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"Navigating Digital Transformation: Ai and Innovations for the Future of Business"

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Department of Business and Management, UiTM Perak Branch

INTERNATIONAL CONFERENCE ON BUSINESS MANAGEMENT & INNOVATION (ICBiv) 2025

NAVIGATING DIGITAL TRANSFORMATION: AI AND INNOVATIONS FOR THE FUTURE OF BUSINESS

Proceeding Book

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Synopsis

The 2nd International Conference on Business Management and Innovation (ICBIV 2025) was successfully organized by the Department of Business and Management, Universiti Teknologi MARA (UiTM), Tapah Campus, Perak, Malaysia, and held virtually on 16th and 17th April 2025. Building on the success of its inaugural edition, the conference aimed to provide an interdisciplinary platform for academics, researchers, practitioners, and postgraduate students to engage in knowledge exchange, present recent research findings, and discuss emerging trends and challenges in the field of business and innovation.

Themed “Navigating Digital Transformation: AI and Innovations for the Future of Business,” ICBIV 2025 brought into focus the increasing relevance of digital technologies—particularly artificial intelligence—as catalysts for transformation within various business sectors. The conference addressed a broad spectrum of topics including, but not limited to business innovation and technology, business and economics, business sustainability, digital marketing and innovation, entrepreneurship, emerging markets, financial management and technology, human resource, Islamic finance, organization behavior, and operation management and supply chain.

The conference received a diverse range of submissions from both local and international scholars, reflecting the global relevance of the issues discussed. All accepted and presented papers were compiled and published in the conference proceedings with an electronic International Standard Book Number (e-ISBN). Furthermore, selected high-quality papers were invited for submission to indexed journals, including those listed in Scopus, ERA, and MyCite, subject to rigorous peer review and editorial processes. It is important to note that publication in these journals required an additional fee, which was not included in the conference registration.

The outcomes of ICBIV 2025 were significantly aligned with the strategic interests of its primary stakeholders, notably UiTM Perak, Malaysia and Universitas Tridinanti, Indonesia, whose collaborative efforts were instrumental in shaping the conference's regional impact. For UiTM, the event reinforced its institutional mission to serve as a hub for research-driven solutions in business and management, while strengthening its global academic presence. For Universitas Tridinanti, the conference provided a valuable platform for cross-border academic engagement, research dissemination, and the promotion of Southeast Asian perspectives on innovation. The collaboration between both institutions fostered mutual capacity building, academic exchange, and potential long-term research partnerships. Through the active involvement of faculty, researchers, and postgraduate students from both universities, ICBIV 2025 successfully addressed the needs of diverse stakeholders, from academia and industry to policy and education sectors, thereby enhancing its relevance, reach, and impact across national boundaries.

ICBIV 2025 successfully facilitated meaningful academic discourse and fostered collaborative research opportunities by creating a space for dialogue on how innovation and digitalization can redefine business strategies, operations, and sustainability in the face of rapidly evolving global economic landscapes. The conference reaffirmed its commitment to promoting research excellence and interdisciplinary collaboration in addressing contemporary and future challenges in business and management.

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THE EFFECT OF TAX DIGITALIZATION, TAX KNOWLEDGE, AND TAX SANCTIONS ON THE INDIVIDUAL TAX PAYERS' COMPLIANCE AT EAST ILIR TAX SERVICE OFFICE

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ABSTRAK

This study aims to analyze the Influence of Tax Digitalization, Tax Knowledge, and Tax Sanctions on the Individual Taxpayers' Compliance in East Ilir Tax Service Office. This study uses Quantitative Analysis and SEM (Structural Equation Modeling) methods; data collection is carried out by distributing questionnaires and analysing the type of data used in this study as primary data. Primary data is obtained from the questionnaire results to obtain the information the researcher needs. The results show that Tax Digitalization, Tax Knowledge and tax sanctions have a positive and significant effect on the individual taxpayers' compliance, and the three variables simultaneously have a positive and significant impact on the individual taxpayers' compliance. This study makes a significant theoretical contribution by integrating tax digitization in detecting taxpayer compliance at East Ilir Tax Service Office. This research's originality lies in applying tax digitalization, tax knowledge, and tax sanctions in the context of the Indonesian tax system, where the use of advanced technology such as E-Billing, E-filling, and E-SPT is still relatively new. This study also combines the Expected utility theory which adds elements of arrogance and competence in the analysis of taxpayer compliance.

Keywords: *Tax Digitalization, Tax Knowledge, Tax Sanctions, Expected Utility Theory, and Taxpayer Compliance*

1.0 INTRODUCTION

Taxpayer compliance is an effort by the community to fulfill tax rights and obligations, with the emphasis that taxpayer compliance is not only about paying a large amount of tax, but also about aligning payments with applicable rights and obligations (Mufarrokhah et al., 2024). Meanwhile, according to Putri & Nadi (2024), states that taxpayer compliance is an important aspect of the tax system, which includes the compliance of individuals or entities to fulfill tax obligations promptly and according to applicable regulations. According to Yuda & Musmini (2024), the higher the taxpayer compliance, the higher the benefits provided to the community. Key partnership mapping is expected to support policymakers and stakeholders in building sustainable cross-border collaboration strategies (Arifin & Putra, 2024). So, taxpayer compliance is the main pillar of a healthy and well-functioning tax system.

Meanwhile, in the research that has been carried out by (Arifin & Fitri, 2024), it is stated that from 1977 to 2024, taxpayer compliance is still being researched by many researchers, because taxpayer compliance is still very popular to be researched. After all, it is still the main problem for the state's tax revenue. Taxpayer compliance is not only about numbers and nominal but also about moral principles and legal responsibility (Hardiyanti, 2024). while taxpayer compliance is not only the duty of individuals or business entities, but also a shared responsibility in society (Aswat, 2024). When taxpayers comply with their obligations correctly, it creates a solid foundation for the country's sustainable economic development and financial stability. In this case, the role of the government in authorizing taxation, and other related institutions, is very important, so that taxpayer compliance can increase and continue to develop.

Table 1. Taxpayer Compliance Ratio in 2020 -2023

Tax Year	Number of Taxpayers Reporting Tax Returns	Number of Taxpayers Who Do Not Report Tax Returns	Number of Taxpayers	Taxpayer Compliance Ratio
2020	59.862	174.064	233.926	25.6%
2021	55.133	191.516	246.649	22.4%
2022	54.173	205.336	259.509	20.9%
2023	59.849	211.565	271.414	22.05%

Source : *East Ilir Tax Service Office (2024)*

It is summarized from the official data of the East Ilir Tax Service Office, that the taxpayer compliance ratio from 2020 to 2023 has experienced an upward and downward trend from 2020. In 2020 the Taxpayer Compliance Ratio was 25.6% or as many as 59,862 taxpayers who reported their taxes, in 2021 the Taxpayer Compliance Ratio decreased to 22.4% or 55.133 Taxpayers who reported their taxes this number decreased from the previous year by 3.2%, in 2022 the Taxpayer Ratio again showed 20.9% or as many as 54.173 taxpayers who reported their taxes which decreased from the previous year by 1.5% in 2023 The taxpayer compliance ratio increased from the previous year, with 22.05% or as many as 59.849 taxpayers who reported, which interpreted taxpayer compliance in paying and reporting their taxes, an increase of 1.15% from 2022. Based on data from the East Ilir Tax Service Office, the number of taxpayers in 2023 is 271.414 individual taxpayers. If the compliance rate is 22.05%, then the number of taxpayers who submit tax returns in 2023 will reach 59.849 people. However, there are still around 211.565 taxpayers who have not reported their tax obligations.

This gap shows that compliance alone is not enough, there needs to be an appropriate increase in the tax base and tax revenue collection. One of the main issues is the expansion of the tax base. Many prospective taxpayers may still be outside the tax network, especially in the informal sector. Strategies to include individuals and businesses in the formal tax system are very important.

Tax digitalization is an innovative approach in tax administration that provides online-based applications or internet-based platforms for taxpayers, making it easier to report and pay taxes, Mufarrokhah (2024). Meanwhile, according to Kawerang (2024), Tax digitalization is the application of the tax system through online digital technology such as *e-filing* and *e-billing* made by the government and tax offices which aims to increase taxpayers' compliance with tax regulations. And according to Hardiyanti (2024), Tax digitalization is an innovation in tax administration that uses online digital technology to provide applications or platforms for taxpayers and it is hoped that taxpayers will be easier and more efficient in fulfilling their obligations in terms of taxation. Thus, the digitalization of taxation will reflect *Global Trends* where the government uses tax technology to increase efficiency and compliance in tax administration.

Digitalization of taxation has shown a significant impact on taxpayer compliance. The implementation of digital technology in tax administration has increased the ease and efficiency in reporting and paying taxes. Based on the latest data, the use of the system *e-filing* and *e-billing* by taxpayers has increased rapidly. According to data from the East Ilir Tax Office in 2023, a total of 59.849 taxpayers reported their tax returns, this increased from the previous year in 2022 when around 54.173 taxpayers reported their annual tax returns online.

The use of tax digitalization aims to increase the effectiveness of reporting, increase the convenience of the public, improve the quality of public services, and improve the overall increase in tax returns. Taxpayer Compliance can be significantly affected by Digital Technology, and Taxpayer Compliance Nurafiza & Kisnawati (2024). Meanwhile, according to Nugraha (2024), Digitalization has no effect on tax sanctions or Taxpayer compliance, but Taxpayer Knowledge has an effect on tax sanctions and the fulfillment of Taxpayers' obligations and tax sanctions have an effect on the compliance of Taxpayers. Although taxpayer compliance in 2024 is increasing, the revenue generated is still less than the government's target.

Research findings, Jatmika & Puspita (2024) The digitalization of the tax system affects taxpayer compliance. Meanwhile, according to (Rhido, n.d.) it is said that changes in the e-Invoice system, perception of convenience, and tax knowledge have a positive and significant effect on taxpayer compliance. And according to Ristiyana et al. (2024), digitalization does not affect taxpayer compliance. This is that tax digitalization is still not widely understood by taxpayers in reporting taxes. Digitalization should provide convenience in reporting taxpayer taxes online, and technology access in some regions, internet access and technology are still limited, which can hinder taxpayers' ability to report and pay taxes online. Concerns about the security of personal and financial data can also be a barrier for taxpayers to use digital systems.

Tax knowledge is an understanding of tax policies implemented in a country to increase taxpayer compliance, they must understand tax provisions and regulations so that they can apply the knowledge about taxation correctly and promptly (Amalia et al., 2024). Meanwhile, according to Nasucha (2004) in his book, the author highlights that one of the main challenges faced by Taxpayers in fulfilling their tax obligations is the complexity of tax regulations. The complexity of this rule is a significant obstacle for taxpayers in complying with their tax obligations, and the complexity of tax regulations also hampers taxpayer compliance (TC).

This complexity requires taxpayers to study and understand these rules in depth. As a result, taxpayers need to have adequate knowledge of the tax system to fulfill their obligations properly. According to Nugraha et al., (2024) Tax knowledge is to grow taxpayer awareness, which can be done by providing education or knowledge about tax obligations for every citizen, with knowledge about taxes, so that it is easy for taxpayers to carry out their tax obligations. So that tax knowledge not only helps in understanding and implementing regulations correctly, but also increases taxpayer awareness and compliance as a whole.

Tax knowledge is the ability possessed by taxpayers to understand and know tax regulations, understanding tax rates that have been determined based on the law, and awareness of tax benefits for taxpayers' welfare, Ageng & Utomo (2011). According to Rahayu (2017), a good level of understanding of tax regulations can increase taxpayers' compliance in fulfilling their tax obligations. So taxpayers who have adequate tax knowledge tend to be able to motivate themselves to carry out their obligations voluntarily and on time. Because it is not only driven by the desire to avoid sanctions contained in tax laws and regulations, but also by the awareness of their role in contributing to the country.

Utility theory states that individuals will take actions that they believe will maximize their profits or satisfaction. In the context of taxation, taxpayers will decide to report a tax return if they feel the benefits or benefits of compliance (for example, avoiding sanctions or getting better public services) outweigh the costs or risks of non-compliance. Prevention models focus on implementing actions and policies that can reduce non-compliant behaviors, such as strict supervision and effective sanctions. According to Article 7 of the Tax Law, taxpayers who do not report their tax returns on time will be subject to sanctions.

Tax sanctions affect the compliance of taxpayers (Nugraha, 2024). According to Karina et al. (2024), in their research, fiscal tax sanctions have a significant positive effect on the implementation of taxation of Individual Taxpayers. Meanwhile, according to Dewi (2024), tax sanctions do not affect the individual taxpayers' compliance. According to Sons (2024) which states that the firmness of tax sanctions does not affect taxpayer compliance. There are still many taxpayers who violate tax sanctions by reporting taxes late to the point of not reporting their taxes, So according to Article 7 of the General Provisions of Taxation Law, sanctions are given to those who do not or are late in reporting the annual tax return (Notification letter) if it is not submitted within the predetermined period, then administrative sanctions are imposed in the form of a fine of Rp.100.000.- for the annual personal income tax return and Rp.100.000.- for other tax returns and can subject to criminal sanctions following article 39 paragraph 1 of the General Provisions of Taxation Law, the sanction is a minimum of 6 months in prison and a maximum of 6 years. In addition, a fine of at least 2 times the amount of tax payable that is not or underpaid, and a maximum of 4 times the amount of tax payable that is not or underpaid.

Based on the description above, it is important to test the influence of tax digitalization, tax knowledge, and tax sanctions on the Individual Taxpayers Compliance at the East Ilir Tax Service Office which is a tax service office.

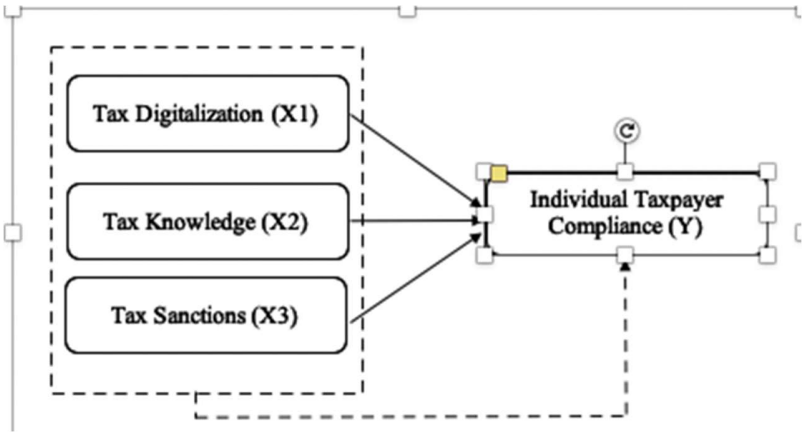

Chart 1. Theoretical Thinking Framework

The hypothesis in this study is as follows:

1. There is an influence of tax digitalization, tax knowledge and tax sanctions on the compliance of individual taxpayers
2. There is an influence between tax digitization and the compliance of individual taxpayers.
3. There is an influence between tax knowledge and individual taxpayers' compliance.
4. There is an influence between tax sanctions on the compliance of individual taxpayers.

According to Sofiyana (2014), Tax digitalization is an effort to implement tax reform to improve or perfect the functions of institutions and make them more economical and efficient. In the increasingly advanced digital era, the Directorate General of Taxes is developing the latest tax information technology innovations. This initiative is believed to increase effectiveness and efficiency in the tax collection process. Utilizing technological advances, this new tax system is expected to significantly optimize state revenue from the tax sector.

This modernization effort reflects the commitment of the Directorate General of Taxes in adapting to the times. By implementing advanced technology, the tax administration process is hoped to become more transparent, accurate, and easily accessible to taxpayers. This will not only increase tax compliance, but also make it easier for people to fulfill their tax obligations, in supporting national development through better tax revenue.

According to Nurafiza & Kisnawati (2024), Tax Digitalization has a significant effect on taxpayer compliance. This research is in line with the research according to Mubin et. al. (2024) who said that the digitalisation of services has a positive and significant effect on taxpayer compliance, and research, according to Indriyanto & Siska (2024) who also said that digitalization positively and significantly affects taxpayer compliance.

Meanwhile, according to Riyani & Sofianty (2024), Tax digitalization does not affect taxpayer compliance. This research is in line with Mufarrokhah (2024), Tax Digitization has no significant effect on taxpayer compliance. And with research according to (RP & Hapsari, 2024), the obstacles taxpayers face when using electronic tax service applications, such as e-filing, e-form, e-billing, and e-invoicing, include applications that often have errors and the taxpayer's internet network.

According to Saragih & Tobing (2024), Tax knowledge has a significant positive influence on taxpayer compliance. This research is in line with the research of Kawerang (2024), which said that tax knowledge positively affects tax compliance. Meanwhile, according to Nugraha (2024) Taxpayer knowledge affects the taxpayer's tax fulfillment. Meanwhile, according to Jatmiko (2024), Taxpayer Knowledge does not affect Taxpayer Compliance. This research is in line with the research of Putra (2024), who said that knowledge about taxes does not affect taxpayer compliance, and according to research, Bantalia (2024), who said that tax knowledge has no significant effect on taxpayer compliance.

According to Karina et al. (2024), fiscal tax sanctions significantly positively affect the implementation of taxation for individual taxpayers. This research is in line with the research, according to Atmanti & Kurniawan (2024) who said that tax sanctions have a positive effect on taxpayer compliance. And according to research, Yasa (2024) who said that tax sanctions have a significant positive effect on the individual taxpayers' compliance. Meanwhile, according to Novita et al., (2024), tax sanctions do not affect taxpayer compliance. Backed by research, Putri & Nadi (2024) which discusses that tax sanctions are not able to affect taxpayer compliance. And research Putri & Yuliati, (2024) who said that tax sanctions do not affect the Individual Taxpayers' Compliance.

2.0 LITERATURE REVIEW

Based on basic knowledge about tax compliance through the Rank-Dependent Expected Utility (RDEU), Arcand and Graziosi (2005), the literature can be expanded to include gender dynamics. Previous research has shown that gender can significantly influence risk perception and decision-making, Henwood et al., (2008), both of which are important factors in tax compliance behavior, Hasseldine & Hite (2003). *Expected Utility Theory* is designed to address risk, not uncertainty. A risky situation is when we know the possible outcomes and can provide a probability for each outcome. In contrast, uncertainty occurs when we cannot provide a definite probability for some possible outcome.

Type *Deterrence* is a law enforcement tool used by tax authorities, such as tax audits, fines, and sanctions, to prevent tax evasion by taxpayers (Muhammad et al., n.d.). For risk-averse taxpayers, the portion of avoided income may decrease, remain or increase along with the actual increase in income, depending on how their risk aversion changes relative to income (Frey & Feld, 2002).

Taxpayer Compliance

According to Rahayu (2020), Tax compliance is the compliance of taxpayers with implementing applicable tax provisions. Meanwhile, in the research that has been carried out by Arifin & Fitri (2024), it is stated that from 1977 to 2024, taxpayer compliance is still being researched by many researchers because taxpayer compliance is still very popular to be researched. After all, it is still the main problem in tax revenue for the state. Research on tax compliance has made significant progress in various countries, Tekin & Sokmen (2023). The study mostly focuses on developed countries with sophisticated tax systems, examining supporting factors such as law enforcement, Bruno (2019), punishment, Swistak (2016), and taxpayer behavior (Alm et al., 2010).

Tax Digitalization

Digitalization of tax services is an innovative approach in tax administration, offering an online-based application or internet-based platform to taxpayers for easy reporting and payment of taxes by the government, Mufarrokhah et al., (2024). In today's digital era, technological advances have brought significant changes, including in the tax administration process. Previously, the Taxpayer Identification Number creation, calculation, payment, and reporting of the Annual Return (Notification letter) were carried out manually.

Tax knowledge

Tax knowledge refers to everything related to tax administration. This information is used as a guide in complying with tax rules. According to Graha et al., (2024, p. 44) Tax knowledge is the ability of taxpayers to understand tax regulations. Meanwhile, according to Amalia et al., (2024) Tax knowledge is also defined as understanding a country's tax policy. Psychological factors and differences in social values between the sexes also play an important role in influencing tax compliance behavior, Seno (2022). However, gender impacts are not *universal* and vary depending on the cultural context, taxation system, and level of education, Alidu (2023).

Tax sanctions

Tax sanctions are a consequence obtained when taxpayers violate tax regulations, Putri and Nadi (2024, 99). Tax sanctions are a guarantee that tax laws and regulations will be complied with, in other words, tax sanctions are a deterrent tool so that taxpayers do not violate tax norms. Atmanti and Kurniawan (2024). According to Yasa (2024), sanctions are actions imposed when a person violates tax laws by the policies and regulations listed in the tax law; sanctions are imposed on individuals or entities that violate tax obligations. In the Tax Law, there are two types of sanctions, namely administrative sanctions and criminal sanctions; administrative sanctions apply when there is an administrative violation by Law 7 General Provisions of Taxation and Criminal sanctions by Article 39 Paragraph 1 of the General Provisions of Taxation Law.

Method

This research is a quantitative research using a quantitative approach, the quantitative approach is a quantitative research, which examines certain theories by examining the relationships between variables (Ahmad et al., 2019). The object of research in this study is tax digitalization, tax knowledge, tax sanctions, and individual taxpayers' compliance in the East Ilir tax service office, East Ilir 1 District, Palembang City. There are two variables in this study, namely the dependent variable in the form of Individual Taxpayer Compliance (Y) and the independent variable in the form of tax digitalization (X_1), Tax knowledge (X_2), and tax sanctions (X_3). The variable measurement uses the Likert scale, which gives a score of 5 for the "Strongly Agree" answer, a score of 4 for the "Agree" answer, a score of 3 for the "Neutral" answer, a score of 2 for the "Disagree" answer and a score of 1 for the "Strongly Disagree" answer.

Population is a very important thing for researchers because it is a source of information. Amin et al., (2023). Meanwhile, according to Sugiyono (2018), Population is a generalization area consisting of objects/subjects with a certain quantity and characteristics, determined by the researcher to be studied and then concluded. The population in this study is East Ilir 1 taxpayers in Palembang City, which totals 67,124 people. The sampling technique used is *Random sampling*. According to Arikunto (2019), the sample is a part or representative of the population studied. The number of samples in this study is 107 respondents aged 20-60 years. The type of data used is primary data collected through questionnaires.

Table 2. Variable Measurement

Variable	Proxy
Tax Digitalization	This variable is measured by three indicators: Electronic Billing, Electronic Filing and Electronic Tax Return.
Tax knowledge	This variable is measured by four indicators absorbed from Halim et al., (2016), namely, Definition of tax, Tax functions, Types of taxes, and Tax collection system.

Sanctions	This variable is measured by two indicators taken from Article 7 of the General Provisions of Taxation Law, namely administrative sanctions and fine sanctions.
Taxpayer compliance	This variable is measured by two indicators taken, namely formal compliance and material compliance.

The methods applied to analyze data and test hypotheses include data quality tests in the form of, Outer model analysis, Form convergent validity, Average Variance Extracted (AVE), discriminant validity, and unidimensionality (Cronbach Alpha). While Inner model analysis (hypothesis test), Direct Effect, Coefficient of Determination (R Square), predictive relevance, goodness of fit Index (GoF) or model fit.

Results and Discussion

The following is a summary of the 107 questionnaires distributed to East Ilir taxpayers.

Table 3. Questionnaire Return Rate

Information	Number of Respondents	Percentage
Distributed questionnaires	107	100%
Returning questionnaire	107	100%
Questionnaires that cannot be processed	0	0
Processor-ready questionnaires	107	100%

Source: Data processed, 2024

So that 107 questionnaires can be processed to the statistical analysis stage.

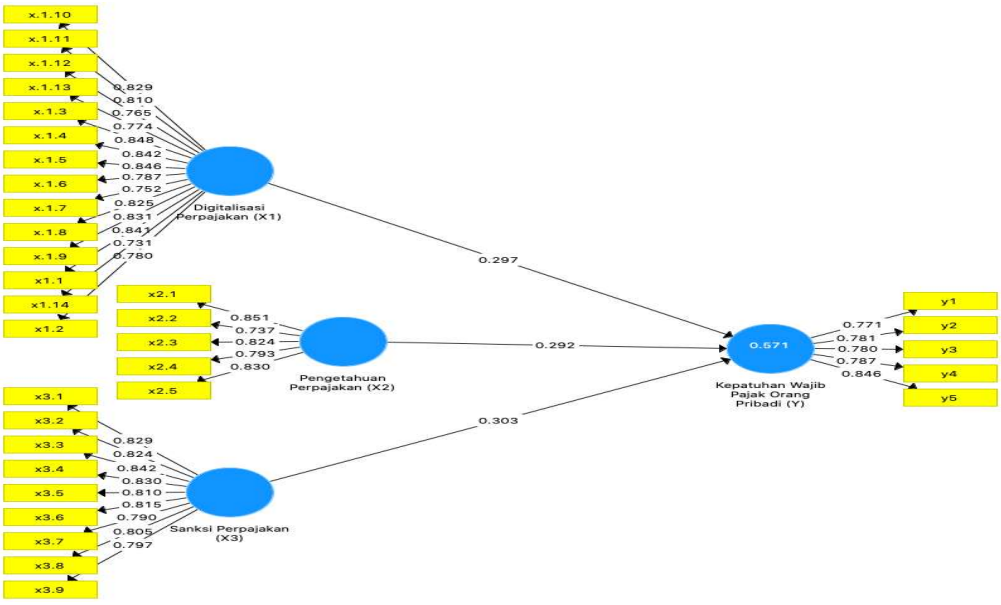

Figure 1 Model of *Outer Loading Data Processing Results*

Source: Data processed, 2024

The variable of Tax Digitalization influences the individual taxpayer compliance variable of 0.297 or 29.7%. The variable Tax Knowledge influences the individual taxpayer Compliance variable by 0.292 or 29.2%. The variable Tax sanctions influence the individual taxpayer compliance variable by 0.303 or 30.3%.

Table 4. Results of the Validity Test of Tax Digitalization Variables

Variable	Indicators	*Loading Factor*	*Rule of Thumb*	Conclusion
Tax Digitalization (X1)	x.1.10	0.829	0.700	Valid
	x.1.11	0.810	0.700	Valid
	x.1.12	0.765	0.700	Valid
	x.1.13	0.774	0.700	Valid
	x.1.3	0.848	0.700	Valid
	x.1.4	0.842	0.700	Valid
	x.1.5	0.846	0.700	Valid
	x.1.6	0.787	0.700	Valid
	x.1.7	0.752	0.700	Valid
	x.1.8	0.825	0.700	Valid
	x.1.9	0.831	0.700	Valid
	x1.1	0.841	0.700	Valid
	x1.14	0.731	0.700	Valid
	x1.2	0.780	0.700	Valid

Source: Data processed, 2024

Table 4 shows that the questionnaire question item on the tax digitalization variable has a value of more than 0.7, meaning that the data from the instrument for the tax digitalization variable is declared valid, (Ghozali, 2018).

Table 5. Results of the Validity Test of Tax Knowledge Variables

Variable	Indicators	Loading Factor	Rule of Thumb	Conclusion
Tax Knowledge (x2)	x2.1	0.851	0.700	Valid
	x2.2	0.737	0.700	Valid
	x2.3	0.824	0.700	Valid
	x2.4	0.793	0.700	Valid

	x2.5	0.830	0.700	Valid

Source: Data processed, 2024

Table 5 shows that the questionnaire question item on the tax Knowledge variable has a value of more than 0.7, meaning that the data from the instrument for the tax Knowledge variable is declared valid (Ghozali, 2018).

Table 6. Results of the Validity Test of Tax Sanctions Variables

Variable	Indicators	Loading Factor	Rule of Thumb	Conclusion
Tax Sanctions (X3)	x3.1	0.829	0.700	Valid
	x3.2	0.824	0.700	Valid
	x3.3	0.842	0.700	Valid
	x3.4	0.830	0.700	Valid
	x3.5	0.810	0.700	Valid
	x3.6	0.815	0.700	Valid
	x3.7	0.790	0.700	Valid
	x3.8	0.805	0.700	Valid
	x3.9	0.797	0.700	Valid

Source: Data processed, 2024

Table 6 shows that the questionnaire question item on the tax sanctions variable is more than 0.7, meaning that the data from the instrument for the tax sanctions variable is declared valid (Ghozali, 2018).

