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Government ownership and corporate performance: evidence from green technology industry in Taiwan

Abstract

Taiwan's green technology industry profitability is high, and the output value growth rate is greater than the global market. However, its credit risk volatility is higher than the average of all industries, indicating that the impact of cost of capital and financing needs is more important than in other industries. This study focused on Taiwan's green technology industry from 2005 to 2009 and explored the impact of the governance structure of the green technology industry on corporate credit risk and operating effectiveness. Data were sourced from the *Taiwan Economic Journal* (TEJ) database; 330 samples were used in this study.

The empirical results demonstrated that a good corporate governance structure can reduce the green technology industry's corporate credit risk and improve operational effectiveness. The study found that government shareholding, trust fund shareholding, and corporate shareholding reveal a supervision effect. However, different governance factors have different incremental effects. The governance structure of the green technology industry with governmental ownership has the greatest incremental effect.

This study also found a U-shaped relationship between the government ownership and corporate performance. Moreover, government ownership has different supervision effects among companies with different levels of innovation capital. Green energy group enterprises or the solar photovoltaic industry can strengthen the supervision mechanism and improve the governance effect through governmental investment shareholdings.

Keywords: green technology industry, government ownership, corporate performance, corporate credit risk.
JEL Classification: M48.

Introduction

According to the data from Taiwan Energy Conference (2009), compared to the output value of the global market, Taiwan's green energy growth rate is expected to substantially increase each year. From 2005 to 2009, the average earnings per share of listed companies in Taiwan was 1.61, while the average earnings per share of 66 companies in the green technology industry included in this study was 1.81, showing the higher profitability in the green technology industry. Although Taiwan's green technology industry is still in the introduction and growth stage, R&D intensity (R&D expenses / net operating income) has been growing year after year, suggesting that a large number of funds are needed to enhance innovation capital to expand industrial development. Tsung-Kang et al. (2011) suggested that the global financial crisis has caused the corporate internal liquidity risk to significantly affect the bond value interest rate. In addition, statistics indicate that Taiwan's green technology industry credit risk volatility is greater than the average of all industries. Thus, the impact on the cost of capital and financing needs is also more important than other industries. Therefore, to improve operational efficiency, the green technology industry indeed needs to find solutions to reduce credit risk and raise funds at lower capital costs.

Jensen and Meckling (1976) proposed that a conflict of interest exists among managers, shareholders, and creditors in the case of the separation of ownership and management, thereby creating various agency problems. Studies have confirmed that reducing the agency problem requires the presence of the supervisory mechanism. Pound (1988) proposed the efficient monitoring hypothesis, which stated that institutional investors have more professional talents, knowledge, and a huge amount of resources. In order to reduce their own investment risk and protect their self-interests, compared to minority shareholders, institutional investors have greater motivation to oversee the management of the company, thereby reducing the agency problem. Bushee (1998) argued that institutional investors can indeed play an effective oversight role, but the oversight strength will be affected by the formation of different institutional investors.

Chava and Jarrow (2004) found that different industries face different levels of competition and accounting ratios characteristics; therefore, industrial defaults are not the same. The green technology industry is an emerging prospective industry. The government plays an important role in the influx of capital. Based on shareholding policy considerations, when the government intends to develop a particular industry, it has the motive to monitor the industry, thereby influencing the effect of the company's governance. Relevant research literature has discussed industry development and business strategy, but has not mentioned corporate stock equity structures or the individual elements' incremental governance effect.

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The study focused on Taiwan's green technology industry from 2005 to 2009 and explored the impact of the governance structure of the green technology industry on corporate credit risk and operating effectiveness. Based on the empirical results, the study found that government shareholding, trust fund shareholding, and corporate shareholding reveal a supervision effect. However, different governance factors have different incremental effects. Those with governmental holding have the greatest incremental effect. Moreover, this study found a U-shaped relationship between the government ownership and corporate performance.

The paper is organized as follows. Section 1 presents the literature review and hypotheses, while section 2 describes the research design and method. Section 3 presents the empirical results and analysis. The final section offers conclusions and suggestions.

1. Literature review and hypotheses

1.1. Government ownership and corporate performance. According to the Organization for Economic Cooperation and Development (OECD), corporate governance mechanisms − whether internal or external − should comply with corporate governance principles. In internal governance mechanisms, institutional investors are often divided into government shareholding, bank shareholding, trust-fund shareholding, and legal authority shareholding. According to Articles 21 and 23 of the Accounting Law, invested objects are to be disclosed and supervised by the Legislative Yuan. The Ministry of Audit regularly inspects the important programs to ensure the effective management of the four funds. Therefore, the government should have a higher supervision result and governance effect over the company.

What matters to corporate value is not whether the government owns shares, but rather who the controlling shareholders are. James and David (2006) found that Singapore government-linked companies have higher valuations and better corporate governance than a control group of non-government-linked companies. Lihui and Saul (2008) studied the listed companies in China from 1994 to 2004 and found that government ownership of the value of the company is not a monotonic, but rather a U-shaped relationship. When the government's holdings are large, the government can actually increase the value of the business. Gongmeng et al. (2009) indicated that state-owned enterprises affiliated with the central government-controlled firms perform best whereas state asset management bureaus and privately controlled firms perform worst. However, Linqiang and Sheng (2012) found that the net effect of government ownership on firm performance is negative. In summary, the government ownership effect has no consensus. Therefore, government ownership and corporate performance are worth further exploration in the green technology industry.

