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An empirical study of green management and performance in Taiwanese electronics firms

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Abstract: Global warming and increased pollution from electronics production highlight the importance of green management (GM) for Taiwanese electronics firms. Through a survey of 213 Taiwanese electronics manufacturers, this study empirically examines the influence of GM on organizational performance improvement. Drawing on a moderated hierarchical regression analysis, we evaluate the general relationship between specific GM practices and performance. The findings indicate that GM has a significant impact on firm performance. We then investigate how contingency factors, circumstance uncertainty (CU), operation management philosophy, and total quality environmental management (TQEM) influence the relationship between GM practices and firm performance. Several crucial relationships are derived from our results. The moderating effects of CU and TQEM demonstrate that in some cases with certain GM practices, the inclusion or exclusion of CU and TQEM might reduce or improve performance. This study also discusses the managerial implications of the research results.

Subjects: Industrial Engineering & Manufacturing; Sustainable Engineering & Manufacturing; Operations Management

Keywords: green management; green product development; circumstance uncertainty; total quality environment management

ABOUT THE AUTHORS

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PUBLIC INTEREST STATEMENT

The increased attention given to the topic of environment management warrants the writing of this paper. The concept of environment management is to integrate environmental thinking into supply chain management and new product development. This research findings indicate that environment management has a tremendous influence on enterprise various performance. Moreover, contingency factors as well as quality management will also tie up with the results of their influence. The research findings are particularly important for Taiwanese electronics manufacturers that are attempting to achieve sustainability performance. The implications and insights for practitioners are also provided.

1. Introduction

Awareness of the importance of protecting the environment and the natural ecology of the planet has grown in recent years in Taiwan. Both in Taiwan and worldwide, many enterprises—particularly those in the electronics industry—have sought to enhance their environmental management capabilities because of customer pressure; environmental laws such as the Waste Electrical and Electronic Equipment directive, Restriction of Hazardous Substances directive, and Bali Communique; and environmental management standards such as ISO 14001 (Kanji, 2008; Koo, Chung, & Ryoo, 2014). Eighty-two percent of raw materials used in electronics products are nonenvironmentally friendly, which ultimately results in billions of tons of unsalvageable materials being discarded in landfills, causing many to overflow (Wong, Lai, Shang, Lu, & Leung, 2012). Electronics firms in Taiwan are widely OEM-oriented (Cheng, 2013), and many of these firms receive customer requests to supply environmentally friendly products; thus, these firms have begun implementing green manufacturing processes (Huang & Wu, 2010).

Effective environmental management, which includes all efforts to minimize the adverse environmental impacts of an enterprise's processes and products throughout their life cycles, has become a priority in virtually all industries (Yang, Yang, & Peng, 2011). By reviewing the relevant literature and adopting an environmental perspective, we developed two factors for GM practices: green product development (GPD) and green supply chain management (GSCM). GM is concerned with overseeing both product- and supply chain-oriented environmental practices to mitigate the damage to natural resources from products and supply chain processes (Ferguson & Toktay, 2006; Wong et al., 2012). These two essential practices, GPD and GSCM, have been gaining momentum in recent years and have been widely accepted in Taiwan's electronics industry (Huang & Wu, 2010; Yang et al., 2011).

1.1. Green product development and green supply chain management

GPD is concerned with developing methods for commodity manufacturing that utilizes ecodesign, ecofriendly material selection, clean manufacturing processes, other environmental management practices throughout the entire product life cycle, and product end-of-life management with the aim of minimizing the amount of waste sent to landfills and the expenses associated with the manufacturing, distributing, using, recycle, and disposing of products (Wong et al., 2012; Yang et al., 2011). GPD ensures quality and environmental conformance, thereby preventing firm reputational damage from environmentally harmful products. GSCM ranges from the monitoring of general environmental management programs in manufacturing, storage, and transportation to implementing more proactive practices in supplier, distributor, and consumer networks (Zhu & Sarkis, 2004). Adopting the perspectives of GPD and GSCM can provide a broad view of GM in Taiwan's electronics industry.

