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Exploring the Effects of Government Policies on Economic Performance: Evidence Using Panel Data for Korean Renewable Energy Technology Firms

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Abstract: Previous studies have investigated how government policies on renewable energy technology (RET) affect economic performance at the industrial level. However, each firm in the RET industry is heterogeneous in terms of their capacities, resources, and the amount of public subsidies they receive. Considering the context in which public subsidies are provided to firms, this study econometrically investigates the effects of government policies on firms' financial performance using panel data from the Korean RET industry. We consider the results of various panel framework tests; establish a panel vector autoregressive model in first differences; and test the dynamic relationships between firms' financial performance, government subsidies (R&D- and non-R&D-related), firm size and age, and organizational slack, using a bias-corrected least squares dummy variable estimator. We find that R&D- and non-R&D-related subsidies positively affect firms' financial performance in the long run. In the short run, there are bidirectional positive causal relationships between firms' financial performance and organizational slack (and non-R&D-related subsidy), and firm size and non-R&D-related subsidy. A positive short-run relationship runs from R&D-related subsidy to firms' financial performance, from firm age to non-R&D-related subsidy, and from firm size to firm age. Further, there are dynamic effects in all estimations, demonstrating that the dependent variables of the previous period enhance their values in the current period. The results provide some policy and strategic implications.

Keywords: renewable energy technology industry; government policies; firms' financial performance; dynamic panel approach

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1. Introduction

The renewable energy technology (RET) sector is one of the most important contributors to a new paradigm for growth in the 21st century that is environmentally sound and sustainable, and conveys a normative message that economic development should harmonize with human and environmental health protection. Given that RET is acknowledged as a sustainable source of energy, the question of how governments promote its growth has motivated policymakers and economists to address the interrelations between public policies and economic performance. Subsequently, the range of policy and research interests in the relationships between public policies and economic growth, energy supply, production of technologies and components, technological innovation, international capital flows, and industry and firm competitiveness has expanded in many countries globally.

By extension of such interests, many studies have investigated the relationships among public policy, export, and financial performance, and more focus has been placed on the analysis of the public policy-export nexus. Despite the fact that firms are the direct beneficiaries of public policy support, the existing literature has explored these relationships primarily at the industry and multi-country levels, and not at the firm and single-country levels. There have been academic efforts to investigate the effects of public policies on firms' financial performance [1–3] and exports [4]. However, apart from research on China, relatively less attention has been paid to analyses at both the firm and single-country levels in a longitudinal context.

Situations where firms of different countries are the direct beneficiaries of public policy support, suggest that to effectively and efficiently implement policy, empirical testing of the effects of public policies on economic performance needs to be conducted at the firm level in each country. In reality, there are differences in the internal circumstances of each firm, even within the same industry—what is called firm heterogeneity—such as response level to policy (e.g., additional investment), technology capacity level (e.g., product and process innovation, input-saving technologies, and organizational learning), system, and functional capacity level due to their internal resources. The amount of government subsidy that each firm receives also varies and changes over time. In this context, the investigation of the question of how public policies may affect firms' financial performance using a cross-sectional research design will not shed light on the dynamic relationships as time passes. Given that each firm is heterogeneous in terms of its internal (e.g., capacities, resources) and external (e.g., government subsidies) circumstances, and that such heterogeneity changes over time, financial performance promoted by government policies will vary across firms within the RET sector. In this context, the current study aims to econometrically investigate the question of how government policies affect firms' financial performance using panel data of firms from the Korean RET industry.

In this vein, the greatest contribution to the existing literature would be to deviate from the arguments from empirical tests that firms are homogeneous in all aspects—which imply that public policy support has similar effects on the economic performance of firms—and apply a heterogeneous firm framework. In particular, this study, based on the results of a literature review (for detailed results, see the Literature Review section), additionally examines how to improve and fill the gaps in the existing literature in two ways. First, from the perspective of a heterogeneous firm framework, in addition to firm age and size, this study considers organizational slack as one of the most important factors of firms' innovation enhancement, which directly leads to an increase in their financial performance; this has been ignored in the existing literature. Taking into account firm heterogeneity and the fact that the amount of public policy support each firm receives changes over time, this study empirically tests the nexus between public policy support and firms' financial performance in a longitudinal context taking a systematic approach. For the literature on performance at the firm level, Jaraité and Kažukauskas [1], Zhang et al. [2], and Zhang et al. [3] test the effects of government policy on performance in a longitudinal context employing a panel approach. Nonetheless, no studies have analyzed the panel data systematically. Considering the characteristics, heterogeneous, non-stationary, and cointegrated panel data, and path-dependence of all economic and social variables within the social system, this study performs various panel framework tests to grasp the characteristics of the panel data before establishing an empirical model, and estimates the model.

The remainder of this paper is organized as follows. In Section 2, we provide a literature review on the relationship between government policies and economic performance at the firm and industry levels, focusing on empirical studies. In Section 3, we propose a model to test the relationships between public policies and firms' financial performance. In Section 4, we describe our data and empirical methods for testing these relationships, carry out empirical tests, and present the results of the estimations. Finally, in Section 5, we summarize our main findings and list the implications and limitations of this study.

2. Literature Review

Most studies in this area, except Rammer et al. [4], have examined how government policies affect export performance at the industry level (see Table 1). The issue has been examined by using dynamic panel [5–9], static panel [10–13], and cross-sectional [14] approaches. At the firm level, Rammer et al. [4] are unique; they use a survey-based cross-sectional approach to test the effects of government policies on export empirically. Recently, although empirical testing of the effects of public policies on firms' financial performance has been performed by Jaraité and Kažukauskas [1], Zhang et al. [2], and Zhang et al. [3], except for research on China, relatively less attention has been paid to analyses at both the firm and single-country levels (see Table 1). Following the literature review, we contribute to the existing literature in four ways by identifying some academic gaps and the need for improvement.

