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Determinants of Sustainable Software Practices in The Malaysian Electronic Industries

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Abstract
The issues of software sustainability are considered a crucial factor and require adequate resolutions to effectively promote the lifecycle of software development. Unfortunately, there has been a slow progression of sustainability software system implementation regarding the modern system. Hence, this study focuses on investigating the determinant of sustainable software practices in the electronic industry of Malaysia. Based on the study's objective, a conceptual model helped to develop following GREENSOFT Reference Model framework. Furthermore, a quantitative approach utilises data gathering and survey data collected through questionnaire distribution among software practitioners and users in the electronic industry. The study used a total of 250 samples with the aid of the SmartPLS approach using version 3.0. The outcome of this study shows that all investigative factors that include; software governance, strategy, practitioners and knowledge accessibility predicted significantly towards sustainable software practices. In addition, the path coefficient result shows that software practitioners were the most influencing factor, followed by software strategy. Hence, the study's outcome would help offer some contributions and enhance awareness for policymakers in the respective research area and assist in the electronic industry's application and practices of sustainable software implementation effectively.
Keywords: Sustainable Software Practices, Software Practitioners, Green IT, Green Software.

Introduction

Malaysian electronic industries empowered for sustainability in the development of software practices have increasingly effectively promoted the sectors regarding its computer systems. In computers, there are hardware and software and which consist of physical and software devices effectively. The utilisation of computers has become a significant issue during the emerging global warming and energy reduction (Sorrell, 2020). Currently, there is research on how to promote sustainable software to develop green energy and encourage technology information effectively (Jalil et al., 2021; Anthony et al., 2020; Dustdar et al., 2018). However, information technology is considered an asset that helps promote green software engineering by encouraging the operation of an ecological friendly that utilises lesser resources available. Unfortunately, there are few efforts in conducting the meeting and conferences on promoting the environmentally friendly process that would help mitigate the challenges of sustainable software practices effectively (Jnr et al., 2019; Jalil et al., 2021). The enhancing of resource-intensive processes can develop with the aid of Information technology such as intelligent energy grids for power utilisation and informatics for water consumption effectively. According to Anthony, Majid, and Romli (2020), over 2.1% of global carbon dioxide (CO2) emissions are utilised by adopting information technology to aid the aviation industry. However, information technology help to promote the efficiency of a software system in actualising the energy consumption and ensuring the management of software practices (Kern et al., 2019; Anthony et al., 2020). There is a high rate of poor sustainability that hinders the modern software system implementation, drastically affecting the electronic industries in Malaysia (Akgün, 2020). Various studies conducted and agreed that inadequate sustainability has dramatically influenced the performance of modern software systems (Mahmoud & Ahmad, 2017; Dustdar et al., 2018). Though, there are limited studies on the factors that influence the practices of sustainable software in the electronic industry of Malaysia. However, it is essential to understand the impact of developing a software practice in an environmentally friendly manner that would promote modern software sustainability in the electronic industry (Ch’ng et al., 2021). However, it perceives that the software developer is virtual when it comes to the Malaysian electronic industry. The utilisation of IT infrastructure has yielded a high productivity capability of 2% on the carbon dioxide (CO2) as same as the aviation industry (Anthony et al., 2020). Various studies focus on the factors that influence the practices that support the development of sustainable software with regards to the electronic industry in Malaysia (Jalil et al., 2021; Alharthi et al., 2019). Still, there are limited findings to support the development of the practices to sustain the software enhancement effectively. These studies further elaborate several challenges relating to the determinant of green sustainable software, which drastically reduces the modern software development towards electronic industries in Malaysia. Thus, most of the prior studies conducted in this area often focused on green sustainable software development while ignoring the sensitive factors that hinder promoting sustainable software in Malaysia. Although several studies intended to investigate the strategy implementation of green sustainable software, to enhance its development, they experience limited findings on the factors that influence software development with regards to the electronic industry (Jalil, Rashid & Kassim, 2019; Alharthi et al., 2019; Akgun, 2020; Dustdar et al., 2018). Therefore, the researcher needs to explore the factors of software governance, software strategy, knowledge accessibility, and software practitioners on promoting the practice of sustainable software in the electronic industry of Malaysia.

