The Influence of Innovation Performance towards Manufacturing Sustainability Performance

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Abstract

Surviving and continually upgrading the manufacturing operations is a great challenge for a manufacturer, especially when the business environment keeps changing. The emergence of sustainability concepts has dramatically widened the aim of business operations. Besides the economic benefits, manufacturers have to take into considerations the environmental and social impacts. The research question addressed in the present work is whether those manufacturers with high innovation performance have actually perform better in terms of achieving the sustainability performance. This paper recognizes that achieving sustainability is a firm's priority and the leading efforts need to be investigated. We developed a generic model for achieving sustainability that reflects a firm's economics, social and environmental performance through innovation performance. Using survey data collected from 150 Malaysian manufacturers, we find that innovation performance is positively associated with all specified indicators of sustainability. The findings in this study align with previous literature that suggests innovation capabilities are the key sources of sustainable competitive advantage.

Keywords
Innovation, sustainable manufacturing, sustainability

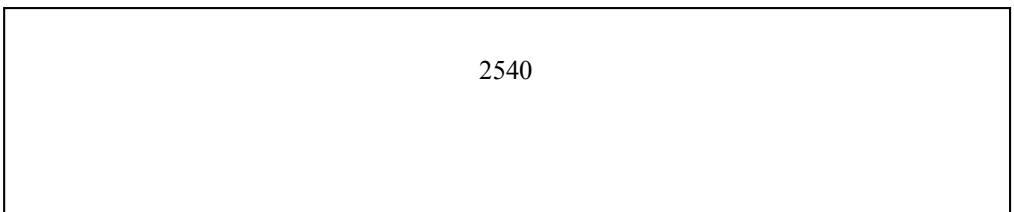
1. Introduction
Sustainability is an evolutionary concept that arises as a consequence of adaptation to changing circumstances. The idea of sustainability in the manufacturing context recognizes the vital interactions between the economic growth, environmental problems and social issues. It seems there is no generally accepted definition of Sustainable Manufacturing (SM). In this study, SM is viewed as a broad notion that was developed through the integration of sustainability concepts into the manufacturing system with an aim to achieve sustainable development in industrial production. Since sustainability has three interdependent and mutually reinforcing pillars involving economic development, environmental protection, and social development, a comprehensive definition of SM should integrate environmental, economic and social aspects of manufacturing in its context.
With the growing concern on sustainability issue from the various stakeholders, practitioners and researchers had paid greater attention to SM strategies and implementation. Although many research works have been devoted to this matter, there are still some shortcomings with existing literature that need to be further investigated. Majority of the discussion tends to focus heavily toward an ecological aspect of sustainability while social perspective is always marginalized (Carter and Rogers, 2008; Dao et al., 2011). Much of the effort of previous research has emphasized the aspect of economy and environment in measuring firm's performance with less attention paid to the social dimension of sustainability. The literature highlights the relatively limited treatment given to the social pillar (Murphy, 2012). The ability to achieve innovation performance has been argued to be an important predictor in improving sustainability performance within a firm level. While much of the previous literature focused on that relationship, most studies have defined innovation in limited perspective to merely include the technical components. The concept is not sufficient to meet the broad context of sustainability performance at firm level. As explained by Kelley and Littman (2006), a great product can be a major component in the formula for business success, but the firms that want to succeed in an

increasingly competitive environment need much more, they need innovation at every point of the compass, in all aspects of the business and among all team members.
The purpose of this paper is to study the effects of innovation performance on sustainability performance. The paper is structured as follows: in Section 2, the proposed model relating to the causal relation of IP and SP are developed and discussed, while Section 3 describes the methodological approach applied for this study. Then, the results of the study are discussed in Section 4. Finally, Section 5 presents the conclusions and suggests the future research directions.