Table 7. Results of the Validity Test of Regional Fund Allocation Management Variables (ADD)

Variable	Indicators	Loading Factor	Rule of Thumb	Conclusion
Individual Taxpayer Compliance (Y)	Y1	0.771	0.700	Valid
	Y2	0.781	0.700	Valid
	Y3	0.780	0.700	Valid
	Y4	0.787	0.700	Valid
	Y5	0.846	0.700	Valid

Source: Data processed, 2024

Table 7 shows that the questionnaire question item on the Individual Taxpayer Compliance variable is more than 0.7, meaning that the data from the instrument for the Individual Taxpayer Compliance variable is declared valid (Ghozali, 2018).

Reliability tests are used to measure the extent to which an instrument or measuring device is consistent and accurate in measuring what is supposed to be measured (Ghozali, 2018). Ghozali (2018) also added that a questionnaire question is reliable if the Cronbach Alpha value is> 0.60.

Table 8. Reliability Test Results

Variable	*Cronbach's Alpha*	*Composite Reliability*
Tax Digitalization (X1)	0.958	0.963
Individual Taxpayer Compliance (Y)	0.853	0.895
Tax Knowledge (x2)	0.867	0.904
Tax Sanctions (X3)	0.937	0.947

Source: Data processed, 2024

Table 8 shows that the Cronbach Alpha value for each variable is for Tax Digitalization 0.958, tax knowledge 0.867, Tax sanctions 0.937, and individual taxpayers compliance 0.853. This means that the data for all these variables is greater than 0.60, and it can be concluded that all variables in this study are reliable.

The normality test is a statistical procedure used to determine the normality of the distribution of research data owned by the Ghozali (2018). The data is declared to be normally distributed if the asymp value of the sig (2-tailed) is more than 5%.

Table 9. *Average Variance Extracted (AVE)*

Variable	Average Variance Extracted (AVE)
Tax Digitalization (X1)	0.648
Tax Knowledge (x2)	0.653
Tax Sanctions (X3)	0.666
Individual Taxpayer Compliance (Y)	0.630

Source: Data processed, 2024

Table 9 above shows that all variables have met the set AVE criteria with a ≥ value of 0.5. This shows that the Convergent Validity Test is acceptable. Furthermore, the validity of the research was continued with the Discriminant Validity test through the Fornell-Larker Criterion and Cross Loading tests (Ghozali, 2018). The greater value indicates the suitability of an indicator to explain its association with constructs compared to other constructs (Henseler, 2014)

Table 10. Discriminant Validity Result: *Fornell-Larcker*

Variable	Tax Digitalization (X1)	Individual Taxpayer Compliance (Y)	Tax Knowledge (x2)	Tax Sanctions (X3)
Tax Digitalization (X1)	0.805			
Tax Knowledge (x2)	0.644	0.808		
Tax Sanctions (X3)	0.480	0.607	0.816	
Individual Taxpayer Compliance (Y)	0.630	0.667	0.623	0.793

Source: Data processed, 2024

Table 10 shows that the value of the AVE of the Tax Digitalization Variable with the Tax Digitalization variable itself is 0.805. This makes the value of the AVE Tax Digitalization on its own greater than other variables. This also applies to the value of AVE Tax Knowledge of 0.808, AVE Tax Sanctions of 0.816 and AVE of Taxpayer Compliance of 0.793.

According to Octavia (2020), Heterotrait-Monotraite (HTMT) is a correlation ratio used to evaluate validity, and *Discrimination* between constructs. This ratio measures the average of all indicator correlations across constructs that measure different constructs (correlation *heterotrait-heteromethod)* relative to the average (average *Geometric*) correlation of the average of indicators measuring the same construct. Technically, HTMT is an estimate of the true correlation between two constructs if they are both perfectly measured (i.e., highly reliable).

Table 11. Discriminant Validity Test Results: *Heterotrait-Monotraite (HTMT)*

Variable	Tax Digitalization (X1)	Individual Taxpayer Compliance (Y)	Tax Knowledge (x2)	Tax Sanctions (X3)
Tax Digitalization (X1)				
Individual Taxpayer Compliance (Y)	0.679			
Tax Knowledge (x2)	0.695	0.760		
Tax Sanctions (X3)	0.485	0.677	0.670	

Source: Data processed, 2024

Table 11 shows that the value of *Heterotrait-mononitrate (HTMT) has been in accordance with the expected value of HTMT,* which is less than 0.90. From the results that have been obtained it shows that this research is valid.

Table 12. Inner Model Analysis Test Results*: Inner VIF Value*

Variable	Tax Digitalization (X1)	Individual Taxpayer Compliance (Y)	Tax Knowledge (X2)	Tax Sanctions (X3)
Tax Digitalization (X1)		1.746		
Individual Taxpayer Compliance (Y)				
Tax Knowledge (x2)		2.127		
Tax Sanctions (X3)		1.617		

Source: Data processed, 2024

Table 12 shows that *the inner VIF Value* has been in line with the expected, where the expected *VIF* is less than 5 (Ghozali, 2018).

Table 13. Inner Model Analysis Test Results*: R Square*

	R Square	R Square Adjusted
Individual Taxpayer Compliance (Y)	0.571	0.558

Source: Data processed, 2024

The *R-square* value of the individual taxpayer compliance variable is 0.571, which means that the variability of the compliance structure of individual taxpayers can be explained by the variability of the tax digitalization structure, tax knowledge, and tax sanctions is 57.1%. In contrast, the rest is explained by other variables outside the research and based on the criteria of moderate influence. And the other 42.9% is influenced by the variables of tax services and tax administration, tax rates and tax audits.

Table 14. Inner Model Analysis Test Results*: F Square*

Variable	Tax Digitalization (X1)	Individual Taxpayer Compliance (Y)	Tax Knowledge (x2)	Tax Sanctions (X3)
Tax Digitalization (X1)		0.118		
Individual Taxpayer Compliance (Y)				
Tax Knowledge (x2)		0.093		
Tax Sanctions (X3)		0.133		

Source: Data processed, 2024

The variable of Tax Digitalization on the Individual Taxpayers Compliance with a value of F square of 0.118, the variable of Tax Knowledge on the Individual Taxpayers Compliance with a value *of F square* of 0.093 and the variable of tax sanctions on the individual compliance taxpayers with *a value of F square* of 0.133 from the three variables, it can be concluded that these variables have a moderate influence.

According to Ghozali (2011), a test *Goodness of Fit* (model feasibility test / F test) was carried out to measure the accuracy of the regression function of the sample in statistically estimating the actual value. Type *Goodness of Fit* It can be measured from the statistical value F, which shows whether all the independent variables included in the model have a joint influence on the dependent variables. At *SmartPLS*, the test model can be seen from R Square, F Square, *Q Square* and SRMR. It is taken through checking the results of the SmartPLS output estimate on the SRMR value. Standardized Root Mean Square Residual (SRMR) is the mean of the covariance residue based on the transformation of the sample covariance matrix and the predicted covariance matrix into a relationship matrix. If the number obtained is less than 0.10, it is considered appropriate (Henseler, 2014).

Table 15. Inner Model Analysis Test Results*: Fit Model*

	Saturated Model	*Estimated Model*
SRMR	0.077	0.077
d_ULS	3.340	3.340
d_G	2.251	2.251
Chi-Square	1061.186	1061.186
NFI	0.690	0.690

Source: Data processed, 2024

From the table above, it can be seen that the SRMR value is 0.077 < 0.10, so the model is suitable or meets the *criteria for the goodness of fit model*. Based on the *R Square, F Square, and Q Square* tables above, the model has qualified for model eligibility and strengthened with SRMR in Table 15 with an SRMR value of 0.077 < 0.10. So, that Tax Digitalization, Tax Knowledge, and Tax Sanctions have a significant effect on the individual taxpayers' compliance.

Partial t-test is a statistical technique used to make decisions about a statement or hypothesis that is put forward regarding a parameter or characteristic in a population (Ghozali, 2018). The main purpose of hypothesis testing is to test whether the empirical evidence obtained from the observed data supports or disproves the hypothesis proposed (Ghozali, 2018). Data is declared to have a positive and significant effect if the significant value is < 0.05.

Table 16. Direct Effect Hypothesis Results

Variable	*Original Sample (O)*	*T Statistics (|O/STDEV|)*	*P Values*
Tax Digitalization (X1) -> Individual Taxpayers Compliance (Y)	0.297	3.093	0.002
Tax Knowledge (X2) -> Individual Taxpayers Compliance (Y)	0.292	2.340	0.020
Tax Sanctions (X3) -> Individual Taxpayers Compliance (Y)	0.303	2.989	0.003

Source: Data processed, 2024

Based on Table 16, it can be concluded that Tax Digitalization affects the individual taxpayers' compliance with the value of *P-Value* 0.002 < 0.05 or with *t-stats* 3.093 > 1.98. So, that Tax Digitalization affects the individual taxpayers' compliance. Tax Knowledge Affects Individual Taxpayers' Compliance with *P-Value* 0.020 < 0.05 or with *t-stats* by 2.340 > 1.98. So, that Tax Knowledge affects the Individual Taxpayers' Compliance. *P-Value* by 0.003 < 0.05 or with *t-stats* 2.989 > 1.98. So, that Tax Sanctions affect the Individual Taxpayers' Compliance.

The results of the study show that tax digitalization, tax knowledge, and tax sanctions have a simultaneous and significant effect on the individual taxpayers' compliance. This means that the better the tax digitalization, tax knowledge, and obedience to Tax Sanctions, the more taxpayer compliance will be increased. In line with the theory, Expected Utility Theory, which explains that tax digitalization, tax knowledge, and tax sanctions together contribute significantly to improving individual taxpayer compliance through a decision-making mechanism based on Expected Utility Theory. Tax Digitalization improves efficiency, accessibility, and certainty, lowering compliance costs and making it more attractive in terms of benefits (utility). Tax knowledge provides taxpayers with a better understanding of the benefits of compliance and the risks of non-compliance, thereby increasing awareness of compliance with the rules. Tax sanctions add to the cost of non-compliance, magnify perceived risks, and make the choice to comply more profitable. Creating synergies that encourage taxpayers to choose compliance as a decision that provides expected utility by maximizing benefits and minimizing risks in the tax system. This research is in line with the results of the research Munyati et al., (2024) and Waryanti (2024), which conclude that the implementation of tax digitalization affects the individual taxpayers' compliance, tax knowledge affects the individual taxpayers' compliance, and tax sanctions affect the individual taxpayers' compliance.

The results of the study show that Tax Digitalization has a partial and significant effect on the individual taxpayers' compliance. This means that the better the tax digitalisation, the more it will increase taxpayer compliance. In line with the theory, Expected Utility Theory which explains that with an easy-to-use tax system, taxpayers see compliance as an action with higher utility. The advantages in the form of efficiency and certainty make them prefer to comply with taxes. Digitalization creates better transparency in tax calculations, clear information and automated systems improve the perception of the benefits of compliance and reduce the perception of losses due to possible violations. This research is in line with the results of the research Nurafiza & Kisnawati (2024) and RP & Hapsari (2024) which conclude that tax digitalization affects the individual taxpayers' compliance.

The results of the study show that Tax Knowledge has a partial and significant effect on the individual taxpayers' compliance. This means that the better the tax knowledge, the more it will increase taxpayer compliance. In line with the theory in this research, Expected Utility Theory explains that tax knowledge functions as the main factor in directing taxpayers' decisions, with the mechanism of Expected Utility Theory increasing expected utility from compliance by providing information about the benefits and advantages of compliance. Lower perceived utility from non-compliance by raising awareness about risks and negative consequences, and helping taxpayers evaluate options more rationally based on the benefits and risks taken into account. That way, tax knowledge encourages taxpayers to choose compliance as the decision that provides the highest expected utility. This research is in line with the results of the research by Saragih & Tobing (2024) and Kawerang (2024) which also conclude that tax knowledge has a significant effect on the individual taxpayers' compliance.

The results of the study also show that Tax Sanctions have a partial and significant effect on the individual taxpayers compliance. This means that the more obedient they are to tax sanctions, the more taxpayer compliance will increase. In line with the Expected Utility Theory, in this study, tax sanctions directly affect taxpayer decision-making through the Expected Utility Theory. By increasing the cost of non-compliance, perceived risk, and the security of compliance, sanctions encourage taxpayers to choose compliance as an option that provides the expected utility. This research is in line with the results of the research Nugraha (2024) and Karina et al. (2024) which also concluded that tax sanctions have a significant effect on the individual taxpayers' compliance. The results of the study show that tax digitalization, tax knowledge, and tax sanctions have a significant effect on the individual taxpayers' compliance. This means that the better the tax digitalization, tax knowledge, and obedience to Tax Sanctions, the more taxpayer compliance will be increased.

3.0 CONCLUSION

Based on the hypothesis proof, it can be concluded that collaboration and cooperation between the Tax service office and the community can accelerate the realization of sustainable compliance. This collaboration can be seen from the behavior of the tax service office based on the expected utility theory, namely involving the community in managing and accounting for the reported taxes. Meanwhile, in terms of society, the expected utility theory provides benefits of continuing to develop knowledge and efficiency of tax reporting time. Based on the results of the research that has been carried out, it can be concluded that the Tax Digitalization, Tax Knowledge, and Tax Sanctions have a significant simultaneous and partial influence on the individual taxpayers' compliance in the East Tax service office.

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Transformation of Transportation Allowance Policy through the Use of Digital Technology to Enhance Public Transport Usage in Palembang

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ABSTRACT

The increase in private vehicles and urbanization in Palembang has led to traffic congestion and pollution, hindering the achievement of Indonesia's Golden Vision 2045. The digital-based transportation allowance policy transformation has the potential to reduce emissions, promote public transport, and enhance efficiency. This study adopts a quantitative approach with regression analysis, correlation, ANOVA, and qualitative interviews to assess the impact of the policy. The findings indicate that the shift from cash allowances to public transport tickets significantly increases public transport acceptance in Palembang, contributing 84.7%. Pearson's correlation test (r = 0.847) shows a strong relationship, while ANOVA reveals uniform impact across all employee groups. This policy is effective in reducing dependence on private vehicles and promoting sustainable transportation.

Keywords: public policy, public transportation, sustainability, public transit tickets

1.0 INTRODUCTION

The increasing number of motorized vehicles and high population mobility have led to hazardous emissions. In the long run, at the micro level, worsening air pollution may hinder Indonesia from achieving its long-term development target, *Indonesia Vision 2045* (Wahiddiyah et al., 2024). The growing complexity of urban transportation issues has driven the government to seek innovative solutions to enhance public transport utilization. Palembang, the capital city of South Sumatra Province, faces severe congestion due to the rapid growth of private vehicles, which corresponds to increased economic and social activities in the region (Bermawi et al., 2022). Addressing this challenge requires strategic measures that align with urban mobility demands in metropolitan areas. These measures should focus on developing a transportation system that enhances service efficiency, effectiveness, reliability, quality, safety, and affordability (Siregar et al., 2017). One of the primary challenges faced by major cities in tackling urban mobility issues is the need for policy transformation in the transportation sector. This transformation can be achieved through a substantial shift in societal behavior, with a targeted reduction of 2.5 million cars and 12.5 million motorcycles by 2050 (Handayani et al., 2021). A promising approach to address this issue is the utilization of digital technology in administering transportation subsidies. The digitalization of payment systems has emerged as a key trend in passenger transportation and is often regarded as a prerequisite for improving service efficiency (Frączek & Urbanek, 2021). Furthermore, the implementation of such a system is expected to support various environmentally friendly transportation initiatives.

Policy implementation is the process of executing strategies and actions outlined within a policy framework to effectively achieve intended objectives (Yulistarini & Manisah, 2024). This initiative can be implemented through policies aimed at reducing traffic congestion, air pollution, and dependence on private vehicles by promoting the use of more sustainable public transport modes. These efforts are also expected to positively impact public transportation ridership and revenue.

The shift toward sustainable mobility has become an urgent necessity in Palembang due to rapid urbanization and increasing private vehicle ownership. One of the key strategies introduced is the transformation of cash-based transportation allowances into a digital system. This approach aligns with global digitalization trends and aims to address local transportation challenges by encouraging public transport usage through modern technology implementation.

This study examines the impact of digital transportation allowance policies on the adoption of public transport in Palembang. It identifies key factors influencing public preferences regarding the implementation of e-money-based transportation allowances by the government. The findings aim to provide insights into the potential of digital policy transformation as a tool to promote sustainable urban mobility and offer recommendations for policymakers to enhance the city's public transportation system.

Using a quantitative methodology, this study contributes to understanding the dynamics of policy innovation, technology adoption, and behavioral change in urban transportation. It aims to elucidate the broader implications of digital policy transformation and its role in achieving sustainable development goals within the transportation sector. The findings serve as a solid foundation for policymakers to make informed decisions regarding digital policy implementation in transportation. Additionally, this study highlights the potential of such policies to support sustainable development objectives, including carbon emission reduction and improved community well-being.

2.0 LITERATURE REVIEW

The literature review in this study is systematically structured by categorizing existing research into three main themes: digital transformation in transportation, the impact of public policies on transportation systems, and behavioral changes in public transport usage. Studies on digital transformation in transportation highlight how technological innovations, such as digital payment systems and data-driven transportation management, enhance service efficiency and accessibility. Furthermore, research on the impact of public policies examines how regulations and incentives can encourage a shift from private vehicles to public transportation. Additionally, studies on behavioral changes in public transport users explore factors influencing individuals' choices of transportation modes, including financial incentives and digital access convenience.

Several regions have implemented digital-based transportation subsidy policies to improve efficiency and user convenience. For instance, Singapore has adopted electronic payment systems, such as the EZ-Link card, to streamline transactions (Ng, 2018). In London, the United Kingdom, the contactless payment system includes the Oyster card and mobile payment methods managed by Transport for London (Line, 2015). Stockholm, Sweden, has integrated electronic ticketing and mobile applications to enhance user experience and operational efficiency (Blythe et al., 2000). Similarly, Beijing, China, facilitates public transport transactions through digital payment platforms such as WeChat and Alipay (Jin et al., 2009). Jakarta, Indonesia, has introduced the JakLingko program, which integrates digital payment systems across various public transport modes to improve accessibility and user convenience (Raihannabil, 2024). Relevant studies on these policy implementations include *"Contactless Payment and Transport in London"* (UK Finance, 2019) and *"Mobile Payment in Urban China"* by (Huang et al., 2020), which examine the adoption and impact of digital payment systems in supporting urban mobility.

Although extensive research has addressed these issues, a gap remains in studies specifically analyzing digital-based transportation subsidy policies. Most existing research focuses on the general effectiveness of transport subsidies or the impact of digitalization on transportation services without examining how digital transport subsidies influence user preferences. Therefore, this study seeks to bridge this gap by investigating the impact of such policies within the context of urban mobility in Palembang, Indonesia.

Moreover, to strengthen the theoretical foundation and relevance of this research, the literature review integrates global best practices and comparative studies from various cities and countries that have implemented similar policies. By comparing policies and outcomes across different contexts, this study provides broader insights into the effectiveness of digital-based transport subsidies and their potential implementation in Indonesia's transportation system.

The hypothesis of this study is as follows:

H0: The shift from cash transportation allowances to public transport tickets does not significantly affect the acceptance of public transportation in Palembang.

This hypothesis assumes that there is no significant relationship or influence between the shift from cash allowances to public transport tickets and the level of public acceptance of public transportation. In other words, this policy does not provide a different impact compared to the previous situation or without the policy.

H1 (Alternative Hypothesis): The shift from cash transportation allowances to public transport tickets significantly affects the increased acceptance of public transportation in Palembang.

This alternative hypothesis suggests that the implementation of the policy to shift from cash allowances to public transport tickets has a significant influence on increasing the acceptance of public transportation. It implies that the policy can enhance the level of public support and acceptance of public transportation in Palembang.

This research model focuses on evaluating the impact of shifting cash transportation allowances to public transport tickets on public transportation acceptance in Palembang. The independent variable in this study is the shift from cash transportation allowances to public transport tickets, which includes policies and initiatives such as the provision of public transport tickets, incentives for public transport users, and campaigns to raise awareness about the benefits of environmentally-friendly transportation. The dependent variable is the level of public transportation acceptance, which is measured through parameters such as frequency of use, user satisfaction, and public support for the public transportation system.

This research model aims to test two hypotheses and will use data collected through surveys, along with statistical analysis, to identify the relationship between the shift from cash allowances to public transport tickets and changes in public transportation acceptance. Through this model, it is expected to provide clear insights into the effectiveness of the cash allowance shift policy in increasing public support for public transport in Palembang.

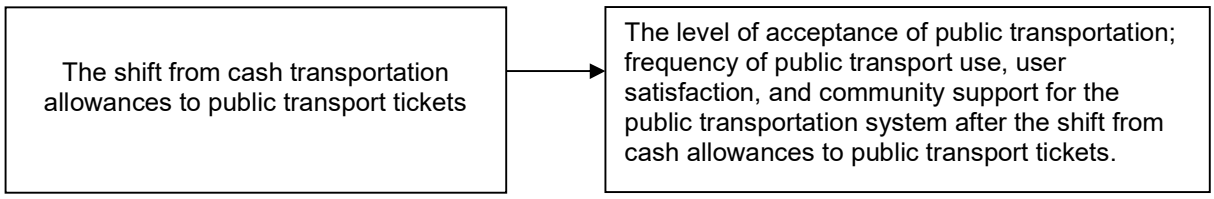

Figure 1. Research Model

This model proposes that the shift from cash allowances to public transportation tickets (independent variable) may influence the level of acceptance of public transportation (dependent variable). This study aims to test the hypothesis of whether there is a significant effect of the shift from cash allowances to public transportation tickets on public transportation acceptance in Palembang.

3.0 METHODOLOGY

This study employs a quantitative research design utilizing regression analysis, correlation, and ANOVA, complemented by qualitative interviews with policymakers to validate the findings. This approach was chosen to measure the impact of digital transportation allowance policies on the increased use of public transportation.

According to (Sugiyono, 2017) and (Hanafiah et al., 2020), a research population encompasses all relevant components for observation, with results that can be generalized from a representative sample. The population in this study consists of employees from both government and private institutions in Palembang, selected based on their relevance to the policy transition from cash-based allowances to public transportation ticket subsidies.

The sample was determined using a purposive sampling technique, considering specific characteristics aligned with the research objectives (J. Supranto, 2000); (Kumara, 2018). The criteria for selecting respondents include several key aspects. First, respondents must be engaged in public transportation usage, either as a primary mode of travel or as a supporting means of daily mobility. Second, respondents were chosen based on their awareness of environmental issues, particularly regarding emission reduction and sustainable mobility. Third, individuals involved in decision-making or policy development in the transportation sector were considered, given their ability to influence regulations. Lastly, participation in educational or socialization programs related to the policy shift from cash-based to digital transportation allowances was a crucial requirement, as it indicates respondents' understanding and involvement in policy transformation.

Data collection was conducted through a questionnaire survey, utilizing a Likert Scale instrument to measure respondents' perceptions and attitudes toward the implemented policy. Data analysis was performed using SPSS software to identify relational patterns between variables and to derive valid and reliable conclusions.

4.0 DATA ANALYSIS

Data collected from the Likert-scale questionnaire were analyzed using SPSS software following a verification process to ensure validity and prevent input errors (Hair, 2011); (Hinton, 2014); (Bougie, 2016); (Ghozali, 2016); (Creswell, 2018). The initial steps included checking for missing data, ensuring consistency, and coding qualitative data from observations and interviews. Respondents evaluated the transition from cash allowances to public transport tickets and public transport acceptance, which were then categorized as independent and dependent variables for further analysis.

Descriptive statistics such as mean, median, mode, and standard deviation were used to provide an overview of the data (Anderson et al., 2008). Linear regression analysis was employed to measure the effect of transitioning cash allowances (independent variable) on public transport acceptance (dependent variable) (Fidell, 2019). Pearson's correlation analysis assessed the strength of the relationship between environmental awareness and public transport usage, where the correlation coefficient (r) indicated the direction and magnitude of the relationship.

Additionally, ANOVA was conducted to identify significant differences among respondent groups in terms of public transport acceptance under the policy. Statistical significance was determined using p-values, where $p < 0.05$ indicated that the null hypothesis was rejected, confirming a significant effect of the policy on public transport acceptance.

This analytical approach ensures that the study's findings are supported by strong statistical evidence, thereby effectively validating the research hypotheses. Consequently, the study provides comprehensive insights into the effectiveness of transitioning cash allowances into public transport tickets and the factors influencing public transport acceptance in Palembang.

5.0 RESULTS

Linear Regression Analysis

The linear regression results indicate that the transition from cash allowances to public transport tickets has a significant impact on public transport acceptance. Table 1 presents two key indicators: Unstandardized Coefficients and Standardized Coefficients.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-7.944	2.818		-2.819	.005
	Public Transport Ticketing Strategy	1.937	.101	.847	19.222	.000

a. Dependent Variable: Public Transport Acceptance

Tabel 1. Unstandardized Coefficients and Standardized Coefficients.

In the Unstandardized Coefficients column, the constant value (B = -7.944) suggests that without implementing this policy, public transport acceptance tends to be low. The coefficient for the transition to public transport tickets (B = 1.937) indicates that each unit increase in policy implementation results in a 1.937-unit increase in public transport acceptance, demonstrating the direct impact of this policy.

Regarding Standardized Coefficients (Beta = 0.847), the results indicate that this policy accounts for 84.7% of the variability in public transport acceptance. The t-value of 19.222 with a significance level of 0.000 supports these findings, where a significance level below 0.05 confirms the statistical significance of the regression model.

These findings highlight that transitioning cash allowances into public transport tickets can effectively reduce private vehicle dependence while increasing public transport acceptance in Palembang. Additionally, public awareness campaigns on the environmental and economic benefits of public transportation could further encourage public transport use.

Correlation Analysis

Pearson's correlation analysis revealed a strong relationship between the transition to public transport tickets and public transport acceptance, with a correlation coefficient of 0.847. This value, which approaches 1, indicates a strong positive relationship between the two variables. Furthermore, the significance value (Sig. (2-tailed)) of 0.000 confirms that the correlation is significant at a 99% confidence level ($\alpha = 0.01$).

Correlations

		Public Transport Ticket Strategy	Public Transport Acceptance
Public Transport Ticket Strategy	Pearson Correlation	1	.847**
	Sig. (2-tailed)		.000
	N	148	148
Public Transport Acceptance	Pearson Correlation	.847**	1
	Sig. (2-tailed)	.000	
	N	148	148

**. Correlation is significant at the 0.01 level (2-tailed).

Table 2. Pearson's correlation analysis

The managerial implications of these findings suggest that policymakers should focus on strengthening eco-friendly programs in the transportation sector. Policies that enhance energy efficiency, promote public transport usage, and reduce greenhouse gas emissions are expected to significantly increase public transport adoption.

ANOVA Test

The ANOVA results indicate no significant differences in public transport acceptance across employee groups, with a significance value of 0.198 (> 0.05). However, the transition to public transport tickets has a significant effect on public transport acceptance, with a significance value of 0.000 (< 0.05).

Dependent Variable: Public Transport Acceptance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	18039.719[a]	47	383.824	10.714	.000
Intercept	89079.562	1	89079.562	2486.503	.000
Employee Group	170.333	3	56.778	1.585	.198
X	13174.647	20	658.732	18.387	.000
Employee Group * **X**	1282.520	24	53.438	1.492	.088
Error	3582.524	100	35.825		
Total	324752.000	148			
Corrected Total	21622.243	147			

a. R Squared = .834 (Adjusted R Squared = .756)

Table 3. The ANOVA results

These findings indicate that the transition from cash allowances to public transport tickets has a significant impact on public transport acceptance overall, with no significant differences among employee groups. This suggests that the policy can be implemented uniformly without requiring specific adjustments for different employee groups.

Overall, the analysis confirms that this policy significantly enhances public transport acceptance in Palembang. These findings align with previous research (Wang et al., 2023), which stated that public transport subsidies can reduce private vehicle dependence. Moreover, the Pearson's correlation coefficient of 0.847 further reinforces the strong relationship between the policy and public transport acceptance.

The ANOVA results indicate that employee group differences do not influence public transport acceptance, with a significance value of 0.198 (> 0.05), meaning the policy's impact is uniform across groups. This is consistent with previous studies (Yulistarini et al., 2025), which found that the effects of green policies are evenly distributed across social groups.

These findings reaffirm that the transition from cash allowances to public transport tickets is effective in increasing public transport acceptance, with a uniform impact across society. The policy implications suggest that strengthening environmentally friendly infrastructure and public education efforts is crucial to promoting more sustainable transportation practices.

