# Factors Influencing Sustainable Information Technology Adoption among Manufacturing Firms: Evidence from Malaysia

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**Abstract:** In recent years, environmental issues have been the central of attention among governments, communities and business organizations. Hence, going green initiatives such as sustainable or green Information Technology (IT) is the latest approach in ensuring responsible IT policies and practices in business organizations. This study investigated factors influencing sustainable IT adoption among manufacturing firms in Malaysia. Based on the Technology-Organizational-Environment Theoretical Model, hypotheses proposed. Questionnaires were distributed to manufacturing firms in Malaysia and data collected was analyzed using Smart PLS Version 2.0.M3. This study found that there is a significant and positive relationship between technological, organizational, environmental factors and sustainable IT adoption. The findings revealed to managers and practitioners the various dimensions involved in sustainable IT adoption and factors that influencing the adoption. This study is also useful for researchers to further investigate on other drivers, antecedents and outcome of sustainable IT adoption among various industry players in developing countries.

**Key words:** Green, sustainable, information technology, Technology-Organizational-Environment (TOE), Malaysia, factor

## INTRODUCTION

Recently, sustainable development has been key attention for governments, societies as well as businesses among the underdeveloped, developing to developed countries. Sustainability addresses how the three extents, economic, environment and social systems should be well-kept for the benefits of future generation. Intense growth in technology has since resulted nations moving towards industrialization and modernization. The revolution of Information Technology (IT) and the Internet had motivated businesses to change and consequently IT plays a significant role in environment sustainability.

Since 1990s, Malaysia's economy has grown significantly and increased its nation living standards. In order to become a modern country and high income nation per Vision 2020, Malaysia had put in substantial efforts to attract foreign direct investment such as setting up factory plants and operating offices in Malaysia. Malaysia manufacturing industry has expanded 6.3% during 2008 despite the economic downturn (Juhaini *et al.*, 2011).

Consequently, manufacturing organizations in Malaysia have witnessed the increase in IT infrastructure demand which resulted increase in power demand. Following that the usage and disposal of IT and its activities had brought negative impact to the environment in which electronic waste (e-Waste) has been one of the major causes to environmental pollution.

The practice of sustainable IT amongst manufacturing firms in Malaysia is still not commonly established. There is an urgent need to determine the level of readiness among manufacturing firms in Malaysia and to investigate drivers that influence these organizations to adopt sustainable green IT. This research examine these issues.

### Literature review

**Hypotheses development:** The increasing need and use of IT in business has created an impact to the sustainability of organizations and environment. Sustainable or green IT refers to environmentally sound IT. This often refers to the practice of designing, manufacturing using and disposing of computers, servers and associated subsystems such as monitors, printers, storage devices and networking and communications systems which efficiently and effectively with minimal or no impact on the environment (Murugesan, 2008). Green IT is defined as an organization's ability to systematically apply environmental sustainability criteria to the design,

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production, sourcing use and disposal of the IT technical infrastructure as well as within the human and managerial components of the IT infrastructure (Molla, 2009).

Researchers found that majority of business organizations adopt and implement technological innovation is influenced by 3 main elements namely technological, organizational and environmental (Bose and Luo, 2011). Technological context refers to the internal technology characteristics of the organization and the technology availability in the external market (Bose and Luo, 2011; Depietro *et al.*, 1990). Organizational context involves structure and capability of the organization, leader's behavior and management style towards green IT adoption (Bose and Luo, 2011; Depietro *et al.*, 1990). Environmental context refers to combination of the characteristics of market structure element whether external support for adopting new technologies is available as well as regulations of government (Bose and Luo, 2011; Depietro *et al.*, 1990). TOE Model has been utilized in various studies on technology innovation adoption including green IT adoption in which the 3 key factors were found influencing IT adoption in business firms.

In this study, the extent of green IT adoption is measured by the breadth and depth of green IT (Molla, 2008, 2009; Kuo and Dick, 2009). Breadth refers to the sourcing, energy efficiency, measuring and monitoring and end of IT life management (Molla, 2008). On the other hand, depth refers to the variety of green IT policies, practices and technologies in each category (Molla, 2008).