1.2. Circumstance uncertainty and total quality environmental management

In this study, we address two research questions. First, how do the GM practices of GSCM and GPD influence enterprise performance? Hypotheses are posed according to a literature review and our field observations. Second, do other factors during a project influence the strength of the relationship between GM and firm performances? Circumstance Uncertainty (CU) encompasses contingency factors of technology, regulations, and societal expectations for cross-firm interactions, which renders predicting the causal relationships of events difficult (Wong, Boon-itt, & Wong, 2011). Firms must be capable of adapting to new circumstances and contingencies in a competitive business environment (Lee, Huang, Barnes, & Kao, 2010). Several studies have shown that total quality management (TQM) benefits companies by improving product quality and firm performance (Jaca & Psomas, 2015; Lam, Lee, Ooi, & Lin, 2011). Because firms have sought to improve their green operations and competitive positions by implementing GM, TQM has gradually shifted into a more environmentally sustainable direction, with the resulting approach called total quality environmental management (TQEM) (Bhat, 1998; Curkovic & Sroufe, 2007; Yang, Lin, Chan, & Sheu, 2010). Accordingly, we hypothesize that the effectiveness of GSCM and GPD varies among firms depending on their CU and TQEM levels. We consider CU and TQEM to be moderators of the relationship between GM and organizational performance. The presence of moderators may distort how firms interpret the role of management in this relationship. This possibility was investigated by examining hierarchical moderated regressions that contain interaction terms of GM and CU as well as TQEM.

2. Framework and hypothesis

A substantial volume of business management literature indicates that GPD and GSCM correlate positively to environmental performance (EP), financial performance (FP), and operational performance (OP) (Chung & Hsu, 2010; Zhu, Sarkis, & Lai, 2012). Effective environmentally friendly practices are clearly critical in moving a firm and its products toward performance improvement (Hwang, Wen, & Chen, 2010; Pujari, Wright, & Peattie, 2003). Various benefits can be derived from product environmental improvement, including increased sales, enhanced market performance and competitiveness, and improved corporate image (Gemser & Leenders, 2001; Pujari, 2006). Close cooperation and mutual communication between firms and suppliers facilitate a clean production process and improved EP, and thus have become a trend in the manufacturing industry (Bai & Sarkis, 2010). Through implementing GM practices, firms cooperate with upstream suppliers to obtain green materials and improve their operational efficiency, and to design green concept products, thereby yielding financial benefits (Gil, Jiménez, & Lorente, 2001; Welford, 1995). The value of green collaboration practices within a supply chain manifests as OP enhancements such as in manufacturing lead times, productivity, and on-time delivery (Vachon & Klassen, 2006). Green product innovation contributes considerable benefits to EP and OP (Alhadid & As'ad, 2014; Chiou, Chan, Lettice, & Chung, 2011; Harts, 1997). More broadly, the implementation of GPD and GSCM are essential to firm EP, FP, and OP. Figure 1 presents the conceptual framework used in this study, which was adopted to investigate electronics firms implementing GM (GPD and GSCM) and the associated changes in EP, FP, and OP.

2.1. Green management and organizational performance

In this research model, we posit that the two GM practices have a positive and direct relationship with organizational performance improvement. We also posit that TQEM and CU moderate the relationship between GM and organizational performance. Therefore, we posit the following hypotheses for determining whether firm GM practices effectively contribute to EP, FP, and OP improvement:

H_{1a}: Firms with higher levels of GSCM adoption have greater EP improvements.

H_{1b}: Firms with higher levels of GPD adoption have greater EP improvements.

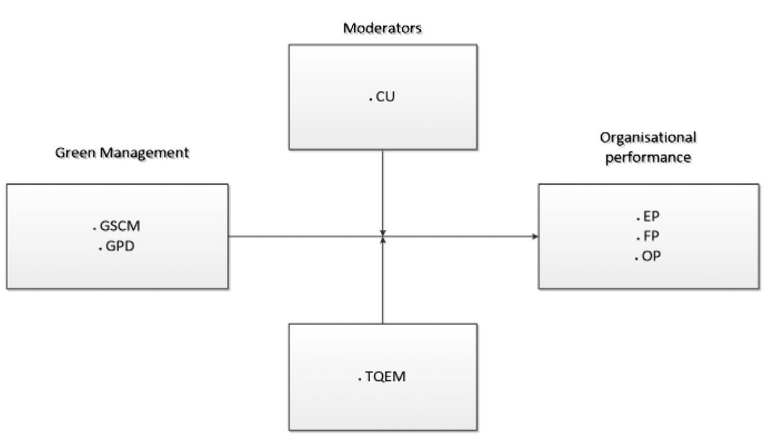
H_{2a}: Firms with higher levels of GSCM adoption have greater FP improvements.