2. Innovation and sustainability performance

The ability of firms to innovate is either created internally or acquired from external sources, impacting the ability of firms to survive and succeed in the future (Knowles, 2007). It is now widely appreciated that in turbulent market economies, innovation is the antidote of life of the firms, regardless of their size or other attributes. Growth, success and survival, all depend on the ability of firms to innovate continuously (Varis and Littunen, 2010). The significant role of innovation in contributing to carbon emission reduction programs and mitigation of climate change is generally acknowledged (Bakhtina, 2011). The concept of eco-innovation has been emerging to accelerate higher environmental improvements. Through the creation of new or improved products, production processes, technologies and organizational systems that places priority on environmental considerations, firms can enhance environmental sustainability by helping to reduce emissions/pollutions and wastes, and store the bio-reserve capacity.
In addition, the adoption of eco-innovation is also a great opportunity to generate economic growth. With the aim to produce innovation outputs that reduce natural resources consumption and decrease harmful emissions into the atmosphere, at the same time, it is also dedicated to yield greater operational efficiencies such as increased productivity, higher quality, cost reduction and continuous improvement as well as increased sales, market share and profits, and new market development. In fact, firms that are innovative in terms of their manufacturing process are likely to be more imaginative in addressing environmental costs and risks (Florida, 1996). Since pollution represents waste and loss of resource productivity, product and process innovations to prevent or at least reduce pollution may improve resource productivity and competitiveness (Rusinko, 2007). Valencia et al. (2010) list some empirical studies that provide evidence of the positive effect of innovation on business performance including profitability, growth and effectiveness. Study by Varis and Littunen (2010) supported the arguments that the growth of firms is positively associated with the creation of innovations. Of the types of innovation studied, they found that new product, process and market innovations were positively associated with firms' growth while organizational innovations were not. However, Chen et. al (2009) have challenged the validity of this finding. They prove that organizational performance is positively affected by administrative innovation as well as product and process innovation. Similarly, Abu Bakar and Ahmad (2010) suggested that product innovation and business innovation capability is important to present business opportunities in terms of growth and expansion into new areas and to allow businesses to gain competitive advantage.
At present, many firms opt to change their organizational approaches or administration systems to be more sustainable. Innovation is no longer the management activities from top to bottom, but appears to be the responsibility of all members of the organization, which can help organic innovation, create a climate where change is embraced. Organizational changes such as open innovation, which recognize the influences of workforce mobility, the expertise of external suppliers and the work done by researchers outside of the organization, lead to better sustainability performance. Based on their study on 204 large and medium-sized manufacturing firms in the Pearl River Delta, Weihong et al. (2008) found that the openness of the organizational culture and the organizational learning capability has a significant impact on the enterprise sustainable competitive advantage. The relationship between organizational innovation attitude and sustainability performance has also been explored by Chang and Lee (2008). According to the result, innovative spirit in the organizational culture and group-oriented teamwork in the culture show a positive impact on job satisfaction of the employees.
Proceeding from the above discussions, a proposed model, linking four components of innovation performance as measured by product innovation, process innovation, organizational innovation and marketing innovation to economic, environmental and social sustainability, is built (Figure 1). Then, three hypotheses are generated as follow:

H1. The greater the extent of innovation performance as measured by product innovation, process innovation, and organizational innovation and marketing innovation, the greater the degree of economic sustainability.
H2. The greater the extent of innovation performance as measured by product innovation, process innovation, and organizational innovation and marketing innovation, the greater the degree of environmental sustainability.
H3. The greater the extent of innovation performance as measured by product innovation, process innovation, and organizational innovation and marketing innovation, the greater the degree of social sustainability.



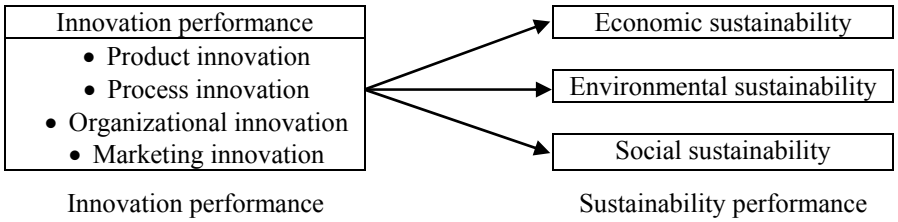


Figure 1: Proposed model

3. Methodology

3.1 Sample and procedures

Derived from the directory of Federation of Malaysian Manufacturers (FMM), a total of 600 manufacturing firms encompassing various industries were randomly selected as a sample in this study. A cross-sectional survey was utilized to collect data from the sample. Empirical data from a wide variety of industry and size of company increased the general nature of our findings. A set of questionnaire, supplemented with cover letter and self-addressed, stamp-attached envelope, was mailed to personnel who are familiar with the topic studied. After discarding five incomplete survey forms and ten for extreme outliers, the survey yielded 150 usable responses, or a 25% effective response rate. Such response rate is acceptable as greater than the suggested cut off of 20% (Ojha and Gokhale, 2009). The profile of respondents is presented in Table 1.