1.2. Corporate governance structure and credit risk. The existence of the agency problem increases the company's financial crisis and credit risk. Scott (1981) argued that, if corporate assets are insufficient to pay the resulting debts or if an enterprise fails to repay its debts, it can be regarded as a failure. Studies have confirmed that reducing the agency problem depends on the presence of the supervisory mechanism. Bhojraj and Sengupta (2003) suggested that corporate governance can reduce agency cost, supervise management performance, abate the asymmetrical information between companies and creditors, and default risk. Ashbaugh et al. (2004) found that rational investors who anticipate the possibility of such problems can request a risk premium as the price of risk bearing, which increases corporate equity capital costs. Ashbaugh-Skaife et al. (2006) found that companies with a larger number of external shareholders and chairmen of the board who concurrently work as general managers have a lower corporate bond rating.

The different corporate governance structures result in different supervision effects, which affect not only agency costs, but also solvency and credit risk. Sulong and Fauzias (2008) found that investors were more confident about companies with a high government shareholding proportion because they believed that such companies have a high corporate value. Brown et al. (2009) indicated that the corporate governance structure can effectively manage the complex risks faced by Australian high-tech companies. Mande et al. (2012) argued that the corporate governance mechanism can reduce agency costs regardless of debt financing and equity financing. In sum, this study proposes the following hypothesis:

H1: The better the corporate governance structure is, the lower the corporate credit risk is.

1.3. Corporate governance structure and operating effectiveness. Jensen and Meckling (1976) proposed their convergence of interest hypothesis, which considered outsiders' shareholding ratio as being positively correlated with corporate performance. Jensen and Ruback (1983) put forth their conflict of interest hypothesis to suggest that the greater shareholding that insiders have, the more sufficient their right to vote is to maximize interest. The maximization of enterprise value is not considered. Mangel and Singh (1993) further demonstrated that an independent board of directors is an important mechanism used to improve the effectiveness of the

board. Meanwhile, both Agrawal and Knoeber (1996) and Barnhart and Rosenstein (1998) found that an equity structure on the board of directors is not significantly related to corporate performance.

Fuerst and Kang (2004) indicated that a better corporate governance system might result in better business performance and higher stock price premium. Bellalah (2004) found that small companies' investment is correlated with performance and corporate governance. Karathanassis and Drakos (2004) suggested that the shareholding ratio of institutional investors is positively correlated with the corporate operation performance. Therefore, the current study proposes the following hypothesis:

H2: The higher the government shareholding ratio of the green technology industry is, the better the corporate governance structure is and the better the operating effectiveness is.

1.4. Influence of corporate governance structure on corporate credit risk and operating effectivenes. Claessens et al. (1998) examined 10,000 companies in East Asia and found that government shareholding is positively related to corporate performance. La Porta et al. (2002) and Lemmon and Lins (2003) found that good corporate governance can improve management efficiency and reduce the risk of shareholders' occupancy of external shareholders' property while increasing corporate performance. Durnev and Kim (2005) concluded that, the more investment opportunities business owners have, the more dependent they are on external financing. A concentrated shareholding company has a more high-quality corporate governance, and its information is more transparent.

Therefore, a green energy company with a higher government shareholding ratio should have a better governance structure, which should increase the effect of corporate credit risk on operating effectiveness. In terms of the literature discussed herein, this study proposes the following hypothesis:

H3: The higher the government shareholding ratio of the green energy companies is, the better the governance structure is. Meanwhile, the lower the corporate credit risk is, the higher the operation effectiveness is.

2. Research design and method

2.1. Research design. This study focused on Taiwan's green technology industry from 2005 to 2009 and explored the impact of the governance structure of the green technology industry on corporate credit risk and operating effectiveness. Data were sourced from the *Taiwan Economic Journal* (TEJ) database; 330 samples were used in this study.

2.2. Empirical model. First, this study conducted a descriptive analysis of the research variables. The linear analysis was conducted after initially determining the sample pattern of various variables to test whether the variables have high collinearity. The study then used a multiple regression analysis to discuss the correlation among corporate governance structure, corporate credit risk, and operating effectiveness of the green energy industry. It also determined whether a good corporate governance structure can increase the effect of corporate credit risk on operating effectiveness. From this, the empirical model of the study continued as follows: equation (1) was used to verify Hypothesis 1; equation (2) was used to verify Hypothesis 2; and equations (3) and (4) were used to verify Hypothesis 3.