H_{2b}: Firms with higher levels of GPD adoption have greater FP improvements.

H_{3a}: Firms with higher levels of GSCM adoption have greater OP improvements.

H_{3b}: Firms with higher levels of GPD adoption have greater OP improvements.

Figure 1. Framework for investigating the relationship between GM practices and organizational performance.



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2.2. Moderator: circumstance uncertainty

Song, Jinhong Xie, and Di Benedetto (2001) argued that the more potential sources of environmental change there are, the greater the uncertainty faced by a firm is. When various CUs are present, it is difficult for firms to make a decision on market investment, which can have a severe effect on business performance (Aulakh & Kotabe, 1997; Cavusgil & Zou, 1994; Selnes & Sallis, 2003). According to the aforementioned arguments regarding the effects of CU, we established the following hypotheses:

H_{4a}: The negative relationship between GSCM adoption and EP is weaker in firms that have more CU conditions than in firms that have fewer CU conditions.

H_{4b}: The negative relationship between GSCM adoption and FP is weaker in firms that have more CU condition than in firms that have fewer CU conditions.

H_{4c}: The negative relationship between GSCM adoption and OP is weaker in firms that have more CU conditions than in firms that have fewer CU conditions.

H_{5a}: The negative relationship between GPD adoption and EP is weaker in firms that have more CU conditions than in firms that have fewer CU conditions.

H_{5b}: The negative relationship between GPD adoption and FP is weaker in firms that have more CU conditions than in firms that have fewer CU conditions.

H_{5c}: The negative relationship between GPD adoption and OP is weaker in firms that have more CU conditions than in firms that have fewer CU conditions.

2.3. Moderator: total quality environmental management

Zhu and Sarkis (2004) found that QM (Quality Management), including the adoption of TQM-type programs and ISO 14000 standards certification, moderated some of the relationships of GSCM with EP and FP. Wayhan, Kirche, and Khumawala (2002) contended that ISO 9000 quality management certification had little or no effect on firm financial and organizational performance. According to the aforementioned literature, we posit the following hypotheses.

H_{6a}: The positive relationship between GSCM adoption and EP is stronger in firms that have more TQEM conditions than in firms that have fewer TQEM conditions.

H_{6b}: The positive relationship between GSCM adoption and FP is stronger in firms that have more TQEM conditions than in firms that have fewer TQEM conditions.

H_{6c}: The positive relationship between GSCM adoption and OP is stronger in firms that have more TQEM conditions than in firms that have fewer TQEM conditions.

H_{7a}: The positive relationship between GPD adoption and EP is stronger in firms that have more TQEM conditions than in firms that have fewer TQEM conditions.

H_{7b}: The positive relationship between GPD adoption and FP is stronger in firms that have more TQEM conditions than in firms that have fewer TQEM conditions.

H_{7c}: The positive relationship between GPD adoption and OP is stronger in firms that have more TQEM conditions than in firms that have fewer TQEM conditions.

2.4. Control variables

Larger firms usually have more available resources than do small- and medium-sized ones. Therefore, large firms are more likely to have well-developed GM, planning, and other environmental practices. We followed Dean and Snell (1991) in measuring firm size as the natural logarithm transformation of the number of firm employees.

3. Methodology

3.1. Operational variables

We developed a questionnaire survey instrument to measure the current GM practices and performance of Taiwanese electronics firms. The measurement variables of the questionnaire were adopted from Krause, Handfield, and Tyler (2007), Zhu and Sarkis (2004), Lai and Wong (2012) and Narasimhan and Kim (2002), and by consulting experts from the Taoyuan City Bureau of Environment Protection as well as several environmental managers from electronics firms in Taoyuan City, Hsinchu Science Park and three other industrial parks in Taiwan.

In the organizational performance estimation, 13 measurement criteria were adopted from established literature, specifically from Lai and Wong (2012) for the EP and OP indicators and from Wong et al. (2011) for the FP indicators. Three measurement indicators for the first moderator CU were adopted from Fynes, de Búrca, and Marshall (2004), Bstieler and Gross (2003) and Wagner and Bode (2008). For the second moderator, TQEM, two measurement items were adopted from Zhu and Sarkis (2004) and Chang (2007). All measurement variables partially derived from the literature were pretested through evaluation by managers from the Taoyuan City Bureau of Environment Protection and environmental managers from electronics firms in Taoyuan City, Hsinchu Science Park, and three other industry parks. Questions about the performance results of GPD and GSCM adoption were answered using a 5-point scale (1 = none at all, 2 = mild, 3 = moderate, 4 = relatively significant, and 5 = significant).