Table 1: Profile of respondents

Characteristics	Frequency	Percentage
Type of industries		
Chemical industry	24	16.0
Electrical & electronics	52	34.7
Food products & beverages	10	6.7
Machinery & equipment	7	4.7
Metals	18	12.0
Textiles & apparel	4	2.7
Transport equipment	30	20.0
Wood based	5	3.3
Number of employees		
less than 5	6	4.0
between 5 and 50	12	8.0
between 51 and 150	26	17.3
more than 150	105	70.0
Missing data	1	0.7
Job title		
CEOs/Managing director/ General manager	55	36.7
Department manager/Assistant manager	30	20.0
Executive/Assistant executive	23	15.3
Engineer/Assistant engineer	40	26.7
Other	2	1.3

3.2 Measures

A diverse range of measurement has been designed to represent the theoretical concepts of sustainability and innovation in manufacturing sector. In this study, the operationalization of constructs for innovation performance (IP) and sustainability performance (SP) were based on the combination of scales developed by previous scholars such as Wagner and Schaltegger (2004), Chien and Shih (2007), Amrina and Yusof (2011), Chong et al. (2011) and Idris and Tey (2011). However, because of the lack of established scales, self-administered measures were undertaken for several items. The measurement items were carefully developed based on the theoretical definition that corresponds to the variables studied.

The innovation performance of firms is normally described in terms of the number of new products or the number of patents. In this study, the performance of firm was not only focusing on new product development. A broader perspective is deemed to be more appropriate within the context of the study. As a result, IP was formulated into twenty-four items in four dimensions that capture the extent to which a firm performs in product innovation, process innovation, organizational innovation and marketing innovation in the last three years. A five-point scale, anchored by one for "strongly disagree" and five for "strongly agree", was selected to measure the level of agreement or disagreement of respondents with each item. A summary of the measurement items of IP is shown in Table 2.

Table 2: Construct validity and reliability, and measurement items for IP

Item	Description	Factor loading	KMO [a]	Eigenvalue	% variance explained	Cronbach's alpha
IP1	Product innovation		0.883	4.232	70.538	0.915
I1.1	Increased number of new products introduced to the market	0.803				
I1.2	Increased number of new products that are first-to-market (early market entrants)	0.826				
I1.3	Use the latest technology for new product development	0.850				
I1.4	Increased speed of new product development	0.901				
11.5	Reduced cost of new product development	0.780				
11.6	Able to produce greater level of newness (novelty) of new products	0.873				
IP2	Process innovation		0.866	4.451	74.183	0.930
I2.1	Increased technological competitiveness	0.833				
I2.2	Use up-to-date technology in manufacturing processes	0.817				
I2.3	Increased speed of adoption of the latest technological innovations in manufacturing process	0.862				
I2.4	Increased the number of new production methods introduced	0.881				
I2.5	Able to change rapidly in manufacturing processes	0.882				
I2.6	Able to change rapidly in manufacturing techniques	0.890				
IP3	Organizational innovation		0.882	4.507	75.120	0.934
I3.1	Better knowledge management system	0.835				
I3.2	Increased organizational flexibility	0.853				
I3.3	Stronger external relations	0.843				
I3.4	Increased speed of adoption of new organizational methods	0.900				
I3.5	Increased the number of new organizational systems introduced	0.902				
I3.6	Apply up-to-date organizational methods	0.865				
IP4	Marketing innovation		0.883	4.366	72.765	0.925
I4.1	New products often take us up against new competitors	0.792				
I4.2	Increased the number of new marketing methods/approaches	0.847				

I4.3	Products' most recent marketing programme is revolutionary in the market compared with competitors	0.846				
I4.4	Higher success rate in new product launch compared with competitors	0.880				
I4.5	Increased the number of new market entry	0.868				
I4.6	Often at the cutting edge of technology in new product introductions	0.883				
Notes: [a] KMO = Kaiser-Meyer-Olkin measure of sampling adequacy; n = 150						

After reviewing how performance is measured in different studies of sustainability research, this study drew up a scale that included twenty-six items to measure SP which is reflected in three dimensions: economic sustainability, environmental sustainability and social sustainability. The items were developed to access the degree of changes in firm's performance in three aspects for the last three years. Consistent with scale type used for assessing IP, respondents were asked to choose a response for each measurement item on a five-point scale, given as one for "strongly disagree" to five for "strongly agree". By expressing in nine items, economic sustainability is intended to capture the extent to which a firm records both internal and external economic success. In total, seven measurement items which are related to the level of resource usage, pollution emitted and waste generated were used to assess environmental sustainability. While, social sustainability is measured the degree of changes in social well being that related to employee, supplier, customer and society by using ten items. A summary of the measurement items for SP is shown in Table 3.

