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SUSTAINABLE DEVELOPMENT ORIENTATION (SDO) PRACTICE AND ITS IMPACT ON INNOVATION PERFORMANCE

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Abstract

Changes in regulation and government policy have stimulated growth of 'green innovation' with sustainability emerging as a key concept. A review of the literature revealed gaps in research in this area of innovation management. The aim of this paper is to test the relationship between SDO practice and innovation performance of a large number of Australian companies in the manufacturing, services, construction and software sectors. Our study showed that proactive management of environmental protection issues and marketing of 'green' products were found to have a positive and significant association with ecological efficiency of products. On the other hand, the design of new products for energy efficiency was found to have a positive and significant relationship with the number of innovation adoptions. Our findings are consistent with the literature, which reveals a significant and positive relationship between SDO and innovation performance. The implications of the research are that SDO should not be considered an additional cost of doing business rather, managers should view SDO as an opportunity to improve innovation performance.

Keywords*: sustainable development orientation, innovation, performance, ecological efficiency*

JEL Classification: L23, L25, L26, M11, M14

Introduction

We present the results of the analysis based on a unique data set of Australian companies in the manufacturing, services, computers and construction industries. This study has implications for managers that are faced with the challenge of reducing their Carbon Footprint (CF), and educators who are faced with changes in regulation and government policy towards 'green innovation' with sustainability emerging as a key concept in future engineering and management education. The Australian Greenhouse Office (2005) defines the CF as "...a measure of the greenhouse gas a person, organisation or entity emits or has caused to be emitted. It should incorporate direct emissions (e.g. emissions produced on-site) and indirect emissions (emissions that result from use or purchase of product such as airline travel)."

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The term 'sustainable development' has been used since the 1980s. However, it is only in the past 4-5 years that we have seen a paradigm shift towards sustainable development. The Brundtland report commissioned by the World Commission on Environmental Development (WCED) in 1987, defined sustainable development as "development that meets the needs of the present without comprising the ability of future generations to meet their own needs" (WCED, 1987, p. 43).

The literature on sustainable development has increased steadily over the past decade. Ottman and Reilly (1998) suggest that firms have responded and profited with the emergence of environmentalism as a core societal value. 'Green' marketing has emerged as an opportunity for innovation (Ottman 1993; Ottman and Reilly 1998). However, many firms are not convinced that 'green' products have an impact on the bottom line. The literature is inconclusive and in most cases anecdotal. For example, Polonsky (2001) argues that going green provides a firm with strategic advantage including lower costs and product differentiation.

Banes, Ridder and Scheidt (2001) used Sony as an example to argue 'green' products lead to significant benefits for the organisation, such as:

1. Reduction in the consumption of material and energy resources during the production process.
2. Reduction in hazardous emissions from production or products.
3. Reduction on energy use during the use phase of the product.
4. Product lifetime extension.
5. Reuse of components and recycling of components and materials.
6. Creation of radically new and less harmful solution that fulfil the same need.

Porter and van der Linde (1995) argue that organisations must develop innovation capability in order to develop innovative solutions, which would reduce their carbon footprint. On the other hand there are other researchers, such as Bansal (2005), who claim that there is a negative relationship between sustainable development and corporate performance. Overall, there is very little research evidence based on methodological rigour to support their argument. Consequently, we address the research question: Which elements of SDP individually and collectively are significant predictors of innovation performance?

Literature review

A literature review was conducted on sustainable development, as part of a larger study on innovation capability, funded by the Australian Research Council. The literature review was used to identify variables that would serve as a basis for the development of a theoretical model and to design a survey instrument for our study. Environmentalism has clearly begun to assert itself as a driver for innovation.

Ottman and Reilly (1998) suggest that firms have profited from environmentalism, as a core societal value. "Green" marketing is increasingly being perceived as an opportunity for innovation. According to Larson (2000, p.304) "Sustainable innovation is an emerging and fundamental force for change in business and society. Its potential to transform technology, products and markets distinguishes it as an area of entrepreneurial opportunity..." However, organisations require knowledge on how to create new "green" products, and how to identify and capitalise on entrepreneurial opportunities and to convert these opportunities to "green" products.

Banerjee (2002), based on a qualitative research study in different industries, discusses the theoretical and practical implications of integrating environmental and social issues into corporate strategies.