$$\begin{aligned} TCRI_{it} &= \beta_0 + \beta_1 GOV_{it} + \beta_2 BANK_{it} + \\ &+ \beta_3 TRUST_{it} + \beta_4 CORP_{it} + \beta_5 MANAGER_{it} + \\ &+ \beta_6 DUALITY_{it} + \beta_7 INDEPRATIO_{it} + \\ &+ \beta_8 LEV_{it} + \varepsilon_i, \end{aligned} \tag{1}$$

$$\begin{aligned} GMS_{it} &= \beta_0 + \beta_1 GOV_{it} + \beta_2 BANK_{it} + \\ &+ \beta_3 TRUST_{it} + \beta_4 CORP_{it} + \beta_5 MANAGER_{it} + \\ &+ \beta_6 DUALITY_{it} + \beta_7 INDEPRATIO_{it} + \\ &+ \beta_8 LEV_{it} + \varepsilon_i, \end{aligned} \tag{2}$$

$$\begin{aligned} GMS_{it} &= \beta_0 + \beta_1 TCRI_{it} + \beta_2 IGOVn_{it} + \\ &+ \beta_3 IGOVn_{it} \times TCRI_{ti} + \beta_4 LEV_{it} + \varepsilon_i, \end{aligned} \tag{3}$$

$$\begin{aligned} GMS_{it} &= \beta_0 + \beta_1 TCRI_{it} + \beta_2 IGOVn_{it} + \\ &+ \beta_3 IGOVn_{it} \times TCRI_{ti} + \beta_4 IND1_{it} + \beta_5 IND2_{it} + \\ &+ \beta_6 IND3_{it} + \beta_7 IND4_{it} + \beta_8 LEV_{it} + \varepsilon_i. \end{aligned} \tag{4}$$

2.3. Variable definition. *2.3.1. Dependent variable.* The dependent variables are the following.

Taiwan corporate credit risk index (TCRI). TCRI is divided into ten degrees (1 through 10). The lower the degree is, the higher the credit will be. TEJ rates TCRI as low risk for enterprises with degrees 1 through 4, medium risk for enterprises with degrees 5 and 6 enterprises, and high risk beyond degree 7. A credit rating at degree 10 means the company is in financial crisis.

Green Market Share (GMS). Based on Comanor and Wilson's (1967) power theories, the greater the market share of the company is, the stronger the capability of knowing the market pricing; meanwhile, the better the profitability, the better the business performance. Thus, this study used GMS as the agency variable for operating effectiveness − that is, the GMS of the sample companies in each year (proceeds of sales revenue of sample companies/total proceeds of sales revenue of the green technology industry).

2.3.2. Independent variables. The independent variables are as follows.

Government shareholding ratio (*GOV*): Number of shares held by the government at the end of the year/number of externally circulated shares at the end of the year.

Bank shareholding ratio (*BANK*): Number of shares held by banks at the end of the year/number of externally circulated shares at the end of the year.

Trust fund shareholding ratio (*TRUST*): Number of shares held by the trust fund at the end of the year/number of externally circulated shares at the end of the year.

Corporate shareholding ratio (*CORP*): Number of shares held by corporations/number of externally circulated shares at the end of the year.

Manager shareholding ratio (*MANAGER*): Number of shares held by managers/number of externally circulated shares at the end of the year.

Chairman of the board concurrently works as the general manager (*DUALITY*): Dummy variable used to measure CEO duality: if the president acts as the general manager, the duality is 1; otherwise, it is 0.

Ratio of independent directors and supervisors (*INDEPRATIO*): Independent director and supervisor seats at the end of the year/board size.

Items of good corporate governance variable (*IGOV*) represents selected good corporate governance variables, $n = 1,2,...,N$; $n \leq 7$.

Industry dummy variable (*IND*): Based on the six new energy industries defined by the Energy Bureau, dummy variables of four green technology industries are set.

*IND*1: Solar PV industry is set to 1; non-solar PV industry is set to 0.

*IND*2: LED lighting industry is set to 1; non-LED lighting industry is set to 0.

*IND*3: Wind power industry is set to 1; non-wind power industry is set to 0.

*IND*4: Energy information and communication are set to 1; non-energy information and communication are set to 0.

2.3.3. Control variable. This section presents the control variable.

Debt ratio (LEV): The debt ratio is defined as the total debt divided by total assets.

3. Empirical results and analysis

3.1. Analysis of descriptive statistics. To determine the effect of government shareholding on the green technology industry, this study divided the samples into government shareholding samples (N = 128) and non-government shareholding samples (N = 202). The corporate credit risk of the green energy companies (mean = 4.27) with government shareholding is lower than that of the non-government shareholding companies (average 5.75). The green market share (2.90% on average) of the government shareholding green energy company is higher than that (0.64% on average) of the non-government shareholding green energy companies. From this, the government shareholding green energy companies have lower corporate credit risk. Therefore, such companies can finance more easily expand the green market share and maintain higher operating effectiveness.

3.2. Regression analysis. *3.2.1. Collinearity analysis.* To avoid empirical result errors due to a high linear correlation among the independent variables, this study applied Pearson's correlation for independent variable correlation before the regression estimate. The correlation coefficients among the independent variables have a low correlation measure or are in the accepted range. Thus, the independent variables in the regression model have non-collinearity.

