

# Effects of Business Greening and Green IT Capital on Business Competitiveness

Shun-Pin Chuang · Sun-Jen Huang

Received: 25 June 2013 / Accepted: 4 February 2014 / Published online: 19 February 2014  
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**Abstract** Despite the fact that the association between business greening and its competitiveness has been confirmed, the effects of green IT capital on the relationship between business greening and competitiveness have largely not been investigated by researchers. To address this gap in the research, this study aims to introduce and define the new concept of green IT capital to bridge the gap for business greening. The results of a sample survey of 148 companies from the top 1,000 manufacturers in Taiwan confirmed that the degree of business greening has significant positive effects on business investment in green IT human capital, green IT structural capital, and green IT relational capital as well as business competitiveness. In addition, the three dimensions of green IT capital positively relate to business competitiveness. In mediating effect, green IT relational capital partially mediates the links between the degree of business greening and business competitiveness.

**Keywords** Degree of business greening · Green IT capital · Green IT human capital · Green IT structural capital · Green IT relational capital · Business competitiveness

## Introduction

In recent years, with the growing awareness of the concept of sustainable development and business greening, environmental protection has become a subject of global concern. The concept of environmental protection being incorporated into IT originally started in 2003 when the European Union issued environmental directives (Chen 2008; Huang and Kung 2011). Later in 2005, 128 countries jointly signed the legally bound Kyoto Protocol, making publicly known their determination to reduce greenhouse gas emissions (Kao et al. 2010). In light of the above arguments, sustainable development and green concepts will have a tremendous effect on the industrial environment (Shrivastava 1995; Porter and Van der Linde 1999).

Since enterprises need to spend money on green activities to follow government policies and rules, they are materially affected by market competitiveness (Russo and Fouts 1997; Cordano and Frieze 2000; Buysse and Verbeke 2003). Existing research has shown that business greening should not be regarded as full compliance with environmental protection rules; instead, it should be used as a force to improve business structures, enhancing the quality of products and services (Florida 1996; Porter and Van der Linde 1999; Chen et al. 2006). Therefore, sustainable development and green concepts have not only become the responsibility of enterprises but an important strategy to strengthen their market competitiveness.

In the era of the knowledge economy, traditional factors of production, such as labor, capital, and land are no longer the way to gain a competitive advantage. Rather, this has been replaced by technological skills such as innovation abilities and technical capabilities based on IT capital and human capital (Hart 1985; Russo and Fouts 1997; Bock et al. 2005; Chen 2008). In addition, some researchers

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S.-P. Chuang · S.-J. Huang (✉)  
Department of Information Management, National Taiwan  
University of Science and Technology, No. 43, Sec. 4,  
Keelung Rd., Da'an Dist., Taipei 106, Taiwan, ROC  
e-mail: huangsj@mail.ntust.edu.tw

S.-P. Chuang  
e-mail: d9909205@mail.ntust.edu.tw

believed that IT could generate an extensive commercial value, including the effectiveness in internal communication, business competitiveness, and the improvement of managerial efficacy (Brynjolfsson et al. 2002). However, some of these values could not be easily attributed to IT, but needed to accompany some commercial interaction with external customers or the suppliers. Nevertheless, many scholars believe that IT is the most important way for enterprises to remain competitive. If companies can accumulate IT capital, they will succeed in increasing their business competitiveness and expanding their market competitiveness (Porter and Millar 1985; Chen et al. 2006; Seng and Tsai 2007).

Despite the above, research into the relationship between the application of green concepts with intellectual and IT capital has been largely ignored by researchers. Therefore, to fill the gap in this research area, this study adopts a literature review approach to introduce and define the new concept of green IT capital to bridge the gap in the knowledge on funding for business greening. In addition, this study investigates the relationship between the degree of business greening, green IT capital, and business competitiveness in the hope of further understanding the effects of the green concept on business competitive advantage. Furthermore, the study verifies the mediating effects of green IT on the relationship between the degree of business greening and competitiveness.

## Literature Review and Hypothesis

### Green Businesses

Over the past 20 years, the environmental protection campaign has been gathering momentum with a variety of newly developed green concepts. Consumers who have a sense of environmental protection are known as “green consumers” and enterprises adopting a sense of environmental protection in their operation and production are referred to as “green businesses” (Peattie 2001). Carlisle and Faulkner (2004) indicated that a green business represents the middle ground between an industrial worldview and an ecological worldview which is a distinctly different way to handle environmental issues.