The author defines sustainable development as *"... a process of change in which the exploitation of resources, direction of investments, orientation of technological development, and institutional change are made consistent with future as well as present needs."*

The study found that corporate environmental orientation focused on the company's internal values, standards of ethical behaviour, commitment to environmental protection, environmental responsibility, perceptions of external stakeholders, the need to respond to stakeholder interests and the need for sustainable development.

The author has identified three emerging areas of research that warrant further attention. The first is social sustainability, the second is a need to analyse sustainability practices in a variety of industry contexts, and the third is giving more attention to the role of stakeholders in the path toward sustainability.

In another study based on 250 firms, Banerjee (2001) explores industry differences in environmental strategy. Management activities focused on four broad areas: employee focus, manufacturing focus, corporate focus and marketing focus. Corporate focus was the highest for firms in chemicals, utilities and pharmaceuticals, followed by manufacturing, employee and marketing focus.

For firms in other industries, manufacturing focus was greater than corporate focus, with the electronics industry having the lowest proportion of firms with an environmental corporate focus. Managers were less sure of the competitive effects of environmental strategies in electronics, foods and consumer product firms.

A consistent pattern that emerged from this study was that firms in high-impact industries tended to perform a greater number of environmental activities. Also, a greater proportion of firms in high-impact industries (chemicals, utilities, and pharmaceuticals) performed these activities, as compared to firms in other industries (foods, electronics and consumer products).

According to Hart (1997), the business logic for greening has been largely technical: with the perception that bottom-up pollution-prevention programmes have saved companies billions of dollars. Rarely is greening linked to strategy and technology development. Hart argues that most companies fail to recognise opportunities. Three factors account for this paradox: stringent environmental regulations; the greening of industry; and the relocation of the most polluting activities. Few companies have incorporated sustainability into their strategic thinking. Instead, environmental strategy consists largely of piecemeal projects aimed at controlling or preventing pollution.

Shrivastava (1995) concludes that 'environmental technologies' can produce ecological efficiencies. Environmental technologies, with their focus on design and manufacturing for the environment, influence all key strategic variables. At the industry level, environmental technologies provide a way of fundamentally altering the profitability dynamics of industries. They affect basic cost parameters of resource use, energy use; manufacturing efficiency, waste disposal and pollution abatement.

At the individual firm level, Shrivastava (1995) argues that environmental technologies provide new basis for creating competitive advantage. The author further concludes that managers must incorporate environmental technologies into strategy formulation and implementation frameworks. A good argument for including sustainable development in innovation capability management is captured by the following statement by Shrivastava (1995):

"In the input system, competitive advantage accrues from materials, labour and energy conservation. TQEM provides a base for revisioning the organisation's role vis-a-vis its customers, society and the natural environment. It allows firms to create new goals, and

reshuffle priorities in favour of preserving ecological value with legitimacy. It systematically conserves inputs to minimise costs."

Researchers agree that there is no such set of practices that comprise SDP and that apply to all enterprises across all industries (Goldsmith & Samson, 2002; Hunt & Auster, 1990). Examples of SD practices are waste minimisation, recoverable manufacturing, and supplier protocols. Cerin and Karlson (2002) showed that the emission costs per net sales were generally higher for manufacturing companies (e.g., home appliance, IT and Telecom, vehicle manufacturer, chemistry, electric power, and mining), than for service products (e.g., broadcasting and mobile telecom provider), but exceptions existed (e.g., airline and road transport). Therefore, sustainable development is of great importance to all industries, but possibly most directly to the manufacturing industry.

Goldsmith and Samson (2002), developed an interim construct of sustainable development orientation (SDO) and proposed a model of the relationships between sustainable development practices and business success that took into account differences between industries: *"SDO describes the degree to which the organisation culture and its set of SD practices are efficient and effective, both in meeting economic, environmental and social needs and in supporting the strategic direction of the business, hence providing greater opportunity for long term superior business success."*

Goldsmith and Samson proposed that enterprises with higher SDO are more likely to be successful in the long term, but not necessarily in the short-term. However, their proposition was not tested. This leads us to our research hypothesis: *Sustainable Development Orientation has a significant and positive relationship with innovation performance.*

Theoretical model

An Innovation Management (IM) model was developed as part of an Australian Research Council (ARC) Discovery Project to assess innovation capability models affecting innovation driven companies. This model was used to design the survey instrument, which subsequently produced the quantitative data used to test the hypothesis in this paper.