Most studies that analyze the relationship between energy-related policies and firms' competitiveness generally focus on environmental policies (see [15–17]). Competitiveness at the firm level can be defined in various ways: the ability of a firm to survive competition in the marketplace; grow and be profitable [18]; sell (the capacity to increase market share); earn (the capacity to increase profit); adjust and attract [19]; and trade, produce, and innovate [20,21]. In this context, Jaraité and Kažukauskas [1], Zhang et al. [2], and Zhang et al. [3], who examined the influence of government policies on firms' financial performance, as well as Plank and Doblinger [21], who tested the relationship between government policies and firms' innovation (measured in terms of patent applications), fall among studies that test the effects of government policies on competitiveness at the firm level in the RET sector. Although export performance and firm performance might seem very similar, they are distinct constructs, because firm performance includes domestic market performance, whereas export performance does not [22]. Furthermore, export and domestic market performance seem to be interdependent and jointly affect firms' financial performance [23]. This means that firm performance is a more comprehensive index than export performance [24]. The modeling approach of the empirical test of the effects of government policies on economic performance in the RET sector at the industry level is often based on the assumption of a representative firm—a single firm that has the average characteristics of firms in the RET sector represents the industry in each country. It takes the perspective that firms within the industry are homogeneous in various aspects, such as their response level to policies, technology-related capacity level, system, and functional capacity level that may affect the dynamic process running from government policies to the firms' economic performance. However, in reality, firms within each industrial sector, including the RET sector, are heterogeneous in terms of their internal conditions, which leads to different performance levels from its response to public policies. Thus, this study focuses on the relationship between government policies and firms' financial performance. Some empirical results in the RET sector have been demonstrated, as follows. Rammer et al. [4] demonstrated that process innovation positively affects their export performance. That is, total assets [1], capital intensity [2,3], and equity share concentration [3] positively contribute to the enhancement of firms' margin of earnings before net interest and tax (EBITM), return on asset (ROA), and net profit. In addition, the subsidies that governments offer vary across firms within the same industry. Given such firm heterogeneity in resources, capabilities, and differences in subsidies, the effects of policies on firms' financial performance will vary across firms within the RET sector.

Second, regardless of the analysis level, most studies, except Jaraité and Kažukauskas [1], Zhang et al. [2], Zhang et al. [3], and Rammer et al. [4], have investigated the effects of public policies on economic performance at the multi-country level. This limits the ability of policymakers and researchers to understand country- and firm-specific characteristics that are likely to moderate the relationship between government policies and financial performance at the firm level. Therefore, to describe this relationship comprehensively, it is necessary to perform an analysis of RET firms within a single country. In particular, to facilitate a more nuanced exploration of the effects of government policies on firms' financial performance over time, and obtain a more accurate estimation of model parameters, it is imperative to utilize panel data for firms at the single-country level.

Table 1. Summary of empirical studies that explore how public policy affects economic performance in the RET sector.

Study	Sample	Level	Methodology	Variables			Major Findings
				Dependent	Independent	Control	
Costantini and Crespi [10]	14 exporting and 145 importing countries (1999–2007)	Industry	PMG (Panel)	Export	R&D expenditure; Environment regulation; Patent application	FDI inflows (% of GDP)	RAD → EX (+); PAT → EX (+)
Jha [14]	34 countries (2007) Aggregated RETs; Solar and Wind energy technology; Ethanol	Industry	MRM (Cross-sectional)	Export	Factor (comprising the contribution of renewable energy to the total energy supply and feed-in tariff) score; Tariff; Patent	-	[Aggregated RETs] FAS → EX (+); PAT → EX (+)
Groba [11]	21 OECD exporting and 129 importing countries (1999–2007) Solar energy technology	Industry	PGM (Panel)	Export	R&D expenditure; Environmental regulation; Patent application	Energy intensity; Real GDP per capita; FDI inflows (% of GDP); Import tariff (of importing country)	RAD → EX (+); PAT≠ EX; EIN → EX (+)
Costantini and Mazzanti [6]	14 exporting and 145 importing countries (1996–2007) High-technology sector	Industry	PMG (Panel)	Export	Environment expenditure Patent	Real GDP per capita Population	ENV → EX (+); PAT → EX (+)
Sung and Song [7]	OECD (18 countries) (1991–2007) Aggregated RETs	Industry	PVECM (Panel)	Export	R&D expenditure; Ratio of renewable energy to total energy supply		[In the long run] RAD → EX (+) [In the short run] RRE → EX (−)
Jaraité and Kažukauskas [1]	EU-24 countries (2002–2010) Electricity generation	Firm	PVAR (Panel)	EBIT margin	Tradable green certificates (dummy); Emission trading system (dummy)	Total assets; Age; Market concentration; Electricity price	TA → EBITM (+); MC → EBITM (+); TGC → EBITM (+); ETC → EBIM (−)
Groba [12]	23 OECD exporting and 129 importing countries (2000–2007) Solar energy technology	Industry	PGM (Panel)	Export	R&D expenditure; Environmental regulation; Ratio of renewable energy to total energy supply	Energy intensity; Real GDP per capita; FDI inflows (% of GDP); Import tariff (of importing country)	RAD → EX (+); ENV → EX (−); RRE → EX (+)
Groba and Cao [13]	China and 43 importing countries (1996–2008) Solar energy technology	Industry	PGM (Panel)	Export	Renewable obligation; Incentive tariff; Patent application; Tax measures	Electricity generation; Real GDP per capita	INC → EX (+); OBL → EX (+); EGE → EX (+)
Sung and Song [9]	19 OECD countries (1991–2008) Solar energy technology; Wind energy technology; Bioenergy technology	Industry	PVECM (Panel) PVAR (panel)	Export	R&D expenditure (technology-push) Ratio of renewable energy to total energy supply (demand-pull)	Real GDP per capita	[In the long run] (Each energy) RAD → EX (+); RRE → EX (−); GDP → EX (+) [In the short run] (Wind) GDP → EX (+) (Solar) RAD → EX (−); RRE → EX (+)

Table 1. *Cont.*

Study	Sample	Level	Methodology	Variables			Major Findings
				Dependent	Independent	Control	
Zhang et al. [2]	China (2007–2010) Solar energy technology; Wind energy technology	Firm	FE (Panel)	ROA	Government subsidy	Political connection (dummy); Marketization; Capital intensity;	[Wind] SUB → ROA (+); MA → ROA (+); SUB × PC → ROA (−) [Solar] CI → ROA (+)
Kim and Kim [5]	16 (Solar)/14 (Wind) countries (1991–2008) Solar energy technology; Wind energy technology	Industry	VECM (Time series)	Export	Incentive tariff; Environment taxes; Public investment; Patent (% of GDP); Renewable obligation	Real GDP	[Solar/Wind] INC → EX (+); OBL → EX (+); ENV → EX (+); PAT → EX (+)
Sung [8]	18 OECD countries (1991–2008) Bioenergy technology	Industry	PVECM (Panel)	Export	Ratio of renewable energy to total energy supply; R&D expenditure	Real GDP per capita	[In the long run] RAD → EX (+); GDP → EX (−); GDP → EX (+)
Zhang et al. [3]	China (2009–2014) Solar energy technology; Wind energy technology	Firm	FE (Panel)	Net profit	Innovative subsidy; Non-innovative subsidy; Market-oriented subsidy; Direct fiscal appropriation	Capital intensity; Age; Share concentration	[Wind] SC → NP (+); CI → NP (+) [Solar] MS → NP (−); IS → NP (−)
Rammer et al. [4]	Germany, Switzerland, Austria (2015)	Firm	MRM (Cross-sectional)	Export intensity	Tax; Regulation on energy use; Subsidies for technologies; Standard and voluntary agreements; Demand for energy-efficient products	Total assets; Age; Ownership; Unit labor costs; Share of material and service input in total assets; Process innovation	REU → EXI (+); PI → EXI; MTS → EXI;