3.2.2. Analysis of correlation between the corporate governance structure and corporate credit risk. According to results of the analysis of the correlation between corporate governance structure and corporate credit risk (see Table 1), Model 1-1 shows that regarding institution investors shareholding, *GOV*, *BANK*, *TRUST*, and *CORP* reveal significantly negative correlations with *TCRI* (α = 0.01 and α = 0.05). Thus, green energy companies with higher institution investor shareholding have a higher supervision effect and lower corporate credit risk.

According to empirical results in Models 1-2 through 1-4, *GOV*, *TRUST*, and *CORP* reveal significant and negative correlations with *TCRI* (α = 0.01). Thus, government shareholding reveals a supervision effect.

Table 1. Analysis of correlation between corporate governance structure and corporate credit risk

$$TCRI_t = \beta_0 + \beta_1 GOV_{it} + \beta_2 BANK_{it} + \beta_3 TRUST_{it} + \beta_4 CORP_{it} + \beta_5 MANAGER_{it} + \beta_6 DUALITY_{it} + \beta_7 INDEPRATIO_{it} + \beta_8 LEV_{it} + \varepsilon_i.$$

	TCRI			
	All green technology industries (N = 330)	Government shareholding green technology industries (N = 128)	Non-government shareholding green technology industries (N = 202)	Government shareholding group enterprise-based green technology industries (N = 101)
	Model 1-1	Model 1-2	Model 1-3	Model 1-4

Table 1 (cont.). Analysis of correlation between corporate governance structure and corporate credit risk

	TCRI			
	All green technology industries (*N* = 330)	Government shareholding green technology industries (*N* = 128)	Non-government shareholding green technology industries (*N* = 202)	Government shareholding group enterprise-based green technology industries (*N* = 101)
	Model 1-1	Model 1-2	Model 1-3	Model 1-4
Intercept	6.102*** (0.000)	5.214*** (0.000)	6.372*** (0.000)	5.622*** (0.000)
GOV	-0.066*** (0.000)	-0.060*** (0.007)		-0.182*** (0.000)
BANK	-0.075** (0.013)	-0.092** (0.050)	-0.064 (0.129)	-0.014 (0.822)
TRUST	-0.068*** (0.000)	-0.041*** (0.000)	-0.093*** (0.000)	-0.065*** (0.000)
CORP	-0.037*** (0.000)	-0.031*** (0.000)	-0.039*** (0.000)	-0.028*** (0.001)
MANAGER	-0.093* (0.095)	-0.145 (0.250)	-0.112* (0.066)	-0.180 (0.128)
DUALITY	-0.084 (0.602)	0.009 (0.976)	-0.164 (0.397)	-0.233 (0.444)
INDEPRATIO	0.227 (0.616)	-0.257 (0.758)	0.456 (0.399)	0.964 (0.346)
LEV	0.026*** (0.000)	0.031*** (0.007)	0.026*** (0.000)	0.028** (0.027)
Adj-R^2	47.4%	37.2%	42.3%	53.1%

Notes: The variables are defined as follows. *TCRI* is the Taiwan corporate credit risk index, which is divided into degree 1~10. The lower the degree is, the higher the credit will be. *GOV* is the number of shares held by government at end of year/number of externally circulated shares at end of year. *BANK* is the number of shares held by banks at end of year/number of external circulated shares at end of year. *TRUST* is the number of shares held by trust fund at end of year/number of external circulated shares at end of year. *CORP* is the number of shares held by corporation/number of external circulated shares at end of year. *MANAGER* is the number of shares held by mangers/number of external circulated shares at end of year. *DUALITY* − if the president acts on general manager, the duality is 1, 0 otherwise. *INDEPRATIO* are the independent directors and supervisor seat orders at the end of year/board size. *IGOVn* represents selected good corporate governance variables, $n = 1,2,..., N$; $n \leq 7$. *LEV* is the debt ratio which is defined as total debt divided by total assets. * Represents significance at $\alpha = 0.10$; ** represents significance at $\alpha = 0.05$; *** represents significance at $\alpha = 0.01$.

3.2.3. Analysis of correlation between the corporate governance structure and operating effectiveness. Based on the analysis results of the correlation between the corporate governance structure and operating effectiveness in Table 2, Models 2-1 through 2-4 indicate that − for the shareholding of institutional investors − the government share-holding ratio is significantly positively correlated with green market shares (α = 0.01 and α = 0.05); the shareholding ratio of trust funds and green market shares has a significant positive correlation ($\alpha = 0.01$); and the shareholding ratio of corporations and green market shares has a significant positive correlation ($\alpha = 0.01$ and $\alpha = 0.05$). Thus, the higher the shareholding ratio of the government is, the higher the shareholding ratio of trust funds and corporations is, the higher the supervision effect is, and the better the operating effectiveness is. Regarding managers' shareholding, except for Model 2-3, the shareholding ratio of managers is negatively correlated with green market shares, but the correlation is insignificant. In terms of the board structure, the correlation between the duality of directors and managers and green market shares is inconsistent and insignificant; the correlation between the ratio of the number of independent directors and supervisors and green market shares is also inconsistent and insignificant. For control variables, except for Model 2-3, the debt ratio and green market shares have a significant positive correlation (α = 0.01), thereby indicating that the higher the debt ratio is, the higher the green market share is and the better the operating effectiveness is.