Technological concerns was identified as a factor to be considered during business firm's decision making towards green IT adoption and hence, technological context proposed to have an effect on green IT adoption (Molla, 2008). Thus, $H_1$ is derived as below:

- $H_1$: technological factor is positively related to the organization's extent of green it adoption

Organization culture which has higher risk appetite and willing to embark on risk taking tends to adopt green IT compare to risk adverse culture organization. On the other hand, different leadership style may affect the organization towards green IT adoption (Molla, 2008). Thus, $H_2$ is developed as:

- $H_2$: organizational factor is positively related to the organization's extent of green it adoption

Environmental context within the TOE Model is an important factor in the adoption of green IT Government's legislations are major force influencing organizations

to adopt green IT (Molla, 2008). Meanwhile, industry competitors and awareness of social responsibility were found to drive organizations to adopt green IT (Kuo and Dick, 2009). Thus, $H_3$ proposed is as:

- $H_3$: Environmental factor is positively related to the organization's extent of green IT adoption

## MATERIALS AND METHODS

**Measurement model:** To assess the measurement model of this study, the factor loadings, composite reliability, convergent validity and discriminant validity was examined. All reliability measures were higher than the recommended level of 0.5 indicating all the questions are representing a particular variable. The Cronbach's alpha values range from 0.736-0.876 which above the threshold of 0.7. Composite Reliability (CR) values range from 0.835-0.915 which exceeded the recommend value of 0.7.

The Average Variance Extracted (AVE) range from 0.521-0.735 and exceeded the recommended value of 0.5. Therefore, the measurement model possessed adequate convergent validity can be concluded. Table 1 lists the correlation matrix for the construct. The diagonal elements in the correlation construct (in bold) is the square root of the AVE. Off-diagonal elements are the correlation among constructs. In this study, the assessment of discriminant validity does not reveal any problem because the AVE for each construct is larger than the correlation of that construct with all other construct in the model (e.g., the diagonal elements are greater than the corresponding off-diagonal elements). Hence, the measurement model exhibited adequate reliability, convergent validity and discriminant validity.

**Structural model:** Structural model was used to test the hypotheses proposed in this study. The t-values are generated using the boot strapping with re-samples of 500. This permits the researcher to measure the statistical significance of the path coefficients. All the independent variables, namely technological factor ($H_1$: $\beta = 0.306$, $p<0.01$), organizational factor ($H_2$:$\beta = 0.209$, $p<0.05$) and environmental factor ($H_3$: $\beta = 0.451$, $p<0.01$) are significant and positively related to green IT adoption among the manufacturing firms in Malaysia (Table 2).

Table 1: Discriminant validity of constructs

| Constructs | Technological | Organizational | Environmental | Green IT |
|---|---|---|---|---|
| Technological | 0.873 | - | - | - |
| Organizational | 0.797 | 0.847 | - | - |
| Environmental | 0.560 | 0.513 | 0.859 | - |
| Green IT | 0.724 | 0.684 | 0.730 | 0.794 |

Diagonal values in bold represent the square root of the AVE

Table 2: Summary of the structural model

| Hypotheses | Description | Beta | SE | t-values | Decision |
|---|---|---|---|---|---|
| $H_1$ | Technological->Green IT | 0.306 | 0.109 | 2.798** | Supported |
| $H_2$ | Organizational->Green IT | 0.209 | 0.090 | 2.310* | Supported |
| $H_3$ | Environmental->Green IT | 0.451 | 0.086 | 5.274** | Supported |

t>*,**,1.96, 2.58 (p<0.05, 0.01)

## RESULTS AND DISCUSSION

A total of 453 questionnaires were circulated through email to manufacturing firms in Penang state, Malaysia. The survey was conducted over 2 month from early of February 2015 till end of March 2015. After two rounds of email reminders a total of 108 completed responses were successfully collected. Although, the response rate was at 23.84% but based on the general rule the minimum number of sample size is 5-1 ratio of the total population (Ramayah *et al.*, 2011). Thus, 23.84% is >5-1 ratio. The 2 questionnaires responses were discarded due to incomplete data. Hence, only 106 questionnaires were used as sample for analysis.

From the responses received 93.4% of respondents are male. Majority of the respondent's age between 26-40 year old which contributing 81.1% while 79.2% of respondents are at managerial position. The 67% of the respondents have >5 year working experience with the current company. This provide strong support on the reliability of the information provided by the respondents.