Notes: PGM = panel gravity model; MRM = multivariate regression model; PVECM = panel vector error correction model; VECM = vector error correction model; PVAR = panel vector auto-regression model; EX = export performance; EXI = export intensity; RAD = R&D expenditure; PAT = patent application; FAS = factor score; EIN = energy intensity; ENV = environment expenditure, environmental regulation, or environmental taxes; INC = incentive tariff; OBL = renewable obligation; EGE = electricity generation; RRE = ratio of renewable energy to total energy supply; TA = total assets; MC = market concentration; TGC=trading green certificate; ETC = EU emission trading system; EBITM = margin of earnings before net interest and tax; ROA = return on asset; PC = political connection; MA = marketization; SUB = government subsidy; CI = capital intensity; SC = share concentration; NP = net profit; MS = market-oriented subsidies; IS = innovative subsidies; GDP = gross domestic product; FDI = foreign direct investment; PI = production innovation; MTS = share of material and service input in total assets; REU = regulation on energy use; →, ↔, and ≠ indicate unidirectional, bidirectional, and neutral relationships, respectively.

Third, a firm's economic performance may be affected by various sources of firm heterogeneity (see Jaraité and Kažukauskas [1], Zhang et al. [2], and Zhang et al. [3]). This means that the relationship between government policies and financial performance at the firm level can be moderated by firm-specific factors. Policy, as the outcome of interaction among government and various interest groups in a society, is the strongest political extrinsic force for firms and firms attempt to become isomorphic with a government's expectations by receiving government support and facilitating various R&D and commercial activities. This might lead to the creation of not only a local market for RETs, but also export markets [7], as government policies can increase financial performance by promoting firms' various innovative activities. Hence, a firm's additional availability of resources for engaging in innovation, and the availability and flexibility of internal resources for innovation [25], also influence its financial performance, which is an additional heterogeneous characteristic that will be examined in this study.

Fourth, despite studies that adopt a dynamic approach at the single- [1] and multi-country [6–9] levels, there lacks a systematic approach in previous studies. Most panel data are heterogeneous, non-stationary cointegrated, and path-dependent, so that contemporary variables (e.g., firms' financial performance) are, to some extent, affected by financial performance in the previous period. Therefore, when using panel data, checking their characteristics before empirically testing their relationship with the variables in question is crucial. Additionally, to minimize bias and to obtain more accurate, consistent, and efficient parameter estimates, the panel estimator for performing empirical tests that suits the sample size should be chosen [26–29]. Thus, this study examines the relationship between government policies and firms' financial performance while systematically applying the panel approach.

3. Theoretical Settings and Data

This study considers three factors that may affect the empirical results in the existing literature vis-à-vis the relationship between government policies and the financial performance of RET firms in Korea.

First, although there are several financial performance indexes (e.g., net profit, return on equity, return on investment, and sales), when investigating the effects of government policies on firms' financial performances, we use ROA. This is because ROA, compared with other indicators (e.g., return on equity, ROE; return on investment, ROI), can better illustrate the profitability of executives utilizing the assets of shareholders and creditors [2]. There are various versions of ROA, such as return on total assets, return on total core assets, return on net asset, and return on total worth. We calculate firms' ROA as the ratio of net profit to total assets.

Second, we adopt the view that there are dynamic effects—learning-by-doing-effects—in firms' financial performance [1,6–9], which implies that the value of financial performance in the present period depends on its value in the previous period, and this includes the other variables in question.

Third, we first control for firm age and size in line with Rammer et al. [4], Jaraité and Kažukauskas [1], and Zhang et al. [3]. We also control for organizational slack—a firm's additional availability of resources for engaging in innovation—and the availability and flexibility of internal resources for innovation [25], and consider the fact that financial performance enhancement is triggered by firms' various innovative activities derived from government policies.

Considering the points mentioned above, we employ the following panel data model to examine the relationship between government policies and financial performance at the firm level:

$$ROA_{i,t} = \alpha + \beta X'_{i,t} + \gamma Z'_{i,t} + \eta_i + \varepsilon_{i,t} \quad (1)$$

where i is the firm, t is the year, η_i is the firm-specific effect, and $\varepsilon_{i,t}$ is the error term. ROA represents a proxy variable for a firm's financial performance, which is measured as the ratio of net profit to total sales based on Zhang et al. [3]. X'_{it} denotes a (2×1) vector of explanatory variables—in this paper, where $X_{i,t} = [RDS_{i,t}, NRDS_{i,t}]$. *RDS* denotes subsidies that the Korean government give to firms for encouraging R&D and protection activities for industrial intellectual properties (R&D subsidies), which is measured as the ratio of R&D subsidies each firm received to its total assets. *NRDS* stands for subsidies that the Korean government give to firms for promoting the acquisition and modernization of machinery and equipment which can promote firms' technology development (non-R&D subsidies), and is measured as the ratio of non-R&D subsidies each firm received to its total assets. Z'_{it} is a (3×1) vector of control variables, where $Z_{i,t} = [AGE_{i,t}, SIZE_{i,t}, SLACK_{i,t}]$. *AGE* is firm age, which is measured as the number of years from registration based on the argument from Jaraité and Kažukauskas [1], Rammer et al. [4], Zhang et al. [3], and Plank and Doblinger [21] that younger firms have higher additional resource constraints, both in terms of assets and their borrowing ability, than older firms. *SIZE* is firm size, which is a firm's capability to achieve scale economies by performing various innovative activities in more effective ways [30]. Firm size can be measured in various ways: total revenue, numbers of employees, total assets, total fixed asset value, and sales. We measure *SIZE* in terms of total assets that serve as an indicator of physical resources based on Jaraité and Kažukauskas [1] and Plank and Doblinger [21]. *SLACK* is an organizational slack, which is generally defined as not only the availability of resources for engaging in innovation, but also the availability and flexibility of internal resources for innovation [25,31]. ROA and net income as a percent of total assets [25], and assets to liabilities [31], can be used to measure organizational slack. We measure *SLACK* as the ratio of assets to liabilities.