Table 2. Analysis of correlation between corporate governance structure and operating effectiveness

$$GMS_{it} = \beta_0 + \beta_1 GOV_{it} + \beta_2 BANK_{it} + \beta_3 TRUST_{it} + \beta_4 CORP_{it} + \beta_5 MANAGER_{it} + \beta_6 DUALITY_{it} + \beta_7 INDEPRATIO_{it} + \beta_8 LEV_{it} + \varepsilon_i .$$

	GMS			
	All green technology industries (*N* = 330)	Government shareholding green technology industries (*N* = 128)	Non-government shareholding green technology industries (*N* = 202)	Government shareholding group enterprise-based green technology industries (*N* = 101)
	Model 2-1	Model 2-2	Model 2-3	Model 2-4
Intercept	-1.731*** (0.010)	-5.527*** (0.003)	-0.341 (0.321)	-6.936*** (0.005)

Table 2 (cont.). Analysis of correlation between corporate governance structure and operating effectiveness

	GMS			
	All green technology industries (*N* = 330)	Government shareholding green technology industries (*N* = 128)	Non-government shareholding green technology industries (*N* = 202)	Government shareholding group enterprise-based green technology industries (*N* = 101)
	Model 2-1	Model 2-2	Model 2-3	Model 2-4
GOV	0.145*** (0.003)	0.191** (0.021)		0.572*** (0.000)
BANK	-0.090 (0.253)	-0.125 (0.473)	-0.071 (0.142)	0.047 (0.848)
TRUST	0.141*** (0.000)	0.142*** (0.000)	0.148*** (0.000)	0.219*** (0.000)
CORP	0.022** (0.027)	0.071*** (0.009)	0.012** (0.024)	0.065** (0.034)
MANAGER	-0.161 (0.270)	-0.503 (0.290)	0.058 (0.401)	-0.493 (0.281)
DUALITY	-0.188 (0.656)	-1.535 (0.171)	0.384* (0.083)	-1.514 (0.200)
INDEPRATIO	1.563 (0.188)	5.290* (0.093)	-1.140* (0.067)	3.687 (0.351)
LEV	0.042*** (0.005)	0.122*** (0.005)	0.007 (0.331)	0.113** (0.020)
Adj-R^2	27.5%	24.3%	43.2%	45.2%

Note: Variable definition is as described in Table 1.

3.2.4. Correlation analysis of the corporate governance structure, corporate credit risk, and operating effectiveness. According to results of the analysis for correlation between corporate governance structure, corporate credit risk, and operating effectiveness in Table 3, we first explored the correlation between corporate credit risk and operating effectiveness while the multiplied items are not included. Models 3-1, 3-4, and 3-7 indicate significant and negative correlations between *TCRI* and *GMS* (α = 0.01). Thus, the lower the corporate credit risk of the green technology industry is, the higher the operating effectiveness will be. According to Models 3-2 and 3-3, a significant and negative correlation exists between *GOV***TCRI* and *GMS* (α = 0.01), *CORP* × *TCRI* and *GMS* (α = 0.05), and *GOV* × *TRUST* × *TCRI* and *GMS* (α = 0.01).

This study further divides the samples into the government shareholding group and the non-government shareholding group. The product effect of Models 3-5 and 3-6 indicate a significant and negative correlation between *GOV* × *TCRI* and *GMS* (α = 0.01) and *GOV* × *TRUST* × *TCRI* and *GMS* (α = 0.01). On the other hand, in green energy firms without government shareholding, the product effect of Models 3-8 and 3-9 shows a significant and negative correlation between *TRUST* × *TCRI*. *CORP* × *TCRI*, and *TRUST* × *CORP* × *TCRI* and *GMS* (α = 0.01).

In order to explore the effect of group enterprises on green technology industry, this study selected group enterprises from the green technology industry with government shareholding. Models 3-11 and 3-12 suggest a significant and negative correlation between *GOV* × *TRUST* × *TCRI* and *GMS* (α = 0.01). According to comparison among Models 3-3, 3-6, and 3-12, in group enterprises with government shareholding, the effect of *GOV* × *TRUST* × *TCRI* on GMS is more significant.

According to the correlation analysis of corporate governance structure, corporate credit risk, and operating effectiveness in Table 4, based on different degrees of innovative capital, the samples are divided into the firms with high innovative capital (high R&D density and high R&D intensity) and low innovative capital (low R&D density and low R&D intensity) in order to determine the effect of governance structure of green energy firms with different degrees of innovative capital. Models 3-13 through 3-24 suggest a significant and negative correlation between *GOV* × *TCRI* and *GMS* in firms with high R&D density (α = 0.05), low R&D density, and low R&D intensity (α = 0.01); in firms with different degrees of innovative capital, a significant and negative correlation exists between *GOV* × *TRUST* × *TCRI* and *GMS* (α = 0.01). Moreover, the effect of the product term in firms with low innovative capital is higher than those with high innovative capital.