6.0 CONCLUSION

The transition from cash-based transportation allowances to public transport tickets has been proven to significantly enhance public transport adoption in Palembang while reducing dependence on private vehicles. This policy demonstrates consistent effectiveness across various employee groups, requiring no specific adjustments based on job status or socioeconomic background. To ensure long-term sustainability, further improvements in digital infrastructure supporting payment systems and transportation services are essential. Additionally, enhanced public awareness initiatives are necessary to encourage behavioral shifts toward more sustainable urban mobility.

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Smart Business in Housing Construction: A Conceptual Framework for Electrochromic Glass in Sustainability and Energy Efficiency

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ABSTRACT

This study aims to establish a conceptual framework for the use of smart electrochromic glass in residential structures, focusing on sustainability and energy efficiency in the housing construction business. This study addresses the issue of high energy consumption associated with conventional building materials, which have adverse environmental impacts and incur significant energy costs. The goals are to (1) develop a theoretical understanding of the capacity of electrochromic glass to reduce environmental impacts while complying with global standards through smart business and (2) propose a sustainable and scalable design strategy that balances cost-effectiveness with sustainable environmental and economic benefits. The research methodology uses secondary data literature analysis, including industry reports and scientific articles related to electrochromic glass technology. Housing developers can explore electrochromic glass as a smart business, as it can significantly reduce energy consumption through automatic heat and light control, improve occupant comfort, and promote sustainability by minimising carbon footprint. However, we still have to face challenges, including high initial costs and constraints in energy integration. This study demonstrates that combining smart glass technology with renewable energy sources, such as solar panels, provides a sustainable and practical solution for contemporary residential structures for consumers. This study enhances the academic discourse by establishing a conceptual framework that outlines the advantages and barriers of electrochromic glass technology while promoting global sustainability objectives through social responsibility by housing developers in their businesses.

Keywords: *Smart Electrochromic Glass, Sustainable Residential Buildings, Smart Business, Housing Construction.*

1.0 INTRODUCTION

Electrochromic smart glass is that altering material that could permit varied control of energy conservation and heat together with light while endowing enhanced comfort to the occupants of a building. It works on the advanced technology that alters its optical performance from shade and transparency to other features when energized or subjected to electrical stimulation enabling automatic optimizations to outer conditions. The use of electrochromic glass is consistent with international objectives on sustainable development where it reduces reliance on artificial lighting and cooling systems thus fostering energy efficiency and lowering carbon emissions. The Malaysian economy is slowly drifting towards integrating green building solutions to augment energy efficiency which in turn is paving way for the wide use of electrochromic glass even though its application in this region is yet to mature. On the other hand, advancement in material science as well as rising brand-awareness allows for that type of eco-friendly and energy efficient construction which does not require high power expenditures is consistently rising, which means that barriers like high initial price as well as establishment difficulties especially in the upscale residential and commercial real estate, will disappear soon. The goals of conceptual paper are to develop a theoretical understanding of the capacity of electrochromic glass to reduce environmental impacts while complying with global standards through smart business and propose a sustainable and scalable design strategy that balances cost-effectiveness with sustainable environmental and economic benefits. This study contributes to the academic discourse by establishing a conceptual framework that highlights the advantages and barriers of electrochromic glass technology. By exploring its integration with renewable energy sources and addressing the economic and technical challenges, this research offers a pathway for housing developers to adopt smart glass as a sustainable business solution. The findings underscore the importance of aligning technological innovation with global sustainability objectives, fostering environmental responsibility, and enhancing energy efficiency in the construction in industry (Cannavale et al., 2020a) (Hasan Alhawari et al., 2022).

1.1 BACKGROUND

Electrochromic smart glass is gaining traction in Malaysia, driven by its energy efficiency and aesthetic versatility. Among these innovations, electrochromic glass has emerged as a promising solution, offering dynamic control over light and heat transmission, which significantly enhances energy efficiency in buildings (Cannavale et al., 2020a). Electrochromic glass is one of the smart glasses that advanced materials led to a change in optical properties, such as transparency and shading, in response to electrical stimulation. The glass technology enables automatic adjustment to external conditions, providing benefits such as reduced reliance on artificial lighting and cooling systems. The integration of electrochromic glass into residential construction aligns with global sustainability goals, particularly in promoting energy efficiency and minimizing carbon footprints. The potential of smart electrochromic glass to enhance building energy performance by dynamically adjusting light transmittance, thereby addressing the inefficiencies of traditional materials (Cannavale et al., 2020b).

In Malaysia, the adoption of electrochromic smart glass is still in its early stages, but growing interest is driven by the need for energy-efficient solutions in the construction industry. Companies like JEB International have begun offering smart glass solutions for both residential and commercial projects, particularly in high-end developments. With Malaysia's hot and humid climate, the potential for significant energy savings through dynamic heat and light control is becoming more apparent, especially in green building initiatives. Overseas countries like the United States and Germany are more advanced in adopting electrochromic glass, with companies like Sage Glass leading the market by providing smart glass for large-scale projects such as the Apple Park in Cupertino, California. These international examples highlight the technology's capacity to enhance energy efficiency and occupant comfort, and as awareness grows, Malaysia is likely to follow suit in adopting such innovative solutions for sustainable development.

Electrochromic smart glass seems as important material to property developers use as it enhances energy efficiency by reducing cooling costs, saving up to 30% in energy expenses. It also helps achieve green building certifications, which can increase a property's market value. By improving comfort, reducing the need for mechanical shading, and supporting sustainability goals, smart glass appeals to eco-conscious buyers and investors. Though the initial cost is higher, the long-term savings and increased attractiveness of the property make it a valuable investment, allowing developers to command higher selling or rental prices while future-proofing their projects.

ASPECT	STATISTIC	SOURCE
Cost of Electrochromic Smart Glass	RM230–RM460 per square foot (approximately $50–$100 per square foot) in Malaysia	Queleparece
Market Growth (CAGR)	12–15% growth projected (2021–2028) in Malaysia	6Wresearch
Energy Efficiency Impact	Up to 30% reduction in energy consumption for cooling in buildings in Malaysia	6Wresearch
Application Trends	Increasing use in commercial buildings, hospitals, and high-end residential projects in Malaysia	6Wresearch

Table 1: Overview of Specific Data of Electrochromic Smart Glass in Malaysia

A rough overview in Table 1 shows the cost of electrochromic smart glass in Malaysia ranges from RM230 to RM460 per square foot, reflecting its advanced technology and suitability for high-end construction projects. The Malaysian smart glass market is projected to grow at a compound annual growth rate (CAGR) of 12–15% between 2021 and 2028, fueled by urbanization, the adoption of green building practices, and government policies promoting energy efficiency. This technology is increasingly being incorporated into commercial buildings, hospitals, and luxury residential developments, showcasing its ability to enhance energy efficiency while offering modern design aesthetics. The combination of these factors highlights the growing relevance of smart glass in Malaysia's construction and sustainability sectors.

Despite its promising potential, the widespread adoption of electrochromic glass faces several challenges, including high production and installation costs, limited awareness, and technical difficulties in integrating with existing energy systems and renewable energy sources. Traditional building materials fail to adapt to varying environmental conditions, leading to significant energy losses and higher carbon emissions. Conventional methods for controlling light and heat, such as curtains and blinds, are less effective in achieving optimal energy savings. However, electrochromic glass offers a transformative solution by dynamically modulating heat and light transmission, enhancing occupant comfort and achieving substantial energy savings. Research by Lisbeth A. Brandt-Garcia et al. (2023) demonstrates that smart glass significantly reduces cooling loads and improves lighting efficiency. Integrating electrochromic glass with renewable energy sources like solar panels offers a sustainable and scalable solution for modern residential structures, aligning with global sustainability goals. The high costs of production and installation remain a major challenge for both developers and homeowners. Additionally, technical issues, such as the integration of smart glass with existing energy systems and ensuring its durability across various climates, need to be addressed (Hasan Alhawari et al., 2022). These challenges also present significant opportunities. Advancements in material science and manufacturing processes are expected to lower costs, making the technology more accessible. The increasing focus on green building certifications and incentives for sustainable construction is driving the widespread adoption of electrochromic glass, presenting a significant opportunity for the construction industry.

2.0 LITERATURE REVIEW

2.1 ELECTROCHROMIC SMART GLASS FOR SUSTAINABILITY AND ENERGY EFFICIENCY

Electrochromic glass is an advanced material capable of altering its transparency or color in response to electrical currents. It is made of materials that enable a quick transition between transparency and opacity, allowing it to control the amount of light and heat entering a building (Budaiwi & Fasi, 2023). Electrochromic (EC) windows operate by adjusting their optical transmittance in response to a low electrical voltage, enabling dynamic regulation of solar radiation and daylight entering a building. This functionality allows them to transition between a tinted state, which minimizes heat gain, and a bleached state, which permits greater light and heat transmission (Li et al., 2023). According to Wen & Meng (2025), EC glass consists of five key layers that enable its ability to regulate light and heat transmission. There are two transparent conducting layers, ion storage layer, electrolyte layer and electrochromic layer. When a small electrical voltage (~3V) is applied, Li+ ions move from the ion storage layer into the electrochromic layer, reacting with tungsten trioxide to create a darker appearance. Conversely, when the voltage is reversed, the ions return to the storage layer, restoring the glass to a transparent state.

Many studies have shown that using electrochromic smart glass can significantly contribute to building sustainability and energy efficiency. For instance, research conducted by Y. Li et al. (2023) on Electrochromic glass performance under tropical climate found that electrochromic glass in fully tinted mode can reduce energy consumption by up to 19% compared to the reference single-glazing window. Further study by Li et al. (2023) on Singapore's tropical climate confirms that electrochromic windows are highly effective for reducing solar heat gain, improving indoor thermal comfort, and saving energy. Another study by Budaiwi and Abdul Fasi (2023) shows that Electrochromic smart windows demonstrate energy savings of up to 23% when used with a daylighting control strategy and 17% when paired with a glare control strategy in an office building in Dhahran, Saudi Arabia. Therefore, it is assured that electrochromic glass can effectively reduce cooling energy demand while maintaining visual comfort, making it a sustainable solution for energy-efficient building designs.

2.2 ELECTROCHROMIC GLASS IN THE CURRENT HOUSING MARKET

In recent years, Malaysia has experienced the urban heat island effect, especially in those highly developed cities where temperatures are noticeably higher than those in surrounding rural areas (Asmadi et al., 2024). The rising temperatures will affect indoor thermal comfort in naturally ventilated homes and raise cooling energy demands in air-conditioned housing (Murtyas et al., 2024). Therefore, growing urgency for energy efficiency (EE) in response to climate change has significantly driven research advancements in smart window technologies (Villa et al., 2024). In line with this, Malaysian government is actively encouraging housing developers to adopt sustainable and energy-efficient construction practices. One of the key initiatives supporting this effort is outlined in the 12th Malaysia Plan (12MP). This action plan mandates that developers integrate sustainability measures at every stage of a project, from the initial design phase to the operational stage (Turner & Townsend, 2024).

Recently, many developing countries such as China, Egypt and Singapore have conducted several research projects to prove the effectiveness of electrochromic glass windows on energy efficiency, thermal and visual performances under various climates. A case study by Moraekip (2025) in Cairo, Egypt, suggest that Architects and developers should incorporate the electrochromic glass into workplaces, schools and healthcare facilities to boost productivity and well-being. Although electrochromic glass is still relatively new in the country, studies and its usage are steadily growing, especially in urban areas where there is a rising demand for green building technologies. Moraekip (2025) also agrees that Electrochromic glass technology has gained considerable attention in recent years for its ability to enhance overall building performance by optimizing thermal comfort, improving daylighting, and reducing energy consumption. A study by (Villa et al., 2024) also suggests that electrochromic windows could play a role in making homes more energy efficient as climate change increases cooling demand. Therefore, the relationship between Electrochromic windows and home energy performance is expected to grow stronger over time, supporting their adoption in residential buildings.

3.0 RESEARCH METHODOLOGY

This study employs a qualitative approach, relying on secondary data analysis to develop a conceptual framework for the integration of electrochromic glass into sustainable housing construction. Data is obtained from 5 academic journals & scientific articles, 2 industry reports and 2 credible online resources to ensure a comprehensive review of existing knowledge on electrochromic glass technology, sustainability, and energy efficiency. The selection of these sources was based on relevance, credibility, and recency, with a focus on publications from the past ten years.

The following table provides a detailed breakdown of the sources used in this study:

Table 2: List of Data Collection

CATEGORY	REFERENCES
ACADEMIC JOURNAL & SCIENTIFIC ARTICLES (5)	Cannavale, A., Ayr, U., Fiorito, F., & Martellotta, F. (2020a) – *Energies* (Journal)
	Cannavale, A., Fiorito, F., Martellotta, F., & Fasanella, L. (2020b) – *Renewable and Sustainable Energy Reviews* (Journal)
	Hasan Alhawari, A. R., et al. (2022) – *International Journal of Electrical and Computer Engineering* (Journal)
	Hasan Alhawari, F., Abu-Dalo, M. A., & Makhlouf, A. S. H. (2022) – *Journal of Materials Research and Technology* (Journal)
	Merriam, S. B. (2015) – *Qualitative Research: A Guide to Design and Implementation* (Book, academic source)
INDUSTRY REPORTS (2)	World Green Building Council. (2020) – Industry report
	6Wresearch. (2021) – Industry report
CREDIBLE ONLINE RESOURCES (2)	GreenSpec. (n.d.) – Online resource
	Thompson, J., & Martin, F. (2010) – Online strategic management resource

The collected data as shown in Table 2 is analysed using content and thematic analysis to identify key themes, such as energy efficiency, sustainability, cost implications, and implementation strategies. Comparative analysis is conducted to evaluate the feasibility of this technology in various geographic and economic contexts. To ensure the reliability and validity of the findings, triangulation was applied through multiple approaches. Methodological triangulation was used by integrating data from diverse sources, including academic journals, scientific articles, and industry reports, providing a comprehensive perspective on electrochromic glass. Source triangulation was also implemented by comparing findings across different studies to identify patterns, inconsistencies, and gaps in the literature. Theoretical triangulation was used to examine electrochromic glass from different perspectives, including sustainability, smart building technology, and business feasibility, ensuring a well-rounded analysis.

The application of triangulation followed a structured process. First, methodological triangulation ensured that findings were cross validated through diverse data sources, reducing reliance on a single type of literature. Second, source triangulation involved comparing data across different studies, allowing the identification of trends, inconsistencies, and gaps in the literature. Lastly, theoretical triangulation strengthened the study's conclusions by incorporating multiple frameworks, ensuring a more comprehensive understanding of electrochromic glass applications. This triangulation process minimized bias, enhanced credibility, and reinforced the reliability of the study's findings.

By applying these triangulation techniques, the study ensures a well-rounded and validated analysis of electrochromic glass in sustainable housing construction. The findings highlight its potential benefits, including reduced energy consumption, improved occupant comfort, and lower carbon emissions, while also addressing challenges such as high initial costs and integration barriers. Practical recommendations are provided for housing developers, aligning this technology with social responsibility and global sustainability objectives (World Green Building Council, 2020). This conceptual framework serves as a valuable reference for developers seeking innovative and sustainable solutions in residential construction.

3.0 METHODOLOGY FOR IMPLEMENTING ELECTROCHROMIC GLASS IN RESIDENTIAL DEVELOPMENTS

The methodology for integrating electrochromic glass into sustainable residential developments is a multi-faceted approach designed to optimize energy efficiency, enhance comfort, and support environmental sustainability. This section in Table 3 outlines the steps required to successfully implement this innovative technology, focusing on planning, technological integration, construction, monitoring, and business strategies.

STEP	KEY ACTIVITIES	PURPOSE
PROJECT PLANNING	• Feasibility Study • Energy Modelling • Life-Cycle Analysis • Compliance with standards	Assess viability and ensure alignment with sustainability goals and local standards.
TECHNOLOGY INTEGRATION	• Install Solar Panels • Integrate Energy Storage • Implement Smart Systems	Enhance sustainability by powering electrochromic glass with renewable energy and automation.
CONSTRUCTION AND INSTALLATION	• Procedure Certified Materials • Ensure Quality control during Installation	Ensure durability, reliability, and adherence to green building certifications.
EVALUATION AND MONITORING	• Energy Monitoring with Sensors • Collect Resident Feedback	Validate energy efficiency and comfort improvements, refine for future projects.
BUSINESS MODEL	• Cost-benefit Analysis • Develop Marketing Strategies • Explore Revenue Opportunities	Maximize financial viability while promoting eco-friendly features to attract buyers or investors.

Table 3: Simplified Methodology for Implementing Electrochromic Glass in Residential Developments

3.1 PROJECT PLANNING AND DESIGN FRAMEWORK

The first step in implementing electrochromic glass involves developing a strong planning and design framework. This begins with a feasibility study to assess the suitability of electrochromic glass in residential projects, considering Malaysia's tropical climate, building orientation, and sunlight exposure. By utilizing advanced energy modeling tools like EnergyPlus, developers can simulate energy savings and evaluate the technology's impact on cooling and lighting demands (Cannavale et al., 2020a). Additionally, conducting a life-cycle analysis ensures the sustainability of materials and aligns with green building standards such as Malaysia's Green Building Index (GBI). This planning phase lays the planning for combining electrochromic glass into building designs that maximize its energy-saving potential while maintaining aesthetic appeal.

For example, The Edge Building in Amsterdam, a commercial office space, integrated electrochromic glass and achieved remarkable energy efficiency improvements. This building optimized its façade orientation and utilized smart technologies to dynamically control natural light, reducing energy usage for cooling and lighting by 40% compared to conventional buildings. These strategies can serve as a blueprint for residential applications (GreenSpec, n.d.).

3.2 TECHNOLOGY INTEGRATION

A critical component of the methodology is the integration of electrochromic glass with renewable energy systems and smart technologies. Electrochromic glass, which adjusts light and heat transmission in response to electrical stimulation, offers significant energy savings by reducing reliance on artificial lighting and air conditioning (Hasan Alhawari et al., 2022). To enhance sustainability, solar panels are installed on rooftops or building facades, providing clean energy to power the glass systems (6Wresearch, 2021). Pairing solar panels with energy storage solutions, such as batteries, ensures uninterrupted operation even during low sunlight periods. Furthermore, the incorporation of automated controllers and mobile applications enables smart management of the glass, allowing homeowners to adjust tint levels manually or through automated settings based on external light and temperature conditions (Cannavale et al., 2020a).

A notable case study is Apple Park in Cupertino, California, which utilized smart glass for its circular façade. The electrochromic glass adjusted to sunlight conditions, enhancing occupant comfort while aligning with Apple's sustainability goals. Although it was implemented in a commercial project, its integration of solar energy and smart controls demonstrates scalability for residential developments (Cannavale et al., 2020a).

3.2.1 THEMATIC ANALYSIS IN DATA INTERPRETATION

This study employs thematic analysis to systematically analyses data from academic journals, industry reports, and case studies. Thematic analysis allows for the identification of recurring patterns and meaningful themes that emerge from the collected literature. The process follows six key phases, as outlined in Table 4 below:

PHASE OF THEMATIC ANALYSIS	DESCRIPTION	APPLICATION IN THIS STUDY
FAMILIARIZATION WITH DATA	Reviewing all collected literature, industry reports, and scientific articles to understand key discussions.	This study analysed research on electrochromic glass, sustainability reports, and market insights to understand its role in energy efficiency and smart housing.
GENERATING INITIAL CODES	Identifying key concepts and patterns from the data.	Key ideas such as energy efficiency, cost implications, implementation barriers, and environmental benefits were extracted from various sources.
SEARCHING FOR THEMES	Grouping related codes into broader themes that capture the essence of the data.	The study categorized data into major themes such as sustainability benefits, cost and investment considerations, integration with renewable energy, and adoption challenges.
REVIEWING THEMES	Refining the themes to ensure they accurately represent the data and are supported by multiple sources.	The selected themes were validated by comparing findings from scientific articles, case studies, and industry reports to ensure reliability.
DEFINING AND NAMING THEMES	Assigning meaningful labels to each theme to enhance clarity and focus.	Themes were named based on their relevance to the study's objectives, such as "Smart Business Strategy," "Cost Barriers," "Sustainability and Energy Efficiency," and "Market Readiness."
WRITING THE REPORT	Structuring the findings based on the themes identified to develop meaningful conclusions.	The thematic analysis guided the discussion in Sections 3.3 to 3.6, ensuring a well-structured analysis of electrochromic glass technology within the sustainability framework.

Table 4: Process of Data Interpretation

3.3 CONSTRUCTION AND INSTALLATION

The construction phase focuses on careful procurement and installation of materials. Electrochromic glass and solar panels are sourced from certified suppliers to meet green certification requirements and ensure durability under tropical conditions (6Wresearch, 2021). During installation, electrochromic glass is fitted into windows and skylights, while rooftop solar panels are connected to the building's energy systems. The wiring is designed to be energy-efficient and reliable, ensuring seamless integration (Hasan Alhawari et al., 2022). Although high initial costs pose a challenge, bulk procurement strategies and partnerships with manufacturers can help reduce expenses. Rigorous quality control during installation ensures that the technology performs optimally over its lifespan (Cannavale et al., 2020a).

The Eagle Rock Apartments project in New York successfully implemented electrochromic glass in a high-rise residential development. This project showcased the effective combination of aesthetic appeal and energy efficiency, resulting in reduced cooling loads and enhanced living comfort for residents. Rigorous quality control during installation ensured that the technology performed optimally over its lifespan (Hasan Alhawari et al., 2022).

3.4 EVALUATION AND MONITORING

To validate the effectiveness of the electrochromic glass system, evaluation and monitoring are conducted after installation. Sensors are installed to measure indoor temperature, lighting levels, and energy consumption, providing real-time data for analysis (6Wresearch, 2021). By comparing energy usage before and after implementation, developers can quantify the system's impact on energy savings. Additionally, feedback from residents helps assess improvements in comfort, such as reduced glare, enhanced privacy, and regulated natural light. Monitoring also focuses on environmental impact by measuring reductions in carbon emissions, ensuring that the project aligns with global sustainability goals (Hasan Alhawari et al., 2022).

One case study is the Indigo Smart Homes in Germany, which adopted electrochromic windows integrated with renewable energy sources. Post-implementation monitoring revealed a 30% reduction in annual energy costs, alongside improved occupant comfort and sustainability outcomes. This approach provides a strong reference for residential projects aiming to balance efficiency and environmental goals (Cannavale et al., 2020a).

3.5 BUSINESS MODEL FOR DEVELOPERS

The final aspect of the methodology emphasizes creating a sustainable business model for property developers. A cost-benefit analysis is conducted to evaluate the long-term financial benefits of electrochromic glass, such as reduced energy expenses and increased property value, against the initial investment (Cannavale et al., 2020a). Developers can leverage the environmental and energy-saving benefits of the technology in their marketing strategies to attract eco-conscious buyers. By highlighting features like lower utility bills, green certifications, and enhanced occupant comfort, developers can position their properties as premium offerings in the market. Additionally, government incentives for sustainable construction and green technology adoption further enhance the financial viability of the project (6Wresearch, 2021).

Developers in Malaysia can draw inspiration from the Crystal City Smart Apartment Complex in Singapore, which marketed its energy-efficient technologies, including electrochromic glass, to eco-conscious buyers. The complex saw higher rental premiums and sales prices compared to similar properties without smart features (6Wresearch, 2021)

4.0 CONCEPTUAL FRAMEWORK OF ELECTROCHROMIC GLASS IN SUSTAINABILITY AND ENERGY EFFICIENCY IN SMART BUSINESS HOUSING CONSTRUCTION

The transformative potential of electrochromic glass is underscored when integrated with renewable energy solutions, with residential living being redefined through enhanced energy efficiency, comfort, and sustainability. This cutting-edge smart glass dynamically adjusts to varying sunlight conditions, ensuring optimal indoor temperatures, reducing glare, and significantly minimizing the reliance on artificial heating, cooling, and lighting systems. Studies indicate that electrochromic glass contributes to energy conservation, with surveys from similar projects reporting up to a 25% increase in residential contentment (Cannavale et al., 2020a). Moreover, this innovation drives a substantial reduction in carbon footprints, actively contributing to global sustainability efforts. Homes equipped with electrochromic glass reduce energy-related carbon emissions by up to 20% by enabling automatic light and heat control (Hasan Alhawari et al., 2022).

Electrochromic glass is an advanced solution for reducing energy usage by automatically regulating heat and light transmission. This technology reduces the demand for air conditioning during hot days while retaining heat during colder months, resulting in significant energy savings. According to study, electrochromic glass in homes can reduce annual energy expenses by up to 30% (6Wresearch, 2021). This innovation not only reduces environmental impact but also ensures financial savings for residents, making it a practical choice for developers to implement in their projects.

For developers, electrochromic glass represents a strategic smart business opportunity. By adopting this technology, developers can enhance their projects' marketability, appeal to environmentally conscious buyers, and align with evolving green building regulations. Electrochromic glass also enables developers to meet sustainability certifications, increasing property values and attracting premium buyers. Furthermore, integrating this technology with renewable energy systems, such as solar panels, amplifies its benefits by offering a comprehensive energy efficient solution. The findings highlight that project featuring electrochromic glass achieve quicker sales turnovers and generate long-term cost savings for all stakeholders.

Today's modern homeowners increasingly prioritize energy efficiency, smart technologies, and sustainability, making the integration of electrochromic glass with renewable energy systems a game changer in residential living. This advanced technology offers automated light and temperature control, ensuring optimal comfort while reducing energy consumption and utility costs by up to 35% annually (Cannavale et al., 2020a). Beyond the financial benefits, these homes align with global sustainability goals, allowing residents to reduce their carbon footprint while enjoying a sophisticated, modern lifestyle. By fostering a healthier indoor environment and appealing to eco conscious buyers, such innovations redefine residential spaces as both practical and forward thinking, creating a compelling choice for those seeking luxury and responsibility in one package.

While the initial implementation costs of electrochromic glass may appear high, this conceptual paper highlights that these expenses are more than offset by long term benefits, both for developers and customers. Developers can mitigate costs through government rebates, strategic partnerships, and economies of scale, while customers enjoy substantial energy savings, increased property values, and enhanced living conditions that gradually recoup the higher upfront costs. Successful pilot projects in other regions have shown that homes with this technology typically offer a 7–10-year payback period, retaining strong market demand and proving their practicality (6Wresearch, 2021). By adopting electrochromic glass and renewable energy solutions, developers position themselves as pioneers in sustainable construction, appealing to eco-conscious buyers and gaining a competitive edge. At the same time, customers experience improved living environments while contributing to global sustainability efforts. Together, these innovations bridge the gap between environmental responsibility and economic feasibility, establishing a new standard in the housing industry where sustainable, smart homes are the norm.

4.1 THEMATIC ANALYSIS TABLE

As indicated in Table 5, a theme analysis was carried out by classifying significant elements obtained from secondary sources to guarantee thorough validation of the results:

THEME	SOURCE	FINDINGS
ENERGY EFFICIENCY	Scientific Articles, Industry Reports	Electrochromic glass reduces cooling costs by up to 30% (Cannavale et al., 2020a)
SUSTAINABILITY	Academic Journals, Green Building Reports	Homes using this technology reduce carbon emissions by up to 20% (Hasan Alhawari et al., 2022)
COST IMPLICATIONS	Market Research Reports	High initial cost, but offers long-term savings through lower energy bills (6Wresearch, 2021)
IMPLEMENTATION STRATEGIES	Case Studies, Government Policies	Integration with renewable energy and automation enhances effectiveness (World Green Building Council, 2020)

Table 5: Significant Elements from Secondary Data

4.2 CONCEPTUAL FRAMEWORK FORMATION

Key elements found in thematic analysis were combined to create the conceptual framework *(Figure 1).* Every component is derived from studies on the effects of electrochromic glass on energy efficiency and sustainability. The framework offers a thorough model for its use in the housing business by bringing technological, economic, and environmental factors into alignment. The conceptual framework plays a very important role in this study because it serves as a theoretical basis and a systematic guide for researchers to understand, explain, and analyses the relationships between the main variables involved.