3.2. Survey questionnaire development

The research data were collected through a questionnaire survey. We focused on the electronics manufacturing and processing industries in Taiwan, and specifically examined sectors that typically involve the constant emission of pollutants or that have the most direct impact on the environment during the production process (e.g. printed circuit board, electroplate, and semiconductor manufacturing). To prevent bias and ensure survey quality, we chose questionnaire respondents who were mid-level managers or were procurement or environmental management department heads for firms with at least 100 employees. Survey recipients were identified using convenience sampling; a total of 827 questionnaires were administered through the postal service, of which 236 were returned. Surveys with missing values were excluded, with 213 questionnaires retained for data analysis. The questionnaire items were answered using a 7-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = neutral, 5 = slightly agree, 6 = agree, and 7 = strongly agree) to assess how the respondents perceived GSM, organizational performance, and the two moderators (CU and TQEM).

3.3. Factor analysis

Prior to the factor analysis, exploratory analyses were conducted after the Bartlett test of sphericity was performed to examine whether the original set of variables were significantly intercorrelated, and the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was used to determine the extent to which the original set of variables were suitable for a factor analysis. The Bartlett test of sphericity result was 91.273 ($p < 0.01$), KMO was 0.819, and the reliability coefficient α was 0.845. These results indicated that the data were appropriate for a factor analysis.

We then conducted a factor analysis to confirm our groupings of GM practice and organizational performance from the survey data. The maximum likelihood method was used to extract the factors, and then a varimax rotation was performed. The Kaiser criterion (eigenvalues > 1) was applied to evaluate the scree plots. From the results of the initial eigenvalue and scree tests, we retained two meaningful factors for GM practices and three for organizational performance, which confirmed our original groupings for the scale items of GM practice and organizational performance. The two GM factors explained 81.9% of the inherent variance in their items. The reliability assessment was conducted using Cronbach's α values, which were 0.91 and 0.89 for GPD and GSCM, respectively. Therefore, the original two factor names of GPD and GSCM were retained. Similarly, the three

Table 1. Descriptive statistics for GM supplier practices

	Mean	Std. deviation
Green supply chain management (α = 0.9247)	5.158	1.074
Green supplier direct involvement	5.370	1.264
Green supplier incentives	4.745	1.122
Green supplier assessment	4.953	1.23
Cooperation with customers for cleaner production	5.624	0.945
Investment recovery (sale) of excess inventories/materials	5.328	1.152
Our firm has a formal green logistics management	4.824	1.042
Our firm has a well-developed green logistics management database for tracking green logistics management performance	5.216	1.341
The level of strategic partnership with green suppliers	5.917	1.209
Information exchange with green suppliers through information technology	5.206	1.314
Green product development (α = 0.912)	5.428	1.085
Design of products for reduced consumption of material/energy	5.584	1.247
Design of products for reuse, recycle, recovery of material, component parts	5.352	1.132
Design of products to avoid or reduce use of hazardous of products and/or their manufacturing process	5.237	1.153
Commitment of GSCM from senior managers	5.785	1.228
Support for GSCM from mid-level managers	5.385	1.104
Environmental management systems exist	5.676	1.027
The participation level of green suppliers in the design stage	5.682	1.276
Company has formal long-term plans	5.941	1.008
Green knowledge transfer and communication	5.108	1.243
Moderator1 TQEM (α = 0.892)	5.482	1.041
ISO 14001	5.238	1.096
TQM	5.645	0.984
Moderator2 CU (α = 0.872)	5.513	0.945
Demand & supply uncertainty	5.844	1.003
Technological uncertainty	5.238	1.045
Regulatory, legal, and bureaucratic uncertainty	5.575	1.027

Notes: GSCM: Green Supply Chain Management; TQEM: Total Quality Environment Management; ISO: International Organization for Standardization; TQM: Total Quality Management; CU: Circumstance Uncertainty.

organizational performance factors explained 85.2% of the inherent variance in their items. The Cronbach's α values for EP, FP, and OP were 0.83, 0.81, and 0.89, respectively; thus, their original three factor names were also retained. All of the descriptive statistics, consisting of the means and standard deviations of the measurement variables for GM practices and organizational performance, are presented in Tables 1 and 2.