The IM model describes how innovation enablers (e.g. new product development, e-commerce or e-business, and sustainable development) contribute to innovation capability (e.g. leadership/ strategy, people competency base, information and organisational intelligence, market and customer orientation, creativity and ideas management, organisational structures/systems, culture and climate, and management of technology). This, in turn, leads to innovation performance (e.g. revenue from new products, innovativeness, time to market, customer satisfaction, productivity, employee morale, and research and development as a percentage of sales). In our paper, we focus on the relationship between the SDO construct and the Innovation Performance dimensions.

Research design

A database of 1000 companies was purchased from Dunn and Bradstreet. Three size categories defined by the Australian Bureau of Statistics (1999) were adopted in this paper across twelve industry codes based on the Australian Standards Industry Classification (ASIC) system and were used in the study: "small" (20-49 employees), medium (50-99 employees) and large (100 or more employees). The organisations were stratified so that the sample contained approximately the same number of small, medium and large companies.

Survey instrument

A total of 130 independent variables and 8 dependent variables were included in the survey instrument. The majority of questions in the survey instrument were designed using variations of the 5-point modified Likert scale in order to capture varying degrees of respondent perceptions, regarding the independent and dependent variables. The Survey Instrument was pilot tested in 25 organisations chosen at random. Questionnaires were sent with letters of appreciation and instructions for completing the survey. Each response that contained seven or more empty cells from the dataset was deleted, which accounted for 1.3 percent of the responses. Within the remaining sample, the variable mean was substituted for the missing cells. This approach yielded 22 responses, a response rate of 22 percent.

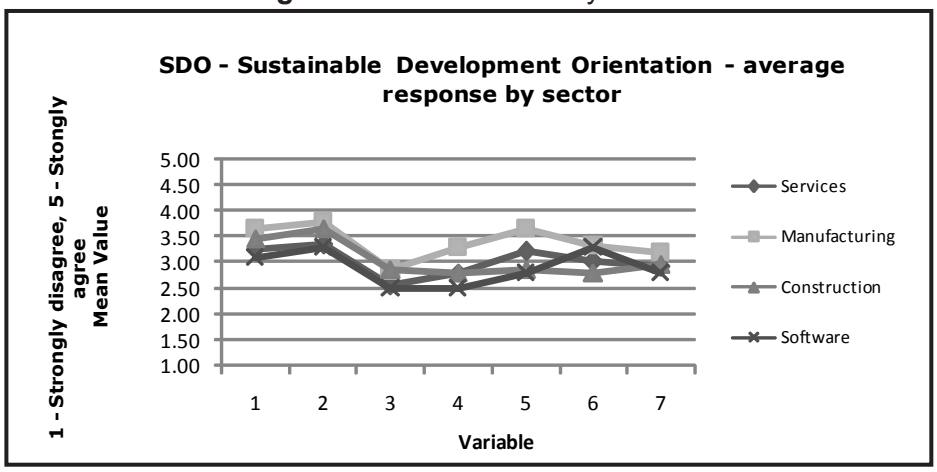
Data analysis

Rigorous statistical analysis was conducted in order to meet professional standards of reliability and validity. Interdependence methods (e.g. confirmatory factor analysis and reliability analysis) and multivariate dependence methods (e.g. multiple regression analysis) were used to quantitatively test the hypothesis.

Descriptive analysis

An analysis of the ownership of companies by size (using Australian sales) shows that the majority of the private companies are under $50 million in sales (112 out of 136 or 91 percent); the foreign owned companies are mainly larger, with the majority (9 out of 14 or 71 percent) having sales over $50 million, and the public companies are both big and small, with 17 over $50 million sales, and 15 under $50 million sales. Almost all the small companies are private companies, with 86 respondents below $10 million in sales. Sixty five percent of the respondents were CEOs, Managing Directors and General Managers. A large number of respondents (70 per cent) did not report overseas employees. The sales distribution in the sample is indicative of a good coverage of the Australian business sector.