This study compares the empirical results from Tables 3 and 5, which indicate that the adjusted R^2 of the terms in Model 4 are higher than in Model 3. In other words, the explained power of Model 4 is higher and the industry dummy variable will influence GMS. In addition, Models 4-1 through 4-6 show a significant and positive correlation between *IND*1 and *GMS* (α = 0.01 and α = 0.05). Therefore, in comparison to other industries, *GMS* of the solar PV industry is higher.

Table 3. Analysis for correlation between corporate governance structure, corporate credit risk, and operating effectiveness

$$GMS_{it} = \beta_0 + \beta_1 TCRI_{it} + \beta_2 IGOVn_{it} + \beta_3 IGOVn_{it} \times TCRI_{ti} + \beta_4 LEV_{it} + \varepsilon_i .$$

	All green technology industries (*N* = 330)			Government shareholding green technology industries (*N* = 128)			Non-government shareholding green technology industries (*N* = 202)			Government shareholding group enterprise-based green technology industries (*N* = 101)		
	Model 3-1	Model 3-2	Model 3-3	Model 3-4	Model 3-5	Model 3-6	Model 3-7	Model 3-8	Model 3-9	Model 3-10	Model 3-11	Model 3-12
Intercept	1.358 (0.186)	-2.288* (0.084)	-1.903* (0.056)	-1.453 (0.552)	-8.108** (0.023)	-8.012*** (0.002)	1.676*** (0.003)	-0.437 (0.468)	1.367** (0.013)	-8.016** (0.011)	-11.268** (0.027)	-9.689*** (0.002)
TCRI	-0.539*** (0.000)	0.107 (0.595)	-0.001 (0.996)	-0.906*** (0.007)	0.552 (0.372)	0.274 (0.453)	-0.330*** (0.000)	0.054* (0.545)	-0.278*** (0.000)	0.073 (0.855)	0.754 (0.340)	0.352 (0.405)
GOV	0.095** (0.040)	0.754*** (0.000)	0.503*** (0.000)	0.139* (0.072)	0.857*** (0.000)	0.646*** (0.000)				0.636*** (0.000)	0.783*** (0.000)	0.654*** (0.002)
TRUST	0.099*** (0.000)	0.207*** (0.000)	0.198*** (0.000)	0.092*** (0.010)	0.097 (0.293)	0.251*** (0.000)	0.115*** (0.000)	0.389*** (0.000)	0.186*** (0.000)	0.231*** (0.000)	0.244** (0.033)	0.362*** (0.000)
CORP	0.004 (0.707)	0.061** (0.033)	0.018* (0.092)	0.030 (0.264)	0.152* (0.055)	0.042 (0.183)	-0.004 (0.500)	0.030** (0.019)	0.003 (0.647)	0.057* (0.065)	0.145 (0.167)	0.050 (0.190)
GOV × TCRI		-0.260*** (0.000)			-0.276*** (0.000)						-0.101 (0.367)	
TRUST × TCRI		-0.014 (0.228)			0.022 (0.358)			-0.071*** (0.000)			-0.002 (0.933)	
CORP × TCRI		-0.011** (0.048)			-0.029 (0.107)			-0.006*** (0.009)			-0.022 (0.344)	
GOV × TRUST × TCRI			-0.005*** (0.000)			-0.006*** (0.000)						-0.018*** (0.000)
GOV × CORP × TCRI			0.001 (0.541)			0.002 (0.618)						0.004 (0.224)
TRUST × CORP × TCRI			0.000 (0.424)						-0.001*** (0.000)			
LEV	0.055*** (0.000)	0.052*** (0.000)	0.035*** (0.007)	0.162*** (0.000)	0.140*** (0.000)	0.111*** (0.003)	0.016** (0.028)	0.015*** (0.008)	0.013* (0.054)	0.125** (0.011)	0.142** (0.008)	0.116*** (0.016)
Adj-R^2	30.5%	42.3%	45.7%	26.0%	38.7%	45.3%	46.6%	67.8%	50.7%	44.5%	44.0%	51.2%

Note: Variable definition is as described in Table 1.

Table 4. Analysis for correlation between corporate governance structure, corporate credit risk, and operating effectiveness − different innovation capital degree

$$GMS_{it} = \beta_0 + \beta_1 TCRI_{it} + \beta_2 IGOVn_{it} + \beta_3 IGOVn_{it} \times TCRI_{ti} + \beta_4 LEV_{it} + \varepsilon_i .$$