Apart from the perspective of facilitating sustainable development in production, some scholars examined green business from the financial standpoint, reiterating that the transformation to green business is not free and that it involves extra costs but that these change can effectively reduce costs in other areas (Ingram and Frazier 1980; Jaffe et al. 1993; Edwards et al. 2002). According to the resource-based view (RBV), Nehrt (1998) was of the opinion that new methods, including hardware and

operational systems, are able to control pollution while helping create market needs and reduce costs.

According to Buysse and Verbeke (2003), business greening refers to any greening activities that businesses take part in. It is believed that environmentally friendly concepts should be interwoven into business management and commitments, so that the product or the service provided by the business can reflect such an idea, reducing the impact upon the environment. In view of the above from the existing literature, this research suggests that a green business must have green ideas integrated into its business management concept so that pollution and resource depletion which are the result of the product or service may be avoided through green management methods and technologies applied to its daily operations.

### Green IT Capital

According to the resource-based theory, a firm can maintain its competitiveness by consecutively building up and making good use of its own business advantages through accumulating core resources and abilities, that is, invisible assets such as knowledge, technology, and human resources (Wernerfelt 1984; Barney 1991). Of the various types of intellectual capital, investment in information technology and its application is one of the ways to create invisible value, therefore IT can bring a high level of both visible and invisible benefits for an organization (Ross et al. 1996).

Bharadwaj (2000) categorized IT capital into: (1) IT visible resources, such as IT infrastructure; (2) IT human resources, such as IT technological and managerial capacity; and (3) IT invisible resources, such as knowledge assets, customer relations, and ability to develop synergy. Similarly, Seng and Tsai (2007) also divided IT capital into visible and invisible capital. Visible IT capital is a kind of structural capital, including IT infrastructure, hardware, software, and networks while invisible IT capital represents a type of human capital and relational capital, including IT employees' ability and experience, relationship between information users and the degree of cooperation between business units.

According to the classification and definition of IT capital suggested by Ross et al. (1996), Bharadwaj (2000), and Seng and Tsai (2007), this study defines green IT capital as an organizational competence and asset which applies green concepts to IT infrastructure, IT staff, IT management and relationships. As a result, green IT capital not only is able to satisfy the consumer's environmental consciousness but can also help a firm create a competitive advantage.

Green IT capital is composed of three dimensions: (1) green IT structural capital, which refers to green IT infrastructure including hardware, software, network, and

information technology established under the concept of greening; (2) green IT human capital, which refers to the ability and experience of IT staff in possessing green professional knowledge and an understanding of conserving energy in technology, as well as developing staff with green IT capabilities through training and education; and (3) green IT relational capital, referring to green IT management and a relationship under which enterprises maintain better relations with partners and users with an environmental protection concept in the offering of products and services.

In their findings from experimental research on business greening, Buysse and Verbeke (2003) concluded that enterprises which have a greater level of business greening are more motivated to be involved in organizational green activities, which indicates a positive correlation between the degree of business greening and the amount of investment in green activities. Drawing on these findings, we propose the following three hypotheses:

**H1a** The degree of business greening relates positively to green IT human capital.

**H1b** The degree of business greening relates positively to green IT structural capital.

**H1c** The degree of business greening relates positively to green IT relational capital.

#### The Degree of Business Greening and Business Competitiveness

From the financial performance perspective, there are a couple of indicators to measure business competitiveness, inclusive of both financial indicators and non-financial indicators. Financial indicators refer to relative market share, revenue growth, etc. (Fitzgerald et al. 1991). Besides, according to Johnson and Kaplan (1987), since corporate financial performance can be influenced by many indicators, longitudinal observation is needed. Therefore, corporate financial statement may not fully represent business competitiveness.

However, in the management field, a frequently mentioned subject is business competitiveness or competitive advantage, which refers to a strategy that makes a business difficult to be replaced by competitors and can help it maintain its profit margins (Porter and Millar 1985; Coyne 1986; Chen 2008). Barney (1991) indicated that if a firm can successfully prevent latent competitors from copying and simultaneously executing the same operating value, the firm can be considered as having a sustained competitive advantage (SCA).

Other scholars suggested that business green activities should not be deemed as adhering to environmental protection rules; rather, they can be used to facilitate the

improvement of organizational structures as well as the quality of products and services. A firm can then raise the level of its productivity and competitiveness by upgrading its image and developing its unique characteristics (Florida 1996; Porter and Van der Linde 1999; Chen et al. 2006).