In the context of this study, which focuses on the use of electrochromic glass in smart housing construction to achieve sustainability and energy efficiency, the conceptual framework helps ensure that the research is conducted in an organised, directed, and fact-based manner. Strategic Management Process Framework (Thompson, J. and Martin, 2010) was chosen in this study because it focuses on how housing developers can critically plan, implement, and evaluate their business strategies, especially in the context of sustainable smart housing development. This theory emphasises the strategic decision-making process based on current situation analysis, a competitive advantage assessment, and setting sustainable long-term goals. This study uses this theory to look into how housing developers can use electrochromic glass technology as part of their smart business plans, taking into account things like cost, market demand, and how energy-efficient the glass is. Strategic management theory, a thorough literature review including previous studies, and researcher's ideas form the foundation of this study's conceptual framework.

According to Merriam (2015), a conceptual framework is a combination of three main elements, namely theory, literature review, and the researcher's ideas or experiences. This forms the basis for building a conceptual framework in a research study. This conceptual framework is meant to give you a clear picture of how smart business strategies used by housing developers relate to the use of electrochromic glass technology and how that technology affects the sustainability and energy efficiency of housing development. It is intended to be a systematic guide for directing this research to produce findings that can be used by the construction industry and other stakeholders.

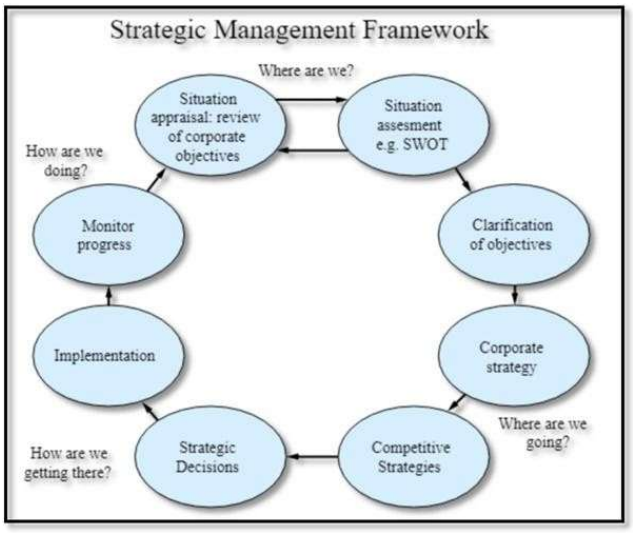

Figure 1: Strategic Management Process Framework

(Thompson, J. and Martin, 2010)

This framework, which includes sustainability goals, energy efficiency measures, cost-benefit analysis, and commercial strategies, demonstrates the interrelated elements that drive the effective application of electrochromic glass. By combining these elements, housing developers may efficiently implement smart glass solutions while optimizing financial and environmental benefits.

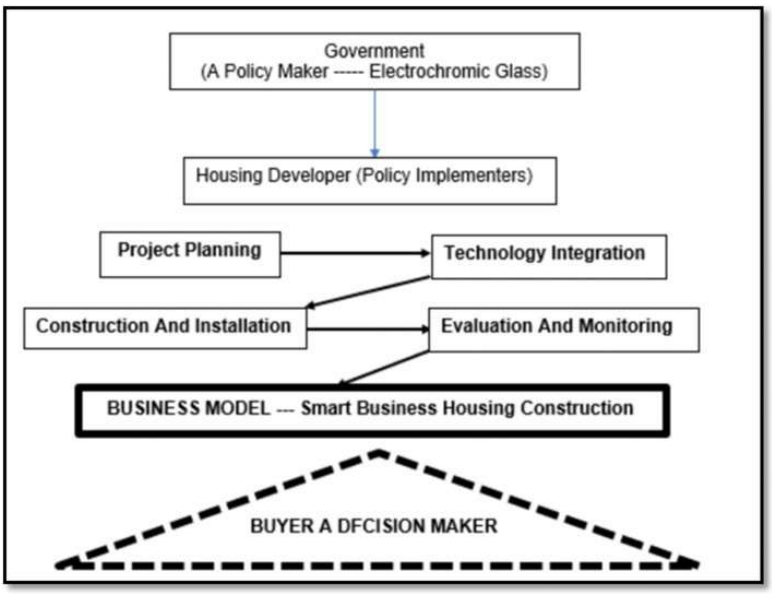

Figure 2: Conceptual Framework of Electrochromic Glass In Sustainability And Energy Efficiency In Smart Business Housing Construction

Figure 2 illustrates the relationships among the key individuals engaged in the application of electrochromic glass technology within the smart housing construction sector complement the study's principal concepts. The figure illustrates the government's function as a policy maker responsible for introducing and formulating policies concerning the implementation of electrochromic glass technology aimed at sustainability and energy efficiency. The government serves as the primary catalyst in establishing guidelines, incentives, and executing policies, including the National Green Technology Policy and the Malaysian Construction Industry Master Plan. Housing developers serve as policy implementers tasked with converting government policies into tangible construction projects. Within this framework, housing developers execute four primary components: project planning, technology integration, construction and installation, and evaluation and monitoring.

The four components constitute the foundation of the proposed business model, Smart Business Housing Construction. This business model emphasises the integration of green technology while considering sustainability, energy efficiency, and enhanced value in smart housing projects. The homebuyer, as the principal stakeholder and decision-maker, significantly influences the project's success or failure. The market acceptance of electrochromic glass technology is significantly influenced by the buyer's perception, awareness, and confidence in its value for enhancing quality of life and reducing long-term energy expenses. This diagram delineates the process flow from policy formulation to project execution and subsequently to the final assessment by the purchaser. The interplay among the government, housing developers, and buyers elucidates how this innovative business model aims to enhance competitiveness in the housing construction sector while advancing the nation's sustainability objectives.

5.0 CONCLUSION & RECOMMENDATION

Electrochromic smart glass is an innovative development that provides great benefits for both domestic and commercial buildings. This gives a remarkable boost to indoor comfort, whilst reducing the consumption of energy and electricity bills due to automatically controlling the light and heat levels. Furthermore, its capacity to curb reduced greenhouse gases is also a major leap in environmentally responsible innovation. Nevertheless, the limitations of electricity use in underdevelopment, limited knowledge, and availability, as well as high production and installation profit margins are obstacles for its thermal comfort enhancement to be quickly adopted.

Ongoing research and development to discover cheaper sources of materials and more efficient manufacturing processes is a key approach to addressing these challenges. Reducing production costs will not only make this technology more accessible to a broader range of stakeholders but also enable it to serve a larger audience. Additionally, integrating smart glass with renewable energy systems, such as solar panels, would enhance its overall effectiveness and appeal, contributing to energy savings and environmental conservation.

Governments and organizations can assist individual adoption through the provision of subsidies and incentives. Such financial assistance could reduce the financial burden of the initial hardware acquisition for both end users and businesses. There should also be public awareness campaigns and advertising campaigns to promote the adoption of electrochromic smart glass technology and its ability to improve comfort and conserve energy. More work is needed in researching the impact of electrochromic materials on the survival and maintenance of the glass, particularly in Malaysia where wide climate variations and high energy requirements are involved. Reinforcing the glass would guarantee dependable operation and enhance its usage in the tropics.

In summary, the revolution that electrochromic smart glass can bring to the construction industry is staggering. This advanced technology will be able to be integrated into sustainable building design with a combination of tackling its current issues through research and a collective effort of additional government incentives and social education.

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The Impact of Social Media Marketing Strategies on Shaping an Individual's Perception of Home Renovation Options – A Review of Traditional Advertising and Platform Selection

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ABSTRACT

This study explores the impact of traditional advertising and social media platform selection on shaping individuals' perceptions of home renovation options. A concept paper was employed, involving a systematic search of academic databases such as Scopus, Web of Science, and Google Scholar. Key search terms included "social media marketing," "traditional advertising," "platform selection," and "home renovation options." This study proposed a conceptual framework which consists of content engagement, trust, perceived usefulness and platform selection interactivity. The literature was screened based on relevance, publication date, and peer-review status. The findings indicate that traditional advertising lacks the interactivity and personalization necessary to engage modern consumers effectively. In contrast, social media platforms enhance brand image, significantly influencing consumer perceptions through targeted, platform-specific content. The study concludes that businesses adopting well-strategized social media marketing can better influence consumer decision-making compared to traditional methods. These insights provide practical guidance for optimizing marketing strategies in the home renovation industry.

Keywords: *Social Media Marketing, Traditional Advertising, Platform Selection, Individual's perception, Brand Image and Home renovation options.*

1.0 INTRODUCTION

In recent years, the home renovation industry had a major impact on human needs and has been driven by changing lifestyle which has been rising home design trends. These changes have been aligned with the impact on digital revolution which resulted in the way people consume marketing content. Besides, traditional advertising such as TV, print media and billboards have been replaced by dynamic social media marketing strategies to interact with others. However, many of the homeowners have decided to make some renovation of their home due to the current situation where the prices of new house become unrealistic with the size provided.

Despite this, home renovation trends have increased due to the social media platform marketing which has interacted with homeowners with the content, product and shared experiences. Social media platforms are not only for marketing but also for visualization, creativity and to gain trust as they play a critical role in influencing an individual's perception towards home renovation options. A study indicated that social media has been inspired by 28% of consumers to initiate home renovation projects and 44% identifying Instagram their platform of choice (USP Research, 2023). Besides, about 83% of individual's reported that social media helps to influence their perception to have a "dream home" from a strong emotional and perception from the platforms (Moneywise, 2024).

Addition, the extensive usage of social media to market items has broadens marketing reach. According to Haudi et al., (2022), increasing a product's visibility on social media can lead to more frequent discussions and promote it through word-of-mouth referrals. In a competitive market, a business must strive to survive and gain market share. Social media marketing will be effective marketing techniques, particularly branding, essentials for customer demand related items offered by diverse brands. They emphasize how brand image influences consumer purchasing behavior. Brand image may refer to customer general perceptions and views about the characteristic, ingredient, benefit, and value of product.

Furthermore, through social media marketing can make brand image gain the value of a product or service and at the same time can attract customers to choose the products easily. An attractive marketing may increase brand image reputation, but a poor image can discourage customers from purchasing the product, (Kazmi & Mehmood, 2016). Besides, according to Pramono et al., (2021), emphasizing the need of good marketing techniques can improve the strong brand image and organization can be competitive. However, according to Prahiawan et al., (2021) found that there are multiple factors being impacted while making purchases. Thus, marketers need to understand and influence customers to create a positive brand image in public (Alhaddad & Alhaddad, 2014).

Other than that, in a study it also stated that a strong brand image can increase customer happiness and loyalty which in turn helps firm become more profitable for businesses. According to Alhaddad & Alhaddad, (2014) suggest that organizations can enhance their brand image by emphasizing product character, originality, and emotional appeal. Brand image in any industry, as pictures and evidence that can draw customer interest to make a choice. Factors of High-quality and visualize attractive images will help guide customers decisions and inspire them with ideas for creating innovative designs for their design selections.

In fact, because of that, advertising has evolved over time to sell products and services in unique ways. Advertising has evolved to align with modern technology and lifestyle, transitioning from printed to digital promotions. The creative and innovative approach of capturing people's attention continues to evolve. According to Rehman et al.,

(2019), advertising can be an engaging approach to deliver new and exciting information with a targeted audience. Furthermore, today's advertising is sophisticated and surprising. Effective advertising requires understanding cultural variances, technical advancements, and societal perspectives. Advertisers must adapt to shifting consumer preferences and provide new concepts to stay relevant. According to Bolanos Melgar & Elsner, (2016) emphasize the complexity of advertising and the need for a comprehensive understanding to thrive in the global market.

However, traditional advertising uses channels such as television, radio, newspapers, magazines, and billboards to promote products and services. These mediums have a lengthy history and are adept at reaching a big audience. A study indicated that 93% of respondents felt TV ads influences customer home renovation selections. However, an enterprise may rely on them to effectively communicate with potential customers because of their proven history of success. Digital advertising uses various media kinds, including text, images, audio, and video, over a digital network. The internet provides a few channels for promoting businesses, such as websites, social media, mobile apps, and emails. Each of these platforms can support several types of advertisements. While traditional advertising succeeds in reaching a broad audience and building brand recognition, digital advertising offers precision targeting and measurable results.

1.1 THEORETICAL FRAMEWORK

1.1.1 TECHNOLOGY ACCEPTANCE MODEL (DAVIS, 1989) OR TAM

According to Davis (1986) established the Technology Acceptance Model (TAM), which is one of the most widely used models to explain how users accept and use technology. There are two main factors in determining user acceptance consisting of Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). This perception influences an individual's attitude to using technology which can affect their behavioral intentions. By using TAM, it helps to explain why individuals have made choices based on their perceptions of usefulness and it is applied to digital technology regarding advertising. For example, social media platforms are seen as more useful and easier to explore, interact and personalize home renovation selections. Businesses that expose television advertisements may be seen as informative but limited for interactivity compared to social media platforms which may be seen as more user-friendly because it is easy to collect ideas and give comments. The two platforms have provided diverse ways of attracting user perceptions based on the brand and service platform provided. Therefore, this study will use TAM as a theory in explaining the influence between platform selection in improving marketing platforms.

2.0 LITERATURE REVIEW

2.1 THE RELATIONSHIP BETWEEN TRADITIONAL ADVERTISING AND INDIVIDUAL PERCEPTION.

Traditional advertising refers to the use of established non-digital mass media channels such as television, radio, newspapers, magazines, and billboards to promote products and services (Belch & Belch, 2020). Decades ago, traditional advertising had an influence on how individuals perceived a product and interacted as customers. For example, television advertisements had the ability to reach major customers in terms of demographic and provide an opportunity for a business to raise awareness and influence the customer opinion. Besides, Newspaper and magazine advertisement, often become informative and effective in attracting the customers.

Addition, according to Dahnil et al., (2014) stated that traditional advertising is still an important platform and plays a significant role in modern business strategies. This has

impacted industry such as automotive, real estate, and fast-moving customers as it has enhanced trust and credibility of a business. However, the emotional and structure of the advertisement have given an impression towards viewers. For instance, a business may create a tagline in a television advertisement which can create a strong brand image and being well-known. Increasing brand image may result in purchase intentions.

Moreover, based on the customer review and feedback on the advertisement a business seen as trustworthy thus increase perceived of reliability of content delivery (Kotler & Keller, 2016). With that, traditional advertising becomes a significant advantage as the information or content delivered by a business being well-known.

In conclusion, traditional advertising has influences individual perception through structured content, review of feedback, and trust of media selection. However, traditional advertising does not show interactive results and performance compared to social media platforms where it might reach large audiences compare to traditional platforms. Thus, hypothesis is constructed as per below.

H1: Traditional advertising strategies have significantly influenced individual perception.

2.2 The Relationship Between social media platform selection and individual perception.

In the digital age, social media platforms such as Facebook, Instagram, TikTok and YouTube are known as effective platforms for a business to connect and interact with customers. From this platform, brands and products nowadays are influenced by the platform's selection. In contrast to Traditional advertising, there is a two- way communication by engaging customers with products, services and experience through likes, comments, and shares.

Salhab et al., (2023) indicated that social media advertising is chosen one in new generation to get compression products. Social media has the highest potential to assist marketers in tackling several marketing objectives, upgrading customer knowledge, comprehension, and influence as well motivating customers to make purchases. For example, Instagram as visual-driven content influences perceptions ideal for brands well-known and lifestyle increase. While platform such LinkedIn is better suited for B2B marketing and professional services.

In addition, social media platforms have significant impact on attracting individual's perceptions of a brand or product as it allows users with two-way communication. In the study of Duffett (2017), social media platforms have increased the level of personalization customers' feedback. For instance, home renovation users might be interested in this platform as they can have before and after transformation videos especially on TikTok. TikTok has brought a positive perception towards brand or services provided.

From social media it creates reviews, testimonials, and influences which significantly impact on an individual's perception. According to Kaplan and Haenlein (2010), good content from users brings higher credibility as it reflects users' experiences. It also can enhance trust and create a beneficial effect that shapes perception positively. As a result, it shows that social media platforms give a significant impact in influencing individuals' perception through the content that may attract audiences' expectations and perceptions. Platform selection not only creates attention but also increases trust. Thus, hypothesis is constructed as per below.

H2: Social Media Platform Selection has influences on individual perception.

2.3 The relationship between brand image and traditional advertising.

Brand image develops through a variety of communication channels, including radio, television, and brochures, which assist customers in associating concepts, emotions, or images with a brand (Sabil Hussein and Hapsari, n.d.). When people think of a certain product or service, they can visualize the brand thanks to these recurring and consistent messaging. This procedure is a type of mental encoding in which the customer retains the brand in their mind because of the messages they have been exposed to. The writers' use of the term "outs image" seems to be referring to the brand's outward manifestation, or how the public sees and interprets it.

Crucially, a brand's image is dependent on the trust and emotional openness of its customers. Credibility is increased and scepticism (weariness) is decreased with a good brand image. A brand gains a stronger place in the minds of consumers and influences their decision-making when its message is more distinct, dependable, and emotionally compelling than that of its rivals. For the illustration Let us say a homeowner is looking for kitchen remodelling services. Their search finds two brands, Brand X is highlighting its experience and client happiness, this brand promoted on television and in premium brochures. Despite having little to no media presence, and Brand Y is well-known locally.

The consumer is more likely to envision and trust Brand X because of its media exposure and well-established brand image, even when Brand Y may have lower prices. The information in the TV show and brochures contributed to the development of trust and a perception of dependability and professionalism. As a result, the consumer's decision is influenced by both pragmatic considerations and their perception of the brand, which is shaped by the media. Thus, hypothesis construct as per below.

H3: Brand Image mediates relationship between traditional advertising influence individual perception.

2.4 The relationship between brand image and social media selection.

According to Kumaradeepan et al., (2023) social media is having a direct influence towards the consumers purchasing intention to aware the brand. This has influenced the buying attitude of the customers. Especially the small and medium enterprises are noticeably different from others because of their marketing campaign. SME could interact with its customers directly through the help of social media. The world has become a global village. Everyone could be able to interact via social media. (Diba et al., 2019), insist the influence of social media is very vital in this current era. (Ismail, 2017) investigated the impact of social media marketing (SMM) on brand loyalty and discovered that the former has a considerable impact on the latter as well as customer purchase intention.

Nowadays social media social media is currently a very effective instrument that shapes buying intentions and raises brand recognition, among other facets of customer behavior. Social media platforms exert an immediate influence on customers' propensity to buy by raising brand awareness, claim Kumaradeepan et al. (2023). This impact is even more noticeable for small and medium-sized businesses (SMEs), furthermore social media to run focused, economic campaigns even though they sometimes lack the massive marketing budgets of larger corporations.

All products and brands can be published using media social platforms such as Instagram, Facebook, TikTok for display the item. Social media platforms can build up the good respond, with clients and sellers. Other than that, products display can merchandise, share client testimonials, and engage with followers by leaving comments or stories. This degree of direct interaction promotes repeat business and brand loyalty in addition to fostering trust. SMEs

have a competitive advantage when they can communicate with customers in real time, addressing issues, promoting deals, and building a brand community.

According to Diba et al. (2019), social media has a critical role in today's market since it allows companies to reach a worldwide audience and overcomes geographical obstacles. Because of this, the world has become a "global village," where customers from all over the world can interact with brands, read reviews, and make judgments about what to buy instantly. Ismail (2017) observed that social media marketing (SMM) significantly improves purchase intention and brand loyalty, which lends more credence to this. Consumers are more likely to create emotional bonds and trust with brands they interact with on social media sites like Facebook, Instagram, and Twitter. This leads to repeat business and enduring brand loyalty.

For example, consider about a tiny handmade soap company that posts videos on TikTok detailing the production process, client endorsements, and environmentally friendly packaging. As the videos get more popular, brand awareness rises and both domestic and foreign consumers are more likely to make a purchase. In addition to increasing awareness, this face-to-face interaction cultivates a devoted clientele.

H4: Brand Image mediates relationship between social media selection influence individual perception.

2.5 The relationship between brand image and individual perception of home renovation option

According to Meenaghan (2023) indicated brand image is a collection of opinions regarding brands. (Kalra, 2016) explains that the brand image is a collection of associations that consumers have with the brand. Customers who are used to a particular brand are more likely to stick with it. According to Salhab et al, (2023) genuineness, excitement, expertise, and sophistication are some aspects of the brand image.

The general perception and collection of connections that customers have about a business because of prior interactions, advertising, word-of-mouth, and reputation is known as brand image (Kalra, 2016; Meenaghan, 2023). When it comes to house renovation, people frequently weigh their alternatives according to product characteristics, cost, design, and sustainability; but the perception of the renovation providers' brands can have a significant impact on their ultimate choices.

For the example situation have client to consider wants to transformation her kitchen. She locates two service suppliers' quotation. Brand A, is a new to the market, provides services at a marginally lower costing for renovation. While Brand B, a well-known company that is well known for its contemporary designs and environmentally safe material.

According to Salhab et al, (2023) Lisa picks Brand B despite Brand A's competitive pricing because she identifies it with sophistication, competence, and reliability. In this case, her decision was mediated by brand image: her emotional faith in Brand B filtered her view of good reconstruction options.

H5: Brand Image mediates the relationship between individual's perception of home renovation options.

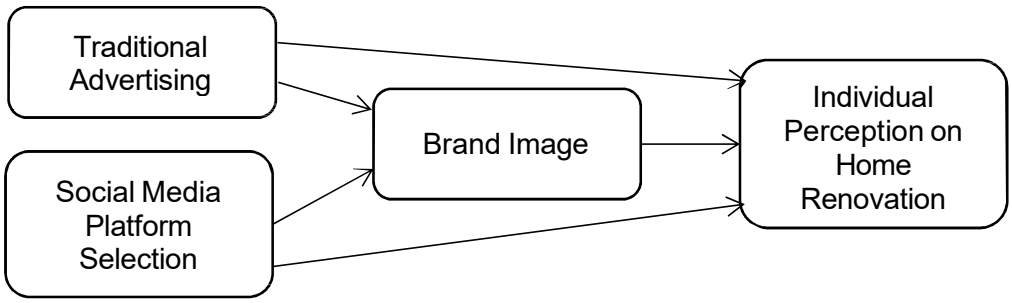

Figure 1.0 Conceptual Framework

3.0 Discussion

Since the beginning, traditional advertising which encompasses media including radio, television, newspapers, magazines, and billboards has been a vital component of marketing plans. This platform has shown themselves to be very successful in reaching a sizable audience and disseminating brands. Other than that, according to Singh (2024) these traditional media have a long history of effectively reaching prospective customers with business communications, greatly enhancing brand awareness. These channels continue to be a crucial tactic for companies trying to increase their market presence because of their capacity to connect with a variety of demographics.

Traditional advertising has several drawbacks even if it is good at reaching a large audience. While traditional media like TV, radio, and brochures are intended to reach a large audience through famous campaigns, (Korenkova et al., 2020) highlights that these approaches are expensive and have trouble tracking results. The challenge of quantifying the direct effects of campaigns is one of the primary problems with traditional advertising. Traditional advertising lacks these exact performance measurement tools, in contrast to digital marketing, which allows marketers to track customer interaction, conversions, and other important indicators in real time. Because of this, it is challenging for companies to evaluate if they are getting the intended results and to ascertain the efficacy of their advertising expenditures (Gabrielle Bartulay Santiago, 2023.)

Another major disadvantage of traditional advertising is its exorbitant expense. Large-scale print campaigns, radio advertisements, and TV commercials can be unaffordable, particularly for small businesses with tight marketing budgets. Businesses looking to market their goods or services through conventional channels may find it difficult to start due to these exorbitant expenses (Gabrielle Bartulay Santiago, 2023.). Because businesses may be spending a lot of money without being able to precisely monitor the return on investment from their efforts, this financial strain may result in inefficiencies.

4.0 Recommendation

As the home renovation industry continues increasing in economic performance with digitalization, future research should explore strategic digitalized marketing techniques that integrate both traditional and digitalization. Although traditional advertising plays a vital role in promoting, it remains used to gain credibility and brand awareness, while for digital marketing focusing on target customer, engagement, and performance monitoring. In future, in context of decision—making could explore more on the influences of customer perception. It will be appreciated to investigate on how to identify best practice and strategies to gain maximize consumer engagement and interest. Besides, a researcher may also focus on how different demographics could access digitalized marketing strategies. In the study also may investigate on the long-term impact towards brand equity, customer loyalty, and behavior. By focusing in these areas, future research can help marketers in the home renovation industry more effectively in promotional, which reflects on the behaviors of modern consumers.

5.0 Conclusion

In summary, this study highlights the most effective of marketing strategies is social media marketing as emphasizing the growing influences of home renovation industry. However, traditional advertising also has a significant impact towards marketing strategies as creating relevant content, customer trust in influencing the effectiveness of marketing efforts.

Both are essential for influencing consumer attitudes and building brand image. Despite its unreasonable prices and poor monitoring capabilities, traditional advertising is still an effective way to reach a large audience and build brand recognition.

Conversely, social media advertising provides a more quantifiable and participatory strategy that enables more accurate targeting and direct consumer interaction. Whether established through conventional or social media means, a brand's image strength is still important in influencing customer loyalty and purchase intentions. Businesses must combine traditional and digital techniques as the marketing landscape changes to develop a unified, dynamic brand image that appeals to their target market.

As the journey becomes more complex, business owners need to adapt their marketing strategies to stay relevant and effective. This study not only contributes to theoretical but also offers practical insight to enhance customer engagement and target market through digitalized marketing strategies.

5.0 ACKNOWMEDGEMENT

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Audit Fees: Profitability and Firm Size in the Food and Beverage Subsector Listed on the Indonesia Stock Exchange (IDX)

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ABSTRACT

Audit fees are the remuneration paid to auditors for their audit services, often influenced by the complexity of the work and audit risk. This study aims to analyze the effect of profitability and firm size on audit fees. The sample used in this study consists of companies in the Consumer Non-Cyclicals sector, specifically the Food and Beverage Subsector, listed on the Indonesia Stock Exchange (IDX). The analytical method used in the research is multiple linear regression analysis. The results indicate that profitability does not significantly affect audit fees. However, firm size is found to have a significant impact on audit fees. Larger companies tend to have higher operational complexity, requiring more time and resources from auditors. These findings have practical implications for auditors in determining fair audit fees and for companies in managing their budgets for audit services. This study also contributes to the literature on the determinants of audit fees in Indonesia.

Keywords: *Audit Fees, Profitability, Firm Size.*

1.0 INTRODUCTION

Audit fees are the compensation paid by a company to auditors for the audit services provided. Auditors play a key role in enhancing the credibility of financial statements and improving audit quality, which is why the determinants of audit fees remain an important issue (Siddhi Joshi et al., 2014). In Indonesia, policies regarding audit service fees are regulated in the Standar Profesional Akuntan Publik (SPAP) No. 2 of 2016, specifically in Article 4. The SPAP outlines principles that require auditors to perform their duties independently, objectively, and professionally. This is important because audit fees should reflect the level of difficulty, complexity, and responsibility faced by auditors during the audit process.

The amount of audit fees is influenced by various factors, including profitability and company size. Research on the determinants of audit fees is significant, given the crucial role of auditors in providing an independent opinion on a company's financial statements. This opinion not only serves as a form of transparency and accountability but also influences the confidence of stakeholders, such as investors and creditors.

According to (Toni et al., 2021), profitability is a measure used to assess how well a company can generate profits at an acceptable level. Companies with high profits tend to pay higher audit fees because high profits may require extensive testing of revenues and expenses, which demands more time and audit resources (Siddhi Joshi et al., 2014). Highly profitable companies often have more complex transactions, requiring auditors to conduct broader examinations to gather more audit evidence. Auditors may need to perform more comprehensive procedures to ensure that the company's financial statements are free from material misstatements.

However, previous studies have shown mixed results regarding the relationship between profitability and audit fees. Research by (Simunic, 1980), (Wallace, 1984), (Fattah & Nurbaiti, 2023), (Fahrie & Hakim, 2021), (Ruth O. Urhoghide Ph.D & Prof. F. O. I. Izedonmi, 2015), and (Nisa & Triyanto, 2022) found that profitability influences audit fees. On the other hand, studies by (Nathalie Gonthier-Besacier & Alain Schatt, 2006), (Naser & Hassan, 2013), (Chan et al., 1993), (Francis & Stokes, 1986), (Basioudis & Fifi, 2004), (Nelvia, 2019), (Himawan et al., 2023), and (Sastradipraja, 2021) found that profitability does not affect audit fees.