Majority of companies are from electrical or electronics industry which consists of 62.3%. The respondent's companies were almost equally distributed among American based, Japanese based, Malaysia based and Germany based companies. Organizations size in this study was being identified by the number of employees. It is observed that the number of employees is directly proportional to the companie's number of IT assets. Larger firms tend to have more IT infrastructure.

As discussed in previous sections, the extent of green IT adoption can be evaluated through its breadth and depth from the dimensions of sourcing, energy efficiency, measuring and monitoring and end of IT life management; covering policies, practices and technologies. From the analysis, it can be seen that manufacturing firms in Penang Malaysia are more likely to practice end of IT life management in their ambition towards green IT adoption and environmental sustainability. On the other hand, manufacturing firms in Malaysia were less likely to practice measuring and monitoring in their organizations. They lack in initiatives towards implementing IT projects to monitor the enterprise's carbon footprint and analysis IT energy bill separately from the overall corporate bill.

The first hypothesis ($H_1$) proposed that there is a significant relationship between technological factor and green IT adoption. Results infer that this hypothesis has a $\beta$ = 0.306 (p<0.01). Thus, $H_1$ is accepted and shows that there is significant relationship between technological factor and sustainable green IT adoption. This support the similar result of a study that found internal and external technologies used by organizations were positively affects the e-business diffusion (Lin and Lin, 2008). This implies that technological factor in this study affects the organizations towards green IT adoption and also leverage their existing information system application along the value chain.

Second hypothesis ($H_2$) posits that organizational factor influences green IT adoption. $H_2$ is supported as its p<0.05 with $\beta$ = 0.209. There is a relationship between organizational factor and green IT adoption. This finding is consistent with another previous study that organization resources and capabilities do impact on green IT initiatives (Sayeed and Gill, 2008). Organizations strategies towards better corporate image positively affects the organizations towards green IT adoption. This was further supported by another study that encouragement and support provided by the top management do positively related to the adoption (Teo *et al.*, 2009).

Third hypothesis ($H_3$) inferences that environmental factor will influence on green IT adoption. The $\beta$-value of environmental factor is 0.451 (p<0.01). Thus, the hypothesis is accepted. This is consistent with another study to seek the innovation diffusion in global contexts by using TOE framework (Zhu *et al.*, 2006) and supported by other researchers that found that competitor's action towards new strategies/technologies create pressure that positively affects them towards the adoption (Lin and Lin, 2008; Wang *et al.*, 2010).

## CONCLUSION

The importance of environmental sustainability has grown incredibly in recent years and since causing pressures facing business organizations. Many efforts and strategies had been carried out to address environmental issues. On the other hand, information technology plays a significant role in improving environmental footprint. Thus, sustainable green IT is the concerns in the business arena and is attracting substantial attention among business organizations.

In this study, technological, organizational and environmental factors had found to have a significant effect on sustainable green IT adoption. Thus, business organizations would be able to select their relevant strategies in order to solve environmental issues as well as bring profit to their businesses alongside with their utilization of information technology and systems to enhance the business operations.

## IMPLICATIONS

In terms of theory this study's conceptualization of sustainable green IT based on the IT activity value chain offers a basis to develop taxonomy of Green IT technologies, practices and policies. Besides this study also contributes to the use of TOE framework in green IT research. Researchers can use such taxonomy to clearly define the dependent variable in future studies of Green IT adoption either by applying the current model and hypotheses or further developed other combination with different perspectives.

This study provides preliminary findings which are relevant to promote discussions among practitioners related to sustainable information system or information technology. It also offers a basis for comparing and contrasting sustainable green IT adoption in other regions and context. The preliminary findings can be used as a basis in defining and investigating antecedents to sustainable green IT adoption in other industries in Malaysia as well as other developing countries.

Practically, the fact that TOE (Technological, Organizational and Environmental) factors are important determinants of Green IT adoption implies that there is a positive tangible and intangible motivations and gains related to the adoption of sustainable green IT. Thus, this study helps managers to identify the activities that are likely to benefit from investing in Green IT.

Although, many industries and organizations are initiating their own strategies or policies to reduce greenhouse gas emissions moving towards sustainability and green future, there are many organizations that yet to have the capacity, commitment and other resources. This study also investigated the current status of Green IT adoption which can then be used to benchmark future developments and improvements. It can also help policy makers in understanding some of the barriers future legislations have to overcome in promoting cleaner and greener environment.

## ACKNOWLEDGEMENT

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