The data used in this study consist of annual measures over the 16 years from 2001 to 2016 for 39 Korean RET firms. Identifying the RET firms is the most important issue in an empirical test at the firm level for two reasons: (1) the RET sector is associated with a variety of industrial sectors, and (2) this sector has not been clearly defined in the Korean Standard Industrial Classification (KSIC). We extracted the firms using the following three steps: First, we extracted the names of the companies from a database of the Renewable Energy Center, Korean Energy Management Corporation. We then matched the names of the companies obtained from the Korea Information Service (KIS)-Value database provided by NICE Information Services Co., Ltd. with the largest credit information database in Korea, which offers credit bureau and corporate intelligence services, based on its extensive credit rating and analysis experiences, accumulated know-how, excellent professionals, and market reputation. Second, by visiting and confirming their business scope on the matched companies' websites individually, we identified firms that manufacture RETs and components. Finally, we used 39 companies for testing the nexus between government subsidies (2001 to 2016) and firms' financial performance; the firms and period were selected based on data availability. The data set is unbalanced, which has 575 observations (see Tables 1 and 2 for the detailed distribution and descriptive statistics of the sample). All data that were necessary for calculating the required variables (ROA, R&D- and non-R&D-related government subsidies, firm age, firm size, and organizational slack) were obtained from the KIS-Value database. The data used to measure ROA, firm size, and organizational slack, including government subsidies, were calculated at 2010 prices and expressed in logarithmic form.

4. Empirical Analysis

4.1. Panel Estimator

Tables 2 and 3 present the distribution and descriptive statistics of the sample. Table 1 illustrates the distribution of the 39 firms that this study investigates. As presented in Table 2, 20 companies specialize in solar energy technologies, which constitute 51.28% of the sample. Five companies work for geothermal energy technologies, and 12 companies are involved in both geothermal and solar, wind, or (and) bioenergy technologies. Two companies specialize in both wind and solar or geothermal energy technologies. R&D and non-R&D subsidies that each company received over the period range from 0 to 21.8 and from 0 to 11.5 billion KRW, respectively.

Table 2. Sample distribution.

ID	Sector	Period	Age	No. of Employees	Total Assets	*ROA*	Slack	*RDS*	ID	Sector	Period	Age	No. of Employees	Total Assets	*ROA*	Slack	*RDS*	*NRDS*
AA	S	2011–2016	22	84	20.7	34.2	25.1	19.5	AU	S	2006–2016	11	87	92.0	85.0	77.4	28.4	0.7
AB	S	2004–2016	22	168	45.0	20.6	10.7	0.3	AV	S	2001–2016	14	253	8.9	92.7	84.0	0.0	0.1
AC	S	2001–2016	31	51	18.2	31.2	25.1	0.5	AW	S	2004–2016	14	154	95.8	42.8	31.6	9.9	2.6
AD	G	2004–2016	15	17	11.1	49.0	31.6	0.0	AX	S	2004–2014	14	63	17.1	78.1	54.6	0.0	0.0
AE	SG	2001–2016	20	80	70.7	36.7	29.3	0.0	AY	S	2003–2016	15	65	7.6	72.6	58.0	0.0	0.0
AF	S	2001–2016	18	59	14.4	32.3	30.4	1.6	AZ	G	2001–2016	18	43	7.5	40.3	32.9	0.2	0.1
AG	SGWB	2001–2016	19	28	33.8	5.9	23.6	2.3	BA	S	2001–2016	31	44	11.9	92.6	78.9	0.0	0.0
AH	S	2001–2016	19	39	8.5	48.2	29.9	2.6	BB	S	2002–2016	17	61	9.5	65.5	43.4	0.0	0.1
AI	S	2001–2016	18	58	17.4	51.8	36.2	0.3	BC	S	2001–2016	83	646	246.1	93.3	76.4	0.0	0.0
AJ	G	2001–2016	18	44	11.1	18.7	16.1	2.7	BD	SWG	2001–2016	35	526	98.4	23.9	42.6	0.0	0.0
AK	SGWB	2001–2016	32	152	29.8	43.6	27.2	21.8	BE	G	2002–2016	33	206	242.5	23.8	17.4	1.6	11.5
AL	S	2001–2016	19	58	18.8	103.3	117.8	0.0	BF	SWG	2001–2016	51	816	288.1	34.6	24.8	6.6	0.2
AM	S	2007–2016	19	208	38.7	61.6	50.5	0.4	BG	S	2001–2016	39	911	214.7	38.2	35.3	0.0	0.2
AN	S	2005–2016	18	180	277.6	51.8	29.9	2.7	BH	SG	2001–2016	43	3406	1370.4	80.0	44.5	17.4	4.2
AO	SGWB	2001–2016	17	139	35.8	47.3	37.6	6.1	BI	G	2001–2016	22	393	285.4	36.0	30.6	0.0	0.8
AP	SGWB	2005–2016	16	167	123.5	70.8	63.7	1.2	BJ	WG	2001–2016	33	201	26.3	32.5	18.6	0.0	0.4
AQ	SWG	2001–2016	21	49	23.1	68.8	49.3	0.0	BK	SW	2001–2016	32	47	12.6	175.4	158.9	0.5	0.1
AR	SG	2002–2016	16	135	52.2	85.4	63.0	9.9	BL	S	2001–2016	33	676	837.2	26.8	25.3	0.0	1.3
AS	SWG	2004–2016	17	151	58.7	109.7	84.4	0.4	BM	S	2007–2016	11	83	39.0	94.8	77.0	6.6	3.0
AT	SG	2003–2016	15	241	8.0	83.8	99.7	0.0										

Notes: S, G, SG, SWG, SGWB, WG, and SW indicate firms that specialize in solar; geothermal; solar and geothermal; solar, wind and geothermal; solar, geothermal, wind and bio; wind and geothermal; and solar and wind energy technologies, respectively. Unit for age is year. Unit for total assets, R&D subsidies, and non-R&D subsidies is billion KRW. Unit for ROA and slack is percent. Total assets, ROA, slack, R&D, and non-R&D subsidies are the averages over the period investigated. Age and number of employees are values as of the last year of the period investigated.

Overall, the companies have received more R&D subsidies than non-R&D subsidies. Seven companies have never received both R&D, and non-R&D subsidies from the government and the firms' ages range from 11 to 83 years.

Table 3 illustrates that over the period, the average ratios of R&D- and non-R&D-related subsidies to total assets are 9.85% and 1.64%, respectively. Tables 2 and 3 present average total assets, ROA, the slack of each company, and all companies, respectively.

Table 3. Descriptive statistics.

Variables	Observations	Mean	SD
ROA	575	57.93	59.69
RDS	575	9.85	37.48
NRDS	575	1.62	4.94
AGE	39 companies	24.12	13.43
SIZE	575	128.25	297.13
SLACK	575	48.17	56.96

Notes: Unit for ROA, RDS, NRDS, and SLACK is percent. Unit for SIZE is billion KRW. AGE represents the number of years since registration as of 2016 (one company as of 2014). All numbers in the cell are average values.

We first verified the degree to which each regressor correlates with all other regressors in the model by performing multicollinearity diagnostic and correlation tests. The results of the two tests reported in Table 4 demonstrate that multicollinearity is not a major concern in our data, as it meets the variance inflation factor (VIF) criteria of less than 10 and tolerance value greater than 0.1 (see Panel B of Table 4).

Table 4. Correlation and multicollinearity tests.