Meanwhile, company size is a more consistent factor influencing audit fees. According to research by (Ghozali, 2017), company size affects audit fees because the larger the company, the more time is required for audit work, and the more audit staff may be needed. Larger companies tend to incur higher audit fees due to the greater complexity and volume of transactions (Simunic, 1980), (Hay et al., 2006), (DeFond & Zhang, 2014); (Choi et al., 2008), (Choi et al., 2008). This is because auditors require more time, effort, and resources to complete the audit, thereby increasing audit fees.

There is inconsistency in research findings regarding the impact of company size on audit fees. Studies by (Sibuea & Arfianti, 2021), (Nisa & Triyanto, 2022), (Fahrie & Hakim, 2021), (Nelvia, 2019), (Simunic, 1980), (Hay et al., 2006), and (Triyanto & Sulistiyaningsih, 2023) found that company size significantly affects audit fees. Meanwhile, research by (Rahayu, 2017) and (M. A. Sanusi & A. Purwanto, 2017) found that company size does not influence audit fees.

Auditors with industry specialization tend to provide higher audit quality (Francis, 2004). The novelty of this study lies in its specific focus on the food and beverage subsector in Indonesia and the research period covering the impact of the pandemic (2020-2023). In Indonesia, the non-cyclical consumer sector, particularly the food and beverage subsector, has unique characteristics. Companies in this sector often have large scales and varying levels of profitability. Given the importance of this sector in the national economy, research on the influence of profitability and company size on audit fees in this subsector is relevant.

2.0 LITERATURE REVIEW

Agency Theory

Agency theory describes the contractual relationship between principal and agent, as explained by (Jensen & Meckling, 1976). Shareholders are the parties who provide funds and facilities to support the smooth running of the business so that they are referred to as capital providers. While agents, namely managers, are responsible for carrying out the company's operational activities. However, it is possible that managers do not always act in the interests of shareholders. This imbalance can trigger a conflict of interest between the principal and agent which can then give rise to agency costs.

Audit Fee

Audit fee refers to the amount received by auditors after completing the audit process. The audit fee received by the auditor indirectly reflects the scope of their duties and the risks involved. The higher the audit fee received by the auditor, the greater the scope of their tasks and responsibilities. There are several factors that auditors must consider when determining the audit fee, such as the client's needs, the scope of the auditor's work, the time required, and the tasks and responsibilities necessary for each stage of the audit.According to (David et al., 2014), the audit fee can be calculated using the following formula:

$$\text{Audit Fee} = \text{Ln (Audit Fee)}$$

Profitability

Profitability ratios are comparisons used to assess the extent to which a company is able to generate profit or earnings from the revenue it earns. According to (Toni et al., 2021), profitability is a measure used to evaluate how well a company can generate profits at an acceptable level. In this study, profitability is measured using Return on Assets (ROA). This indicator can be calculated using the following formula:

$$\text{ROA} = \frac{\text{Net Profit after Tax}}{\text{Total Asset}}$$

Firm Size

Firm size refers to the scale that describes the size of a company, which can be measured by total assets and sales. Assets are anything that holds economic value and can be owned either by individuals, companies, or the government, and can be assessed financially (Wahyuni & Khoirudin, 2020). In this study, the formula used to measure firm size is:

$$\text{Firm Size} = \text{Ln (Total Asset)}$$

The Effect of Profitability on Audit Fees in Consumer Non-Cyclicals Sector Companies, Food and Beverage Sub-Sector Listed on the Indonesia Stock Exchange (IDX) for the Period 2020-2023

Previous studies have shown inconsistent results regarding the impact of profitability on audit fees. Some research, such as (Simunic, 1980), (Wallace, 1984), and (Fattah & Nurbaiti, 2023), found that profitability has an effect on audit fees. They argue that companies with high profitability tend to have more complex transactions, requiring more resources and time for auditing, which ultimately increases audit costs.

On the other hand, studies by (Nathalie Gonthier-Besacier & Alain Schatt, 2006), (Naser & Hassan, 2013), and (Nelvia, 2019) found that profitability does not have a significant effect on audit fees. They argue that audit fees are more influenced by operational complexity and audit risk rather than a company's profitability. Companies with high profitability do not necessarily require more intensive audits if the complexity of transactions and audit risk are low.

These differing findings can be explained through the theoretical framework of Agency Theory (Jensen & Meckling, 1976). Companies with high profitability may have greater conflicts of interest between management and shareholders, thus requiring stricter audits to ensure transparency and accountability. As a result, auditors will need more time, leading to higher audit costs. Research conducted by (Fattah & Nurbaiti, 2023), (Fahrie & Hakim, 2021), and (Nisa & Triyanto, 2022) shows that a company's profitability affects audit fees. Therefore, the proposed hypothesis is:

H1: Profitability affects audit fees.

The Effect of Firm Size on Audit Fees in Consumer Non-Cyclicals Sector Companies, Food and Beverage Sub-Sector Listed on the Indonesia Stock Exchange (IDX) for the Period 2020-2023

Company size is a scale that can be measured by the level of total assets and sales, reflecting the company's condition. Larger companies tend to have advantages in funding sources to finance their investments and generate profits (Toni et al., 2021). Company size has a significant impact on audit fees because larger companies require more complex audit work and more audit staff to examine the available evidence. Most studies, such as (Ghozali, 2017), (Hay et al., 2006), and (Sibuea & Arfianti, 2021), found that company size has a significant effect on audit fees. Larger companies tend to have more complex operations, higher transaction volumes, and more intricate organizational structures, thus requiring more resources and time for audits.

However, some studies, such as (Rahayu, 2017) and (M. A. Sanusi & A. Purwanto, 2017), found that company size does not have a significant effect on audit fees. They argue that larger companies may have better internal systems, thereby reducing audit complexity.

Based on Agency Theory, larger companies tend to have more assets and complex transactions, requiring more in-depth audits to ensure that financial statements are free from material misstatements. Therefore, the proposed hypothesis is:

H2: Firm Size affects audit fees

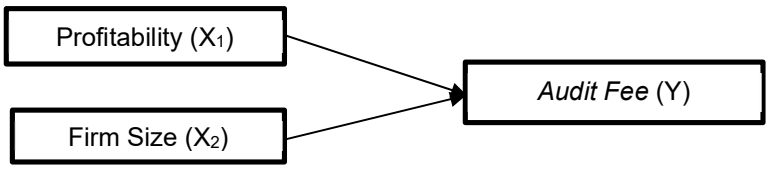


Figure 1: Conceptual Framework

At the end of 2023, the Indonesia Stock Exchange recorded 89 companies in the Consumer Non-Cyclicals Sector, specifically in the Food and Beverage Sub-Sector. This study selected 14 companies as samples using the purposive sampling method, with the criteria being Consumer Non-Cyclicals Sector companies in the Food and Beverage Sub-Sector listed on the Indonesia Stock Exchange (IDX) for the period 2020-2023 that have complete financial reports and possess complete data for the variables under study. In this regard, these companies can be considered representative samples for this research. All data for the variables tested in this study were extracted from the annual reports of the 14 companies for the years 2020-2023.

We use multiple linear regression analysis to test the effect of profitability and firm size on audit fees. The regression model in this study is as follows:

$$\text{Audit Fees} = \alpha + \beta_1 \text{Profitability} + \beta_2 \text{Firm size} + \varepsilon$$

3.0 RESEARCH FINDINGS

Results of Descriptive Statistical Analysis

Here are the results of the descriptive statistical test:

Table 1 Descriptive Statistics Analysis Results

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
ROA	56	-.13	.52	.0719	.09728
Size	56	25.56	31.38	29.3987	1.54521
Fee Audit	56	19.11	25.49	21.6913	1.44707
Valid N (listwise)	56				

Source: Data Processed (2024)

The results of the descriptive statistics analysis above can be described as follows: the profitability variable has an average value of 0.0719, with a minimum value of -0.13 and a maximum value of 0.52. The standard deviation is a statistical value used to determine how the data is distributed in the sample and how close individual data points are to the mean (average value of the sample). The standard deviation of the profitability variable is 0.09728. For the firm size variable, it can be described that the firm size variable has an average value of 29.3987, with a minimum value of 25.56 and a maximum value of 31.38. The standard deviation is 1.54521. The audit fee variable has an average value of 21.6913, with a minimum value of 19.11 and a maximum value of 25.49. The standard deviation is 1.44707.

Results of Normality Test

Here are the results of the normality test:

Table 2 Results of the Normality Test

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		49
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	.03840323
Most Extreme Differences	Absolute	.083
	Positive	.083
	Negative	-.073
Test Statistic		.083
Asymp. Sig. (2-tailed)		.200[c,d]

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

d. This is a lower bound of the true significance.

Source: Data Processed (2024)

Results of Classical Assumption Test

Results of Multicollinearity Test

Here are the results of the multicollinearity test:

Table 3 Results of the Multicollinearity Test

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	-.345	.356		-.967	.339		
	Ln_X1	-.006	.005	-.098	-1.154	.255	.995	1.005
	Ln_X2	1.007	.106	.807	9.540	.000	.995	1.005

a. Dependent Variable: Ln_Y

Source: Data Processed (2024)

The tolerance value for the profitability variable is 0.955, and the VIF value is 1.005, while for the firm size variable, the tolerance value is 0.955, and the VIF value is 1.005. From the multicollinearity test results table, it can be concluded that there is no multicollinearity issue between the profitability variable and the firm size variable, as indicated by the tolerance value of each variable being greater than 0.10 and the Variance Inflation Factor (VIF) being less than 10.

Results of the Autocorrelation Test

Here are the results of the autocorrelation test in this study:

Table 4 Results of the Autocorrelation Test

Runs Test

	Unstandardized Residual
Test Value[a]	.00218
Cases < Test Value	24
Cases >= Test Value	25
Total Cases	49
Number of Runs	19
Z	-1.730
Asymp. Sig. (2-tailed)	.084

a. Median

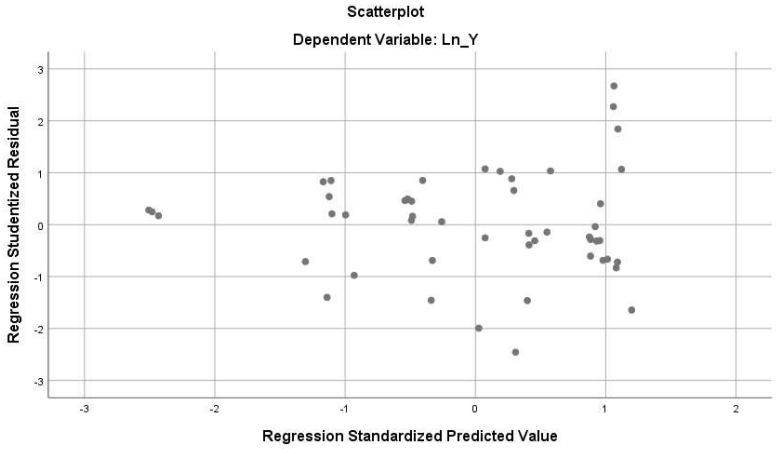
Source: Data Processed (2024)

The results of the autocorrelation test using the Runs Test in this study, indicate an Asymp. Sig. (2-tailed) value of 0.084, which is greater than 0.05, meaning that no autocorrelation is present.

Results of the Heteroscedasticity Test

Here are the results of the Heteroscedasticity Test in this study:

Figure 2 Results of the Heteroscedasticity Test



Source: Data Processed (2024)

Based on Figure 2 above, it can be seen that there is no specific pattern, as the points are irregularly scattered above and below the 0-axis on the Y-axis. Therefore, it can be concluded that there is no sign of heteroscedasticity.

Results of Multiple Linear Regression Analysis

Here are the results of the multiple linear regression test:

Table 5 Results of Multiple Linear Regression Analysis

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.345	.356		-.967	.339
	Ln_X1	-.006	.005	-.098	-1.154	.255
	Ln_X2	1.007	.106	.807	9.540	.000

a. Dependent Variable: Ln_Y

Source: Data Processed (2024)

Audit Fees = -0,345 – 0,006 Profitabilitas + 1,007 Firm size + Ɛ

The equation above can be explained as follows:

1. The constant has a negative value of -0.345, indicating that if the independent variables, profitability and firm size, are assumed to be 0, the level of audit fees would be -0.345.
2. The regression coefficient of the profitability variable is -0.006. This value indicates a negative relationship between profitability and audit fees. This means that if profitability increases by one unit, the audit fees will decrease by 0.006, assuming other independent variables remain constant.
3. The regression coefficient of the firm size variable has a positive value of 1.007. This value indicates a positive relationship between firm size and audit fees. This means that if firm size increases by one unit, the audit fees will increase by 1.007, assuming other independent variables remain constant.

F-Test Results

The following are the F-test results:

Table 6 F-Test Results

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.145	2	.073	47.211	.000[b]
	Residual	.071	46	.002		
	Total	.216	48			

a. Dependent Variable: Ln_Y

b. Predictors: (Constant), Ln_X2, Ln_X1

Source: Data Processed (2024)

The results of hypothesis testing using the F-test show that profitability and firm size simultaneously influence audit fees, as the significance value obtained is 0.000 < 0.05.

t-Test Results

The following are the results of hypothesis testing in this study:

Table 7 t-Test Results

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.345	.356		-.967	.339
	Ln_X1	-.006	.005	-.098	-1.154	.255
	Ln_X2	1.007	.106	.807	9.540	.000

a. Dependent Variable: Ln_Y

Source: Data Processed (2024)

The t-test results show that profitability does not affect audit fees (Sig. 0.255 > 0.05) and firm size affects audit fees (Sig. 0.000 < 0.05).

Results of the Coefficient of Determination (R^2) Test

The following are the results of the coefficient of determination (R^2) test in this study:

Table 8 Results of the Coefficient of Determination (R^2) Test

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.820[a]	.672	.658	.03923	1.241

a. Predictors: (Constant), Ln_X2, Ln_X1

b. Dependent Variable: Ln_Y

Source: Data Processed (2024)

Based on the results of the determination test, the R^2 value is 0.672. This result indicates that the effect of profitability and firm size in this study accounts for 67.2%, while the remaining 32.8% is influenced by factors outside the independent variables in this study.

The Influence of Profitability on Audit Fees in Consumer Non-Cyclicals Sector, Food and Beverage Sub-Sector Companies Listed on the Indonesia Stock Exchange (IDX) in 2020-2023

Based on the test results, it was found that profitability does not have a partial effect on audit fees. This finding aligns with research conducted by (Nelvia, 2019), (Himawan et al., 2023), and (Sastradipraja, 2021), which state that profitability does not influence audit fees. Profitability does not affect audit fees because the audit process is inseparable from a company's need to obtain reliable financial reports free from manipulation and ensure transparency. Companies with high or low profitability are still required to conduct audits as part of regulatory compliance. This makes profitability not always a determining factor for audit fees (Simunic, 1980). Companies will continue to use audit services to carry out the audit process, regardless of whether the company is in a profit or loss condition. Therefore, companies will still pay audit fees, and the determination of audit fees is usually agreed upon in advance between the auditor and the company owner before the audit process begins.

Audit fees are more influenced by the complexity of a company's operations, such as company size, business structure, or industry sector, rather than profitability (Hay et al., 2006). Audit fees vary significantly across industry sectors due to differences in operational complexity, risk, and sectoral regulations (Craswell et al., 1995). More complex companies require more time and resources to audit, regardless of their profitability level. Additionally, strict regulations and audit standards (such as the SOX Act in the US or IFRS globally) require auditors to perform more detailed audit procedures, regardless of the company's profitability. This makes audit fees more influenced by regulatory demands than by the company's financial performance (Ghosh & Pawlewicz, 2008). Auditors may focus more on audit risk and client reputation than profitability. Companies with high risks (e.g., risk of fraud or material misstatement) will incur higher audit fees, regardless of their profitability (Defond & Jiambalvo, 1993).

The determination of audit fees is usually agreed upon in advance between the auditor and the company owner before the audit process begins (Sabrina, 2018). The reputation and size of the audit firm (such as Big 4 vs. non-Big 4) have a greater influence on audit fees than the client's profitability. Large audit firms tend to charge higher fees due to their reputation and the quality of audit services they provide (Defond & Jiambalvo, 1993). Setting audit fees in advance provides transparency and certainty for both parties. The company being audited knows the fees to be paid, while the auditor knows the compensation they will receive for the audit services provided. Companies typically allocate a budget for audit fees, and this planning requires accurate cost estimation. By determining audit fees in advance, companies can better plan their budgets. Agreeing on audit fees before the audit process also helps define the scope of the audit. By knowing the costs involved, both the company and the auditor can determine an appropriate audit scope based on the available budget.

The Influence of Firm Size on Audit Fees in Consumer Non-Cyclicals Sector, Food and Beverage Sub-Sector Companies Listed on the Indonesia Stock Exchange (IDX) in 2020-2023.

Based on the test results, it was found that company size has a partial effect on audit fees. This finding is consistent with the research conducted by (Sibuea & Arfianti, 2021), (Nisa & Triyanto, 2022), and (Fahrie & Hakim, 2021), which state that company size affects audit fees. Company size affects audit fees because the larger a company is, the more complex the audit process becomes, meaning the level of difficulty or complexity in understanding, managing, and auditing the financial information of a company increases.

Large companies may have economies of scale in their operations, but the complexity and scale of those operations can also increase audit costs. Economies of scale can provide advantages, but at a certain point, the size of the company can lead to higher audit costs due to the complexity associated with that size. Additionally, transaction complexity plays a role—large companies are often involved in more complex transactions, such as acquisitions, mergers, or cross-border transactions. These complex transactions can increase the complexity of the audit and require more effort from the auditor. Auditors may need to allocate additional resources to understand and verify complex transactions, which will, of course, impact audit fees.

Firm size is a scale that reflects the magnitude of a company, which can be measured by total assets and sales. Firm size can be a factor that influences audit fees, because the larger and more complex a company is, the more resources are required by the auditor to conduct a thorough and accurate audit. This includes time, labor, technology, and coordination needed to analyze transactions, review financial statements, and ensure compliance with regulations (rules and company policies). As a result, audit fees tend to increase in line with the scale and complexity of the company.

4.0 CONCLUSION

Based on the findings of this research, it can be concluded that profitability does not have a significant effect on audit fees, while company size has a significant influence on audit fees. This finding indicates that the complexity of operations and the scale of the company have a greater impact in determining audit fees compared to the company's profitability level. This is consistent with several previous studies which state that larger companies tend to require more resources and time for audits, resulting in higher audit fees.

These findings can serve as input for the Indonesian Institute of Accountants (IAI) and Public Accountants to evaluate audit fee determination standards, thereby helping to create greater transparency in setting audit fees and preventing unreasonable fee-setting practices. Suggestions for future research could explore additional variables, such as Corporate Governance, Auditor Reputation, and Company Risk. Furthermore, future studies could expand the scope of sectors and research periods to determine whether similar findings apply in other sectors or in different economic contexts, such as during economic crises or periods of high economic growth.

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Financial Constraints In The Perspective Of Small and Medium Industry: The Impact Of Digital Finance On Firm Growth

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ABSTRACT

Small and Medium Industries in Indonesia play a crucial role as the backbone of the country's economy. According to data released by the Ministry of Cooperatives and IMK in 2022, the IMK sector has contributed 60.5% to Indonesia's total Gross Domestic Product (GDP). The large economic contribution from this sector shows that IMK has an important role as the main driver of the economy in Indonesia. Similar conditions also occur in the province of South Sumatra, which was purposively selected as the location for this research. IMK (Small and Medium Industries) until now continue to face classic problems in the form of problems in the financial sector. These problems are not only related to access to capital alone but have developed into problems related to growth and financial constraints. Digital finance, which includes access to and use of digital technology for financial services, can have a positive impact on corporate growth. Through digital finance, companies can access broader financial resources, such as capital financing, credit, and investment. Therefore, it is important to further understand how digital finance can significantly affect corporate growth. This study aims to find out in more depth the financial constraints that occur and also the various factors that influence these financial constraints. In addition, financial constraints are then also used to predict various possible problems that will arise in the future, especially in terms of company efficiency.

Keywords: *Small and Medium Industries, Financial Constraints, Digital Finance, Firm Growth*

1.0 INTRODUCTION

1.1. BACKGROUND

SMEs have classic problem in the form of financial problems. These SMEs problems are not only related to access to capital but have developed into problems related to growth and financial constraints. Both of these things are closely related to increasing the quantity and quality of SMEs and in the end will of course be related to the economic contribution of SMEs in Indonesia. If these classic problems are allowed to continue, they will certainly lead to low growth of SMEs themselves. Many previous studies have linked the phenomenon of these limitations, especially financial limitations, with SMEs growth. The risk of financial constraints on SMEs is also an interesting research topic regarding SMEs, especially related to the development of digital finance.

Research by Mittal and Raman (2021) in North India shows that the severity of financial constraints can affect the growth of SMEs, with the financial behavior of business owners playing an important role. Shaikh and Koso (2019) in Pakistan found that SMEs growth is also limited by financing, weak financial ecosystems, and unsupportive government policies. In the context of the Western Balkans, Ahmeti and Fetai (2021) found that financial constraints are an important determinant of SMEs growth, and large companies tend to face fewer constraints than small companies. In Indonesia, Aryanti et al. (2022) conducted a study with the object of SMEs in the city of Palembang and found several problems faced by SMEs in the city of Palembang which were proven to hinder their growth, namely education, skills, market penetration ability, capital, industrial technology, networks, business climate and facilities and infrastructure. If these classic problems are not addressed, the growth of SMEs will be hampered.

A significant problem experienced by businesses, especially small and medium businesses, is also related to access to financing which is crucial for their growth and sustainability. Based on the statement of Bratkowski et al. in Krasniqi (2004), new companies (de novo) are considered to have no business or credit history, which is why banks or financial institutions are reluctant to lend funds to these companies. This condition also occurs in Indonesia, where there is a significant gap in access to financing for existing businesses, resulting in limited potential for economic growth and reduced employment opportunities.

Based on the literature review, there are several strong reasons why research with a model of the influence of digital finance on firm growth mediated by financial constraints is very important to study. The literature review shows that digital finance, which includes access and use of digital technology for financial services, can have a positive impact on firm growth. Through digital finance, companies can access broader financial resources, such as capital financing, credit, and investment. Therefore, it is important to further understand how digital finance can significantly affect firm growth. From the various descriptions above, especially based on the initial survey that the researcher has conducted and the low realization of KUR in South Sumatra, the researcher is interested in exploring the phenomenon of these SMEs constraints from the perspective of financial accessibility.

This research is expected to be able to provide information, analysis, and scientific solutions that can be used by stakeholders (provincial and district/city governments, investors (banking and non-banking) and other related parties in taking strategic steps towards the development of the SMEs sector, especially in the province of South Sumatra. The main purpose of this research is to analyze financial constraints and their causal factors, especially among SMEs and to find out how digital finance influences firm growth in SMEs in South Sumatra Province. This study aims to gain a deeper understanding of the influence of digital finance on the growth of SMEs through financial constraints. Thus, this study has the potential to contribute to the development of relevant knowledge and policies to improve the condition of SMEs and the economy overall.

2.0 LITERATURE REVIEW

The term digital finance generally refers to any organization that offers financial applications to the public via the internet or other IP networks. Digital finance institutions describe digital finance startups as companies that create innovations to integrate distributed digital banking, mobile solutions and delivery platforms, microfinance institutions, payment solutions, peer-to-peer lending, and crowdfunding (Digital Finance Institute, 2018). However, digital finance is not limited to startups. Established service providers are also trying to get involved in this field. Furthermore, according to Leong (2018), financial technology is considered as “any innovative idea that improves the financial service process by proposing technological solutions according to different business situations”. The early development of financial technology was marked by integration in e-finance innovation, internet technology, social networking services, social media, artificial intelligence, and big data analytics (Lee & Shin, 2018). So it can be concluded that digital finance refers to institutions that provide financial services through digital platforms such as the internet and IP networks. Although often associated with startups, traditional financial institutions are also starting to get involved in this field. Financial technology (fintech) is an innovation that improves the financial service process with technological solutions tailored to specific business situations. The development of fintech was initially driven by the integration of internet technology, social media, artificial intelligence, and big data analytics.

Nivaeza and Choskun (2019) conducted a study on the determinants of financial constraints and their impact on the growth of small and medium-sized enterprises (SMEs) in Southeastern Europe (SEE). In this study, firm data from the fifth round of the Business Environment and Enterprise Survey (BEEPS V) conducted in 2012-2016 were used, and empirical analyses including ordered probit, probit, and feasible generalized least squares (FGLS) specifications were conducted. The findings prove that financial constraints significantly harm the growth of SMEs in the region.

Chiappini et al, (2022) Financial constraints hamper the ability of small and medium-sized enterprises (SMEs) to undertake innovative activities, which in turn impact the long-term growth of a country. Improving access to external finance for SMEs is therefore an important challenge for policymakers. This study investigates whether innovation subsidies provided by the Public Investment Bank in France to French SMEs have resulted in better access to debt and equity financing through the certification effect. The study finds a significant increase in access to bank financing for subsidized firms, but the effects are heterogeneous and are mostly concentrated in

the micro and small sector of firms that have been operating for about six years. The study does not find anything significant regarding the increase in access to equity financing. The study explains the substitution effect between bank debt and equity financing.

Edith Penrose: In her book "The Theory of the Growth of the Firm" Penrose (2019) developed the concept of the "Resource-Based View" which states that the growth of companies is related to their ability to manage and allocate scarce and valuable resources. For her, company growth occurs when companies succeed in combining these resources effectively.

David J. Teece: In his book "Dynamic Capabilities and Strategic Management: Organizing for Innovation and Growth" Teece (2019) developed the concept of "Capability Dynamics" which emphasizes the importance of continuous adaptation and innovation in supporting company growth. For him, companies that can continue to adapt to environmental changes will grow sustainably. Bui et al. (2021) stated that company growth can be measured by sales growth.

Following Lee et al. (2020), sales growth is the average growth in sales (Bui et al., 2021). The two main indicators used in measuring company growth are revenue growth and asset growth (Du & Nguyen, 2022), which are percentage changes in sales revenue and fixed assets. Companies are able to make greater profits from the capital they have. On the other hand, companies that are not financially limited tend to have lower returns on capital and there is a possibility that they may not even get any returns on capital at all. So it can be said that if a company experiences financial constraints, by understanding the theory of financial access which means that the company is in need of funding, then the company is a company that can have the opportunity to improve performance and even grow if given access to finance (funding) as one of which is digital financing McKenzie & Woodruff (2008).

Research Method

The research method that will be used is quantitative research design with data collection through a survey of SMEs in South Sumatra. The data collected will be analyzed using descriptive analysis techniques and Structural Equation Modeling (SEM)-Partial Least Square (PLS) to test the relationship between research variables. In this study, the primary data collected was obtained through a survey by distributing questionnaires to SME actors in South Sumatra who were registered with the Ministry of Cooperatives and Small and Medium Enterprises in South Sumatra. In this study, the data collection technique used was a questionnaire.

This research involves direct interaction with participants. After the data is collected, the next step is to conduct data analysis. The data obtained will be analyzed systematically to identify patterns, trends using Trend Testing with Linear Regression, or relationships that can help answer research questions. This analysis process involves various techniques such as statistics, classification, or interpretation. The results of the data analysis will be interpreted by linking the findings to relevant theories. The conclusions drawn from the interpretation of the results become the basis for answering the research questions that have been formulated.

This study will test the hypothesis that the use of digital finance has a positive influence on company growth in MSMEs, in line with the findings that financial access helps companies overcome liquidity constraints and improve resource allocation in the economy. And then this study will explore whether financial constraints have a negative impact on SMEs growth, along with the finding that companies facing financial constraints have a significantly higher rate of return on capital, indicating that they previously experienced credit constraints.

In this study, the primary data collected was obtained through a survey by distributing questionnaires to SME actors in South Sumatra who were registered with the Ministry of Cooperatives and Small and Medium Enterprises (Kemenkop UKM) in South Sumatra. The population in this study was Small and Medium Enterprises (SMEs) registered in South Sumatra, namely 126,489 businesses in 2020 (Central Statistics Agency of South Sumatra Province, 2022). This study uses the Indonesian standard business field classification code as the research stratum. Where for SMEs in South Sumatra there are 23 classification codes from number 10-33. So the number of samples in this study is 399 IMKM. Calculation of the number of samples in each classification code in this study using the PSRS technique.