Literature Review

Sustainable Software Practices

Anthony and Pa (2018) prove that the adoption of software engineering needs to explore the life cycle of software development that encourages rules and procedures towards continuous improvement of stainable software practices effectively. Reviews on existing scientific studies on sustainable software practices support the model examining the determinant of software practices (Deng & Ji, 2015). Among the studies, Simmonds and Bhattacherjee (2014) developed an approach to facilitate migration strategy to provide a current, ecologically sustainable software system throughout the development lifecycle. Subsequently, Koçak et al (2014) indicate that the green software development would help to offer a suitable framework to trigger the Analytical Network Process (ANP) towards ensuring adequate decision making. However, there are two approaches to promoting sustainable software practices: green sustainable software and criteria in developing its software. Studies have shown that efficiency, usability, reliability, functionality and energy consumption, return investment and energy usage are considered factors that promote sustainable software practices. Therefore, there is a need to investigate the database-deployed software on the power consumption analysis to yield high sustainable software practices. Though, it is confirmed that green software design exhibit quality that promotes the efficiency of software energy. Various studies have shown that green software helps to reduce the usage of power in the function of mobile platforms (Barroso et al., 2021; Jnr et al., 2020). Thus, there is a need to improve the mobile system software functions regarding power usage. Krishnadas and Radhakrishna (2014) proved that the formation of sustainable software practices has continuously promoted the model's life cycle that enhances the development of green software engineering and promotes sustainable software practices.

Determinants of Sustainable Software Practices

Software Governance

In this study, software governance involves the overseeing, regulations and administrative policies that would enhance the operation daily. It further refers to the policies that trigger the implementation of decision-making for practical sustainability (Langgat, 2019). Thus, it would also increase the management level and provide a plan to promote the industry's awareness on issues of sustainability governance to achieve sustainable software practices. These policies incorporate the management support and commitment in ensuring adequate software governance to create ecological friendly that would reduce dangers to the well-being of humans effectively. This incorporation serves as a factor that contributes excellently to the development of industrial operations' (Savita et al., 2014). Software governance is an exogenous construct in this study. However, prior studies have shown a limitation in software governance regarding the development of software sustainability in Malaysia's electronic industry. It is crucial to recognise how the electronic industry would incorporate environmentally friendly practices to effectively promote the software products into modern software systems (Kocak et al., 2014). Therefore, software governance in Malaysian electronic sectors is a crucial testable construct with green sustainable practices in Malaysia electronic industries. In addition, implementing testing in this construct is essential to understand how to address the sustainability issues that affect the adoption of software sustainability in the Malaysian electronic industry. Thus, the first hypothesis derives from the study;

H_1: Software governance has a significant and direct effect on sustainable software practices in Malaysian electronic industries.

Software Strategy

Based on the GREENSOFT Reference Model and its principles, software strategy consists of various procedures required to develop electronic industries. However, software strategy is a significant factor that continuously promotes the industrial and ensures sustainable practices regarding software development towards achieving economic, social and environmental benefits in the future (Paiva, Freire & de-Mattos, 2020). In addition, reducing operational costs and minimising carbon emissions are the strategies explored in this study. Hence, the electronic industry must explore this strategy to help trigger actualising neutral carbon operation (Simmonds & Bhattacherjee, 2014; Deng & Ji, 2015). However, software strategy is an exogenous construct in this study. Prior studies have shown a limitation or research gap in software strategy with regards to the electronic industry of Malaysia. However, various studies have outlined the procedures and strategies that would enable the

migration of software systems due to their graphic processing unit. However, the studies above emphasised the deployment of software regarding the consumption of power analysis while ignoring the critical role software strategy plays in the practice's development of sustainable software in the electronic industry of Malaysia. Therefore, software strategy in Malaysian electronic industries is a crucial testable construct about sustainable green practices in Malaysia. Thus, the second hypothesis derived for the study;
H_2: Software strategy has a significant and direct effect on sustainable software practices in Malaysian electronic industries.