Table 3: Construct validity and reliability, and measurement items for SP

Item	Description	Factor loading	KMO [a]	Eigenvalue	% variance explained	Cronbach's alpha
S1	Economic sustainability		0.912	5.987	66.521	0.936
S1.1	Reduced costs	0.718				
S1.2	Improved product quality	0.770				
S1.3	Reduced lead times	0.844				
S1.4	Improved customer service	0.838				
S1.5	Increased productivity	0.879				
S1.6	Increased revenues	0.771				
S1.7	Increased market share	0.829				
S1.8	Improved reputation	0.851				
S1.9	Better new market opportunities	0.829				
S2	Environmental sustainability		0.906	5.220	74.575	0.943
S2.1	Reduced water usage	0.826				
S2.2	Reduced energy consumption	0.853				
S2.3	Reduced non-renewable resources usage	0.883				
S2.4	Reduced hazardous inputs usage	0.832				
S2.5	Reduced solid waste	0.847				
S2.6	Reduced waste water emissions	0.902				
S2.7	Reduced emissions of polluting gases	0.899				
S3	Social sustainability		0.923	6.620	66.202	0.943
S3.1	Increased employee satisfaction	0.844				
S3.2	Better recruitment and staff retention	0.811				
S3.3	Increased occupational health and safety	0.825				
S3.4	Improved employee education and skill	0.831				
S3.5	Improved supplier commitment	0.831				
S3.6	Increased certified suppliers	0.805				
S3.7	Increased customer satisfaction	0.814				
S3.8	Increased public health and safety	0.798				

S3.9	Reduced local community complaint	0.793				
S3.10	Improved local community conditions and infrastructure	0.782				
Notes: [a] KMO = Kaiser-Meyer-Olkin measure of sampling adequacy; n = 150						

3.3 Data analysis technique

In this study, Pearson product-moment correlation and multiple regression analysis were adopted to test the proposed model. The first approach was chosen to analyze the inter-correlation among all constructs studied. On the other hand, the second technique was applied to test the causal relationships between dependent and independent variables. Regression analysis results indicated the direction and strength of these relationships. All of the statistical analyses in this study were conducted in IBM SPSS Statistics 19 software.

4. Results and discussion

4.1 Validation of measurement

Following the validation guidelines for measurement suggested by Sekaran (2006) and Coakes and Steed (2007), the measurement scales developed for the purpose of this study were tested for internal consistency reliability and construct validity.

In this study, Cronbach's alpha coefficient was employed to test the interim consistency reliability, which is related to the consistency of respondents' answers to all the items in a measure. Using the SPSS reliability analysis procedure, an internal consistency analysis was performed separately for the items of each factor. The result for the test is presented in Table 2 and 3. Referring to the results, all Cronbach's alpha values are greater than 0.900, indicating high internal consistency and therefore proving the reliabilities.

In order to assess construct validity of each factor in IP and SP, a principal-component factor analysis was performed. By treating the items of each factor separately, each factor was subjected to individual principal components analysis. If each factor is valid as a construct, then its set of items would form a single factor. As presented in Table 2 and 3, all sets of items were loaded onto single factor as designed with accounted for more than 66% of variance explained by the respective item sets. All of the values of Kaiser-Meyer-Olkin measure of sampling adequacy were far greater than the suggested cut-off of 0.6.

4.2 Descriptive statistics

The mean, standard deviation and correlations for each variable in this study are presented in Table 4. The mean values for specific IPs range from 3.76 to 3.91 indicating the ability of surveyed firms in improving their innovation performance in all aspects related to product, process, organizational and marketing. At the same, they also were able to increase their economic, environmental and social sustainability as implied by value means ranging from 3.89 to 4.20.

Each of the bivariate correlation tested in this study is found to be significant at the 0.01 level. The correlation coefficients ranging from 0.411 to 0.707 indicated the strong positive relationships between the variables studied.