Results and Discussion

The results of the descriptive analysis show that the impact of digital finance on SMEs is quite varied, with an average score of 3.7 on a scale of 5. The involvement of financial constraints also varies, with firm growth. SEM analysis produces a good model fit ($\chi 2/df = 2.34$, CFI = 0.95, RMSEA = 0.062). The results of the hypothesis testing are presented in Table 1.

Table 1. Hypothesis Testing Results

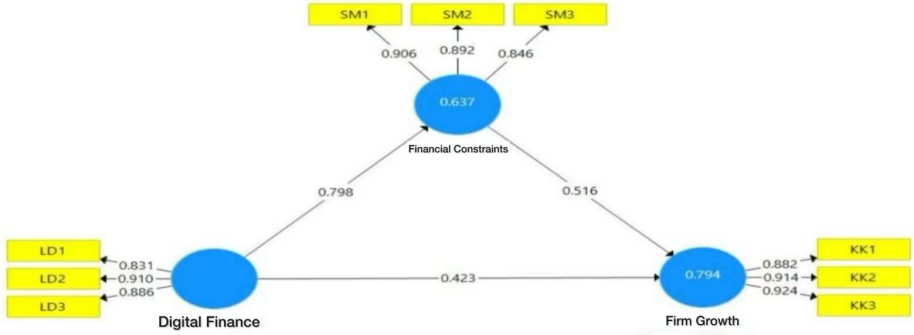
Hypothesis	Path Coefficient	t value	Results
H1: Digital Finance → Financial Constraints	0.56	7.23*	Accepted
H2: Financial Constraints → Firm Growth	0.48	6.15*	Accepted
H3: Digital Finance → Firm Growth	0.32	4.78*	Accepted

*p < 0.01

Source : Author`s processed data

Graphical Result

Figure 1. Frame Work



Source : Author`s processed data

3.0 CONCLUSION

This study confirms the positive influence of digital finance on company growth, in this case MSMEs, both directly and through the mediation of financial constraints. This finding emphasizes the importance of efforts to use digital finance for SMEs players as a strategic step in increasing company growth. The main contribution of this study is in the development of a digital finance model, financial constraints, and the growth of SMEs companies. This model can be a reference framework for further studies and for stakeholders in formulating policies and programs for SMEs firm growth in the digital era. The limitations of this study lie in the limited geographic coverage and the use of cross-sectional data. Digital finance is of course a form of adoption of innovation and technology carried out by companies to obtain more optimal growth. Firm growth itself is something that can be measured. Bui et al. (2021) stated that company growth can be measured by sales growth. Following Lee et al. (2020), sales growth is the average growth in sales (Bui et al., 2021). This research has the potential to contribute to the development of relevant knowledge and policies to improve the conditions of SMEs and the economy as a whole.

4.0 ACKNOWMEDGEMENT

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Gen-Z at Work: Enhancing Engagement Through HRM Practices in the Hotel Sector

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Abstract

Work engagement, characterized by vigor, dedication, and absorption, is essential for employee performance and organizational success, particularly in the hospitality industry. With Gen-z increasingly comprising the workforce, understanding the factors that drive their engagement is critical. This study examines the relationship between specific HRM practices (career development, compensation, performance appraisal, and training) and work engagement among Gen-Z employees in the hotel sector. Using the quantitatve survey and partial least squares path modeling tools, the results showed that career development and compensation had a positive impact on the work engagement of hotel staff. This finding is important because it shows how the HR managers can buffer the negative impact of a lack of career development and unattractive compensation on the work engagement of employees. Whereas training and performance appraisal were found to have no significant impact on work engagement. These findings contribute to the theoretical understanding of work engagement by emphasizing the role of generational perspectives and industry-specific contexts. Practically, they highlight the need for hotel managers to prioritize career development opportunities and competitive compensation strategies while reevaluating traditional performance appraisal and training practices. This

study offers actionable insights for enhancing Gen-Z employee engagement and advancing HRM practices in the hotel sector.

Keywords: HRM practices, work engagement, Gen-Z, hospitality

1.0 Introduction

The hospitality industry is inherently labor-intensive, relying heavily on the commitment and engagement of its workforce to deliver exceptional guest experiences. The hospitality industry is acknowledged for its vital role in global economic growth by fostering socio-economic development and creating job opportunities. The hospitality industry encompasses several key sectors, including accommodation (such as hotels, motels, resorts, and serviced apartments), food and beverage services (including restaurants, cafés, catering, and bars), travel and tourism (such as travel agencies, tour operators, and cruise services), recreation (including theme parks, museums, and sports facilities), and meetings and events (such as convention centers and event planning services), reflecting its diverse and evolving nature (LIMBD, 2024). In short, the hospitality sector includes several service industries, including transportation, amusement parks, hotels, restaurants, and event planning (Holston-Okae & Mushi, 2018).

Among the myriad of challenges faced by this sector, fostering employee work engagement has emerged as a critical concern. Research by the Gallup organisation indicates that global work engagement remains at an average of 15% across all industries, including the hospitality sector (Harter and Rubenstein, 2020). To compete effectively, businesses must motivate their staff to fully engage and utilise their strengths in their work. Consequently, organisations anticipate their staff to exhibit complete commitment, engagement, and initiative in the workplace. Organisational success is driven by dedicated and committed employees (Noesgaard and Jørgensen, 2023).

In recent years, a significant demographic shift has occurred in the global workforce. Kunze and Menges (2017) identify disparities between younger and older employees in the workplace. As to Andrea et al. (2016), the latest cohort entering the workforce is termed Generation Z, henceforth referred to as "Gen-Z," encompassing individuals born between 1995 and 2010. Gen-Z employees are distinct from their predecessors, valuing flexibility, purpose, and innovation in their workplaces (Deloitte, 2023). However, their engagement levels often hinge on the human resource

management (HRM) practices adopted by employers, which need to align with their unique expectations and preferences.

The hotel sector is a crucial component of the hospitality business (de Souza Meira et al, 2022). In the context of hotel industry, which is well known for its high turnover rates and demanding work environments, the need to engage Gen-Z employees is crucial. Effective HRM practices, such as training and development, and effective performance management can play an essential role in addressing this challenge. However, the extent to which such practices influence work engagement among Gen-Z employees in this sector remains underexplored.

The purpose of this study is to examining the relationship between HRM practices and work engagement among Gen-Z employees in the hotel sector. This study seeks to provide actionable insights for hotel managers and HR professionals striving to foster a motivated and high-performing Gen-Z workforce. Specifically, this study examine the relationships between HRM practices (career development, compensation, performance appraisal and training) and work engagement. The question guiding this study are:

i) Do career development affect work engagement among Gen-Z in the hotel sector?

ii) Do compensation affect work engagement among Gen-Z in the hotel sector?

iii) Do performance appraisal affect work engagement among Gen-Z in the hotel sector?

iv) Do training affect work engagement among Gen-Z in the hotel sector?

2.0 Literature Review

2.1 Work engagement

Work engagement describes a psychological condition wherein individuals perceive their work positively and derive satisfaction from it. It is classified by vigor, dedication, and absorption (Schaufeli et al, 2006). According to Al Zaabi et al (2016), highly engaged employees are likely to be physically and emotionally connected to their work, motivated and eager to develop their work-related skills and knowledge.

Work engagement is an essential aspect for organisations, due to many positive results, including a significant influence on both employees and organisations (Mitonga-Monga & Cilliers, 2015). Work engagement quantifies the degree of individuals' involvement in their employment, incorporating physical, emotional, and cognitive dimensions (Christian et al., 2011). Highly engaged employees demonstrate positive attitudes and behaviours that actively promote the attainment of the organization's objectives (Ribeiro et al., 2023).

2.2 HRM practices

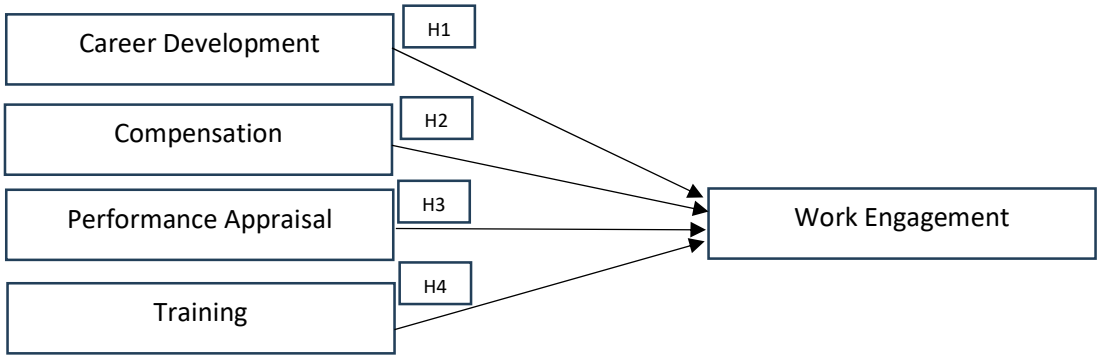
Human Resource Management strategies are essential in promoting constructive organisational behaviours among employees and mitigating adverse inclinations such as turnover intentions (Duarte et al., 2015). Yousaf et al. (2018) discovered that HRM methods facilitate the enhancement and expansion of employees' skills, knowledge, and commitment. As a result, employees are motivated to remain in their careers and are more inclined to retain their current positions for an extended period.

Compensation indicates the aggregate worth of rewards and benefits that employees obtain from the organisation in exchange for their labour and services (Delery et al., 2000). Training is an essential component of Human Resource Management that facilitates the execution of organisational strategies by improving employees' skills and abilities to adapt to change (Noe, 2019). Performance appraisal is a systematic and periodic process of evaluating an employee's performance against established objectives (Kampkotter, 2017). Career development indicates a systematic and intentional procedure designed to align an individual's professional ambitions with the organization's workforce needs (Leibowitz et al, 1986).

2.3 Theoretical Framework

This study was conducted to investigate the relationship in between the independent variables of HRM practices (i.e. career development, compensation, performance appraisal, and training) and dependent variables of work engagement. A comprehensive framework was developed based on the support of literature reviews. The framework consists of four distinct variables that will undergo testing to assess their impact or influence on the dependent variable of work engagement, as illustrated in Figure 1.

Figure 1: Theoretical Framework



2.4 Theoretical background

2.4.1 Social Exchange Theory (SET)

The foundation of SET is reciprocity standards in social relationships (Blau, 1986). SET is a significant theory that provides an extensive understanding of exchange dynamics in interpersonal and organisational environments. The findings of social exchange research significantly enhance our comprehension of workplace behaviour (Cropanzano & Mitchell, 2005). Zhang et al. (2020) assert that SET posits individuals engage in trade connections with the expectation of acquiring various social and economic benefits.

According to the Social Exchange Theory (Blau, 1964), the implementation of beneficial strategies by organisations, including HRM activities such as recruitment, training, performance management, compensation systems, and employee involvement, can enhance employee retention. According to SET, Huang et al. (2017) posited that organisational practices offering support and encouragement (i.e., HRM practices) convey a significant message to employees regarding the genuine appreciation of their work, fostering a sense of obligation and enhancing engagement as a kind of reciprocation.

2.5 Hypotheses development

Alfes et al. (2013) discovered that employees are more likely to be engaged in their work when they had positive perceptions of HRM practices. A study by Jose et al. (2024) involving nurses in South India revealed a significant positive correlation between HRM practices and employee engagement. A study by Pimenta et al. (2024) in Portugal found

a positive association between the deployment of SR-HRM practices by organisations and employee work engagement levels.

Bai and Liu (2018) discovered in their study that career advancement significantly enhances an employee's dedication and engagement in their professional responsibilities. Consistently, Liu et al. (2016) shown that career development significantly enhances employee engagement in their work. Robianto and Masdupi (2020) discovered that career advancement significantly enhances an individual's dedication and engagement in their work. Consequently, they determined that enhanced career development for employees results in increased work engagement. This study posits a positive association between career development and employee engagement.

H1: Career development positively affects work engagement among Gen-Z in the hotel sector.

A study has shown a positive relationship between compensation and employees' work engagement (Robianto and Masdupi, 2020; Tensay and Singh, 2020; Alias et al., 2014). Previous research indicate that compensation are essential since they have the ability to motivate employees to enhance their engagement levels. To test the relationship between compensation and work engagement, the following hypothesis is proposed

H2: Compensation positively affects work engagement among Gen-Z in the hotel sector.

Effective performance feedback mechanisms can create a supportive psychological atmosphere that improves employee engagement (Volpone et al., 2012). The practice of performance appraisal is an inherent and integral component of the organization (Obeidat, Masa'deh, & Abdallah, 2014). Uraon and Kumarasamy (2024) revealed in their research that the implementation of JPPA procedures serves as a more significant predictor of job engagement. Tensay and Singh (2020) identified a favourable and strong correlation between training and employee engagement. This study indicates a positive correlation between performance appraisal and employee engagement, leading to the development of the following hypothesis:

H3: Performance appraisal positively affects work engagement among Gen-Z in the hotel sector.

In Human Resource Management (HRM), training and development are acknowledged in the research as critical determinants of employee behaviour and

performance (Huang et al., 2017). The presence of training opportunities and managerial guidance stands as a significant factor in fostering the growth of employee motivation and commitment (Nandi et al, 2020). Kwon et al. (2024) discovered in their integrative literature analysis that employee development programs improve employee engagement, hence diminishing intentions to depart from the organisation. Consequently, it is evident that training positively influences employee engagement, which may result in the following hypothesis:

H4: Training positively affects work engagement among Gen-Z in the hotel sector.

3.0 Data collection

The data collection was disseminated online via a designated link shared through WhatsApp and email, with an approximate response time of 5 minutes. Participants were required to read an introductory section of the study, which outlined the objectives and provided essential instructions for completing the survey. This introduction also featured details regarding anonymity and confidentiality, necessitating the validation of the respondent's informed consent. The sampling criteria were defined as i) the respondents had to be born between 1996-2010 (Gen-z) and they had to work in an hotel (3-5 stars) in Kota Kinabalu. Thus, it is a non-probabilistic convenience sample.

The final questionnaire was comprised of three sections: 1) HRM practices 2) work engagement, 3) respondents' socio-demographics. In this question section, respondents were asked to chose their answer based on a five-point Likert scale with 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly agree. In section 2, nine questions were included to measure employees' work engagement. In the last section of questionnaire, a series of demographic queries were included to identify respondents' gender, income, length of service, and department.

The questionnaire used in this study consists of multiple items adapted from validated sources to measure the key variables. The table 1 presents the items used in the questionnaire, categorized according to their respective constructs.

Table 1: Questionnaire Items

Variable	Code	Item	Source
Work Engagement	WE1	When I get up in the morning, I feel like going to work.	

	WE2	At my work, I feel bursting with energy.	Memon et al
	WE3	At my job, I feel strong and vigorous.	(2018)
	WE4	My job inspires me.	
	WE5	I am enthusiastic about my job.	
	WE6	I am proud of the work that I do	
	WE7	I get carried away when I am working.	
	WE8	I am immersed in my work.	
	WE9	I feel happy when I am working intensely	
Career Development	CD1	The organization is supportive of my long-term career development.	Rubel et al., (2021)
	CD2	The organization provides an environment where I will accomplish my career goals.	
	CD3	The organization provides me with an opportunity to grow.	
	CD4	The organization provide me an opportunity to exploit my potential to excel and achieve my career goals.	
Compensation	COM1	I am compensated based on my knowledge, skills and abilities.	Rubel et al., (2021)
	COM2	I am familiar with the criteria used to determine my compensation.	
	COM3	My pay is fair relative to the pay received by others who hold similar positions in other organizations	
Performance Appraisal	PA1	My performance goals are clearly defined in the appraisal process.	Rubel et al., (2021)
	PA2	Performance appraisal in the organization is fair.	
	PA3	I receive feedback from my supervisor on my performance.	
Training	TR1	The organization provides a supportive learning environment via a training and development programs.	Rubel et al., (2021)
	TR2	I have opportunities to use the knowledge and skills I have learned from the training and development programs.	
	TR3	Opportunities to learn (training) are made available in the organization.	

4.0 Results

4.1 Demographic profile

Frequency analysis was performed to review the overall profile of respondents' demographics. A majority of respondents were females. The highest income level for most of the respondent was less than RM2000. A majority of respondents have served the company for less than 2 years. Most of respondents of this study working in housekeeping department. A profile of respondent's socio-demographic information is summarized in Table 2.

Table 2: Demographic Information of Respondents

Variable	Items	Frequency	Percent
Gender	Male	67	45%
	Female	83	55%
Income	<RM2000	80	53%
	RM2001-RM3000	35	24%
	RM3001-RM4000	18	12%
	RM4001-RM5000	17	11%
Length of Service	Less than 2 years	65	43%
	2-5 years	50	33%
	6-10 years	24	16%
	More than 10 years	11	8%
Department	Front Office	21	14%
	Housekeeping	37	25%
	Food & Beverage	36	24%
	Sales & Marketing	7	5%
	Finance	10	7%
	Engineering	9	6%
	Food Production (Kitchen)	16	10%
	Purchasing	10	7%
	Security	4	2%

4.2 Statistical analysis

This study used partial least squares (PLS) modeling using the SmartPLS 4 version (Ringle et al., 2024) as the statistical tool to examine the measurement and structural model as it does not require normality assumption and survey research is normally not normally distributed (Chin et al., 2003). Prior to evaluating the quality of the constructs and the model, the researcher assessed for common method bias (CMB), given that the research data were from a single source, as advised by Kock et al. (2021). Figure 1 reveals that no substantial variation in R^2 values of the endogenous variables was detected. The R^2 change was less than 10% and the significant paths in the baseline model remain significant in the *method factor model*. Thus, the analysis of the PLS marker variable revealed no common method variance issue in the present study. Result for marker variable technique shown in figure 2 and 3.

Figure 2: Baseline Model

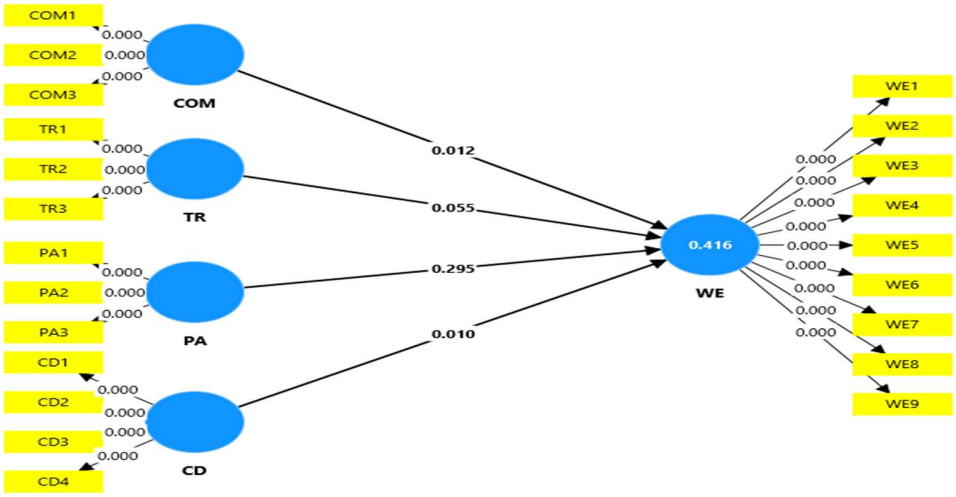
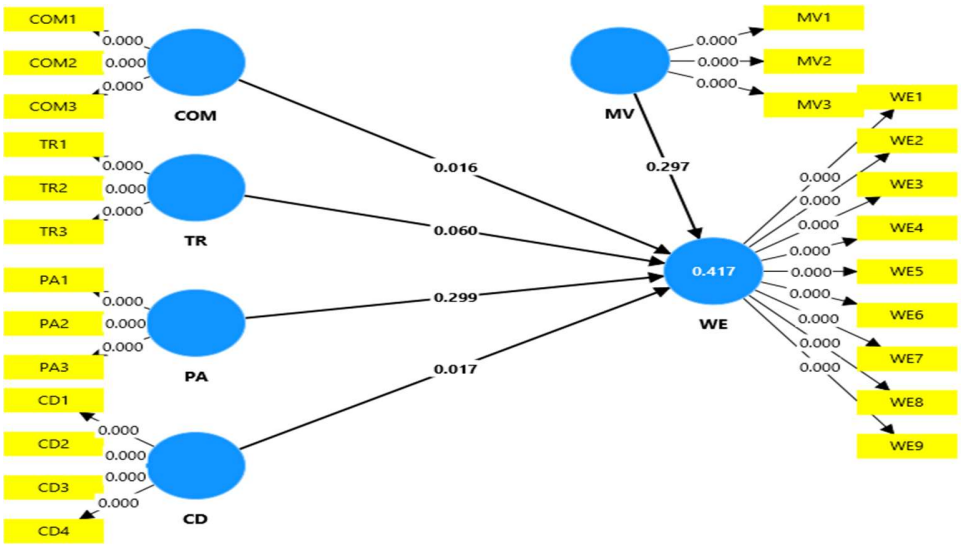


Figure 3: Method Factor Model



This study employed structural equation modelling (SEM) to assess the data and evaluate the hypotheses. Partial least squares (PLS) was employed, a model intended to assess connections among latent variables, utilising SmartPLS 4 version (Ringle et al., 2024). Two methodologies were employed to examine and interpret the results. The initial technique involved assessing reliability and validity to measure the model, whereas the subsequent approach focused on evaluating the structural model (Hair et al., 2021).

Measuring the model entails examining its quality, which includes reliability, defined as the consistency of the measurement. Internal consistency reliability assesses the validity of similar items on a test. Convergent validity refers to the extent to which a test correlates with other assessments that evaluate the same or similar constructs. Discriminant validity pertains to the extent to which a test is unrelated to other assessments measuring distinct constructs.

Table 3: Measurement Model

	Items	Loadings	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
CD	CD1	0.938	0.953	0.966	0.877
	CD2	0.945			
	CD3	0.935			
	CD4	0.928			
COM	COM1	0.923	0.857	0.913	0.779
	COM2	0.878			
	COM3	0.844			
PA	PA1	0.889	0.857	0.913	0.777
	PA2	0.906			
	PA3	0.849			
TR	TR1	0.914	0.879	0.925	0.805
	TR2	0.914			
	TR3	0.863			
WE	WE1	0.830	0.945	0.954	0.703
	WE2	0.868			
	WE3	0.918			
	WE4	0.897			
	WE5	0.910			
	WE6	0.821			
	WE7	0.907			
	WE8	0.564			
	WE9	0.774			

A series of model construct validity assessments were carried out through examining the factor loadings, composite reliability, and the average variance extracted (Fornell and. Larcker, 1981). The findings indicate that all items exceed 0.5, so affirming the reliability of each indicator. The internal consistency dependability of the indicator was validated, since all Cronbach's alpha and composite reliability values exceed 0.7 (Hair et al., 2021). Concerning the convergent validity of the indicator, all constructs have composite reliability values over 0.70. The average variance extracted (AVE) values

exceed 0.5. Consequently, all previously indicated things are affirmative and substantial (Hair et al., 2021).

The heterotrait-monotrait ratio (HTMT) was employed to assess discriminant validity, as illustrated in Table 4. The results imply that discriminant validity has not been demonstrated between the two reflective constructs.

Table 4: Discriminant Validity (HTMT)

	CD	COM	PA	TR	WE
CD					
COM	0.722				
PA	0.861	0.817			
TR	0.816	0.796	0.822		
WE	0.621	0.620	0.562	0.622	

4.3 Findings

The results in Table 5 show that career development (β=0.339, t-value =2.324, p-value =0.010) has a positive direct effect on work engagement. These results do support H1. The results in Table 2 show that compensation (β=0.254, t-value =2.255, p-value =0.012) has a positive direct effect on work engagement. These results also do support H2. Next, Hypothesis H3 explored the impact of performance appraisal on work engagement. Result of this study indicated that this hypothesis was not supported, as this study found there is no significant influence of performance appraisal on work engagement (-0.072, t-value =0.539, p-value =0.295). Using H4, which examined the impact training on work engagement, this finding indicated that this relationship was insignificant. It suggests that the training program provided by the organization does not guarantee a significant impact on work engagement (β=0.192, t-value =1.595, p-value =0.055).

Table 5: Hypothesis Testing

Hypothesis	Path	Path Coefficient	(STDEV)	T statistics	P values
H1	CD -> WE	0.339	0.146	2.324	**0.010**

H2	COM -> WE	0.254	0.113	2.255	**0.012**
H3	PA -> WE	-0.072	0.133	0.539	0.295
H4	TR -> WE	0.192	0.121	1.595	0.055

5.0 Discussion

This study examined the relationships between HRM practices (i.e., compensation, training, performance appraisal and career development), and turnover intention among Gen-z employee in the hotel sector. The results of the hypothesis testing showed that two of the HRM practices factors are positively associated with Gen-Z work engagement. The following are managerial implications based on the findings of this study.

Career development was one of the most influential factors that affect Gen-Z employees'work engagement. Allowing Gen-Z employees to develop their career are important factor for work engagement. Gen-Z employees want to feel progress in their career and given a chances to move along the organization. Being able to develop their career within the workplace is essential for this generation who want to be appreciated as they perform their duties. In order to foster higher levels of work engament in the workplace, it is important for managers to create and promote an environment where employees are given opportunity to develop their career.

The results support previous research eg; Robianto and Masdupi (2020), Bai and Liu (2018), and Huang et al (2017). Previous finding suggesting that career development opportunities act as a key resource, fostering greater employee engagement by enhancing their sense of purpose and connection to the organization. For the hotel industry, where roles can sometimes be perceived as transient or stagnant, providing clear career pathways and mentorship opportunities may serve as a critical strategy for retaining and engaging this workforce.

Secondly, it is vital for employers and managers to realize how important the attractive compensation package is to employees, otherwise their organization may suffer from low work engagement. The compensation packages was one of the influential factor for Gen-z employees when deciding whether to highly engage or not. This finding aligns with the growing recognition of compensation as a fundamental driver of employee

satisfaction and commitment, particularly among Gen-Z employees. This finding consistent with most of previous studies (e.g. Robianto and Masdupi, 2020; Tensay and Singh, 2020; Alias et al., 2014) which found that rewards play a crucial role since to inspire employees to elevate their level of engagement.

Unlike previous generations, Gen-Z is more vocal about the importance of financial stability and transparent pay structures. Competitive compensation packages, including benefits and performance-based incentives, can thus serve as a strong motivator, addressing both their financial and psychological needs (Bhakuni & Saxena, 2023). For the hotel industry, which often struggles with high turnover, focusing on compensation strategies may not only enhance engagement but also improve retention rates. The results indicate that it is important for companies to ensure that employees received an appropriate compensation packages as expected. Based on the characteristics of Gen-z employees, it is likely that they would prefer compensation packages which meet their expectations. Hospitality businesses should try to design compensation packages which suitable with this generation.

Interestingly, performance appraisal did not significantly influence work engagement in this study. This finding is contradicted with previous studies such as Uraon and Kumarasamy (2024) and Tensay and Singh (2020) which found that performance appraisal positively affects job engagement. This may reflect a misalignment between traditional performance appraisal practices and the expectations of Gen-Z employees. Research suggests that Gen-Z prefers real-time, continuous feedback rather than formal, periodic evaluations (Chillakuri, 2020). Chillakuri (2020) notes that both Millennials and Generation Z cohorts prefer frequent and immediate feedback, suggesting that new performance management systems should accommodate this preference to maintain engagement. The lack of a significant relationship could also indicate that current appraisal methods in the hotel industry fail to address the developmental needs and aspirations of this demographic. Organizations may need to adopt more agile and personalized approaches, such as frequent one-on-one discussions or digital feedback tools, to better align with Gen-Z preferences.

Similarly, training was not found to have a significant relationship with work engagement. This finding contradicts with the previous arguments of Kwon et al (2024) and Tensay and Singh (2020) in which training is found to influence employees' work

engagement. This finding challenges the traditional view that training is universally beneficial for enhancing engagement. For Gen-Z employees, training programs may be perceived as routine or disconnected from their career goals unless they are highly customized and relevant. This result suggests the need to rethink how training is designed and delivered. Incorporating innovative methods such as gamification, virtual reality, or microlearning modules could make training more engaging and impactful for Gen-Z employees in the hotel sector.

6.0 Limitations and future study

The results of this research should only be generalized with caution. This study focused on four functions in HRM practices (i.e., compensation, training, performance appraisal, and career development); however, other factors may also influence Gen-Z employees' work engagement in the hotel sector. These include leadership style, organizational culture, job design, work-life balance, psychological well-being, and employee recognition. Future research could explore these aspects to provide a more holistic understanding of work engagement among Gen-Z hotel employees.