Knowledge Accessibility
Knowledge accessibility defines as the skills that promote the accessibility of the practice on the enhancement of software sustainability to encourage practitioners and developers to develop Malaysia's electronic industry. It further elaborates the capabilities of assets earned by facilitating a green competitive edge towards the development process of sustainable software practices (Akman & Mishra, 2014). However, the knowledge-intensive approach is one of the accessibilities of knowledge obtained from software practitioners and developers in the electronic industry. It further helps disseminate the knowledge to various electronic industries to save cost and time and effectively enhance software practices (Uddin et al., 2015; Deng & Ji, 2015). Although prior studies have examined the role of knowledge on sustainable software practices, some limitations or research gaps still exist that need to be addressed in further research. For instance, the integration adoption of the model has continuously promoted web-based knowledge in disseminating information that would help manage the system control and improve the team member knowledge on the software development effectiveness (Deng & Ji, 2015). However, this model would create sustainable software that would leverage its technical, economic and social dimensions towards sustainable software practices. However, limited studies indicate that this model did not effectively provide sustainability characteristics at the initial lifecycle of this software implementation. It further indicates that knowledge accessibility is a crucial testable construct with green sustainable practices in Malaysia electronic industries. This construct is essential to measure green sustainable practices to offer valuable insights that contribute to knowledge and close the research gap. Thus, the third hypothesis derives as:
H_3: Knowledge accessibility has a significant and direct effect on sustainable software practices in Malaysian electronic industries.

Software Practitioners
The software practitioners comprise various practitioners such as developer, professional, software experts and software team that helps to promote the knowledge and skills to sustain the development of software practices (Mangla et al., 2015). In addition, the employees are also involved in the industrial operations that would significantly increase the software practitioners productivity. Therefore, software practitioners refer to the number of employees that works in the electronic industry and which would enforce the implementation of sustainable software practices effectively (Jnr et al., 2020). Society depends on software practitioners for intensive applications of sustainable software to drive the organisation that is becoming distributed and decentralised. This interdependency operating between the society and software practitioners for the sustainability of software had shown a dynamism between practitioners in the software industry and practices (Condori-Fernandez & Lago, 2018). Sustainable software expects to be ubiquitous, and sustainability has reached various

domains whereby software practitioners in the twenty-first century are urgently keying into a dynamic environment to meet user demand. The longevity of sustainable software will depend on the decentralisation of the accessibility of products among software practitioners (Sheikh, 2020; Thiry et al., 2018). Previous studies had used qualitative and quantitative data to examine these relationships and show significant results (Condori-Fernandez & Lago, 2018). However, in the Malaysian context, such a relationship has not been investigated. Thus, it proposed that the construct; software practitioners will significantly impact sustainable software practices.

H_4: Software practitioners have a significant and direct effect on sustainable software practices in Malaysian electronic industries.