In light of the above, Kao et al. (2010) conducted an empirical study and found that business green management has a significantly positive effect on business competitive advantage. Ravindra and Pradeep (2012) further confirmed that business involvement in green activities relates positively to business competitiveness. Thus, when a firm achieves a higher degree of greening, it will gain greater market competitiveness. Based on these arguments, we proposed the following:

**H2** The degree of business greening relates positively to business competitiveness.

#### Green IT Capital and Business Competitiveness

According to the RBV, Pike et al. (2005) and other scholars suggested that the benefits of a business accrue from IT resources and abilities, which are specificity, uniqueness, scarcity, ambiguity, irreplaceability, inseparability, and excludability. In addition, Davern and Kauffman (2000) opined that invisible benefits and indirect costs of information technology are weightier than its visible benefits and direct costs and that IT is capable of combining different organizational resources to form new abilities which can offer a unique competitive advantage.

Previous research suggested that a firm's green innovation performance will exert a positive effect on business competitiveness and that this performance will lead to a greater degree of effects on business competitive advantages when its competitors have a lower level of competitive edge (Chen et al. 2006; Kao et al. 2010).

In addition, Chen (2008) pursued a study on the effects of green intellectual capital on business competitiveness in Taiwan's information electronics industry, indicating that green intellectual capital and its three sub-dimensions, including green human capital, green structural capital, and green relational capital, jointly produce a positive effect on business competitiveness. Based on the above research results, when a firm invests in a higher degree of green IT capital, it will gain greater market competitiveness. Drawing on these arguments, we proposed the following hypotheses:

**H3a** Green IT human capital relates positively to business competitiveness.

**H3b** Green IT structural capital relates positively to business competitiveness.

**H3c** Green IT relational capital relates positively to business competitiveness.

## Mediating Role of Green IT Capital

Based on the above discussion in the literature review, the level of business greening has a positive effect on business competitiveness (Berry and Rondinelli 1998; Porter and Van der Linde 1999; Kao et al. 2010; Ravindra and Pradeep 2012), and may facilitate better environmental performance (Hart 1985; Berry and Rondinelli 1998; Kao et al. 2010). However, the transformation to a green business is not free, and involves extra costs for green activity investment (Ingram and Frazier 1980; Jaffe et al. 1993; Edwards et al. 2002), indirectly exercising effects on business competitiveness (Russo and Fouts 1997; Cordano and Frieze 2000; Buysse and Verbeke 2003).

Accordingly, when a firm has a higher degree of business greening, relatively, it will contribute more green IT structural capital, green IT human capital, and green IT relational capital to achieve a higher degree of business greening, thereby generating a significant effect on business competitiveness (Chen 2008).

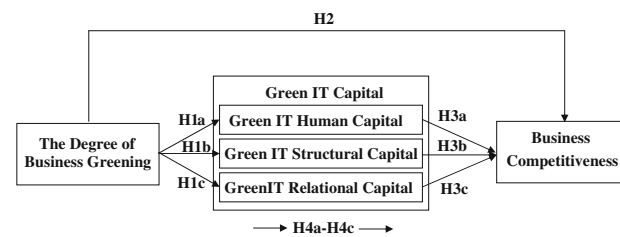
Drawing from the aforementioned hypotheses, it is apparent that the improvement in the degree of business greening can raise business competitiveness, but enterprises must provide extra expenses to follow concerned government policies and regulations so as to exert effects on business competitive advantage. Owing to the change of the outside market environment, enterprises can get more competitive by performing business greening, but relatively it will become successful only when investing the green IT capital to further its competitiveness. It can infer that the degree of business greening affects enterprises' investment in green IT capital, which would further affect business competitiveness. Accordingly, green IT capital serves as a mechanism through which the degree of business greening affects competitiveness. Based on these findings, we proposed the following hypotheses:

**H4a** Green IT human capital mediates the relationship between the degree of business greening and business competitiveness.

**H4b** Green IT structural capital mediates the relationship between the degree of business greening and business competitiveness.

**H4c** Green IT relational capital mediates the relationship between the degree of business greening and business competitiveness.

This study investigates whether the degree of business greening affects green IT capital and business competitiveness, respectively, as well as the effects of green IT capital on business competitiveness. Further, this study also verifies the mediating effect of green IT capital on the relationship between the degree of business greening and business competitiveness.