3.4. Estimation procedure for moderators

In the data analysis methodology, especially for empirical operational management researches, modified hierarchical regression was utilized to test our various hypotheses. It is an appropriate technique for identifying moderator variables, accompanied by procedures for clarifying relationships (Anderson, 1986). H_{4a}/H_{4b}–H_{9a}/H_{9b} posit that the relationship between GM and organizational performance is moderated by CU and TQEM. To verify the moderating influences of CU and TQEM on the relationship between GM and organizational performance, we conducted a moderated regression analysis using a four-model regression. All analyses were performed using SPSS (Version 17.0). In the first model, the control variable, the corporation size is entered into the regression as the first

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Table 2. Descriptive statistics for organizational performance

	Mean	Std. deviation
Environmental performance	5.721	0.951
Reduction of waste emission	4.723	1.103
Decrease in consumption for hazardous/harmful/toxic materials	5.337	1.037
Decrease in frequency for environmental accidents	5.682	1.021
Improve enterprises' environmental situation	5.941	1.141
Financial performance	4.723	1.017
Production cost	4.935	1.232
ROA (income/assets)	5.368	1.182
Profit margin	4.825	1.012
Asset turnover	4.623	1.164
Cash conversion cycle	4.756	1.023
Operational performance	5.460	1.065
Delivery	5.690	1.034
Order fulfillment rate	4.814	1.121
Inventory	5.237	1.083
Production flexibility	5.497	1.017

Note: ROA: Return on assets.

block. In the second model, one of the GM variables, GSCM and GPD, is entered into the regression as the second block. In the third model, the two moderators, CU and TQEM, are entered as the third block. In the fourth model, the two interaction terms of GSCM (or GPD) and with the moderators (CU or TQEM) are entered as the fourth block. If the change in the relationship from the interaction of CU and TQEM was statistically significant, a significant moderator effect was supported. To confirm the significance of the moderating effect, only the incremental variance was assessed rather than considering any individual statistically significant variables to be relevant (Hair, Black, Babin, Anderson, & Tatham, 2006). Evidence of moderation exists if the interaction terms account for significant incremental variance in a dependent variable, either individually (conveyed by the beta values) or collectively (conveyed by the incremental *F*-statistic values) (Dean & Snell, 1991). A centring procedure was employed to diminish any possible multicollinearity and because the approach yields readily interpretable coefficients that are relatively free of multicollinearity.

4. Results

4.1. Main effects and control variable relationships

Tables 4 and 5 show the results of the one-tailed hierarchical moderated regression analyses. The analysis results indicate that the control variable, corporation size, does not have a significant relationship with any of the performance measures, suggesting that the additional available resources for larger firms that engage in GSCM and GPD are irrelevant to their performance.

The Pearson correlation coefficients in Table 3 indicate that engaging in GM practices has a significant and positive relationship with firm performance. Moreover, the highly significant values of deltas *F* and *R* in Model 2 (Tables 4 and 5), which were analyzed using a multivariate regression analysis, reveal the same results. Thus, the analysis results strongly support H_{1a}/H_{1b}–H_{3a}/H_{3b}.

4.2. Moderating effects

Tables 4 and 5 present the relationships of specific sets of GM practice factors and performance outcomes, showing that both CU and TQEM moderate the GM practice–organizational performance relationship. Table 4 shows that the main effects of GSCM were all significant. In Model 4, when the

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Table 3. Correlations between GM practice and organizational performance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) GSCM	1							
(2) GPD	0.616*	1						
(3) CU	0.346***	0.571*	1					
(4) TQEM	0.523**	0.374*	0.261*	1				
(5) EP	0.417**	0.569***	0.322**	0.438	1			
(6) FP	0.337**	0.312**	0.423**	0.221***	0.342**	1		
(7) OP	0.423***	0.455***	0.268*	0.365**	0.387**	0.327**	1	
(8) Corporation size	0.023	0.011	0.117	0.031	0.024	0.045	−0.0354*	1

Notes: GSCM: Green Supply Chain Management; GPD: Green Product Development; CU: Circumstance Uncertainty; TQEM: Total Quality Environment Management; EP: Environmental Performance; FP: Financial Performance; OP: Operational Performance.

*$p < 0.05$.