Conceptual Framework

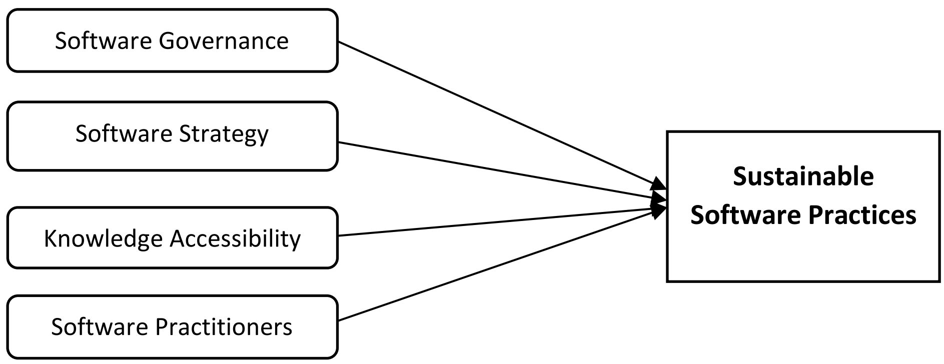

Figure 1: Conceptual Framework

Research Methodology

The researcher effectively adopted simple random sampling in data collection from employees in the electronic industry of Malaysia. The validation of questionnaires was successful with the aid of various experts that have adequate knowledge of sustainable software practice in the Malaysian context. The instrument's pilot study was conducted, which provided an acceptable level of reliable statistics ranging from .845 to .910 for the constructs. The questionnaires administer and distributed face-to-face to the electronic industries employees. Out of 275 questionnaires distributed to the target employees of electronics industries in Malaysia, the researcher received 250 questionnaires from the respondents as a sample size of this study with success and an effective response rate of 90.1%. The measurement of variables involves sustainable software practices, software governance, software strategy, knowledge accessibility and software practitioners. This study adopted a five-Likert scale from (1) Strongly disagree to (5) Strongly Agree for the constructs to obtain the data required for this study (Hair et al., 2020). Seven (7) item each was adopted for sustainable software practices, software governance, software strategies and software practitioners. At the same time, six (6) item was adopted for knowledge accessibility in this study. The Cronbach alpha for all the constructs ranged from 0.798 to 0.920, which indicates they are reliable and suitable for this study (McGibbon & Van, 2013; Ch'ng et al., 2021). The data generated for this study explores the SmartPLS to show the relationships between software governance, software strategy, knowledge accessibility, software practitioners and sustainable software practices. The descriptive analysis was conducted to analyse the demographic data of respondents effectively with the aid of SPSS. In addition, the PLS-SEM explores various analyses, including reliability and validity of the constructs, analysing the discriminant measurement, and showing the structural model of this study (Sarstedt et al., 2017).

Results

Demographic Data Analysis

The profile shows that 46% of the respondents are Chinese, 26.4% are Indians, 19% are Malays and others are made up of 8%. The age of respondents shows that 36.8% of respondents are between 45-55 years, 34.4% of respondents are between 35-44 years, 20.4% of respondents are between 25-34 years, and 4.8% are below 25 years. With regards to gender, 51.6% are male, while the remaining 48.4% are female. The working experience shows that 35.2% possesses experience of fewer than five years, 29% possesses experience between 5-10 years, 16.4% possesses experience between 11-15 years, 13.6% possesses experience between 16-20 years, and 5.6% possesses working experience of over 20 years. On the job title, 24.4% are software network, 22.8% are database administrators, 22.4% are software managers, 14% are software security, 10.8% are system analysts, while 5% belong to others. Regarding organisation size, 58.4% has above 1000 employees, 37.6 has between 251-1000 employees, 2.8% has between 51-250 employees, and 1.2% has less than 50 employees. On annual organisation revenue, 31.6% has above RM9,000,000. 26.8% has between RM50,000- RM900,000. 26.4% has between RM 4,500,001- RM9,000,000. 8.8% has between RM900,001- RM2,700,000. 5.6% has between RM2,700,001- RM4,500,000, while 0.8% has less than RM50,000. Regarding organisation date of establishment, 39.2% of respondents exhibits between 2000-2010, 36% (1981-1999), 21.6% (2011-2021), 2.8% (1957-1980), and lastly, 0.4% (before 1957). The level of education amongst the respondents, 48.8% were bachelor’s degree holders, 30.8 were high school education holders, 8.4% were master’s degree holders, 5.2% had no formal education, 4% were diploma holders, 1.2% were PhD and professional’s degree holders. In comparison, 0.4% of respondents identify as others in this study.

Table 1: Respondents Demographic Data (N = 250)

Items	Frequency	Percentage (%)	Items	Frequency	Percentage (%)
Races			**Sizes**		
Malay	49	19.6	<50	3	1.2
Chinese	115	46.0	51-250	7	2.8
Indian	66	26.4	251-1000	94	37.6
Others	20	8.0	>1000	146	58.4
Gender			**Job Title**		
Male	129	51.6	System Analyst	27	10.8
Female	121	48.4	Software Manager	56	22.4
Age			Software Network	61	24.4
<25	12	4.8	Database administrator	57	22.8
25-34	51	20.4	Software Security	35	14
35-44	86	34.4	**Establishments**		
45-55	92	36.8	<1957	1	0.4
>55	9	3.6	1957-1980	7	2.8
Experiences			1981-1999	90	36
<5	88	35.2	2000-2010	98	39.2
>5-10	73	29.2	2011-2021	54	21.6
>11-15	41	16.4	**Education**		
>16-20	34	13.6	No Formal Education	13	5.2
>21	14	5.6	High School Education	77	30.8
Revenue			Diploma	10	4
<50,000	2	0.8	Bachelor's degree	122	48.8
50,000-900,000	67	26.8	Master's degree	21	8.4
900,001-2,700,000	22	8.8	PhD	3	1.2
2,700,001-4,500,000	14	5.6	Professionals	3	1.2
4,500,001-9,000,000	66	26.4	Others	1	0.4
>9,000,000	79	31.6			