The respondents who participated in this study were working in Hotel (3-5 stars) in Kota Kinabalu; therefore, the results presented within might not be generalized to employees working outside Kota Kinabalu. Several factors such as average educational attainment, availability of employment, mean socioeconomic status of the local population, access to and affordability of consumer goods and services, as well as will unemployment rate likely play a role in shaping the perceptions and opinions of all potential respondents.

This study, if expanded to hotel employees outside the Kota Kinabalu, may likely render divergent results from those presented in this study while introducing alternative factors that influence Gen-z work engagement. Future research could employ longitudinal studies, qualitative approaches such as in-depth interviews or focus groups, or experimental designs to gain deeper insights into the evolving nature of work engagement among Gen-Z employees in the hotel sector.

7.0 Conclusion

This study examined the effect of HRM practices (compensation, training, performance appraisal and career development) on work engagement among Gen-z in hotel sector. The findings indicate that compensation and career development influence their work engagement. The significance of career development indicates that Gen-Z employees are highly motivated by opportunities for personal and professional growth. Clear career progression pathways, mentorship programs, and upskilling initiatives play a vital role in sustaining their engagement and fostering long-term commitment.

Similarly, the strong relationship between compensation and work engagement highlights the importance of competitive and transparent remuneration structures in addressing this generation's financial needs and lifestyle preferences. These findings suggest a need for organisations to strive to develop attractive compensation packages and clear career development for their employees. Hotel operator should focus on these function by prioritizing career development and provide attractive compensation packages, which would enhance work engagement among Gen-z.

Conversely, the lack of significant relationships for performance appraisal and training suggests that traditional approaches to these practices may not resonate with Gen-Z employees. Performance appraisal systems might need to shift from annual reviews to more dynamic, continuous feedback mechanisms that align with Gen-Z's preference for immediacy and relevance. Similarly, training programs may require greater customization, leveraging innovative and technology-driven methods such as gamification, microlearning, or virtual reality to increase their impact and relevance.

From a theoretical perspective, this study contributes to the growing body of literature on work engagement by highlighting the importance of generational considerations and industry-specific contexts. It supports the notion that engagement drivers are not universal and must be tailored to the demographic and organizational characteristics of the workforce. For the hotel industry, known for its high turnover and labor-intensive nature, these findings provide a roadmap for designing HRM strategies that effectively address Gen-Z employees' unique needs.

Practically, the study offers actionable recommendations for hotel managers and HR professionals. By prioritizing career development and enhancing compensation strategies, organizations can create a more engaged and motivated workforce. At the same time, the results suggest the need to rethink and innovate performance appraisal and training practices to ensure they align with the evolving expectations of younger employees. Future research could expand on these findings by exploring additional factors that influence work engagement among Gen-Z employees, such as workplace culture, leadership styles, and job design. Cross-industry and cross-regional studies could also provide broader insights into the generalizability of these results. Understanding these dynamics will be crucial for organizations aiming to attract, retain, and engage the next generation of talent in an increasingly competitive labor market.

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Digital Well-Being Towards Leadership Dynamics and Emotional Resilience Among Employees in Organisation

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ABSTRACT

This research paper explores the intersection of digital well-being, leadership dynamics, and emotional resilience among employees within organisational settings. As the workplace increasingly incorporates digital technologies, the impact of digital devices on employee well-being has gained prominence. This study examines how leadership styles and dynamics influence employees' experiences of digital well-being, focusing on emotional resilience outcomes. This study employed a quantitative survey method by analysing data from 411 employees in multinational organizations that used digital devices to perform their daily office tasks. Findings reveal that positive leadership dynamics significantly enhance digital well-being, improving employees' emotional resilience. Conversely, negative perceptions correlate with heightened stress and disengagement. Data were analysed using SPSS software version 29 in assessing the relationship between digital engagement, leadership support, and mental health indicators. The paper highlights the importance of fostering supportive leadership practices to promote digital well-being, ultimately contributing to healthier organisational environments. The study relies on cross-sectional data, which captures only a glimpse of employee experiences. A longitudinal approach could provide deeper insights into how digital well-being and leadership dynamics evolve over time. Recommendations for organisations to enhance leadership strategies and digital health initiatives are provided to ensure employee mental well-being in a digital age.

Keywords: *Digital Well-being, Leadership Dynamics, Emotional Resilience, Employees, Organisation.*

1.0 INTRODUCTION

In today's rapidly evolving digital landscape, employee well-being has emerged as a crucial element in organisational success. Since employee well-being has grown in importance, leaders must adjust to the challenges of technological change and give priority to developing encouraging and effective work environments in the face of digital innovation. Effective leadership in the digital era necessitates both technical expertise and the capacity to promote and improve the well-being of team members. Building on their influence, leaders are responsible for setting the tone and play a crucial role in influencing digital well-being by developing strategies that encourage responsible technology use and support employees in overcoming the difficulties presented by the digital workplace. Furthermore, leaders may reduce the possible negative consequences of digital engagement, such as stress and burnout, by encouraging behaviours that enhance well-being and emotional resilience (Agustina et al., 2020; Bakker et al., 2007; Blankson, 2021, Shatha & Bajaba, 2024). Leaders who emphasise digital well-being can create environments that improve emotional resilience, that is, the ability to adapt to stress and adversity, enabling employees to manage the demands of modern work life. Strategies leaders can adopt to emphasise digital well-being include fostering open and honest communication, demonstrating empathy, conduct training, and engaging in proactive problem-solving (Blankson, 2021; Yang et al., 2024). Strong emotional resilient workers are better able to withstand the demands of constant digital engagement and the fast-paced environment of a tech-driven workplace (Kohn, Frank & Holten, 2023).

Despite the growing recognition of the importance of digital well-being and emotional resilience, studies on their intersection with leadership dynamics remains limited. This is especially true for multinational organisations that operate in highly digitalised contexts. This study aims to explore how leadership styles and dynamics influence digital well-being, focusing on fostering emotional resilience outcomes. It seeks to provide insights into the interplay between leadership strategies and employees' psychological adaptation to digital workspaces, addressing a critical gap in contemporary organisational research. The convergence of digital well-being, leadership dynamics, and emotional resilience is notably important as it affects both individual performance and the overall health of the company. This article analyses the tactics and techniques leaders may utilise to foster digital well-being and emotional resilience, hence enhancing a more dynamic and resilient workplace culture.

2.0 LITERATURE REVIEW

2.1 DIGITAL WELL-BEING IN ORANISATIONAL SETTINGS

The concept of digital well-being has gained significant attention as organisations increasingly rely on digital technologies to enhance productivity and streamline operations (Marsh, Vallejos & Spence, 2022). Defined as the impact of these technologies on leading a meaningful and balanced life, digital well-being is often contrasted with negative behaviours such as excessive use or addiction, which are commonly linked to digital ill-being (e.g., Abeele, 2021; Burr, Taddeo & Floridi, 2020). In organisational settings, digital technologies are widely used for communication, managing tasks, and collaboration (Kraus et al., 2022). While these tools can improve efficiency among its employees, studies show that employees who frequently engage with digital devices for work are more likely to experience stress related connectivity and excessive workload such burnout, and demotivation (Bunjak, Černe & Popovič, 2021; Marsh, Vallejos & Spence, 2024a; Marsh, Vallejos & Spence, 2024b). Non-stop connectivity and information overload are now seen as common challenges that affect employees' well-being (Bunjak, Černe & Popovič, 2021; Marsh, Vallejos & Spence, 2024a). Thus, strategic initiatives are needed to ensure digital tools are used in ways that support employee well-being rather than hinder them (Johnson et al., 2020). Organisations that fail to address these challenges often see declines in productivity and performance, (Bourlakis, Nisar & Prabhakar, 2023; McParland & Connolly, 2019).

Conversely, well-designed digital interventions can improve employee well-being. For instance, organisations that prioritises work-life balance and promote occasional digital disconnections report greater levels of employee engagement and happiness (Agustina et al., 2020; Marsh, Vallejos & Spence, 2022; Pansu, 2018). Additionally, reducing the negative consequences of digital interaction can be achieved by offering training on effective digital tool usage and setting clear communication boundaries (Flanagin, Pearce & Bondad-Brown, 2010).

A comprehensive grasp of the ways in which digital tools interact with organisational cultures and employee behaviours is necessary for effective digital well-being strategies, emphasising the role that leadership plays in creating supportive environments. In this sense, leadership is crucial because a more positive workplace culture is created by leaders who set an example of balanced digital practices and assist employees in handling digital demands (Pontefract, 2024).

2.2 LEADERSHIP AND DIGITAL WELL-BEING

Leadership styles play a major role in supporting employee's experiences of digital well-being (Larjovuori et al., 2016). Leadership in the digital era demands a profound blend of emotional resilience and a deep commitment to staff well-being. Digital leaders must embody vision and agility, guiding their teams through the complexities of technological transformation while safeguarding emotional and mental wellness (Tagscherer & Carbon, 2023). Effective leaders create environments where innovation thrives alongside well-being by balancing the fast-paced demands of digital change with a compassionate understanding of employee needs. They address the technical challenges of digitalisation and the psychological, social, and physical dimensions of workplace dynamics, fostering a culture of support and resilience that empowers individuals and organisations to excel (Duarte & Dias, 2023).

Leadership dynamics, including transformational, ethical, and e-leadership approaches, have been shown to significantly impact employee well-being by promoting adaptability, reducing stress, and enhancing psychological safety (Maheshwari et al, 2024). Positive leadership behaviors, such as providing support, recognition, and fostering inclusivity, contribute to employee satisfaction and emotional well-being, particularly in the context of digital work environments (Azila-Gbettor et al, 2024). Research has highlighted that transformational leadership, which emphasizes vision, empathy, and motivation, positively impacts employee digital well-being. Transformational leaders encourage healthy digital practices by promoting boundaries between work and personal time, ensuring employees are not overburdened by the 'always-on' nature of digital communication tools (Tagscherer & Carbon, 2023).

In contrast, authoritarian or laissez-faire leadership styles may exacerbate digital stress, leading to burnout and reduced well-being. Digital leadership, a subset of transformational leadership, is defined by a leader's ability to navigate digital transformation while fostering an inclusive and supportive work culture (Wang et al., 2023). Leaders who embody digital leadership facilitate the integration of digital tools while mitigating risks associated with digital overload, such as constant connectivity and loss of personal time.

2.3 EMOTIONAL RESILIENCE IN ORGANISATIONS

Emotional resilience, often described as the ability to adapt, recover, and thrive in the face of adversity, is critical for employees navigating the complexities of modern organisational environments (Bharwaney, 2015; Murden et al., 2018). Within the context of digital well-being and leadership dynamics, emotional resilience emerges as a vital factor influencing employee performance, engagement, and overall well-being. Resilience enables employees to handle pressures effectively, reducing burnout and improving productivity (Khammarnia et al., 2024).

In the workplace, emotional resilience is not only a personal trait but also a skill that can be nurtured through supportive environments, effective leadership, and organisational policies (Murden et al., 2018). Stressful events in organisations may be caused by factors such as high workload, interpersonal conflicts, or rapid technological changes (Marsh, Vallejos & Spence, 2022). These challenges demand adaptive responses from employees, influenced by factors both within the employees' control, such as mindset and coping strategies, and beyond it, including organisational culture and leadership support.

The digital workplace introduces challenges of emotional resilience. Digital fatigue resulting from excessive screen time and constant connectivity can be seen as an increasing issue within the digital workplace (Hamperl & Kunze, 2023). Employees often face information overload, blurred work-life boundaries and 'always-on' culture (McDowall, A. & Kinman, G., 2017; Tagscherer & Carbon, 2023). Employees with higher levels of resilience, are able to adapt to these challenges and maintain their well-being despite the excessive pressures of digital environments (Liu et al., 2023).

3.0 METHODOLOGY

This deductive research applies a research survey among employees from selected multinational organisations in Klang Valley. The respondents were purposively selected to meet the following criteria:i) aged 20 until 60 years old. ii) employed by multinational organisations, and iii) digitally literate. Purposive sampling was used as this sampling method allows the researcher to select samples who meet the criteria listed above, which are specific and relevant to the study. This can help to ensure that the samples are highly relevant to the research objective, which can lead to more accurate and reliable findings for the study (Hossan et al., 2023).

3.1 SAMPLING

Data were collected from October to December 2024 using a 40-item questionnaire administered via an online survey. Initially, 430 respondents participated; however, following rigorous data cleaning procedures, which verify the sample criteria. All duplicate data from the items will be eliminated to guarantee that each data point is unique and free from redundancy. A scatter plot is employed to ascertain the presence of any outliers within the data collection. Items with a factor loading below 0.6 will be eliminated. Data is routinely verified to confirm that all variables align with the study and that requisite data are provided. Straight lining was detected by looking for patterns from samples in their responses. The final sample comprised 411 respondents who met the established criteria.

3.2 MEASUREMENT TOOL

The questionnaire tool utilised for this study was adapted from various sources (Kupiek, 2021 & Fischer et al, 2023) to determine the relationship of those who are digitally literate towards leadership dynamics and their emotional resilience. The questionnaire was distributed through an online survey for data collection. The questionnaire covered 11 items for digital well-being, 11 items for leadership dynamics, and 10 items representing emotional resilience. In addition, socio-demographic data such as gender, age group, department, organisational level, and types of organisation they are serving, besides their usage on digital media, was gathered as a part of the data collection. Reliability analysis was employed to assess reliable instruments to enhance the precision of the collected data, resulting in more credible and correct results. Through reliability analysis, Cronbach alpha's value of more than 0.6 is acceptable for data collection (Kennedy, 2022).

Data were analysed using SPSS software version 29 as it is the latest SPSS version that is useful for quantitative data analysis. SPSS was used to analysed the descriptive analyses, including the age group and most frequent digital platform utilised by respondents, were determined by frequencies and percentages for variables. Pearson correlation was applied to determine the relationship between digital well-being towards leadership dynamics and emotional resilience. Identification of class intervals was also employed in order to identify the level for all variables.

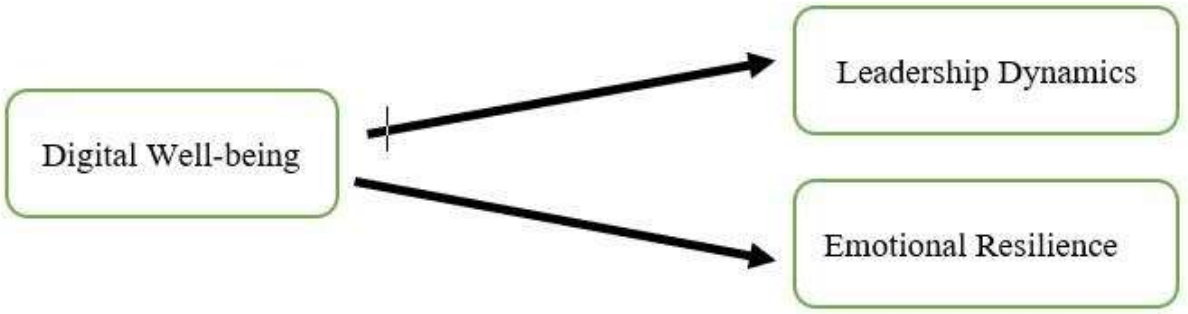

Figure 1: Framework of Digital Well-being towards Leadership Dynamics and Emotional Resilience

4.0 RESULTS

Age	Frequency	Percentage
20-30	139	33.8
31-40	220	53.5
41-50	36	8.8
51 -60	16	3.9
Total	**411**	**100**

***Table 1:** Age Group of the Respondents.*

The majority of the respondents (53.5%) were in the age group of 31–40. This age group was those who were the majority working in organisations. Referring to Statista in 2023, approximately 2.43 million employees from various organisations between the ages of 30 and 40 years old were employed in Malaysia, making it the largest age group of people in employment. Employees aged 30-40 years old also contributed to the majority of digital media usage in organisations. Ewing, Men and O'Neil (2019), mentioned that organisations with best practices in applying digital media will engage employees involving leadership and employees social advocates that relate to their emotional stability.

The majority age group was followed by fresh graduates aged 20-30 (33.8%). By comparison, the least employed were those 51–60 years old (3.9%). Older employees aged 50 and above may have had less exposure to digital technologies throughout their careers compared to younger colleagues, leading to lower digital fluency (Hamperl & Kunze, 2023). Digital fluency encompasses both digital knowledge and digital self-efficacy—the belief in one's ability to use digital tools effectively.

Frequent Digital Media Used	Frequency	Percentage
Facebook	64	15.7
X	67	16.3
Instagram	73	17.8
Tik Tok	86	20.8
LinkedIn	90	21.9
Snapchat	31	7.5
Total	**411**	**100**

Table 2: *Most Frequent Use of Digital Media in Organisations.*

LinkedIn emerged as the predominant digital platform utilised by organisations, accounting for 21.9%, followed by TikTok and Instagram. Recent trends indicate that organisations extensively utilise social media platforms such as LinkedIn, Instagram, and X (previously Twitter) for marketing, consumer engagement, and internal communications. LinkedIn remains the premier medium for professional networking, while Instagram and Facebook are favoured for brand promotion and visual content (Auxier & Anderson, 2021). Numerous organisations are progressively utilising YouTube for content marketing and TikTok to engage younger digital users.

LinkedIn is specifically tailored for professional networking and career advancement, rendering it an ideal platform for organisational use (Cho & Lam, 2021). In contrast to other social media sites that emphasise personal relationships and entertainment, LinkedIn offers a venue for professionals to network, exchange industry knowledge, and investigate career prospects (Davis et al., 2020). This emphasis corresponds with the organisation's objectives of promoting professional development and teamwork.

Digital Well-being	Frequency	Percentage
High	71	17.3
Moderate	298	72.5
Low	42	10.2
Total	**411**	**100**

Table 3: *Level of Digital Well-Being Among Employees in Organisations.*

The finding reveals that the majority (72.5%) of the staff in organisations have a moderate level of digital well-being due to their increased screen time. Many employees are willing to spend their amounts of time on digital devices, which can lead to digital fatigue and might negatively impact their mental health.

Digital wellbeing, marked by exhaustion and diminished productivity due to extended digital interaction, is an escalating issue in the workplace (George, 2024). Findings indicate that prolonged screen exposure might result in digital tiredness, adversely affecting mental health. Digital well-being is often caused by prolonged screen time that can lead to several symptoms such as eye discomfort, headaches, overall tiredness, and emotional resilience (Nakshine et al., 2022). These symptoms can affect daily work tasks and overall well-being. Extended screen exposure, particularly in the absence of sufficient pauses, might intensify these symptoms and lead to a deterioration in general well-being.

Leadership Dynamics	Frequency	Percentage
High	12	2.9
Moderate	252	61.3
Low	147	35.8
Total	**411**	**100**

Table 4: *Level of Leadership Dynamics of Employees in Organisations.*

Leadership dynamics shows a moderate level of leadership (61.3%) towards digital well-being in organisations. Different leadership styles, such as autocratic, democratic, transformational, and transactional, impact how digital well-being is managed. Walter (2024) agreed that leaders who are not well-versed in digital tools or who do not prioritise digital well-being may contribute to moderate levels of support and guidance to their employees.

Leaders might need proper communication channels to enhance digital well-being in the organisation. Effective communication is crucial for leadership dynamics. Leaders who maintain open lines of communication and encourage feedback are better able to support digital well-being (Burr, Taddeo & Floridi, 2020). Conversely, poor communication can lead to misunderstandings and moderate levels of digital well-being. Monteiro and Joseph (2023) mentioned that improving leadership dynamics through better training, fostering a supportive culture, and ensuring effective communication can help enhance digital well-being among employees in organisations.

Emotional Resilience	Frequency	Percentage
High	19	4.6
Moderate	294	71.5
Low	98	23.8
Total	**411**	**100**

Table 5: *Level of Emotional Resilience of Employees in Organisations.*

Employees experienced a moderate level (71.5%) of emotional resilience related to digital overload due to constant exposure to digital devices and information leading to digital fatigue, making it harder for employees to maintain a high level of emotional resilience. The support systems from the organisations, including access to mental health resources and training on digital well-being, play a vital role in supporting employees in managing their emotions towards adapting to digital devices in the workplace. Inadequate support results in only a moderate level of emotional resilience.

On the condition of enhancing emotional resilience among employees, organisations can improve digital well-being initiatives, provide better support, and foster a positive organisational culture (Ayaji & Udeh, 2023).

Variable	Digital Well-Being	
	r-value	p-value
Leadership Dynamics	0.580	.001
Emotional Resilience	0.477	.001

Table 6: *Relationship between Digital Well-Being towards Leadership Dynamics and Emotional Resilience in Organisations.*

Findings from Table 5 reveal that digital well-being has a significant and moderate relationship with leadership dynamics and emotional resilience among employees in the organisation ($r=0.580$, $p<0.05$. $r=0.477$, $p<0.05$). Moderate relationships between digital well-being, leadership dynamics, and emotional resilience among employees are attributed to effective digital leadership, which involves guiding their teams through digital transformation, which can be challenging. Leaders who possess strong digital skills will create a supportive digital culture that tends to enhance employees' digital well-being (Chatterjee et al., 2023). Although leaders might lack some of the skills, they still can lead to moderate levels of digital well-being among employees.

Digital well-being significantly impacts emotional resilience, although at a moderate level. Employees who manage their digital interactions well are better equipped to handle stress and adapt to changes. However, constant connectivity and digital overload can strain emotional resilience, leading to only a moderate level of digital well-being. Organisations might need to focus on other factors related to individual differences and organisational support through comprehensive digital well-being programs, supportive leadership (Trenerry et al, 2021) and fostering a positive digital culture that can help to improve the overall relationship between digital well-being, leadership dynamics, and emotional resilience.

4.0 DISCUSSION

Based on the results, it can be seen that organisations need to develop strategies that could improve digital skills among its employees. These strategies should be suitable to be adopted across demographics to ensure inclusivity and effectiveness. For instance, employees aged 31-40 years, who are often in the middle of their career progression, tend to engage more with digital media compared to other age groups. Their higher engagement in digital media highlights the need for digital well-being initiatives tailored to their needs. Such initiatives can help them navigate the digital workspace effectively while reducing the risks of digital fatigue and technostress. This aligns with the research objectives of identifying key factors influencing digital well-being and how they differ across age groups. Additionally, it reinforces findings from past literature, which indicates that digital engagement patterns vary significantly across demographics, affecting overall digital fluency and resilience (Hamperl & Kunze, 2023).

4.1 THE ROLE OF LEADERSHIP IN SUPPORTING DIGITAL WELL-BEING

The study's findings show that leadership is essential to promoting digital well-being within organisations, especially as the usage of digital tools in the workplace increases. The respondents reported moderate levels of emotional resilience (71.5%), leadership dynamics (61.3%), and digital well-being (72.5%), highlighting the urgent need for leaders to create relevant strategies to address these challenges. Digital well-being involves creating a well-balanced of usage of digital tools that can increase productivity in the workplace and ensures that the tools do not lead to well-being issues such as burnout, fatigue, or stress. As organisations are increasingly relying on digital tools to function, leaders must ensure that these tools are integrated successfully within the day-to-day work of their employees while ensuring their mental well-being is not compromised. These findings highlight the crucial role of leadership in shaping digital well-being. Leaders who adopt transformational leadership styles can reduce technostress and improve workplace digital adaptation, ultimately fostering a more resilient and engaged workforce (Tagscherer & Carbon, 2023).

Findings also highlight on the importance of leadership styles in supporting employee digital well-being. It was found that different leadership styles such as autocratic, democratic, transformational, and transactional have an impact on how digital well-being is managed. This is similar to the study conducted by Maheshwari et al. (2024). They indicated that leaders who adopt more transformational, ethical, or e-leadership approaches would be able to promote adaptability, help reduce stress, and enhance psychological safety among their employees (Maheshwari et al., 2024). Transformational leadership has been linked to better outcomes in digital well-being and those who adopts this style would improve employee efficiency and satisfaction (Antonopoulou et al., 2021; Maheshwari et al., 2024; Tagscherer & Carbon, 2023). In addition, transformational leaders are more likely to promote work-life balance (Khan et al., 2020). The results support the claim that employees' digital well-being is significantly impacted by leadership styles. According to Larjovuori et al. (2016), effective leadership creates a positive digital workplace where employees may overcome obstacles and remain resilient.

Current findings also suggest that leaders must be well-versed in digital tools and prioritise digital well-being to support their employees (Ahuja et al., 2023). As mentioned previously, Tagscherer and Carbon (2023) believe that effective digital leadership requires a blend of both emotional resilience and commitment to employee well-being. In addition, leaders who encourage balanced use of technology, respect for work-life boundaries, and open communication can create a work environment that allows employees feel supported and reduce the pressure of digital work environments (Duarte & Dias, 2023). Also, digital leaders should act as facilitators, ensuring that digital tools enhance productivity without leading to employee burnout (Pontefract, 2024).

4.2 IMPROVING DIGITAL SKILLS AMONG EMPLOYEES

Findings also show that younger employees (20-30 years) and older workers (51-60 years) differ significantly in their level of digital fluency. This may be due to limited exposure to digital tools throughout older employees' career compared to younger employees who are more digitally adept. However, younger employees are seen vulnerable to digital fatigue due to excessive screen time and connectivity demands. With more than half of employees reporting moderate digital well-being, the findings also highlight a pressing need for organisations to ensure that employees improve in digital skills, and at the same time, prevent them from experiencing digital overload.

The ability to effectively use digital tools in today's technology-driven workplace, is important. Employees with higher digital fluency are able to demonstrate better emotional resilience, enabling them to adapt to the pressures of digital work environments. Thus, to guarantee inclusive involvement in digital workflows, specific digital skill-building initiatives are required, especially for senior employees. Hamperl and Kunze (2023) had indicated that digital fluency, which comprises both knowledge and self-efficacy, is important for workplace adaptation and engagement. By providing employees with the digital skills they require through training, organisations can improve the overall workplace experience of their employees (Monteiro & Joseph, 2023). Digital literacy training plays a crucial role in employee engagement and producitivyt (Bergson-Shilcock, 2020). Tailored training programs based on employee demographics are essential as older employees could benefit from foundational digital skills training compared to younger employees who may benefit from advanced tools (Bergson-Shilcock, 2020). Tailored programs could also bridge the digital divide that organisations are currently facing (Hamperl & Kunze, 2023).

4.3 PROMOTING EMOTIONAL RESIILENCE IN THE DIGITAL WORKPLACE

Another key strategy that organisations can implement is to promote emotional resilience. The current study shows that 71.5% of employees demonstrated moderate levels of emotional resilience and this was mainly caused by digital fatigue and inadequate organisational support. Prolonged screen time, digital overload, and lack of mental health support have prevented employees from managing their stress effectively. Tagscherer and Carbon (2023) had highlighted that organisations must integrate mental health resources into digital well-being initiatives to strengthen emotional resilience. Resilient employees are better equipped to cope with digital demands, minimizing fatigue and enhancing overall well-being (Maheshwari et al., 2024; Murugan & Natarajan, 2022). Furthermore, structured breaks and digital policies can mitigate digital fatigue (Hamperl & Kunze, 2023; Sanchez-Segura et al., 2023). Tagscherer and Carbon (2023) further argue that emotionally resilient employees are more capable of thriving in digital work environments. Digital fatigue is a growing workplace issue requiring structured interventions (McDowall & Kinman, 2017).

As mentioned previously, leaders play a vital role in supporting employee resilience. The study's findings show that positive leadership dynamics may reduce stress and enhance psychological safety among employees. Transformational leaders, in particular, can foster resilience among its employees by motivating them and recognising their digital contributions (Duarte & Dias, 2023). By fostering a culture that prioritises well-being, leaders can create a workplace where employees feel valued and supported, ultimately leading to a healthier and more sustainable digital work environment.

5.0 CONCLUSION

The interplay between digital well-being, leadership dynamics, and emotional resilience is complex and multifaceted. The findings indicate that organisations are moderately committed to digital well-being, with leadership dynamics scoring 61.3%. Employees report a moderate level of emotional resilience at 71.5%, suggesting challenges in maintaining high resilience due to digital overload and fatigue. Notably, digital well-being shows a significant and moderate correlation with both leadership dynamics ($r=0.580$, $p<0.05$) and emotional resilience ($r=0.477$, $p<0.05$), underscoring the interconnectedness of these factors in organisational settings.