**Fig. 1** Research model of the degree of business greening, green IT capital, and business competitiveness

According to the resource-based theory (Wernerfelt 1984; Barney 1991) and greening concept, the accumulation of intelligence capital has become one of the primary sources of competitiveness for the investment and the application of IT, which also brings both tangible and intangible benefits to businesses (Ross et al. 1996; Laudon and Laudon 2000; Porter and Millar 1985; Chen et al. 2006; Seng and Tsai 2007). Therefore, this study expects to explore the correlations between the degree of business greening, green IT capital, and business competitiveness. The research model of this study is shown in Fig. 1.

## Methods

### Participants and Procedures

The participants in this study included the manager of management information systems (MIS) from 148 companies ranked in the top 1,000 in Taiwan's manufacturing industry. A cover letter attached to each questionnaire described the objectives of the survey in general terms and assured respondents of confidentiality as well as the voluntary nature of participation in the survey. Of these, 148 valid copies were obtained, yielding a response rate of 15.02%. Nearly one half of companies (46.6%) had more than 30 years of firm age, and over half possessed capital of between 100 million to 5 billion dollars (64.2%), with 43.2% having employee size of between 101 and 1,000 persons (see Table 1).

### Definitions and Measurements of Variables

To follow Brislin's (1986) recommendation of ensuring accuracy and conceptual equivalence in both Chinese and English versions, all questionnaire items were translated and back-translated by bilingual native speakers of both languages. Participants rated items on a 7-point Likert-type scale ranging from 1 (strongly disagree) to 7 (strongly agree). The questionnaire comprised four parts with a total of 40 questions: (a) the descriptive data of companies,

**Table 1** Descriptive Statistics for 148 companies

	Number of sample	%
Firm age		
≤5 years	5	3.4
6–10 years	8	5.4
11–20 years	37	25.0
21–30 years	29	19.6
>30 years	69	46.6
Capital (NT dollars)		
<50 million	2	1.4
50 million–100 million	5	3.4
100 million–1 billion	47	31.8
1 billion–5 billion	48	32.4
5 billion–10 billion	17	11.5
>10 billion	29	19.6
Employees size		
≤100 persons	15	10.1
101–1,000 persons	64	43.2
1,001–2,000 persons	20	13.5
2,001–5,000 persons	27	18.2
>5,000 persons	22	14.9

(b) the business greening metrics, (c) green IT capital, and (d) business competitiveness.

### The Business Greening Metrics

Previous researches argued that green business must have integrated green ideas into its business management concept so that pollution and resource depletion may be avoided through green management methods and technologies applied to its daily operations (Peattie 2001; Kao et al. 2010). On the other hand, green business has three determinants: green business environment and resources, business management, technology (Ministry of Economic Affairs 1999). The measurement of green business comprises the following nine items ( $\alpha = 0.92$ ): (1) the company currently promotes environmentally friendly design, green purchasing, and clean production; (2) the company currently fosters environmental auditing system (like ISO40001); (3) the company currently implements energy and water conservation and exploit renewable energy; (4) the company implements the concept of sustainable business development and green environment; (5) the company currently executes staff training and cultivates talent for protecting the environment; (6) the company currently promotes green office environmental protection campaigns; (7) the company actively improves local environmental quality and participates in community environmental protection activities; (8) the company has technologies to

develop smart automation and improve production procedures; and (9) the company currently has invested in the development of green products or technologies (Ministry of Economic Affairs 1999; Kao et al. 2010; Makower 2012).

### Green IT Capital

Previous researches regarded green IT capital as an organizational competence and asset which applies green concepts to IT infrastructure, IT staff, IT management and relationships. As a result, green IT capital not only is able to satisfy the consumer's environmental consciousness but can also help a firm create a competitive advantage (Ross et al. 1996; Bharadwaj 2000; Seng and Tsai 2007). On the other hand, green IT capital has three determinants: green IT human capital, green IT structural capital, green IT relational capital (Ross et al. 1996; Bharadwaj 2000; Seng and Tsai 2007). The measurement of green IT capital comprises the following 10 items. The items on green IT human capital ( $\alpha = 0.89$ ) include: (1) the company currently has allocated budgets to train green IT staff; (2) the employees of this company diligently use IT for conservation; (3) the IT staff of this company have professional knowledge of green IT technologies. The items on green IT structural capital ( $\alpha = 0.79$ ) include: (4) the company currently has allocated budgets and resources for green IT; (5) the company has concerned continually invested in IT infrastructure (such as storage, servers, and networks) aimed at improving efficiency in the use of energy; (6) the company has considered an energy management system for desk computers and notebooks. The items on green IT relational capital ( $\alpha = 0.89$ ) include: (7) the top manager of the company has listed green IT management as a priority issue; (8) the company has adopted green IT-related systems (such as server virtualization and an energy recycling system); (9) the company is concerned about issues relating to the carbon footprint of its IT suppliers; and (10) the company is concerned about issues relating to the recycling of IT materials (Seng and Tsai 2007; Molla et al. 2011).