Table 4: Correlations and descriptive statistics

	IP1	IP2	IP3	IP4	SP1	SP2	SP3
IP1 Product innovation							
IP2 Process innovation	0.702**						
IP3 Organizational innovation	0.624**	0.707**					
IP4 Marketing innovation	0.597**	0.616**	0.665**				
SP1 Economic	0.619**	0.614**	0.556**	0.424**			
SP2 Environmental	0.411**	0.433**	0.485**	0.354**	0.532**		
SP3 Social	0.552**	0.586**	0.664**	0.509**	0.684**	0.629**	
Mean	3.76	3.88	3.91	3.78	4.20	3.89	3.95
Standard deviation	0.69	0.65	0.61	0.62	0.61	0.68	0.61
Number of items	6	6	6	6	9	7	10
Notes: ** $P < 0.01$; n = 150							

4.3 Hypotheses testing

Multiple regression analysis was used to assess the effects of IP on SP. Using the simultaneous regression analysis procedure, the test was performed separately for each indicators of SP. The regression results are presented in Table 5. Hypothesis 1 suggested the significant effect of IP on economic sustainability. Based on the results found, the R^2 value of 0.463 indicated that the 46.3% of variance in improving economic sustainability is significantly explained by the combination of four components of IP, which is highly significant as indicated by the significant F. However, only three components significantly contributed to the prediction of improved economic sustainability, product innovation ($\beta = 0.308$, $p < 0.01$), process innovation ($\beta = 0.265$, $p < 0.05$) and organizational innovation ($\beta = 0.195$, $p < 0.05$).

Hypothesis 2 postulated the significant impact of IP on economic sustainability. IP was found to have significant impact on environmental sustainability with R^2 value of 0.259. The value implied that 25.9% of the variation in environmental sustainability was explained by the four components of IP. However, significant and positive effects was found only in organizational innovation ($\beta = 0.368$, $p < 0.05$).

Similarly, in hypothesis 3, IP yield significant result in predicting social sustainability and organizational innovation was the single significant predictor ($\beta = 0.265$, $p < 0.05$). The R^2 value is 0.481indicated that almost half of the total variation in social sustainability was explained by the four components of IP. In summary, based on the regression results, all of the hypotheses developed to test the proposed model in this study were supported.

Table 5: Regression results

Independent variables	F-statistics	Significance	R^2	Beta coefficients[a]
Dependent variable: S1 Economic sustainability				
Independent variable:				
IP1 Product innovation	31.200	< 0.001	0.463	0.308***
IP2 Process innovation				0.265**
IP3 Organizational innovation				0.195**
IP4 Marketing innovation				-0.089
Dependent variable: S2 Environmental sustainability				
Independent variable:				
IP1 Product innovation	12.689	< 0.001	0.259	0.13
IP2 Process innovation				0.12
IP3 Organizational innovation				0.368**
IP4 Marketing innovation				-0.018
Dependent variable: S3 Social sustainability				
Independent variable:				
IP1 Product innovation	33.606	< 0.001	0.481	0.136
IP2 Process innovation				0.134
IP3 Organizational innovation				0.444**
IP4 Marketing innovation				0.034
Notes: [a] $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$; $n = 150$				

5. Conclusions

The major premise of this study was to determine the effects of IP on three indicators of SP, economic sustainability, environmental sustainability and social sustainability. The overall regression results produce significantly positive effects for the relationships between IP and economic sustainability, IP and environmental sustainability and IP and social sustainability. However, mixed results emerged when we analyze the predictive abilities of each component of IP (i.e. product innovation, process innovation, organizational innovation, marketing innovation) in improving SP. Organizational innovation was the single predictor that could bring about significant changes in all of three individual criteria in SP. Such finding is consistent with recent study, Chen et. al (2009), in which proving the important of changes within the administration and management side of organizational operations on leading better organizational performance. Surprisingly, no significance effects were found for marketing innovation in predicting all indicators of SP. A plausible reason may be that the marketing personnel constantly encounter uncertainties in the process of linking the new marketing strategies involving significant changes in marketing efforts such as product positioning, product design or packaging, product pricing or promotion with the dynamic business environment. While this study is conducted in quantitative setting, further research is suggested to test the arguments empirically using qualitative approach. Future studies may also utilize longitudinal analysis in studying the effects of innovation on sustainability performance, which in turn, may enrich knowledge about these two variables.

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Biography

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