**$p < 0.01$.

***$p < 0.001$.

Table 4. Hierarchical regression according to the GSCM, CU, and TQEM interaction

Variable entered	Dependent variable											
	Environmental performance				Financial performance				Operational performance			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Corporation size	0.004	0.036	0.074	0.104	−0.032	−0.042	−0.087	−0.113	−0.032	−0.042	−0.087	−0.113
GSCM		0.278**	0.267**	0.229**		0.319***	0.247**	0.332*		0.428***	0.278**	0.227*
CU			−0.273**	−0.335***			−0.322**	−0.217*			−0.422**	−0.416*
TQEM			0.341**	0.349**			0.227**	0.215*			0.324**	0.226*
GSCM × CU				−0.189*				−0.108				−0.286**
GSCM × TQEM				0.416**				0.114				0.287*
F for the regression	0.145	24.376***	16.484***	14.573***	0.173	12.998***	11.529***	7.723*	0.271	11.291***	10.342***	9.327***
Δ*F*		36.995***	23.511***	12.677**		23.478***	19.873***	17.884*		16.273***	12.478***	8.224**
R^2	0.327	0.565	0.631	0.787	0.283	0.294	0.334	0.536	0.131	0.148	0.215	0.462
ΔR^2		0.238***	0.166**	0.276**		0.011	0.040	0.194**		0.017	0.067	0.253**

Notes: Table contains standardized coefficient betas. GSCM: Green Supply Chain Management; CU: Circumstance Uncertainty; TQEM: Total Quality Environment Management.

*$p < 0.05$.

**$p < 0.01$.

***$p < 0.001$.

moderator CU was entered into the regressions, the incremental F for the block of interaction was significant for EP (12.677), FP (17.884), and OP (8.224), and the incremental R^2 was significant for all three terms (0.276, 0.194, and 0.253, respectively). The two interaction terms of GSCM and CU had slightly significant and significantly negative beta values for EP ($\beta = -0.189$, $p < 0.05$) and OP ($\beta = -0.286$, $p < 0.01$); the beta value was nonsignificant for FP. When the moderator TQEM was entered into the regression, the two interaction terms of GSCM and TQEM had significant and slightly positive beta values for EP ($\beta = 0.416$, $p < 0.01$) and OP ($\beta = 0.287$, $p < 0.05$); the beta for FP was nonsignificant. Table 5 reveals that the main effects of GPD were all significant. In Model 4, when the moderator CU was entered into the regressions, the incremental F for the block of interactions was significant for EP (11.336), FP (5.821), and OP (6.846), and the incremental R^2 was significant for all three terms (0.225, 0.218, and 0.197, respectively). The interaction terms GPD and CU had nonsignificant beta values for EP and FP, but a slightly significant beta value for OP ($\beta = 0.183$, $p < 0.05$).

Table 5. Hierarchical regression according to the GPD, CU, and TQEM interaction

Variable entered	Dependent variable											
	Environmental performance				Financial performance				Operational performance			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Corporation size	0.004	0.017	0.035	0.094	−0.032	−0.073	−0.094	−0.109	−0.023	−0.045	0.094	−0.124
GPD		0.505***	0.472***	0.389**		0.684**	0.565***	0.513**		0.489**	0.345**	0.417**
CU			0.211**	−0.329**			0.219*	−0.217*			0.221*	−0.126*
TQEM			0.196*	0.278*			0.139**	0.283**			0.236**	0.246**
GPD × CU				−0.029				−0.017				0.183*
GPD × TQEM				0.676***				0.257*				0.369**
F for the regression	0.195	17.421***	13.192***	8.095**	0.138	4.369**	3.114**	2.358**	0.214	4.223**	3.335**	1.393
Δ*F*		21.326***	14.447***	11.336**		15.434***	11.573***	5.821*		19.434***	16.573***	6.846**
R^2	0.127	0.386	0.453	0.598	0.006	0.134	0.272	0.394	0.026	0.158	0.201	0.293
ΔR^2		0.165**	0.157*	0.225**		0.128*	0.038	0.218*		0.032	0.043	0.197*

Notes: Table contains standardized coefficient betas. GPD: Green Product Development; CU: Circumstance Uncertainty; TQEM: Total Quality Environment Management.

*$p < 0.05$.

**$p < 0.01$.

***$p < 0.001$.

When the moderator TQEM was entered into the regression, the two interaction terms GPD and TQEM had significantly positive beta values for EP ($\beta = 0.676$, $p < 0.001$), FP; $\beta = (0.257$, $p < 0.05)$, and OP ($\beta = 0.369$, $p < 0.01$).