### Business Competitiveness

Previous researches argued that business competitiveness refers to a strategy that makes a business difficult to be replaced by competitors and can help maintain its profit margins (Porter and Millar 1985; Coyne 1986; Chen 2008). In brevity, the reason why a business can maintain its competitive edge is that it is rich in resources with market value and not easily duplicable or surpassable (Barney 1991). The measurement of business competitiveness comprises the following 11 items ( $\alpha = 0.94$ ): (1) in comparison with your competitors, you have an advantage in



lower costs; (2) compared with your competitors, you can offer better products and services; (3) in comparison with your competitors, you have a greater ability in R/D and innovation; (4) compared with your competitors, you are better in management; (5) you gain more profit margins than your competitors do; (6) your growth in revenue surpasses that of your competitors; (7) your industrial position is difficult for your competitors to surpass; (8) you have a better business image than your competitors; (9) in comparison with your competitors, you can offer more products and services, (10) your innovative ideas are not easily imitated by your competitors; and (11) compared with your competitors, you hold a special position which is difficult to replace (Chen 2008).

### Control Variables

To reduce the potential confounding effects and maximize statistical power, we adopted the factors of capital, and number of employees as control variables in the present study due to their potential effects on the degree of business greening and green IT capital (Chen 2008; Kao et al. 2010). Previous researches found that the size of the enterprise is of importance in IT adoption, since the accumulation rate and the strength of IT capital vary, along with concerning environmental issues, which altogether make IT adoption even more complicated (Damanpour and Schneider 2006; Molla and Abareshi 2012). Therefore, we retain these two control variables in this study: “the size of the enterprise” and “the number of staff.”

### Analyses

We used a hierarchical regression analysis to test all the hypotheses. Moreover, before testing the hypothesized model, we conducted a confirmatory factor analysis (CFA) to assess the discriminant validity of the five constructs by the  $\chi^2$  statistics; the comparative fit index (Bentler 1990); the goodness-of-fit index (Jöreskog and Sörbom 1988); and root mean square error of approximation (Vandenberg and Lance 2000).

To test the mediation model (H4a–H4c), we followed Baron and Kenny’s (1986) three-step procedure. First, the independent variable should be significantly related to the mediating variable; second, the independent variable should be significantly related to the dependent variable; and third, the mediating variable should be related to the dependent variable when the independent variable is controlled in the model. If the unstandardized  $\beta$  weight of the independent variable is still significant in the last step, partial mediation is present. If the unstandardized  $\beta$  weight of the independent variable is not significant, full mediation is present.

## Results

### Correlations and Confirmatory Factor Analysis

The means, standard deviations, intercorrelations, and reliabilities of measures of all the variables are presented in Table 2. In addition, we conducted CFA to assess the discriminant validity of each construct (Jöreskog and Sörbom 1988). Data with list wise deletion of missing values was used for the LISREL analysis, resulting in a final sample size of 148. The overall measurement of model fit was assessed with four indices: the  $\chi^2$  statistics; the comparative fit index (Bentler 1990); the goodness-of-fit index (Jöreskog and Sörbom 1988); and root mean square error of approximation (Vandenberg and Lance 2000).

In addition, the ratio of subject-to-item would be too low (4:1) if all 30 of the original items were used (148 companies); that is, the ratio would be far below the ideal ratio of 10:1 and even below the acceptable lower bound limit of a 5:1 ratio (Bandalos 2002). To reduce the number of parameters in the analysis and keep the model’s degree of freedom reasonable (Bandalos 2002), we used the item-parceling method recommended by Bagozzi and Edwards (1998) to conduct the CFA. These constructs were modeled with two parcels, each using randomly assigned items.

