since firms with higher number of such facilities are less likely to spur innovations associated with environmental technologies, while they directly affect firms' environmental performance.

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3. Main Findings

By using the sample of Japanese firms spanning from 2013 to 2018, we found that the effect of green patents on environmental information transparency is not statistically significant as shown in Column (1) in Table 1. Intuitively, it takes time for a technology to be applied and to affect disclosure, to which we attribute the little effect of patents on contemporaneous rankings. Disclosure is only found to be responsive to the number of unregulated facilities, which suggests a link between environmental performance and environmental disclosure. Moreover, the increasing difference between thresholds indicates a larger response from lower-ranked firms to changes in explanatory variables. Regarding the innovation effect of disclosure, being rated D or A is associated with an increase in the number of green patents while we found no evidence that a C or B grade promotes green innovations. In terms of magnitude, an A ranking is particularly effective in spurring innovations.

Table 1: Main Results

Dependent variable		Ranking (1)		Patents (2)
Key explanatory variables	Patents	0.0004 (0.0025)	Pr(ranking = D)	0.6853 (0.2714)
	Number of unregulated facilities	-0.4542 (0.1803)	Pr(ranking = C)	-0.0061 (0.2327)
	Threshold 1	1.4540	Pr(ranking = B)	-0.8088 (0.7430)
	Threshold 2	3.5443	Pr(ranking = A)	21.4888 (7.0488)
	Threshold 3	6.8752		

Note: Other explanatory variables are omitted from the table.

4. Conclusion

The findings suggest that green patents are indeed driven by a voluntary environmental regulation, while the reinforcing relationship between them is not confirmed. Environmental disclosure is a driving force of green innovations, particularly a disclosure with comprehensive information. Even a small step from F ranking (fail to disclose) to D ranking makes difference in improving green technologies. Policies that encourage environmental disclosure, therefore, would provide firms with incentives for innovation and increase technological advancement. Moreover, since we confirmed that disclosure activities are responsive to environmental performance, policy instruments that improve corporate environmental performance could make firms more confident in disclosing environmental information, particularly for those that perform poorly, thus lead to development in green technologies.

References

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