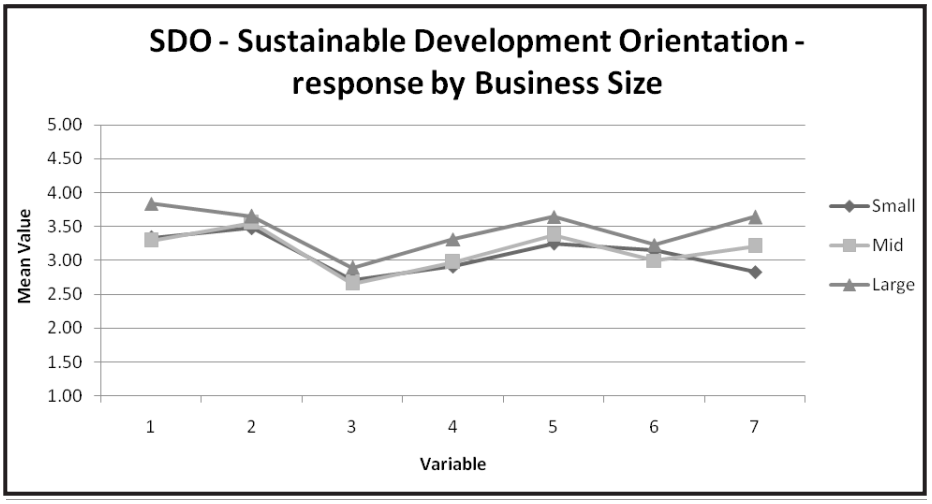
Figure 1. SDO vs. industry sector



We make the observation from Fig. 1 that all industries seem to operate in a relatively tight band, with manufacturing being the most sustainable oriented sector, and software generally

the least sustainable oriented. Construction performs relatively well on some of the variables (1-3) but less well on others, especially 5 energy efficiency, and 6 design for recycling.

Figure 2. SDO vs. organisational size



We make the observation from Fig. 2 that large businesses (sales over $100 million) across all variables are consistently reporting higher mean levels of orientation to sustainable development. Small (sales less than $25 million) and medium (sales between $25 and 100 million) businesses provide very similar responses on their sustainable development orientation. The manufacturing sector appears more interested in energy efficiency design than services. Based on the size of Australian business, there seems little pattern to exist between size and interest in energy efficiency design, but it seems quite clear that larger global businesses are more design conscious with regards to energy efficiency. Ownership type (i.e. public or private ownership) was not found to have any impact on interest in energy efficiency.

Bivariate correlations and multiple regression analysis

In this section, we test the influence of the Sustainable Development Orientation (SDO) variables on Innovation Performance Measures (IPM). These variables are summarised in Table 1. However, prior to the quantitative analysis, we need to determine the internal consistency for the SDO and IPM items. Internal consistency is simply an assessment of how reliably survey or test items measure what they that are designed to measure. Cronbach's Alpha is used to measure internal consistency.

Both SDO and IPM questions show a high Cronbach's Alpha of 0.878 and 0.690 respectively, which shows a strong internal consistency. The numerical scale for both SDO and IPM is typical ordinal, which suggested the use of non-parametric approaches in the area of correlation. Two non-parametric measures are used, the Spearman rho correlation coefficient $\rho_{s,}$ which preserves monotonic relationship among the variables, and the Kendall Tau τ. The advantage of Spearman rho is that this coefficient is able to capture some non-linear relationships (i.e. quadratic, etc). The survey estimator for ρ will be denoted by $r_{s.}$

Correlation analysis

- Revenue from new products developed in the last three years is only weakly related to design of new products for energy efficiency (r_s = 0.139; p-value =0.049).

- Number of innovation adoptions shows highly significant relationships with several variables of SDO.
  1. The design of new products for energy efficiency (r_s=0.335; p-value=0.000).
  2. The development of SDO plans which always incorporate customer requirements (r_s= 0.254; p-value=0.000).
  3. The design of new products for ease of disassembly/recycling (r_s=0.245; p-value=0.000), the sourcing of 'environmental' technologies as an integral part of efforts to strengthen for innovation capability (r_s = 0.222; p-value = 0.010).
  4. The Marketing of 'Green' products as an improvement for the competitive position (r_s= 0.188, p-value= 0.007).
  5. The number of innovation adoptions is also weakly related to environmental ("green") protection issues which are proactively managed at this organisation (r_s= 0.136, p-value = 0.051 and the "learning" culture supported by training has triggered environmental driven change (r_s = 0.121, p-value = 0.085).

- The time of innovation adoptions shows a degree of association with the following variables.
  1. The design of new products for energy efficiency (r_s=0.271,p-value = 0.000).
  2. The development of SDO plans which always incorporate customer requirements, (r_s=0.184, p-value = 0.008).
  3. The design of new products for ease of disassembly/recycling (r_s= 0.181, p-value = 0.01).

- Time to market (TTM), Customer Satisfaction and Employee Morale does not show any significant relationship with the set of SDO questions.