Pertaining to the measurement model, CFA results showed that the five-factor model ( $\chi^2 = 388.36$ ,  $df = 179$ ,  $p < 0.01$ ; CFI = 0.91, GFI = 0.80, RMSEA = 0.09) yielded a better fit than the single-factor model ( $\Delta\chi^2$  (10,  $N = 148$ ) = 828.71,  $p < 0.01$ ; CFI = 0.67, GFI = 0.56, RMSEA = 0.19). Therefore, the results indicated the five variables were distinct constructs (see Table 3).

### Test of the Hypotheses

Hierarchical regression analysis was conducted to test Hypothesis 1–4. To test Hypotheses 1a–1c, after entering all of the control variables in Step 1, the capital was found to be positively related to green IT human capital ( $\beta = 0.26$ ,  $p < 0.05$ ) and green IT structural capital ( $\beta = 0.24$ ,  $p < 0.05$ ) (see Table 4, model 1 and 3).

Furthermore, after entering all of the control variables in Step 2, the degree of business greening had significantly positive effects on green IT human capital ( $\beta = 0.63$ ,  $p < 0.01$ ), green IT structural capital ( $\beta = 0.44$ ,  $p < 0.01$ ), and green IT relational capital ( $\beta = 0.66$ ,  $p < 0.01$ ), thus supporting H1a–H1c (see Table 4, model 2, 4, and 6), which proposed that enterprises with a higher degree of business greening will raise more investment on green IT human capital, green IT structural capital, and green IT relational capital. In addition, to test Hypotheses 2 and 3a–3c, after entering all of the control variables in Step 2 and Step 3, the degree of business greening ( $\beta = 0.53$ ,  $p < 0.01$ ), green IT

**Table 2** Descriptive statistics and correlations analysis

$N = 148$ . Figures in parentheses are  $\alpha$  reliabilities  
 \*\*  $p < 0.01$

Variables	Mean	SD	1	2	3	4	5
1. Degree of business greening	5.1	1.2	[0.92]				
2. Green IT human capital	4.3	1.4	0.66**	[0.89]			
3. Green IT structural capital	4.7	1.4	0.57**	0.85**	[0.79]		
4. Green IT relational capital	4.6	1.4	0.67**	0.79**	0.75**	[0.89]	
5. Business competitiveness advantage	4.9	1.2	0.45**	0.38**	0.31**	0.40**	[0.94]

**Table 3** Comparison of measurement models

*CFI* comparative fit index, *GFI* goodness-of-fit index, *RMSEA* root mean square error of approximation  
 For  $\chi^2$ ,  $N = 148$   
 \*\*  $p < 0.01$

Model	Factor	$\chi^2$	df	$\Delta\chi^2$	CFI	GFI	RMSEA
Baseline model	Five factors	388.36	179	–	0.91	0.80	0.09
Model 1	Three factors: green IT human, structural, and relational capital were combined into one factor	458.94	186	70.58**	0.89	0.77	0.10
Model 2	Two factors: degree of business greening, green IT human, structural, and relational capital were combined into one factor	887.39	188	499.03**	0.80	0.63	0.16
Model 3	One factor: all variables were combined into one factor	1,217.07	189	828.71**	0.67	0.56	0.19

**Table 4** Hierarchical regression analysis with the effect of degree of business greening on green IT capital

Capital: NT dollars  
 $N = 148$ , \*  $p < 0.05$ ,  
 \*\*  $p < 0.01$

Dependent variable	Green IT human capital		Green IT structural capital		Green IT relational capital	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
<i>Step 1</i>						
Control variables						
Capital	0.26*	0.23**	0.24*	0.22*	0.16	0.13
Number of employee	0.11	–0.10	–0.02	–0.17	0.16	–0.06
<i>Step 2</i>						
Independent variables						
Degree of business greening		0.63**		0.44**		0.66**
$R^2$	0.12	0.47	0.05	0.22	0.10	0.47
$F$	9.85**	41.76**	3.99*	13.28**	7.08**	42.16**
$\Delta R^2$		0.35		0.17		0.37

human capital ( $\beta = 0.20$ ,  $p < 0.05$ ), green IT structural capital ( $\beta = 0.16$ ,  $p < 0.05$ ), and green IT relational capital ( $\beta = 0.39$ ,  $p < 0.01$ ) had significantly positive effects on business competitiveness, thus supporting H2 and H3a–3c (see Table 5, model 2 and 3), which proposed that enterprises with a higher degree of business greening and more investment on green IT capital will raise the business competitiveness.