Panel A: Correlation Between Independent Variables					
	RDS	*NRDS*	*AGE*	*SLACK*	*SIZE*
RAS	1				
NRDS	0.056	1			
AGE	−0.052	−0.021	1		
ASLACK	−0.063	0.087	−0.174	1	
SIZE	−0.038	0.215	0.581	−0.173	1
Panel B: Multicollinearity					
	RDS	*NRDS*	*AGE*	*SLACK*	*SIZE*
VIF	1.010	1.110	1.570	1.060	1.660
Tolerance	0.986	0.904	0.635	0.942	0.600

Next, we confirmed whether there were structural breaks in the individual time series by conducting a cumulative sum of recursive residuals (CUSUM) tests to see if the regression coefficient estimates demonstrate systematic variation over the long term, and cumulative sum of recursive residuals of squares (CUSUMQ) tests to see if deviations from the short-term constancy of regression coefficients are randomized. With the exception of the CUSUM test for one company and the CUSUMQ test for seven companies, the two test results demonstrated that all the series are stable over time (the results are available upon request from the author).

We found the sign of autocorrelation of order one (F statistic = 9.570, $p < 0.003$) using Wooldridge's [32] test. We conducted a panel groupwise heteroscedasticity test, which demonstrated the presence of heteroscedasticity within cross-sectional units at the 1% significance level (Wald test statistic = 336.000, $p = 0.000$). To detect the presence of cross-sectional dependence (CD), this study employed Pesaran's CD test [33], which is well-known, where N (cross-section) is larger than T (time; as is the case in this study). The three tests indicate that the cross-sectional units are independent, demonstrating that the null hypothesis of no cross-sectional dependence is not rejected at the 1% significance level (Pesaran CD statistic = 0.458, p = 0.647).

We used the Fisher-type panel unit-root test proposed by Maddala and Wu [34] to confirm whether the series is stationary, considering the results that the series are stable over time and that there is no cross-sectional dependence. A big benefit is that the test can handle an unbalanced panel (as in the case in this study). Furthermore, the lag lengths of the individual augmented Dickey-Fuller tests are allowed to differ.

The results of panel unit-root tests presented in Table 5 demonstrate that the level of ROA and SLACK in the test regressions with intercept and a time trend, and level of ROA and SIZE in the test regressions with no time trend, are not stationary and that the first difference of the three variables is stationary. However, the tests indicate that RDS, NRDS, and AGE do not have a unit-root, which means they are stationary.

Table 5. Results of panel unit-root tests.

Variables	With Trend		Without Trend	
	ADF-Fisher Chi-Square		ADF-Fisher Chi-Square	
	Level	First-Difference	Level	First-Difference
ROA	66.290 (<0.825)	130.216 (<0.000)	91.106 (<0.147)	168.938 (<0.000)
RDS	155.790 (<0.000)	168.645 (<0.000)	171.266 (<0.000)	125.092 (<0.000)
NRDS	152.608 (<0.000)	166.699 (<0.000)	156.575 (<0.000)	202.012 (<0.000)
SIZE	112.537 (<0.000)	175.264 (<0.000)	70.654 (<0.710)	114.116 (<0.004)
AGE	274.263 (<0.000)	259.820 (<0.000)	273.793 (<0.000)	259.800 (<0.000)
SLACK	85.503 (<0.265)	150.529 (<0.000)	134.873 (<0.000)	135.001 (<0.000)

Notes: Individual intercept and time trend are included in the panel unit test. Automatic lag length selection (Schwarz Information Criteria) is used. *P*-values are in parentheses. The null hypothesis for the test is a unit root (assume individual unit root process).

The results of the panel unit-root tests suggest the presence of a long-run equilibrium relationship between the variables in question. Hence, we use Pedroni's [35] heterogeneous panel co-integration test, which assumes cross-sectional independence, to confirm whether there is a long-run relationship. Seven statistics for panel and group tests demonstrate that there is co-movement among *ROA*, *RDS*, *NRDS*, *SIZE*, *AGE*, and *SLACK*, demonstrating that the null hypothesis of no co-integration in heterogeneous panels is rejected at the 1% significance level (see Table 6).

Table 6. Panel co-integration test.

Alternative Hypothesis: Common AR Coef. (Within Dimension)		Alternative Hypothesis: Common AR Coef. (Between-Dimension)	
Panel ν-statistic	−4.473 (<0.000)		
Panel ρ-statistic	6.163 (<0.000)	Group ρ-statistic	8.481 (<0.000)
Panel PP-statistic	−8.292 (<0.000)	Group PP-statistic	−11.660 (<0.000)
Panel ADF-statistic	4.363 (<0.000)	Group ADF-statistic	5.513 (<0.000)

Notes: *P*-values are in parentheses. The test assumes an individual intercept and deterministic trend. Automatic lag length selection (Schwarz Information Criteria) is used.

When cointegration exists, an error correction model can be estimated using the Engle and Granger [36] approach. Therefore, we establish a panel vector error correction model (VECM), allowing us to estimate the underlying dynamic relationships between the variables without applying any prior restriction. The panel VEVM can be expressed as follows:

$$\Delta Y_{i,t} = \rho \Delta Y_{i,t-1} + \beta \Delta X'_{i,t} + \gamma \Delta Z'_{i,t} + \lambda ECT_{i,t-1} + \Delta \varepsilon_{i,t} \quad (2)$$

where Δ is the first difference operator, $Y_{i,t}$ is a vector of the logs of dependent variables, $X'_{i,t}$ is a vector of the logs of independent variables, $Z'_{i,t}$ is a vector of the logs of control variables, and $\varepsilon_{i,t}$ is a vector of idiosyncratic errors. The vectors of dependent, independent, and control variables are composed of *ROA, RDS, NRDS, SIZE, AGE,* and *SLACK*.

For Equation (2), differencing causes a simultaneity problem where the lagged endogenous variables on the right-hand side correlate with the new differenced error term. Genuine errors across the firms are characterized by heteroscedasticity. To deal with the problems in inferring causal relationships among the variables in question, we can use the instrumental variable (IV) estimator [37] or generalized method of moments (GMM) estimator, especially the difference GMM [38] and system GMM [27,39]. When the sample is finite, as in this study, the estimators tend to generate considerable bias by asymptotically increasing the variance of the estimates [27]. As an alternative to the IV and GMM estimator techniques, the least squares dummy variable (LSDV) estimator is recommended. However, the LSDV estimator is consistent and is biased only to a negligible degree when $T\ (time) \rightarrow \infty$ [25]: when $T < 30$, the LSDV estimator has a bias of up to 20% of the time value coefficient of interest [22]. When $T < 30$, as in this study, a bias-corrected LSDV (LSDVC) estimator performs well, compared to the IV or GMM estimation techniques, for a balanced panel [28], and for an unbalanced panel [29], in terms of bias and root-mean-square error. Therefore, we applied the LSDVC estimator in Equation (2) and determined causality and complex dynamic relationships between the variables by running the Wald tests on the coefficients of the variables.