To further illustrate the moderating effects, we adopted the graphical procedure of Aiken, West, and Reno (1991) to draw the regression lines in Figure 2(a)–(d) and Figure 3(a)–(d) to explore the nature of the interaction. To plot the moderating effects, we assigned to CU and TQEM the values of one standard deviation above and below their means. Figure 2(a) shows that the sloped regression line for the relationship between GSCM and EP manifests a slightly significant moderating effect for low CU ($\beta = -0.767$, $p < 0.05$), and no moderating effect for high CU ($\beta = -0.119$, $p = 0.23$). Similarly, the moderating effect of low and high CU for the relationship between GSCM and FP was confirmed as nonsignificant. Regarding the moderating effect on the relationship between GSCM and OP, it was confirmed as significant, as Figure 2(b) shows. Thus, H_{4a} and H_{4c} were supported for this particular GM practice. H_{4b} was not supported.

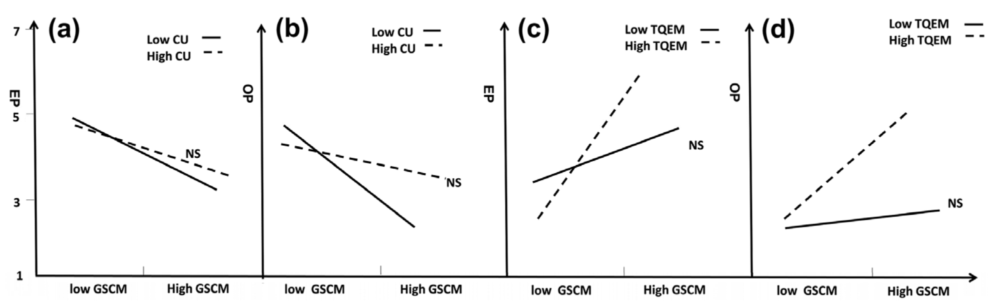

Figure 2. (a) Moderating effect of CU on the relationship between GSCM and EP. (b) Moderating effect of CU on the relationship between GSCM and OP. (c) Moderating effect of TQEM on the relationship between GSCM and EP. (b) Moderating effect of TQEM on the relationship between GSCM and OP.

Note: NS-Not significant.

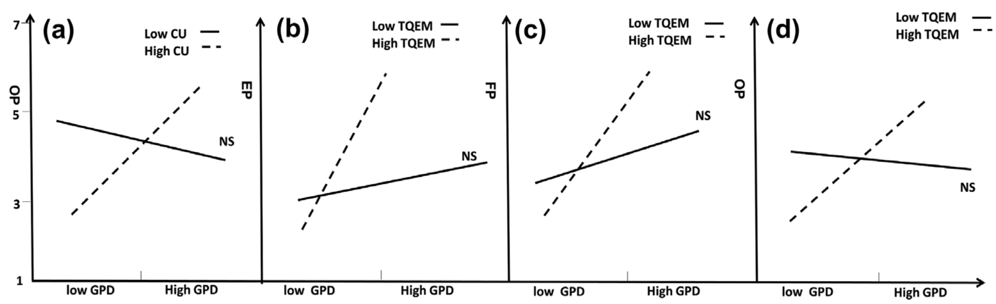

Figure 3. (a) Moderating effect of CU on the relationship between GPD and OP. (b) Moderating effect of TQEM on the relationship between GPD and EP. (c) Moderating effect of TQEM on the relationship between GPD and FP. (d) Moderating effect of TQEM on the relationship between GPD and OP.

Note: NS-Not significant.

Table 6. Hypothesis support results obtained using hierarchical regression and the graphical procedure

Hypothesis support	Moderator	β	*p*
$H4_a$	High CU	−0.767	<0.05
	Low CU	−0.119	0.23
$H4_c$	High CU	0.584	<0.01
	Low CU	−0.047	0.36
$H6_a$	High TQEM	0.832	<0.01
	Low TQEM	0.014	0.17
$H6_c$	High TQEM	0.561	<0.01
	Low TQEM	−0.032	0.27
$H5_c$	High CU	0.374	<0.05
	Low CU	−0.212	0.11
$H7_a$	High TQEM	0.915	<0.001
	Low TQEM	0.217	0.19
$H7_b$	High TQEM	0.744	<0.05
	Low TQEM	0.015	0.28
$H7_c$	High TQEM	0.592	<0.01
	Low TQEM	0.107	0.34

Notes: CU: Circumstance Uncertainty; TQEM: Total Quality Environment Management.