- Research and Development shows different degrees of association with the following variables, ordered in terms of importance:
  1. The design of new products for energy efficiency (r_s= 0.282; p-value = 0.000), the design of new products for ease of disassembly/recycling (r_s = 0.262; p-value = 0.000).
  2. The Marketing of 'Green' products as an improvement for the competitive position (r_s= 0.199; p-value = 0.005).
  3. The design of new products are weakly related to the development of SDO plans which always incorporate customer requirements (r_s = 0.138, p-value = 0.008).

- The ecological efficiency is the variable most highly related to all the variables of SDO. In order of importance, we have:
  1. The environmental ("green") protection issues are proactively managed at the organisation (r_s = 0.474, p-value =0.000).
  2. The marketing of 'Green' products improved the competitive position (r_s= 0.465, p-value=0.05).
  3. The sourcing of 'environmental' technologies is as an integral part of the effort to strengthen the innovation capability (r_s = 0.428, p-value = 0.000).
  4. The design of new products for ease of disassembly/recycling (r_s=0.407, p-value= 0.000).
  5. The "learning" culture supported by training has triggered environmental driven change (r_s = 0.395, p-value = 0.000).
  6. The design of new products for energy efficiency (r_s = 0.392, p-value = 0.000).
  7. The design of new products for ease of disassembly/recycling (r_s=0.348, p-value=0.000).

We observe that all correlation r_s are positive, emphasising the increasing monotonic between IPM variables and the SDO variable. In order to determine the possible contribution of each SDO into each IPM, a multiple regression approach is suggested. As it was mentioned before, because of the ordinal characteristics of these variables, we resort to a multiple ordinal logistic regression approach. There are different types of link functions, the choice of which is essential in order to obtain the best predictive model, as defined below:

Function	Form	Typical application
Logit	$\log(\gamma / (1- \gamma))$	Evenly distributed categories
Complementary log-log	$\log(-\log(1- \gamma))$	Higher categories more probable
Negative log-log	$-\log(-\log(\gamma))$	Lower categories more probable
Probit	$\Phi^{-1}(\gamma)$	Latent variable is normally distributed

An analysis of each IPM variables suggested the use of different link functions, namely

Table 1. IPM variables link functions

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOGISTIC LINK FUNCTION	Logit	Probit	Neg. log-log	Neg. log-log	Probit	Compl. log-log	Logit	probit

Where:
(1) Revenue from new products developed in the past three years.
(2) Number of Innovation Adoptions
(3) Time of Innovation Adoption
(4) Time to Market (TTM)
(5) Customer Satisfaction
(6) Employee Morale
(7) Research and Development as a percentage of Total Sales
(8) Ecological Efficiency degree of recycling

The suitability of the multiple ordinal logistics models is summarised in Table 2 below by the pseudo coefficient of determination of Nagelkerke's R^2.

Table 2. Ordinal logistics regression approach

VARIAB	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Logistic Significance p-value	>0.05 Non signif.	0.00	0.01	> 0.05 Non Signif.	>0.05 Non Signif.	>0.05 Non Signif.	0.00	0.00
Nagelkerke R-square	0.048	.148	.12	0	0	0	.185	.37

Table 2 indicates that the multiple ordinal logistic models, in order to explanatory power, can easily explain the following IPM variables:

1. Ecological efficiency degree of recycling
2. Research & Development as a percentage of Total Sales
3. Number of innovation adoptions
4. The time of innovation adoption

Table 3. Best IPM variables described by SDO variables

VARIABLES	(2)	(3)	(7)	(8)
Model Significance p-value	0.00	0.01	0.00	0.00
Variables chosen at p = 0.05	SDOPlans-4b SDODesig-4e	SDOPlans-4b SDODesig-4e	SDOGreen-4a SDOMktg-4c SDODesig-4e SDORecyc-4f SDOLearn-4g	SDOGreen-4a SDOMktg-4c SDORecyc-4f
Nagelkerke R-square	0.148	0.12	0.185	0.37

Table 3 describes the best IPM variables described by SDO variable, where:

4a) Environmental ("green") protection issues are proactively managed at this organisation.
4b) When we develop our SDO plans we always incorporate customer requirements.
4c) Marketing of 'Green' products has improved our competitive position.
4d) We source 'environmental' technologies to strengthen our innovation capability.
4e) We design new products for energy efficiency.
4f) We design new products for ease of disassembly/recycling.
4g) Our "learning" cultures supported by training has triggered environmental driven change.