4.2. Empirical Results

The evidence of co-integration implied that we could evaluate the short-run and long-run relationships between the variables in question. Various single equation estimators can be used to estimate the long-run relationships. The fully modified OLS (FMOLS) estimator proposed by Pedroni [40] is consistent and efficient in estimating long-run co-integrating coefficients by allowing for endogenous regressors and serial correlation. To determine the long-run equilibrium relationship among the variables in question, we used the FMOLS technique for heterogeneous cointegrated panels. However, to estimate the long- and short-run parameters of the panel VECM, we used the pooled mean group (PMG) estimator proposed by Pesaran [41]. The PMG requires reparameterization into the error correction form; it combines both pooling and averaging in its estimation procedure. It is considered an intermediated estimator that can allow the evaluation of two different Granger causality relationships: a short-run causality that tests the significance of coefficients related to the lagged difference between the variables in question (heterogeneous short-run dynamics), and a long-run causality related to the coefficient of the error correction term in the panel VECM (identical long-run dynamics). Table 7 illustrates the FMOLS results obtained using the cointegration equations, which can be interpreted as long-run coefficients.

As presented in Table 7, the results of the FMOLS demonstrate that the R&D-related and non-R&D-related government subsidies, available slack, and size elasticity estimates are 0.099, 0.007, 0.781, and 0.017, respectively, which are statistically significant at the 1% or 10% level. However, firm age elasticity estimates are not statically significant.

Table 7. Panel long-run estimates.

Estimator	**Variables**				
	RDS	***NRDS***	***SIZE***	***AGE***	***SLACK***
FMOLS	0.099 (0.052) [0.087]	0.007 (0.003) [0.066]	0.017 (0.029) [0.548]	−0.078 (0.140) [0.579]	0.781 (0.031) [0.000]

Notes: Dependent variable is ROA. *P*-values are in brackets. Standard errors are in parentheses.

We then estimated a dynamic panel VECM to determine a causal relationship between the variables in question, using LSDVC. The results are reported in Table 8 (for the panels regression results from difference and system GMM estimators, and other two LSDVC estimators, see Table A1 of Appendix A, which can be used to compare with the LSDVC estimation results).

The panel vector error correction results (Panels A and B of Table 8) demonstrate that, in the short run, there exist bidirectional positive causal relationships between *ROA* and *SLACK*, *ROA* and *NRDS*, and *SIZE* and *NRDS*, whereas a bidirectional negative causal relationship exists between *SIZE* and *ROA*. This study also finds the presence of positive significant short-run relationships running from *RDS* to *ROA*, and from *AGE* to *NRDS* and *SIZE*, and that *AGE* has a negative effect on *ROA*. However, there are no causal relationships between *SLACK* and *RDS*; *SLACK*, *NRDS*, *AGE*, and *SIZE*; *RDS* and *SIZE*; *RDS* and *NRDS*; and *AGE* and *RDS*. The dynamic panel regression results demonstrated that R&D subsidies (similar to the results of the existing literature at the industry level; Kim and Kim [5], Sung [8], Sung and Song [7,9] Costantini and Crespi [10], Groba [12,13]), and non-R&D subsidies (similar to the results of the existing literature at the industry level; Kim and Kim [5], Groba and Cao [13]) and firm (Jaraité and Kažukauskas [1], Zhang et al. [3]) levels, are the main forces for economic performance in the RET industry.

Table 8. Panel vector error correction results.

Independent Variables		Independent Variables					
		$\Delta ROA_{i,t}$	$\Delta RDS_{i,t}$	$\Delta NRDS_{i,t}$	$\Delta SIZE_{i,t}$	$\Delta AGE_{i,t}$	$\Delta SLACK_{i,t}$
	$\Delta ROA_{i,t}$		0.047	2.341 ***	−0.173 ***	−0.001	0.684 ***
	$\Delta RDS_{i,t}$	0.109 **		0.265	0.021	−0.001	−0.027
	$\Delta NRDS_{i,t}$	0.012 ***	0.003		0.018 ***	−0.001	−0.001
	$\Delta SIZE_{i,t}$	−0.038 ***	−0.038 ***	0.571 *		−0.006	−0.006
	$\Delta AGE_{i,t}$	−0.127 ***	−0.080	3.505 ***	1.247 ***		−0.122
	$\Delta SLACK_{i,t}$	0.451 ***	−0.040	−0.464	0.060	0.001	
	ECT_{t-1}	0.440 ***	−0.010	−1.353 ***	0.214	−0.001	−0.078 *
	Each dependent variable in $t-1$	0.164 ***	0.642 ***	0.470 ***	0.169 ***	0.236 ***	0.236 ***
Independent Variable		**Dependent Variable**					
		ΔROA	**ΔRDS**	**ΔNRDS**	**ΔSIZE**	**ΔAGE**	**ΔSLACK**
Short-run	*ΔROA*		1.890	17.240 ***	3.890 **	0.020	217.440 ***
	ΔRDS	4.140 **		0.150	0.004	0.080	0.180
	ΔNRDS	15.550 ***	1.510		7.730 ***	0.519	0.110
	ΔSIZE		0.100	3.500 *		0.450	0.050
	ΔAGE	2.680 *	1.560	11.390 ***	52.580 ***		1.440
	ΔSLACK	181.090 ***	1.530	0.760	0.530	0.020	
Long-run	*ECT*	238.700 ***	0.140	8.900 ***	9.300 ***	0.070	4.430 *
Joint	*ΔROA ECT*		1.660	4.370 **	0.310	0.190	272.670 ***
	ΔRDS ECT	92.030 ***		0.150	3.740 *	0.040	2.020
	ΔNRDS ECT	247.930 ***	0.060		10.600 ***	0.160	3.420 *
	ΔSIZE ECT	128.970 ***	0.260	2.270		0.030	3.070 *
	ΔAGE ECT	15.160 ***	1.910	4.130 **	72.340 ***		3.760 *
	ΔSLACK ECT	673.040 ***	1.350	6.660 ***	5.950 **	0.010	

Notes: Panel A contains the results of tests based on bias-corrected LSDV estimates. Bias is corrected up to the first order, 0 (1/T), and 100 replications are used in the bootstrap procedure to find the asymptotic variance-covariance matrix of estimators. Panel B reports χ^2-statistics. In Panel A and B, ***, **, and * denote the 1%, 5%, and 10% significance levels, respectively. Each dependent variable in period $t-1$ denotes $\Delta ROA_{i,t-1}$, $\Delta RDS_{i,t-1}$, $\Delta NRDS_{i,t-1}$, $\Delta SIZE_{i,t-1}$, $\Delta AGE_{i,t-1}$, and $\Delta SLACK_{i,t-1}$ in order of estimation presented in Panel A.