Assessment of the Measurement Model

Construct Validity and Reliability

Checking the item level reliability is the first criteria for examining the internal consistency of the items by measuring the items are internally consistent. Notably, the underlying constructs explain the items variance, which signifies item reliability. According to Hair, Howard and Nitz (2020) agreed that the factor loading required must be 0.5 or 50% or more than the stated rate as indicated. Creswell and Tashakkori (2007) recommend that the factor loadings need to be higher than 0.70. However, Zikmund, Carr and Griffin (2013) suggests that the factor loadings should not be less than 0.5. Table 2 presents the result of measurement model analysis, which manifests that the factor loadings are between 0.762 to 0.932 and have met the threshold criterion minimum requirements (Creswell & Tashakkori, 2007). In Table 2, indicates that the Cronbach's and composite reliability is recommended when they are more 0.7 (Saunders & Welch, 2012). Precisely, convergent validity is adopted to examine the relationship between the variables. In the current research, convergent validity tests by using the universally established method "Average Variance Extracted" (AVE) (Tabachnick & Fidell, 2007). It further indicates that the AVE for each construct experiences higher than 0.5, proving that each variable would yield more than 50% of the constructs variance on the average of measuring each item (Tabachnick & Fidell, 2007).

Table 2: Internal consistency and convergence validity results

Constructs	Items	F.L	CA	CR	AVE
KA	KA1	0.892	0.957	0.965	0.823
	KA2	0.932			
	KA3	0.875			
	KA4	0.915			
	KA5	0.920			
	KA6	0.907			
SG	SG1	0.867	0.926	0.940	0.690
	SG2	0.810			
	SG3	0.758			
	SG4	0.801			
	SG5	0.882			
	SG6	0.843			
	SG7	0.847			
SP	SP1	0.768	0.907	0.925	0.638
	SP2	0.834			
	SP3	0.844			
	SP4	0.804			
	SP5	0.763			
	SP6	0.790			
	SP7	0.785			
SS	SS1	0.782	0.938	0.949	0.728
	SS2	0.896			
	SS3	0.884			
	SS4	0.880			
	SS5	0.844			
	SS6	0.814			
	SS7	0.868			
SSP	SSP1	0.769	0.932	0.945	0.711
	SSP2	0.875			
	SSP3	0.902			
	SSP4	0.762			
	SSP5	0.865			
	SSP6	0.803			
	SSP7	0.913			

Notes: CR: Composite Reliability; AVE: Average Variance Extracted; CA: Cronbach's Alpha

Measurement of Discriminant Validity

In this study, the discriminant validity helps to examine the difference amongst each construct effectively (Sekaran & Bougie, 2016). However, there are many methods of determining the discriminant validity. It also indicates that the square root of AVE for each construct must be higher than the value of inter-correlations between the constructs in this study (Hair et al., 2019).

Table 3: Discriminant Validity – Fornell and Lacker Criterion

Constructs	KA	SG	SP	SS	SSP
KA	0.907				
SG	0.172	0.831			
SP	-0.047	0.056	0.799		
SS	0.146	0.071	0.018	0.854	
SSP	0.193	0.208	0.277	0.247	0.843

The off-diagonal values are the correlations between latent variables, and the diagonal is the square root of AVE

Assessment of the Structural Model

Direct Effect (Path Coefficient) Analysis

Table 4 shows the path coefficient evaluation outcome amongst the four hypotheses, and they are fully supported. At 0.05 significant level, all the hypotheses are below the minimum requirement with the t-values more than 1.96 and proved there is a significant positive effect (Hair et al., 2020; Sekaran & Bougie, 2016). Furthermore, there is a highly significant path between SP and SSP (β=0.272 or 27%, p=0.000), and the least significant path was between KA and SSP as the value of β=0.149 or 15% p=0.020. Secondly, a highly considerable path was between SS and SSP as the beta value is 0.210 (21%), t-value is 3.690, and the p-value is 0.000, which is less than 0.05. Furthermore, the third highly significant path was between SG and SSP as the beta value is 0.152, the t-value is 2.343, and the p-value is 0.020, which is also less than 0.05. Thus, all the proposed hypotheses revealed statistically and positively significant.