	Green technology industries with high innovation capital						Green technology industries with low innovation capital					
	High R&D density GMS (*N* = 84)			High R&D intensity GMS (*N* = 109)			Low R&D density GMS (*N* = 246)			Low R&D intensity GMS (*N* = 221)		
	Model 3-13	Model 3-14	Model 3-15	Model 3-16	Model 3-17	Model 3-18	Model 3-19	Model 3-20	Model 3-21	Model 3-22	Model 3 -23	Model 3-24
Intercept	0.059 (0.845)	-0.247 (0.601)	0.534* (0.085)	0.879 (0.012)	-0.297 (0.594)	0.949*** (0.004)	2.312* (0.085)	-3.385* (0.054)	-2.108* (0.096)	1.473 (0.323)	-4.390** (0.021)	-3.093** (0.032)
TCRI	-0.081* (0.056)	-0.014 (0.863)	-0.128*** (0.003)	-0.180 (0.002)	0.015 (0.867)	-0.204*** (0.000)	-0.688*** (0.000)	0.278 (0.281)	0.059 (0.739)	-0.626*** (0.001)	0.370 (0.184)	0.109 (0.564)
GOV	0.380*** (0.000)	0.578*** (0.000)	0.645*** (0.000)	0.411 (0.000)	0.421*** (0.005)	0.517*** (0.000)	0.062 (0.249)	0.759*** (0.000)	0.588*** (0.000)	0.072 (0.202)	0.815*** (0.000)	0.556*** (0.000)
TRUST	0.001 (0.890)	0.002 (0.934)	-0.011 (0.369)	-0.005 (0.518)	0.049 (0.209)	-0.009 (0.524)	0.110*** (0.000)	0.227*** (0.000)	0.228*** (0.000)	0.117*** (0.000)	0.231*** (0.000)	0.241*** (0.000)
CORP	0.011*** (0.001)	0.017** (0.040)	0.004 (0.287)	0.007 (0.028)	0.025*** (0.005)	0.003 (0.391)	0.004 (0.758)	0.125*** (0.006)	0.019 (0.147)	0.013 (0.458)	0.137*** (0.005)	0.027 (0.107)
GOV × TCRI		-0.086** (0.019)			-0.040 (0.184)			-0.276*** (0.000)			-0.295*** (0.000)	
TRUST × TCRI		0.000 (0.980)			-0.011 (0.187)			-0.011 (0.477)			-0.007 (0.643)	
CORP × TCRI		-0.002 (0.405)			-0.004** (0.022)			-0.022*** (0.008)			-0.023** (0.012)	
GOV × TRUST × TCRI			-0.006*** (0.001)			-0.004*** (0.001)			-0.006*** (0.000)			-0.006*** (0.000)
GOV × CORP × TCRI			0.000 (0.872)			0.001 (0.560)			-			0.001 (0.655)
TRUST × CORP × TCRI			0.000* (0.051)			0.000* (0.069)			-			0.000 (0.792)
LEV	0.012** (0.011)	0.012*** (0.008)	0.011** (0.016)	0.009 (0.126)	0.016*** (0.008)	0.012** (0.023)	0.053*** (0.005)	0.052*** (0.003)	0.027* (0.096)	0.063*** (0.002)	0.055*** (0.002)	0.038** (0.026)
Adj-R^2	59.2%	63.9%	66.4%	59.7%	64.1%	67.0%	32.2%	46.6%	49.9%	32.3%	47.3%	50.4%

Note: Variable definition is as described in Table 1.

Table 5. Effect of industry sectors on correlation between corporate governance structure, cost of capital, and operating effectiveness

$$GMS_{it} = \beta_0 + \beta_1 TCRI_{it} + \beta_2 IGOVn_{it} + \beta_3 IGOVn_{it} \times TCRI_{ti} + \beta_4 IND1_{it} + \beta_5 IND2_{it} + \beta_6 IND3_{it} + \beta_7 IND4_{it} + \beta_8 LEV_{it} + \varepsilon_i.$$