The positive effect of *SLACK* on *ROA*, considering that *SLACK* is measured as the ratio of net income of the assets, denotes the importance of continuously enhancing profitability. The results of the effects of *AGE* on *ROA* are insignificant (in the long run) and significantly negative (in the short run), and so there is no learning effect with experience. *AGE* (firm age), denoting experience, is one of the factors that affects firms' learning and innovation. How firms' learning and innovation changes with firm age, as described in the previous literature, could not be determined. However, innovation, which directly leads to economic performance, is entirely affected by learning (i.e., being able to build on capability), and obsolescence (i.e., not being able to succeed in the changing business environment) is affected by age [42,43]. In this context, the unexpected results of this study (insignificant and significant negative effects of firm age on economic performance) present the importance of the consideration of inertia due to aging that can lead to a decrease in learning effects and an acceleration in obsolescence in the RET industry. *SIZE* (firm size) is measured as its total assets, which means physical resources. Hence, the results of *SIZE* on *ROA* of this study, significantly positive (in the long run) and negative (in the short run), suggest that despite the relatively minor importance of exploring firms' advantage compared to intangible assets, physical resources, as an essential source in the Korean context, are helpful for the enhancement of economic performance, at least in the long run. This study also highlights the presence of dynamic path effects in all six estimations, demonstrating that the dependent variables in the previous period enhance their values in the current period at the 1% significance level, which indicates there are dynamic effects on performance and these are factors including the production process and policy. The coefficients of the error correction term (*ECT*) in the estimations, wherein non-R&D government subsidy and organizational slack are the dependent variables, are negative and significant at the 1% level, indicating that *NRDS* and *SLACK* could be key adjustment factors for closing the gap with regard to the long-run relationships. Here, the coefficients mean the speed of adjustment toward equilibrium in cases that depict a deviation from the long-run equilibrium relationship because of particular shocks in the short run. The joint test results show that *ROA*, *AGE*, and *SLACK* affect non-R&D government policy and organizational slack by jointly interacting with the ECT, and that non-R&D government policy influences organizational slack by jointly interacting with the *ECT*.

5. Conclusions

5.1. Implications

We empirically tested the effects of government policies on firms' financial performance, using unbalanced data of Korean firms in the RET sector over the period 2001–2016. We verified the data characteristics before establishing the empirical model, by conducting various panel framework tests. We confirmed the evidence of co-movement among the series. We established a panel VECM to test the complex dynamic causal relationships among the variables in question. The FMOLS technique provided the long-term policy elasticities to firms' ROA. Finally, we used the LSDVC dynamic estimator, which is the most appropriate when time T (time) < 30 (as in this study), to estimate the complex dynamic causal relationships among the series. Then, we determined the causality by running Wald tests on the coefficient of each variable from the LSDVC estimation.

We can draw the following main results and implications regarding government policies and firms' performance in the RET sector based on the results of this study.

First, this study finds solid and compelling evidence that R&D and non-R&D subsidies have significant positive effects on firms' performance in both the short and long run. From the perspective of RET policy focus and a framework of heterogeneous firm theory, the results of this study demonstrated that policies implemented by the Korean government to promote the RET sector work to some extent. Inducing firms' innovation is a main goal of government support in the RET sector (e.g., [44–46]). Although innovation is crucial for increasing profits, it is not easy for firms to utilize their full innovation potential [47]. This means that firms tend to underinvest in innovation activities. Therefore, public support is necessary, which is especially relevant for immature technologies, such as RETs, that face large systemic barriers in innovation creation [48]. Under these circumstances, government subsidies encourage firms from the RET sector to promote numerous innovation and technology development [21]. This is possible by alleviating the debt and equity gap for innovation activities by lowering the required amount of external financing and reducing a firm's default risk, making lenders more willing to provide loans [49–51], and changing the risk–return relationship in RET investment for innovation activities. Consequently, this could affect investors' behavior and interests [52,53] by providing an observable signal to external investors about innovation activity quality [49,54,55], promoting different entrepreneurial activities related to RETs, and guaranteeing favorable conditions to develop and diffuse RETs [55,56]. Such innovation, as a core source of productivity growth, positively affects firms' economic performance, which becomes most evident in extant empirical studies using the theory of heterogeneous firms [57]. In this context, the results of this study suggest that the government should make serious efforts to continue firmly toward creating reliable and positive short- and long-run policies with regard to firms' economic performance. Such efforts should consider limited financial resources [58,59], uncertainty concerning technological prospect regarding R&D costs and eventual performance [60–63], uncertainty about the demand and preferences of different customer groups regarding the characteristics of RETs [60,61,64,65], concerns over spillovers, accumulated technological knowledge, and practical know-how that firms possess by conducting innovation activities. Other firms could freely use these resources to develop their technology and productivity [66–71], which are the main reasons for the difficulty in fully utilizing innovation potential by firms in the RET sector. Despite government policies as a catalyst to promote firms' innovation, herd behavior derived from government subsidies can promote overinvestment, which is likely to negatively affect firms' growth without improving profitability due to the deterioration of their capital structure. Therefore, policymakers should effectively implement public policies to induce firms' optimal investment for innovation activities, thereby increasing their sustainability and growth rates, simultaneously.

Second, this study demonstrates that organizational slack has a positive effect on firms' economic performance in the long run and that in the short run, there are bidirectional relationships between organizational slack and firms' economic performance. It presents the importance of increasing organizational slack to improve firms' performance. Organizational slack, as the stock of resources in an organization that is in excess of the necessary minimum to produce a given level of organizational output [25], supports firms' innovation efforts [31]. Hence, the results of this study suggest that organizational slack can positively affect firms' performance by interacting with public policies. Firms with additional resources, and the availability and flexibility of internal resources, promote investment in productive resources for innovation activities, in response to government policies. Therefore, when immature technologies such as RETs face large systemic barriers to the creation of innovation [48], organizational slack can play a key role in promoting several entrepreneurial activities related to RETs and can further enhance the effectiveness and efficiency of public policies. It also suggests that firms should make efforts to attempt to accumulate an appropriate amount of slack efficiently based on their performance, and the government should devise and implement policy instruments to efficiently utilize firms' slack to be able to achieve innovation beyond the goals that their policies seek to accomplish.

Third, in the short run, this study finds evidence of bidirectional positive causal relationships between firms' economic performance and non-R&D government policy, and firm size and non-R&D government policy, and bidirectional negative causal relationships between firm size and firms' economic performance. These results mean that non-R&D subsidies contribute to an increase in total assets that serve as an indicator of physical resources [1,2] by promoting the acquisition and modernization of machinery and equipment and that non-R&D subsidy-induced total assets further increase innovation and realize additional performance growth. Considering firms' economic performance, defined as the return on assets in this study, the results present the importance of the efficient utilization of non-R&D subsidies in promoting the growth of firms fraught with profitability issues. To this end, making significant efforts to determine the optimal combinations for decision-making based on a balanced consideration of firms' financial status and growth should be the highest priority. This should be followed by policy measures that can prevent firms' overinvestment and increase the efficient use of non-R&D subsidies.