To test the mediation model (Hypotheses 4a–4c), following Baron and Kenny’s (1986) recommendation, the first step was to examine the direct effects of degree of business greening on business competitiveness. Results indicated that after entering all of the control variables in Step 1, we regressed the mediator [green IT human capital

( $\beta = 0.63$ ,  $p < 0.01$ ), green IT structural capital ( $\beta = 0.44$ ,  $p < 0.01$ ), and green IT relational capital ( $\beta = 0.66$ ,  $p < 0.01$ ) on the independent variable (degree of business greening) in Step 2 (see Table 4, model 2, 4, and 6). Green IT human capital, green IT structural capital, and green IT relational capital were found to be positively related to degree of business greening, meeting the first requirement of mediation.

In model 2 (See Table 6), which satisfied the second requirement of mediation, we found that degree of business greening was positively and significantly related to the business competitiveness ( $\beta = 0.53$ ,  $p < 0.01$ ). To test the third requirement of the mediation model, we regressed the dependent variable on the mediating variable with the

independent variable controlled for in model 3 (see Table 6). The unstandardized  $\beta$  for both the green IT human capital ( $\beta = 0.03, p > 0.05$ ) and green IT structural capital ( $\beta = -0.07, p > 0.05$ ) were not significant for business competitiveness.

**Table 5** Hierarchical regression analysis with the effect of degree of business greening and green IT capital on business competitiveness

	Business competitiveness		
	Model 1	Model 2	Model 3
<i>Step 1</i>			
Control variables			
Capital	-0.02	-0.04	-0.10
Number of employee	0.17	-0.01	0.08
<i>Step 2</i>			
Independent variables			
Degree of business greening		0.53**	
Green IT human capital			0.20*
Green IT structural capital			0.16*
Green IT relational capital			0.39**
$R^2$	0.03	0.27	0.24
$F$	1.84	17.49**	11.32**
$\Delta R^2$		0.24	0.21

Capital: NT dollars

$N = 148, ** p < 0.01$

**Table 6** Hierarchical regression analysis with mediating effect of green IT capital

Dependent variable	Business competitiveness		
	Model 1	Model 2	Model 3
<i>Step 1</i>			
Control variables			
Capital	-0.02	-0.04	-0.06
Number of employee	0.17	-0.01	-0.02
<i>Step 2</i>			
Independent variables			
Degree of business greening		0.53**	0.37**
<i>Step 3</i>			
Mediating variable			
Green IT human capital			0.03
Green IT structural capital			-0.07
Green IT relational capital			0.26*
$R^2$	0.03	0.27	0.32
$F$	1.84	17.49**	11.06**
$\Delta R^2$		0.24	0.29

Capital: NT dollars

$N = 148, * p < 0.05, ** p < 0.01$

Hypotheses 4a and 4b were, therefore, not supported. However, the unstandardized  $\beta$  for green IT relational capital ( $\beta = 0.26, p < 0.05$ ) was significant for business competitiveness. In addition, the unstandardized  $\beta$  of degree of business greening was also significant for business competitiveness ( $\beta = 0.37, p < 0.01$ ). The results indicated that green IT relational capital partially mediated the links between degree of business greening and business competitiveness. The results, therefore, partially supported Hypothesis 4c.

## Discussion and Implications

### Theoretical Implication

Our findings confirmed that the degree of business greening has a significantly positive effect on green IT human capital, green IT structural capital, and green IT relational capital. This indicated that when a firm has a higher degree of business greening, it will contribute more green IT structural capital, green IT human capital, and green relational capital to achieve a higher degree of business greening. Thus, when a firm has a higher degree of business greening, it will become more active in investing the related resource and performing green management

**Table 7** Summary of results

Hypothesis number	Propose hypotheses	Result
H1a	The degree of business greening relates positively to green IT human capital	Yes
H1b	The degree of business greening relates positively to green IT structural capital	Yes
H1c	The degree of business greening relates positively to green IT relational capital	Yes
H2	The degree of business greening relates positively to business competitiveness	Yes
H3a	Green IT human capital relates positively to business competitiveness	Yes
H3b	Green IT structural capital relates positively to business competitiveness	Yes
H3c	Green IT relational capital relates positively to business competitiveness	Yes
H4a	Green IT human capital mediates the relationship between the degree of business greening and business competitiveness	No
H4b	Green IT structural capital mediates the relationship between the degree of business greening and business competitiveness	No
H4c	Green IT relational capital mediates the relationship between the degree of business greening and business competitiveness	Yes



activities (Buysse and Verbeke 2003). This conclusion has been proved in this research. A summary of the results is shown in Table 7.