	All green technology industries (*N* = 330)			Government shareholding green technology industries (*N* = 128)			Non-government shareholding green technology industries (*N* = 202)			Government shareholding group enterprise-based green technology industries (*N* = 101)		
	Model 4-1	Model 4-2	Mode 4-3	Model 4-4	Model 4-5	Model 4-6	Model 4-7	Model 4-8	Model 4-9	Model 4-10	Model 4-11	Model 4-12
Intercept	-0.441 (0.692)	-2.989** (0.029)	-2.547** (0.015)	-5.309** (0.045)	-8.152** (0.036)	-8.414*** (0.001)	1.573** (0.011)	-0.678 (0.295)	1.150* (0.054)	-10.052*** (0.005)	-11.917** (0.031)	-10.661*** (0.002)
TCRI	-0.473*** (0.001)	0.116 (0.568)	0.036 (0.799)	-0.738** (0.030)	0.184 (0.784)	0.183 (0.630)	-0.352*** (0.000)	0.103 (0.292)	-0.293*** (0.000)	0.228 (0.591)	0.627 (0.460)	0.358 (0.423)
GOV	0.115** (0.015)	0.736*** (0.000)	0.471*** (0.000)	0.168** (0.045)	0.784*** (0.000)	0.550*** (0.004)				0.636*** (0.000)	0.726*** (0.001)	0.574** (0.011)
TRUST	0.108*** (0.000)	0.198*** (0.000)	0.200*** (0.000)	0.113*** (0.003)	0.074 (0.466)	0.228*** (0.000)	0.113*** (0.000)	0.390*** (0.000)	0.187*** (0.000)	0.240*** (0.000)	0.235* (0.070)	0.338*** (0.000)
CORP	0.012 (0.275)	0.064** (0.025)	0.022** (0.046)	0.043 (0.117)	0.120 (0.151)	0.038 (0.241)	-0.002 (0.774)	0.035*** (0.008)	0.005 (0.371)	0.072** (0.035)	0.128 (0.257)	0.048 (0.238)
GOV × TCRI		-0.248*** (0.000)			-0.235*** (0.000)						-0.056 (0.631)	
TRUST × TCRI		-0.011 (0.329)			0.027 (0.295)			-0.072*** (0.000)			0.002 (0.939)	
CORP × TCRI		-0.011* (0.056)			-0.018 (0.335)			-0.007*** (0.003)			-0.014 (0.571)	
GOV × TRUST × TCRI			-0.005*** (0.000)			-0.005*** (0.000)						-0.017*** (0.001)
GOV × CORP × TCRI			0.002 (0.385)			0.002 (0.437)						0.005 (0.171)
TRUST × CORP × TCRI			0.000 (0.408)			0.000 (0.780)			-0.001*** (0.000)			0.000 (0.847)
*IND*1	2.178*** (0.000)	1.287** (0.020)	1.104** (0.041)	4.422*** (0.001)	2.943** (0.024)	2.450** (0.049)	0.449 (0.181)	0.104 (0.694)	0.588* (0.069)	2.397 (0.154)	2.125 (0.239)	1.705 (0.310)
*IND*2	0.949* (0.100)	0.139 (0.798)	-0.135 (0.799)	2.156* (0.095)	1.071 (0.402)	0.212 (0.864)	0.151 (0.650)	-0.090 (0.729)	0.229 (0.472)	-0.187 (0.912)	-0.183 (0.917)	0.033 (0.984)
*IND*3	1.576** (0.023)	0.662 (0.308)	0.369 (0.560)	2.001 (0.191)	1.646 (0.266)	1.026 (0.474)	0.347 (0.394)	-0.323 (0.324)	0.351 (0.368)	1.194 (0.507)	1.308 (0.479)	0.848 (0.630)
*IND*4	1.956*** (0.005)	0.696 (0.296)	0.640 (0.318)	4.807*** (0.007)	1.974 (0.284)	1.982 (0.252)	-0.140 (0.708)	-0.130 (0.655)	-0.052 (0.884)	1.724 (0.397)	1.320 (0.541)	1.848 (0.358)
LEV	0.049*** (0.001)	0.049*** (0.000)	0.033** (0.011)	0.153*** (0.000)	0.132*** (0.002)	0.105*** (0.007)	0.015** (0.037)	0.016*** (0.006)	0.012* (0.078)	0.115** (0.022)	0.127** (0.024)	0.117** (0.021)
Adj-R^2	33.3%	43.2%	46.7%	33.4%	39.8%	46.7%	46.7%	67.7%	51.1%	45.3%	43.8%	50.5%

Note: Variable definition is as described in Table 1.

3.2.5. Further analysis of government ownership. According to the government shareholding ratio, the study further divided the sample into three groups. The results show that *GOV* reveals negative correlations with *GMS* when $0 < GOV \leq 1.30\%$ and $1.30\% < GOV \leq 3.36\%$. It also shows that *GOV* reveals significant and positive correlation with *GMS* when $GOV > 3.36\%$ ($\alpha = 0.01$). The result of this study is the same as Lihui and Saul's (2008) results – namely, we identified a U-shaped relationship between the government shareholding and operating effectiveness. Therefore, when the government shareholding ratio is low, the government does not have the governance effect; however, when the government shareholding ratio is greater than 3.36%, the government has the effect of supervision, which can increase operating effectiveness.

Yet the results of this study differ from those of Lihui and Saul (2008), mainly due to the fact that the green technology industry is an emerging industry; thus, the number of samples is limited. Second, most of the green technology industry in Taiwan is not a state-owned enterprise. In order to develop the green technology industry, the government has been actively increasing investment in recent years.

Conclusion

The government is the key driver of the development of the green technology industry. The findings indicate that the green technology industry should avoid corporate credit risk when expanding investments and increasing technical R&D. The industry can easily acquire financing from banks, increase green market shares, and enhance corporate performance. To sum up, this study identified several empirical results.

In the corporate governance structure of green technology industry, government shareholding, trust fund shareholding, and corporate shareholding reveal a supervision effect and can significantly reduce corporate credit risk as well as enhance corporate operating effectiveness.

For green technology industry, the governance effect of government ownership is the most significant. Moreover, there is a U-shaped relationship between the government ownership and operating effectiveness. Thus, the higher government ownership is, the better governance structure and the higher the supervision effect will be.

The reduction of corporate credit risk in green energy firms can significantly enhance operating effectiveness. Moreover, good variables of corporate governance structure will enhance the effect of corporate credit risk on operating effectiveness.

In green energy companies with different degrees of innovative capital, government ownership effects will be different.

The solar PV industry has higher green market shares. The effect of the governance structure in the solar PV industry on corporate credit risk and operating effectiveness is higher.

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