Table 4: Path Coefficient Result

Hypotheses	OS/Beta	LL	UL	T	P	Decision
H1: SG -> SSP	0.152	0.032	0.269	2.343	0.020	Significant
H2: SS -> SSP	0.210	0.099	0.323	3.690	0.000	Significant
H3: KA -> SSP	0.149	0.022	0.267	2.330	0.020	Significant
H4: SP -> SSP	0.272	0.150	0.386	4.481	0.000	Significant

Significant: $p < 0.05$

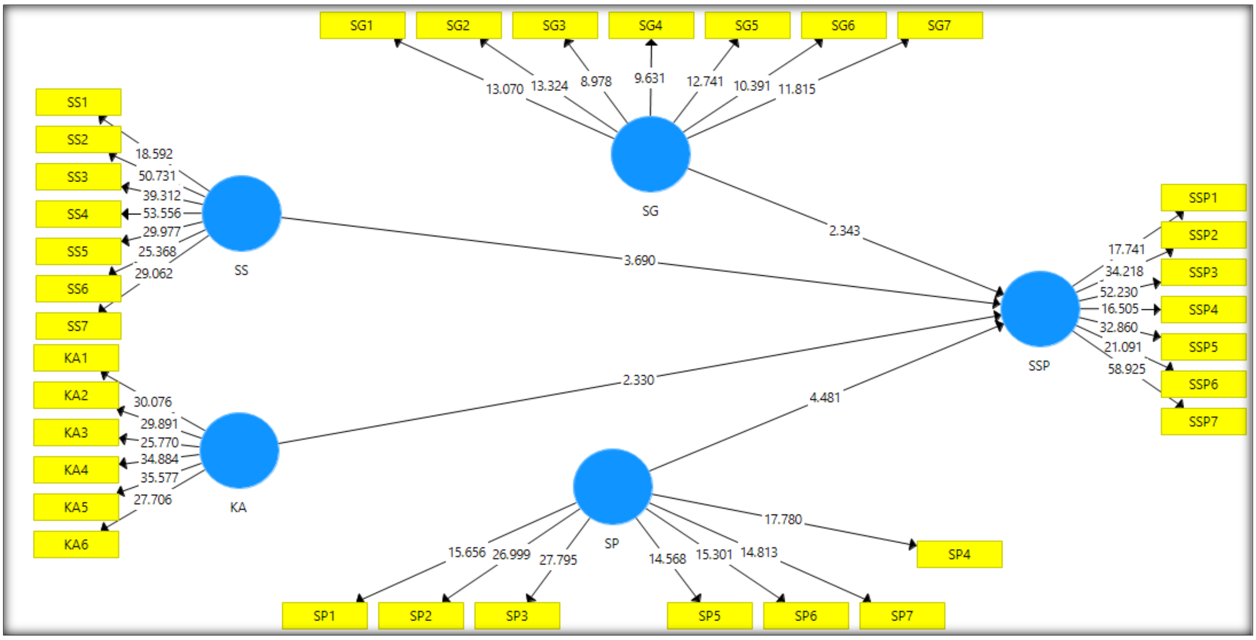

Figure 2 Structural Model with t-values (Bootstrapping result)