Using the graphical procedure method to validate $H_{5a}/H_{5b}/H_{5c}$; $H_{6a/}$ H_{6b}/H_{6c}; $H_{7a/}$ H_{7b}/H_{7c}, we obtained the following results. Figure 2(c) and (d) demonstrate that H_{6a} and H_{6c} were supported, but H_{6b} was not supported. H_{5a} and H_{5b} were not supported; although H_{5c} was supported, the effect was in the opposite direction as that suggested in Figure 3(a). Figure 3(b), (c), and (d) reveal that H_{7a}, H_{7b}, and H_{7c} were fully supported. The hypothesis results are summarized in Table 6 for comparison.

5. Discussion

5.1. Main effects

The empirical results suggest that the examined GM practices are effective for EP, FP, and OP improvement, as expected. The relationships between GM practice and organizational performance are all significantly positive, particularly in GPD. Our investigation demonstrated that the mean of GPD (5.428) was higher than the mean of GSCM (5.158). We expect that effectively engaging in GPD plays a crucial role in reducing the bottleneck when adopting GM practices.

5.2. Interaction effects

Our research results demonstrate that the moderating role of CU produced mixed results regarding the relationship between GM and organizational performance. Higher CU increases the extent to which the relationship between GSCM and OP decreases, which is consistent with the finding of Iyer, Germain, and Claycomb (2009). This result is also in line with the intuitive assumption that a negative relationship exists between CU and organizational performance. These results indicate the imperfect role of GSCM under uncertainty, suggesting that firms should recognize that uncertainty in such circumstances must be considered when evaluating the payoff from GSCM implementation efforts.

Contrary to the original hypothesis-H_{5c}, the moderating effect of CU on the relationship between GPD and OP did not weaken; by contrast, CU actually improved firm OP when interacting with GPD. In this situation, CU functions as a facilitator of effective organizational performance. Circumstance uncertainty exerts a positive moderating effect unexpectedly on OP when interacting with GPD, which also confirms the research results of Calantone, Schmidt, and Benedetto (1997). A possible explanation for the positive moderating effect of CU is that the relatively high degrees of competitive environment in GPD forces electronics firms to establish more effective cross-functional coordination, develop more effective green knowledge transfer methods, gain stronger support from middle or top management, and formulate more unique expertise to cope such uncertainty.

TQEM interaction effects signify whether TQEM programs implemented by a firm have some importance in terms of implementing superior GSCM to strengthen the relationships with customers and suppliers to help firms further enhance the scenarios of EP and OP improvement. The moderating effect of TQEM is especially clear for GPD practices. This is quite an important discovery because companies that seek to develop green products from an environmental, financial, and operational performance perspective seems to encounter difficulty in executing these practices unless TQEM-type programs (e.g. TQM and ISO 14000 certification) are in place. Therefore, TQEM or TQM programs are critical antecedents to many GPD practices.

6. Conclusion

This study offers several insights into GM practices and provides implications as well as contributions to GM and the moderating effects of CU and TQEM in the context of the Taiwanese electronics industry. The first implication is concerned with the conceptualization of constructs. This study demonstrates the benefits of conceptualizing GM by segregating GPD and GSCM as multidimensional constructs. GPD practices matter organization performance more than GSCM practices. GSCM practices tend to produce external cooperation opportunities for both enterprises and their partners (suppliers/customers). The second implication of this study is that the inclusion or exclusion of moderators might lead to an improvement or decline in organizational performance. To sustain improved organizational performance, firms should strategically utilize the efficiency of TQEM and integrate this with innovative strategic GPD ideas or other complementary GPD mechanisms to varying extents. Furthermore, the interplay of CU with GPD and GSCM practices must be considered. Broadly, our findings confirm that superior OP sometimes arises not from a firm itself but from external sources of advantage, in this case, the CU between GPD practices. It is essential to develop means of exploiting these driving forces to leverage the status of CU and transfer it into a competitive advantage for firms. Electronics firms in Taiwan should realize that green products will become a mainstream manufacturing concept and that GM will become a core business principle. Electronics firms must be able to make effective use of these green opportunities to transfer the original environmental pressures into a competitive advantage, improve corporation image, develop new market segments, expand into new markets, and maximize benefits.

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