Discussion of results

Seven environmental themes were investigated with our respondents, including its relation to their learning, marketing, customers, planning, and products. Sustainable development is seen as an enabler of innovation. The hypothesis that sustainable development orientation has a significant and positive relationship with innovation performance was partially supported. Time to market (TTM), Customer Satisfaction and Employee Morale do not show any significant relationship with the set of SDO questions. All other IMP variables had a significant and positive relationship with SDO practices.

The ecological efficiency is the variable most highly related to all the variables of SDO. The top three SDO practices, which have the greatest impact on ecological efficiency in order of importance, are:
- Environmental ("green") protection issues are proactively managed at the organisation;
- Marketing of 'Green' products improved the competitive position;
- Sourcing of 'environmental' technologies is as an integral part of the effort to strengthen innovation capability.

From our descriptive analysis we found that the manufacturing sector and large businesses are more in agreement with the use of sustainable development processes. The software industry is the least receptive, and construction performs well on some, and poorly on others, including energy efficiency and recycling. Large businesses were more receptive to sustainability, due to greater availability of resources to invest in new processes.

The highest explanatory power, as indicated by Nagelkerke R-square value, is 0.37. That is 37% of variance in ecological efficiency was explained by three SDO practices:
- Environmental ("green") protection issues are proactively managed at this organisation.
- Marketing of 'Green' products has improved our competitive position.
- We design new products for ease of disassembly/recycling.

We also found that the level of Research and Development as a percentage of sales was explained by organisations which adopted a number of SDO practices simultaneously (Nagelkerke R-square value was 0.185).

- Environmental ("green") protection issues are proactively managed at this organisation.
- Marketing of 'Green' products have improved our competitive position.
- We design new products for energy efficiency.
- We design new products for ease of disassembly/recycling.
- Our "learning" culture supported by training has triggered environmental driven change.

We further investigated the relationship between the variable "Research and Development" and the independent variables, studying the estimate coefficient of the ordinal regression b_j and the corresponding odd-ratios. Table 4 shows this information.

One key assumption of this model is that all βs are equal across logit equations for the different cut points θ_j, which is known as the proportional odds assumption and it is tested by the Brand Test, which indicates that the assumption of all βs equal was not violated at alpha=0.05. From Table 4, we can see that there are two distinct significant groups:

- Environmental ("green") protection issues are proactively managed at this organisation.
- Our "learning" culture supported by training has triggered environmental driven change.

A simple interpretation to the odds ratio is that, as the value of Environmental ("green") protection increases by 1, the odds of high "Research and Development" versus the combined lower categories are 0.653 greater, given that all of the other variables in the model are held constant. Similarly, the odds of the combined middle and high categories versus low apply is 0.653 times greater, given that all of the other variables in the model are held constant.

The group of variables formed by Environmental ("green") protection and our "learning culture" has odd less than one, therefore any increase in one unit by them provides a decrease in the odds. The opposite is true for the following variables:

- Marketing of 'Green' products have improved our competitive position.
- We design new products for energy efficiency.
- We design new products for ease of disassembly/recycling.

That is, an increase in one unit in the independent variable provides "higher than one" increase in their odds ratio.

Table 4. Relationship between the variable "Research and Development" and the independent variables

IPMresde 61f	Estimated Odds Ratio	Estimate Coefficients
SDOGreen 41a	0.653	-0.426
SDOMktg 41c	1.446	0.369
SDODesig 41e	1.564	0.447
SDORecyc 41f	1.449	0.371
SDOLearn 41g	0.732	-0.311

Conclusion and implications for managers

We conclude with respect to the research question that several SDO practices individually and collectively predict several dimensions of innovation performance, particularly ecological efficiency and degree of recycling. The SDO practice that has the greatest explanatory power of ecological efficiency was found to be the proactive management of environmental ("green")

protection issues. The marketing of 'green' products and the sourcing of 'environmental' technologies follow this. Shrivastava (1995), who found that 'environmental technologies' have a significant effect on ecological efficiency, supports our findings.

We also conclude that the manufacturing sector and large businesses are more in agreement with the use of sustainable development practices. It is reasonable to speculate that large businesses were more receptive to sustainability, due to their greater availability of resources to invest in new processes. The software industry is the least receptive of sustainable development practices, and the construction industry performs well on some dimensions, and poorly on others, including energy efficiency and recycling.

The implication for managers is that sustainable development practices should not be considered as an additional cost of doing business, rather managers should view sustainable development practices as an opportunity to improve innovation performance.

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