Discussion

The outcome of this study has confirmed that software governance, software strategy, knowledge accessibility and software practitioners support the development of sustainable software practices in the electronic industry of Malaysia. It further agreed that the path model result also yielded a highly significant to enhance the electronic industry in Malaysia. These results support the justification of the GREENSOFT Reference Model, and one study made previously has also examined these factors in a similar context (Naumann et al., 2015). The determinant of sustainable software is a relevant issue that ought to investigate in the software process's developmental stage. Based on the hypothesis (H_1), software governance has influenced the development of software practices and helped facilitate sustainability amongst Malaysia's electronic industries. Substantial level of results ($\beta=0.152$, $t=2.343$, $p<0.020$). The outcome of the findings supports the development of sustainable software, which was in line with the past studies (Jnr et al., 2018). However, the findings from this relationship show that software governance plays a leading role in sustainable software practices. The study also shows that software governance helps policy utilisation reduce environmental waste regarding policy application. The study also shows that software governance plays a leading role in budgeting and resource allocations in sustainable software practices. However, the relationship between software governance and sustainable practices also shows that industrial management promotes Malaysia's electronic industry. Based on the hypothesis (H_2) – software strategy has a significant and direct effect on promoting software practice sustainability in Malaysia. Thus, the findings confirmed the level ($\beta=0.210$, $t=3.690$, $p<0.000$). This result proved that the adoption of software strategy had significantly impacted enhancing sustainable software practices since both paths were found empirically significant. The ties further show that long term strategy is critical to achieving a long-term sustainability goal and software investment strategy. Furthermore, the relationship also shows that software law strategy is essential when environmental law is enforced and helps to minimise the carbon footprint in the Malaysian electronic industry. Based on the hypothesis (H_3), the findings confirmed that the substantial level of results ($\beta=0.149$, $t=2.330$, $p<0.020$) and further shows a significant direct effect on the improvement of practices in enhancing the sustainable software in the Malaysian electronic industry. However, this study shows a strong relationship between knowledge accessibility and sustainable practices is vital to provide the latest data on the environment and climate across Malaysian electronic industries. The relevance of sustainable data is essential within the Malaysian electronic industries for active engagement and knowledge accessibility, which is vital in promoting sustainable software practices and electronic industries in Malaysia. Based on the hypothesis (H_4), the findings strongly shows that ($\beta=0.272$, $t=4.481$, $p<0.000$). In addition, this finding believes that there are many software practitioners towards enhancing sustainable software practices in Malaysia. Both ties also reveal that ethical consideration of software practitioners is an essential dimension to continuously develop and promote sustainable software practices in Malaysia's electronic industry (Knapton, 2017). While these findings correspond with past studies, the implications are that the experience of software practitioners in Malaysian electronic industries is an essential factor and attribute to consider in sustainable software practices (Jnr et al., 2018). In this study, all the factors observed include software governance, software strategy, knowledge accessibility and software practitioners. Therefore, following the Path co-efficient result presented in the Bootstrapping results – the most influencing factor to sustainable software practices in Malaysian electronic industries was software practitioners with a path coefficient result of 4.481. These studies show that software practitioners have the most substantial influence on eco-practices for the application of sustainable IT.

Conclusion

The findings of this study agreed that software governance, software strategy, knowledge accessibility, and software practitioner positively impact sustainable software practices. It further supports the alignment of GREENSOFT Reference Model in this study. The findings of this study supported the development of the research objectives as it shows a significant impact on promoting the practices exhibited in enhancing software sustainability in Malaysia's electronic industry. However, this study's objectives and questions successfully supported the hypothesis, which has helped provide desirable solutions in this study. In addition, the coefficient of determination shows 18.7% on the development of sustainable software practices, which consist of software governance, software strategy, the accessibility of knowledge, and software practitioners effectively. Given the explanatory strength of the research model, the study presented the theoretical and managerial implications. However, the theoretical implications show a framework that connects all the predictive factors such as software governance, software strategy, knowledge accessibility and software practitioners has promoted the practices expected to yield a high level of sustainable software in the electronic industry of Malaysia. The outcome of this study shows a strong correlation between software governance, software strategy, knowledge accessibility, software practitioners, and sustainable software practices. It further confirmed that software governance, software strategy, knowledge accessibility, and software practitioners positively influence the sustainable software practices in this study. The managerial implications maintained that policymakers must enhance and promote software improvement practices amongst the practitioners and developers to improve the electronic industry. The outcome of this study has established the significance of green software to the development of the Malaysian electronic industry. In addition, this study would help to provide adequate service quality delivery and enhance its competitive edge effectively. Lastly, these study findings would help promote the employee's well-being, increase the productivity and performance of Malaysian electronic industries, and increase managers and practitioners' efficiency amongst the public and private electronic industry in Malaysia.

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