Furthermore, in terms of the effects of green IT capital on business competitiveness, this research found that green IT human capital, green IT structural capital, and green IT relational capital have a significantly positive effect on business competitiveness and that of the three types of capital, green IT relational capital has a greater influence on business competitiveness than the other two. The reason could be that manufacturers of electronics and information in Taiwan attach greater importance to the green relationship between suppliers, clients, and strategic partners (Chen 2008). This conclusion has also been proved in this research.

This study found that the degree of business greening can be seen as a force of assistance instead of costs or a force of resistance in raising its business competitiveness. In other words, the degree of business greening has a positive effect on business competitiveness. As Makower (2012) also pointed out, the activities of the green economy, such as green industry, green consumption, green technology, green employment, green building, and green investment, help balance the challenges between the environment and society, and create new opportunities and challenges for small and medium businesses across various industries.

As for the mediating effect of green IT capital on the relationship between the degree of business greening and business competitiveness, this research reveals that there are no significant mediating effects of green IT human capital and green IT structural capital on the relationship between the degree of business greening and business competitiveness. Many scholars pointed out that when following environmental protection standards, that is, promoting green activities as a way of environmental management, enterprises can acquire a better environmental performance, and further improve their financial performance in the future (Klassen and McLaughlin 1996; Molla and Abareshi 2012).

Nevertheless, green IT relational capital has a partially mediating effect on the relationship between the degree of business greening and business competitiveness. Chen (2008) confirmed that compared with green IT human capital and green IT structural capital, Taiwan's IT industry attaches more importance to the investment of green relational capital in that it devotes much closer attention to the maintenance of interaction on green relationships between upstream and downstream suppliers, clients, and strategic partners, aiming to create a three-win situation in the marketplace.

### Practical Implications

The manufacturing industry in Taiwan plays an important role in the process of industrial development and makes an

enormous contribution to economic growth. With the emerging issues of sustainable development and the green concept, green business has been regarded as a competition strategy; hence an enterprise has to place an emphasis on how to gain substantive benefits in various challenges. According to our research findings, firms which attach more importance to the degree of business greening and green IT capital will attain a greater competitive advantage.

Of the three types of green IT capital, Taiwan's manufacturing industry pays much more attention to green IT relational capital. This means that Taiwan's manufacturers place importance not only on the visible investment in green IT infrastructure but on the cooperative and interactive relationship between enterprises, clients and strategic partners, thereby heightening the value and loyalty of business partners. That is, enterprises can collaborate with suppliers, consumers, and strategic partners that have a similar concept of the green environment to jointly achieve the goal of carbon reduction and the sustainable development of the environment, creating a three-win situation in the marketplace. Accordingly, in addition to increasing business investment in green relational capital, Taiwan's manufacturing industry should also aim to expand cooperative opportunities and the power of cooperation with their green partners to secure a competitive advantage in the marketplace.

In addition, the research findings demonstrate that if Taiwan's manufacturing industry can improve the degree of business greening and adopt a practical green approach to manage its operations, this will help raise its business competitiveness. Hence, in light of the above, this research strongly suggests that business managers embody environmental concepts into their business plans and commitments so as to establish a green image. In the meantime, enterprises should implant the concept of sustainable development into their organizational cultures by conforming to green regulations in all processes of production and service.

### Conclusions

Very little research has focused on the application of green concepts to IT capital. Coming from this perspective, this research has bridged the gap by introducing a new concept of greening—green IT capital—and has thus generated much more diverse discussions of business greening. Moreover, the measurement instrument for green IT capital developed by this research has not been extensively investigated in previous research.

The findings of this research have shown that this measurement instrument of green IT capital yields an adequate reliability and validity. In other words, the green

IT capital instrument is able to appropriately measure the level of green IT capital investment of enterprises and can also help researchers better confirm the level of enterprises' green IT capital investment.

Finally, this study was conducted in a cross-sectional fashion. Since environmental sustainable development and business greening is an ongoing and dynamic process, other contingency or contextual factors may also contribute to the relationship development. Therefore, future longitudinal studies may enrich our understanding of business greening dynamics in organizations and its effects on business competitiveness. Furthermore, when corporates try to transform into green business, is there any other hidden costs present apart from the investment in greening IT? And who is it to afford the extra costs? How can corporates decide how much green IT costs to invest? Not much existing research has been done on these issues. It is therefore suggested that future research works can be conducted to enhance the understanding of these issues.

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