Fourth, this study presents the coefficient of the *ECT* in the estimations, wherein non-R&D government subsidies and organizational slack (dependent variables) are negative at the 1% significance level. This means that non-R&D subsidies and organizational slack could be a key adjustment factor for filling the gap with respect to the long-run equilibrium between public subsidies and firm performance.

In the estimation, firm performance has a positive effect on the dependent variables. This performance could deviate from the long-run equilibrium because of shocks in the short-run; however, after the shock, it eventually converges to equilibrium in subsequent periods. In such a framework, the long-run firm performance dynamics are driven by non-R&D subsidies, organizational slack, and the stable nature of the long-run equilibrium. The adjustment factor thus reflects the speed of adjustment toward the equilibrium in the case of deviation. Furthermore, based on the Granger representation theorem, a negative and significant adjustment coefficient implies a long-run relationship between the variables, which is confirmed in this study. The results also demonstrate that short-run non-R&D subsidies and organizational slack play important roles in promoting a steady and stable firm performance in the long run by converging to equilibrium with the discrepancy corrected in each period. This suggests that firms can increase slack and receive non-R&D subsidies by enhancing their economic performance. The results of the joint tests of *NDRS*, *SLACK*, and *ECT*, and of the bidirectional relationship between *NDRS* and *SLACK* that interact with the *ECT*, also confirm that the main driving force for increasing organizational slack and non-R&D subsidies comes from firm performance. This improved performance may therefore lead to non-R&D public expenditures and slack enhancement, which can promote the acquisition and modernization of machinery and equipment and increase innovation for additional performance growth. These results suggest that policymakers and firm managers should formulate and implement policy strategies that aim to enforce mechanisms that can build a positive relationship between firm performance, slack, and non-R&D subsidies.

Fifth, this study demonstrates that the values of *ROA*, *RDS*, *NDRS*, *SIZE*, *AGE*, and *SLACK* in the present period depend on their values in the previous period at the 1% significance level. This means that there is a dynamic-path dependency (learning-by-doing) where the present outcome is largely driven by previous achievements. Hence, the results suggest that policymakers should take into account the dynamic-path dependence process when implementing RET policies, along with the positive effect of R&D subsidies on firm performance, the bidirectional relationship between firm performance and non-R&D subsidies (and organizational slack), firm size and non-R&D subsidies, and positive effects of firm age and size on non-R&D subsidies. This implies that the time lag, along with the relationship between the variables in question, should be carefully considered in developing and implementing various policy measures to promote firms' economic performance in the RET sector.

5.2. Limitations

The results of the data analysis presented above should be interpreted while considering some limitations. The results may not be generalizable to other countries because this study is Korea-specific. The relationships found here do not exactly hold in non-Korean contexts. Each country has its specific factors and contexts associated with the promotion of the RET industry. Hence, investigations into the question of how public policies improve firms' economic performance in each country should be conducted, entirely taking into account country-specific factors and contexts. As the results are also based on the aggregated data of RET firms, this limits our ability to draw RET subsector-specific implications. Given the differences in cost structure and the level of maturity of different renewable energy sources, the effect of public policies on RET firm performance is likely to vary across subsectors. Hence, to implement effective policies that suit firms in each industry-specific situation, further investigation should be performed at the RET subsector level. While this study, in the context of firm and single-country, investigated the question of how public subsidies affect RET firms' economic performance, it did not address subsector-specific, market, and economic factors that might influence the relationship between public policies and RET firms' economic performance. These issues should be addressed in future research. The variables related to policy strategies (e.g., industry-specific environmental policy and sales promotion) that are relevant to and likely to affect the extent of RET firms' growth should also be considered in future research. Furthermore, some factors tackled in the existing literature, such as tariffs, renewable energy obligations (quotas), marketization, and market concentration can also influence domestic firms by increasing or decreasing sales to companies operating outside their own countries. Nonetheless, this study did not deal with these factors due to the unavailability of the required data. Therefore, further study should analyze these factors as they may affect the economic performance of companies operating outside their own countries, and further research could examine the relative impact of imports from companies outside the countries on domestic firms' economic performance.

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Appendix A

Table A1. Dynamic panel regression results.

Independent Variables	Dependent Variable $\Delta ROA_{i,t}$				
	(1) Difference GMM	(2) System GMM	LSDVC		
			(3) Initial (AH)	(4) Initial (AB)	(5) Initial (BB)
$\Delta ROA_{i,t-1}$	0.207 (0.079) ***	0.255 (0.045) ***	0.168 (0.029) ***	0.164 (0.029) ***	0.160 (0.028) ***
$\Delta RDS_{i,t}$	0.235 (0.114) **	0.244 (0.089) ***	0.111 (0.055) **	0.109 (0.053) **	0.112 (0.052) **
$\Delta NRDS_{i,t}$	0.013 (0.005) **	0.014 (0.004) ***	0.012 (0.003) ***	0.012 (0.003) ***	0.012 (0.003) ***
$\Delta SIZE_{i,t}$	−0.063 (0.016) ***	−0.055 (0.031) *	−0.038 (0.024)	−0.038 (0.023)	−0.039 (0.023)
$\Delta AGE_{i,t}$	0.059 (0.114)	0.067 (0.132)	−0.130 (0.079) *	−0.127 (0.077) *	−0.138 (0.077) *
$\Delta ASLACK_{i,t}$	0.635 (0.076) ***	0.619 (0.040) ***	0.452 (0.034) ***	0.451 (0.033) ***	0.449 (0.032) ***
$ECT_{i,t-1}$	0.062 (0.047)	0.083 (0.031) ***	0.440 (0.029) ***	0.440 (0.028) ***	0.439 (0.027) ***
Instruments	GMM-dif	GMM-sys			
$Wald(\chi^2)$	268.680 ***	384.140 ***			
$F(N(0,1))$	31.055 ***				
$Sagan(\chi^2)$	100.76	114.933			
$m_1(N(0,1))$	−3.640 ***	−3.842 ***			
$m_2(N(0,1))$	−0.790	−0.821			

Notes: The Sargan test of over-identifying restriction tests H_0 of instrument validity; m_1 tests for the first-order autocorrelation of residuals by testing H_0 of no first-order autocorrelation; m_2 tests for second-order autocorrelation of residuals by testing H_0 of no second-order autocorrelation. Robust in models (1) and (2), and bootstrapped in models (3), (4), and (5), with 100 replications. One-step estimations were applied to test models (1) and (2). ***, **, and * denote the 1%, 5%, and 10% significance levels, respectively. Standard errors are in parentheses.

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