The insights from this study underscore the pivotal role of leadership in promoting digital well-being and supporting employees' emotional resilience amid the challenges posed by constant digital exposure. Leaders who prioritize digital well-being can help mitigate the adverse effects of digital overload, thereby enhancing overall employee resilience. This is particularly important as digital transformation reshapes workplace dynamics, necessitating adaptive leadership strategies to foster a supportive and resilient organisational culture.

In the digital era, leadership extends beyond traditional management practices to encompass a deep understanding of digital tools and their impact on employee well-being. Leaders are now expected to be digitally savvy, updates with the latest technology. This shift requires leaders to develop new competencies and embrace a mindset that values empathy, inclusion, and adaptability. Furthermore, leaders who exhibit digital leadership skills play a crucial role in mitigating the negative effects of technostress by fostering an empowering work environment, thereby enhancing employee engagement and innovation. Digital leaders who foster a culture of innovation, adaptability, and open communication can inspire employees to think creatively and develop novel ideas, effectively countering the adverse effects of technostress.

Moreover, promoting emotional resilience through supportive leadership and organisational practices is essential in helping employees navigate the challenges of digital transformation more effectively. Leadership qualities such as effective communication, emotional intelligence, self-awareness, and the ability to foster trust and autonomy are critical for navigating contemporary challenges. By embracing these attributes, leaders can create a supportive environment that enables employees to adapt to digital disruptions and leverage technology for innovation and growth. By focusing on enhancing digital leadership skills, implementing targeted training programs, and promoting emotional resilience, organisations can better navigate the complexities of the digital age, ensuring both employee well-being and organisational success. This approach not only addresses the immediate challenges posed by digital transformation but also positions the organisation for sustained growth and competitiveness in an increasingly digital world.

However, this study has some limitations. The research was conducted within multinational organisations in Klang Valley, which may not reflect broader industry trends or the experiences of employees in different organisational contexts. Additionally, the study relied on self-reported data, which may introduce bias or inaccuracies. The complexity of digital well-being and leadership interactions also means that factors such as cultural differences and industry-specific challenges require further exploration.

In conclusion, to effectively address digital fatigue and bolster emotional resilience, organisations should focus on strengthening leadership dynamics that prioritise digital well-being. By doing so, organisations can create a more supportive environment that enables employees to navigate the demands of the digital era more effectively. Future research should explore the long-term effects of digital tool reliance on employee well-being and examine the efficacy of specific leadership strategies in mitigating digital fatigue and enhancing emotional resilience. Also, investigating cross-industry comparisons and qualitative insights into employees' lived experiences could provide a deeper understanding of how different leadership approaches influence digital well-being across various organizational settings.

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TRACK 6:

Operation Management and Supply Chain

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The Predictors of Work Overload and Work Conflict towards Work-life Balance among Public Schools Teachers

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Abstract: *Every profession has its own specific level of work-related stress. However, being a teacher is considered a highly stressful occupation due to the increased responsibilities and demanding work structure. Previous research revealed that one out of three teachers testified that teaching is extremely stressful and has caused this profession to have one of the highest annual turnover rates among professional occupations. The purpose of this study was to predict work stressors (work overload and work conflict) towards work-life balance. This research was conducted among school teachers at six selected public schools in Perak. A quantitative research methodology was utilized and data were collected using questionnaires. Census survey technique was employed where the whole population in all six selected public schools in Perak were taken as the respondents. Descriptive statistics and Multiple Regression analyses were applied in this study using SPSS 25. The findings revealed that work conflict were predictors towards work-life balance (β=-.477, p<0.01 and β=.181) among teachers, while work overload was not found to be the predictor (β=-.020, p>0.05). Although teachers in government schools may view work overload as part of their job and was not the influential factor towards their work-life balance, it is recommended that future researchers should look into areas of conflicting work demands, work conflict and changing or demanding*

work instructions from their supervisors that may impact work life balance or as factors that may reduce work stress. In addition, future researchers should look into other work stressors and work-life balance among teachers at private and semi-private schools and to expand the study nationwide involving both rural and urban school teachers.

***Keywords**: Public School Teachers, Work stressors, work overload, work conflict, work-life balance*

1. INTRODUCTION

Schools are becoming more stressful environment because teachers are facing work overload, increasing in job demands and this may jeopardize their work life balance (Toprak, Tosten & Elcicek, 2021). Compared to other profession, teachers have higher levels of psychological stress and burnout (Fathi, Greenier & Derakhshan, 2021). Teachers are being assigned with variety of responsibilities including helping school with administrative work, managing behavior of the students, participating in extracurricular activities, keeping track on students attendance and grading their assignments (Johari, Yean Tan & Tjik Zulkarnain, 2018). Johari, Yean Tan and Tjik Zulkarnanain (2018) also highlighted that because there is no longer a clear separation between work and life, teachers nowadays have a harder time to have a good work-life balance. When job and family are not properly balanced, negative outcomes including stress, tensions, and psychological distress may result (Sana & Aslam, 2018).

Work-life balance is an essential phenomenon and a significant issue that both public and private sector need to be concerned about because the impact of good work life balance will affect employees' job performance (Tamunomiebi, 2021). Similarly, Fazal, Naz, Khan and Pedder pointed out that work-life balance can be achieve when an employees is able to manage and prioritize both personal and work responsibilities. On the other hand, Ogechi & Nwaeke (2019) stated that employees are facing challenges in coping between work and life balance thus resulting in work-life imbalance. Work life balance among employees is essential since it will increase organizational effectiveness, lower stress level and enchance the health and well-being of an employee (Sánchez-Hernández, González-López, Buenadicha- Mateos, & Tato-Jiménez, 2019). Perhaps, one of the most work-life imbalance occupations is the teaching profession. In fact, the occupation of a teacher has been classified as an occupation that has high risk of facing failure to achieve a good balance between work and life because of the expectations of the stakeholders as well as the requirement to work after office hours and during holidays (Adam, 2020).

Umma and Zahana (2021) proposed that the establishment of work-life balance is crucial for an individual because having -life imbalance will contribute negative impact to an individual's work performance and personal life. Kashbuntoro, Maemunah, Mahfud, Fahlevi and Parashakti (2020) indicated the balance between work and life is when an individual can successfully handle and have equal time between their job and other activities such as time with the family, involvement in community activities and volunteering type of work, have good personal life, is able to improve personal growth and have time for leisure and recreation, they are said to have achieved a good work-life balance.

On the other hand, Omar, Aluwi, Fauzi and Hairpuddin (2020) stated that employees who successfully able to balance between work and life experience favorable work attitude, while those who fail to do so will experience negative effects for instance increase in level of work stress, decrease work productivity and increase absenteeism. Similarly, Ross & Vasantha (2014), pointed out that work-life balance and stress are inextricably linked in the sense that the effectiveness of workplace policies and practices to balance the employees' lives is important in order to support them in achieving their goals. Ghani, Ahmad and Ibrahim (2014), explained that teachers have significant responsibilities as they play a vital role in the formation and shaping Malaysia's future generation, in addition to imparting knowledge and serving as the students' role model. The researchers also added that, this stereotype can lead to work stress and deteriorate teacher's work-life balance. Ghani et al., (2014) explained that teachers face work-life imbalance due to overload and being unable to distribute time between family and work. Due to the blurring of the line between life and work, teachers are facing difficulties in striking a balance between their profession and personal life (Johari & Zulkarnian, 2018).

2. LITERATURE REVIEW

2.1 Work Overload and Work-life Balance

According to Hakro, Jhatial, and Chandio (2022), work overload is when the employees are expected to perform beyond their capabilities and having work overload will restraint the employees to perform well for the job thus lead to high level of work stress. Furthermore, Ramos, Francis and Philipp (2015) emphasized that the increase of work load will contribute to work-life imbalance among teachers because they were compromised between their family and leisure time. According to Johari and Johanim (2018), the occupation of a teacher is not only teaching but they need to carry out other tasks too for instance involving in the school's administration, managing students' discipline, grading homework and keeping track of the students' attendance. The researchers also stated that great amount of workload among teachers will also lead to undesirable work-life balance. As reported by Sinar Harian (September 29, 2020), The National Union of the teaching Profession (NUTP) had received a tremendous number of complaints from teachers venturing their frustration that they are being burdened with work overload resulting the Union to urge the Ministry of Education to reduce the work load of teachers.

Work overload generally refers when the management gives an employee with multiple tasks and require them to complete it with a tight deadline. This will result in a high level of stress among employees since he or she has limited skills, insufficient knowledge and experience to complete the task given (Khalil, Khan, & Shah, 2020) It has been found that work overload occurs due to the work demand and conflict that employees faced at their workplace and this will contribute to work exhaustion and eventually employees will decide to quit their job. (Tabassum, Farooq, & Fatima, 2017). This is supported by Zorec, Hocevar, and Erzen (2021) stressed out that employees with work overload are more prone to suffer from work stress and fatigue, which can cause an imbalance between their personal and professional lives. Moreover, according to Karatepe (2012), past research stated that teachers who faced excessive workload will have a lower work-life balance, emotional exhaustion and will affect the quality of their lives. According to Chana, Laib and Boeyc (2010) the occupation of teacher was reported to have the highest level of work overload against lawyers, nurses, engineers, insurance agents and doctors. This can be supported by a survey conducted by Berita Harian (September 27, 2012) stated that the

occupation with highest work overload is among teachers, police, nurses, firefighters, doctors and pharmacy assistants.

Similarly, Kimura, Bande and Ferrin (2018) found that work overload is critical in the organization especially for the occupation of a teacher. Majority of primary and secondary teachers reported that they encountered high level of stress due to work overload, country obligation and challenging in fulfill students' needs (Wang, 2021). Work overload occurs when there are various demands, either qualitatively or quantitatively and exceed the available resources, while qualitative workload occurs when the work is too difficult to do. Conversely, quantitative workload is when the employees face too many tasks to be completed (Razak, Yusof, Azidin, Latif & Ismail, 2014). Meanwhile, Goh, Ilies and Wilson (2015) claimed that there are no direct relationships between work overload and life satisfaction among employees.

2.2 Work Conflict and Work-life Balance

Work conflict is linked to contradicting role expectations when there is a difference between the expectations of employer and employee performance (Rizwan, Tariq, Hussain, & Khawar, 2013). Work conflict occurs when employees are presented with conflicting and incompatible expectation behaviors in carrying out their duties (Ebbers & Wijnberg, 2017) Kamel (2011) on the other hand, argued that work conflict happens within a single role, for instance when the employees receive orders or messages from two or more individuals on how to execute the tasks. Department of Justice and Attorney General (2012), stated that one factor of work stress to occurs when there are conflicting roles in the organization. According to Ebbers and Wijnberg (2017), work conflict at the workplace can have a positive effect that is when employees are forced to define their work roles.

A study conducted by Hazalena, Nurul and Panji (2017), reported that in the organization, assigning workers roles that are not compatible with their responsibilities or having standards that go beyond their responsibilities can lead to work conflict. According to Bakar and Salleh (2015), teachers always encounter work conflict due to the need to complete more than one expectation from the school's management, thus will increase work overload of teachers, such as increased teaching hours, the need to attend meetings and paperwork. In addition to work conflict, Sana & Aslam (2018) pointed out that over the past 20 years, there has been a significant study on teachers' role demands, such as role conflict and role ambiguity whereby teachers encounter role conflict and role ambiguity because they find it difficult to balance the conflicting and incompatible expectations made by parents, administrations and students.

Yesilitas (2014), reported that work conflict occurs when there are too many requests that come from multiple stakeholders, and these requests lead the employees being unable to fulfill them. Moreover, several studies have found negative relationships between work-life balance and work conflict. In addition, according to Steiner and Woo (2021) found out that number of people who are interesting to work as a teacher is declining and high percentage of teachers are becoming more open of changing their careers due to work conflict. The main cause of stress among teachers are work conflict that shows positive relationship with poor job performance, work-life imbalance, unhappy with their job and mental illness (Pervez, Noshaba, Arshad & Noureen, 2021).

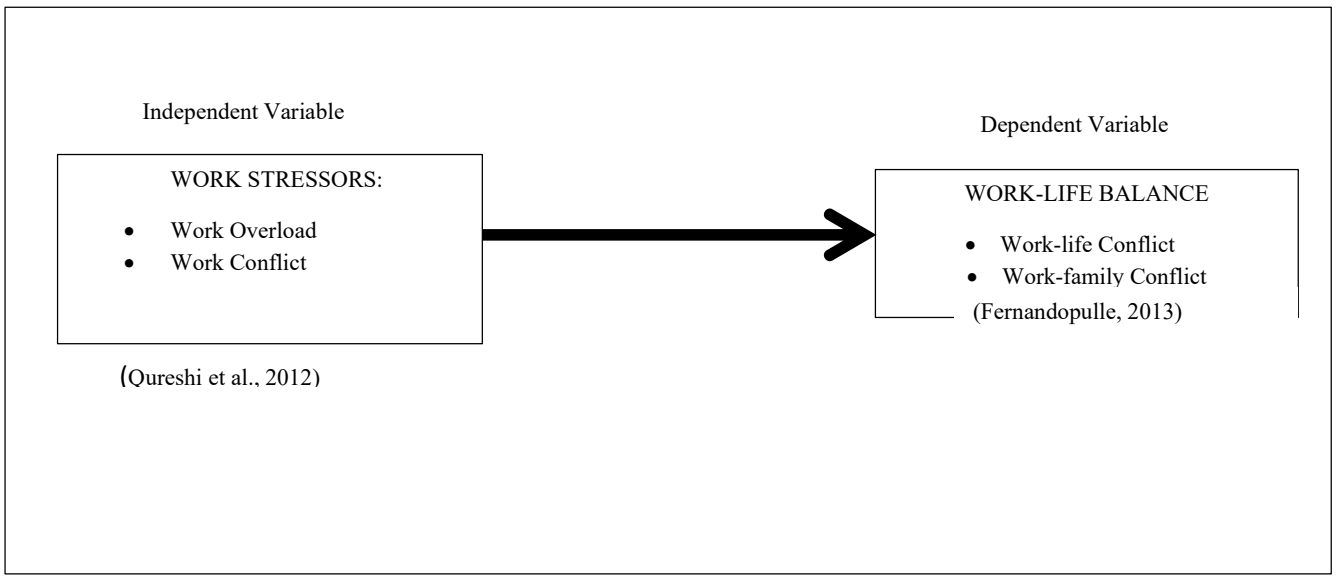
Teachers encountered work stress due to the work conflict they experienced at the work place, because teachers need to carry out various job demands such as teaching and performing administrative tasks which cause stress and fatigue (Roslan, Ho, Ng & Sambasivan, 2015). Work and family are an important element in teachers' work life, thus when they encountered work conflict, it will jeopardize their work-life balance (Asfahani, 2021). This can be supported by research conducted by Haider and Agha (2019), stated that teachers face work stress due to work overload and work conflict time constraint to complete their task makes it difficult to balance between their work and non-work obligations, which can lead to a failure to main a healthy work-life balance.

2.3 Research Hypotheses and Objectives

Figure 1 shows the conceptual framework on the relationship between work stressors and work-life balance among teachers. Two research objectives were formulated for this study which were: (1) To identify the relationship of work stressors and work-life balance among teachers and (2) To predict the dimension (s) of work stressors towards work-life balance among teachers. Several hypotheses were also formulated for this study which were:

H1 Work overload has a relationship towards teachers' work-life conflict.
H2 Work conflict has a relationship towards teachers' work-life conflict.
H3 Work overload has a relationship towards teachers' work-family conflict.
H4 Work conflict has a relationship towards teachers' work-family conflict.
H5 Work overload is the predictor towards teachers' work-life balance.
H6 Work conflict is the predictor towards teachers' work-life balance.

Figure 1 Conceptual Framework on the Relationship between Work Stressors and Work-life Balance



3. Results and Discussions

3.1 Reliability Analysis

Cronbach's alpha was administered in order to measure the reliability of the instruments. Sekaran & Bougie (2010) reported that instruments used in a study must be tested for their consistency and stability. Table 2 shows the Cronbach's alpha reliability value for each of the sub variables. According to Hair et al., (2003) the rules of thumb is that

the reliability of 0.90 and above is considered as excellent. While reliability of >0.70 and >0.80 are good. A reliability is <0.60 is considered as poor.

Table 2: Reliability Analysis

Variables	Cronbach's Alpha
Work Stressors	
Work Overload	.712
Work Conflict	.642
Work-life Balance	
Work-life Conflict	.927
Work-family Conflict	.783

3.3 Pearson-Correlation and Multiple Regression Analysis

Table 3 shows the findings on the correlation between two sub-variables from work stressors which are work overload, and work conflict toward work-life balance which are work-life conflict and work-family conflict among teachers at six selected schools in Perak. The results pointed out that all variables were positively and significantly related to work-life balance with the r values of (r=--.323, r=.380, r=-.596, r=.435, r=p<.01) respectively. Therefore, hypotheses H_1 H_2, H_3, H_4, were supported.

Table 3: Correlation between respondents' Work Stressors and Work-life Balance

		WORK OVERLOAD	WORK CONFLICT	WORK LIFECONFLICT	WORK FAMILYCONFLICT
WORK OVERLOAD	Pearson Correlation	1	.440**	-.323**	.380**
	Sig. (2-tailed)		.000	.000	.000
	N	309	309	309	309
WORK CONFLICT	Pearson Correlation	.440**	1	-.596**	.435**
	Sig. (2-tailed)	.000		.000	.000
	N	309	309	309	309
	Sig. (2-tailed)	.402	.001	.000	.003
	N	309	309	309	309
WORK LIFECONFLICT	Pearson Correlation	-.323**	-.596**	1	-.556**
	Sig. (2-tailed)	.000	.000		.000
	N	309	309	309	309
WORK FAMILYCONFLICT	Pearson Correlation	.380**	.435**	-.556**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	309	309	309	309

**. Correlation is significant at the 0.01 level (2-tailed).

Multiple Regression Analysis

Findings from the regression analyses between work stressors sub-variables which are work overload, and work conflict towards work-life balance were tabulated in **Table 4.** It was found that R2 was .293, in which all of the sub-domains of work stressors explained 29.3% of the variance (R square) for work-life balance, with significant of F value of .000. In addition, the Durbin Watson value was 1.815, which indicated a positive autocorrelation, in line with one of the assumptions for bivariate and multivariate correlation analyses. The analysis revealed that the sub-domain of work stressors which was work conflict as the highest predictor towards work-life balance (β=.181, p<.000. Finally, the sub-variable of work overload was not found to have any significant influence towards work-life balance among teachers. In conclusion, it can be concluded that work conflict was the only positive predictor towards work-life balance. Therefore, H5 is rejected and H6 is accepted.

Table 4 Multiple Regression Analysis

Independent Variables	Standardized Coefficients Beta	T	Sig.
Work Overload	-.020	-.376	.707
Work Conflict	**.181**	3.668	**.000**
R Square		.293	
F		32.496	
Sig. F value		.000	
Durbin Watson		1.815	

The level of work-life balance among teachers revealed some very interesting facts. For the purpose of this study, descriptive statistics were computed for both independent and dependent variables. The interpretation of the scores were based on the Best Principle (Thaoprom, 2004). Scores were divided by three ranges which are high, average and low with the computation like this: 5-1/3=1.33.

Thus, the results are:

- Mean scores between 1-2.33= Low Scores
- Mean scores between 2.34-3.67 = Moderate Scores
- Mean scores between 3.68-5.00 = High Scores

Based on the results displayed in the Table 5, the level of work stressors among teachers at selected schools in Perak is high which is 3.82 (SD=0.319). On the other hand, the level of work-life balance among teachers can be considered as medium with the level scores of 2.89 (SD=0.514). Thus, it can be concluded that the score for work stressors was the highest M=3.82 and followed by work-life balance with the value of M=2.89.

Table 6: Level of Teachers' Work-life Balance

Variables	N	Mean	Std. Deviation	Level
Work Stressors	309	3.82	.31934	High
Work-life Balance	309	2.89	.51415	Medium

Based on the result indicated above, the level of work stressors among teachers at selected schools in Perak can be considered as high level and work-life balance among the teachers was medium. The high level of work stressors and medium level of work-life balance among teachers are indicative that actions should be taken by authorities to reduce the level of work stressors in order to improve work-life balance among teachers.

Nayeem & Tripathy (2012), revealed the findings in their study that teachers are experiencing the highest level of work stress among other occupations in the world and the causes of work stress has been associated with work overload and students' behavior. Moreover, Major & Margason (2011) reiterated that work conflicts are one of the indicators of work stressors and it was found to decrease the work-life balance among teachers. The result of this study is similar with the study conducted by Punia & Kamboj (2013) which revealed that the scores of work-life balance among teachers in India was at medium level (M=3.60, SD=.89). The researchers also stated that if teachers were able to devote a considerable time between work and family, they would be able to feel more satisfied with their work and a balanced work-life. Thus, the result in this research suggest that in order to improve the level of work-life balance among teachers, it is crucial for the educational institution to control and reduce the work pressures among teachers and review the policies imposed (Punia & Kamboj, 2013).

4. CONCLUSION

This research was conducted with the intention to determine the relationship between work stressors and work-life balance among teachers at six selected schools in Perak. Based on the statistical analyses, it was found that two dimensions of work stressors (work overload, and work conflict) had significant relationships towards teachers' work-life balance. Moreover, it was also found that the work conflict was a positive predictor towards teachers' work-life. Therefore, it would be a wise step for the school's administrators to minimize and be aware of work stressors encountered by teachers to improve their work-life balance. As mentioned before because being a teacher is considered as a highly stressful occupation due to the increased responsibilities and demanding deadlines and has caused teachers to be more stressful than ever.

5. RECOMMENDATIONS

The schools' administrators should conduct seminars and awareness programs pertaining the importance of having a good work-life balance so that every teacher will have the knowledge and be able to balance between work and life. There are various types of seminar and awareness programs that can be utilized by the management for the teachers. This move will definitely worth the time and investment. Another good move will be to appoint a dedicated counsellor tailored to address concerns among teachers to address their psychological well-being and mental health. Counselling sessions are able to help individuals to understand themselves better, help them in making better decisions and regain well-being and balance of an individual life.

Furthermore, it is crucial for the schools' management to regularly review the workloads of the teachers in order to ensure that teachers should have manageable workloads. If the school management is able to control the workload of the teachers, it will assist teachers in achieving a better work-life balance. The school management should always assist the teachers in completing their work. By giving the teachers clear guidance and deadlines, it will able to help teachers to arrange and organize their work more efficiently and effectively. This is because blurred instruction and lack of guidance will create conflict among the teachers. As discussed, work conflict at the workplace may decrease the work-life balance among teachers. Last but not least, the school management should always ask feedback from the teachers regarding their work to help minimize issues that bother teachers. It is also to seek teachers' opinion and view regarding their work so that the management can improve the deficiency and to better understand them. By seeking feedback, it can help the management to discover the imbalance between teachers' work and life matters and find ways to increase teachers' well-being.

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An Integrated review of AI Literacy on Organization Acceptance towards AI Technology: A Review

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ABSTRACT

The development of Artificial Intelligence (AI) has enhanced organization efficiency, decision-making, and innovation. However, the effectiveness of AI Integration depends on organization acceptance, which greatly influences AI knowledge but there are deficiencies in managerial understanding and readiness. It shows that the importance of AI Literacy in influencing organization acceptance and readiness is essential for the smoothness of AI Integration and optimizing its potential advantages. The aim of this study is to explore how AI Literacy influences Organization Acceptance towards Artificial Intelligence Technology by utilizing a comprehensive literature review. By employing an integrated review approach, utilizing a Prisma Diagram to select the related article from Scopus and web of sciences which focusing on "Artificial Intelligence", "AI Literacy", "Organization Acceptance" and "Artificial Intelligence Technology" across industries. As a result, it indicates that greater AI Literacy positively influences Organization Acceptance and the success of AI Implementation. Thus, organizations should prioritize AI education and training.

Keywords *Artificial Intelligence, AI Literacy, Organization Acceptance, AI Technology.*

1.0 INTRODUCTION

In today's technological world, Artificial Intelligence (AI) is growing rapidly and emerging as a transformation force (Vlachopoulou, 2023). To continue growing with advanced technology an organization will gain power and influence economic performance in the next coming years, since it turns the operational process, decision making procedures, and encourage innovative strategies. Thus, AI has become a cornerstone for an organization that achieved competitive advantage in various fields such as manufacturing, healthcare, and finance (Dwivedi, 2019). However, to achieve this, an organization needs to close the gap and boundaries towards the acceptance and implementation of Artificial Intelligence (AI). The success of AI Integration not only depends on technology capabilities own selves but also needs strong support from managerial to ensure the integration of AI in organizational practice become smooth (Mikalef, 2019).

Despite AI's potential demonstrate the effectiveness and success of an organisation, several gaps hinder on the organisation acceptance in AI Literacy consist of knowledge gap, misinformation, ethical concern, resistance to change and lack of training. It became challenging to may managers as they lack technical expertise to fully understand AI systems, making difficult for them to access the benefit, risks, and limitations of AI. This lack leads to hesitation in AI Integration as decision-makers struggle to interpret AI-driven insights and align them with the organisation objectives (Bughin et a., 2018). Meanwhile, according to Glikson & Woolley (2020) AI is often misunderstood due to media exaggeration or insufficient education, leading to unrealistic expectations or fear of job displacement. Misconceptions on AI have also slowed the adoption and create resistance, as managers fear about the workforces changes rather than recognizing AI's role in increasing productivity.

In fact, lack of AI literacy may lead to a lack of awareness regarding on ethical issues such as bias, data privacy, and regulatory compliance. Poor judgement by managers may occur as they do not have a clear knowledge, which raises the possibility of legal violations and reputational damage (Jobin et al., 2019). For example, AI-powered recruiting tools have been criticized for making biased decision due to flawed datasets. In addition, managers with lack of AI literacy may see AI as a threat rather than an opportunity, resisting its use due to concerns about job loss, lack of trust, or uncertainty about its impact (Raisch & Krakowski, 2021). Leadership in traditional industries is the one that unwilling to adopt AI-driven automation as they would lose over decision-making processes. Eventually, organisations also fail to invest in AI education for their leaders, thus resulting in unprepared for AI-driven transformation. Managers with lack of skills and training will struggle to align AI Capabilities with business needs, leading to missed opportunities in areas such customer analytics, operational efficiency, and strategic planning (Shin,2021)

Thus, to encourage management support, AI literacy plays a vital role in influencing management's belief and acceptance of AI (Kong, S., 2021). AI literacy refers to the knowledge, skills, and competencies required for individuals to interact with artificial intelligence systems successfully and ethically. A high-level of AI literacy among managers may lead to a better understanding of AI technology strategies, reduce risk, and foster AI adoption in an organization (Shin, D., 2021). However, a lack of AI literacy may result in dissatisfaction, disagreement, and lack of opportunities to receive help from AI's revolutionary capabilities.
In fact, studies have yet to comprehensively examined the ways in which organizational culture, employee engagement, and decision-making interact with AI Literacy to influence organization acceptance towards AI Technologies.

At last, this paper is structured as follows: Begins with Introduction, followed by objective of the study, Significant of the study, Scope of the study, Literature Review, Data & Methodology, Discussion and Conclusion.

2.0 OBJECTIVE OF THE STUDY

To identify the influence of AI Literacy on organization acceptance and readiness which directly impacts AI integration and organization success, this study construct research objective as below:

1) To examine AI Literacy levels among management
2) To analyze the impact of AI Literacy on management acceptance
3) To identify challenges in AI Acceptance due to Literacy gaps

3.0 SIGNIFICANCE OF THE STUDY

The main interest of this study is to investigate the influence of AI Literacy on organization acceptance and readiness which directly impacts AI integration and organization success. By investigating the challenges of knowledge gaps, misinformation, ethical concern, resistance to change and lack of training, this study can provide useful insights for academic and practical purposes. In addition, the findings can serve as a platform for future study into the acceptance of Artificial Intelligence (AI) in engineering contexts, prompting more in-depth studies into each of the highlighted factors. Furthermore, the framework developed in this study may be extended to a variety of sectors or professional groups, regarding the acceptance of artificial Intelligence (AI) and helping to build specific methods for improving AI integration across several areas. In general, this paper contributes to the study of Malaysian Managerial Level that will benefit organizational performance.

Considering these issues, this study aims to address the influence of AI Literacy on organization acceptance and readiness which directly impacts AI integration and organization success. Specifically, investigating how organization's understanding and readiness on accepting AI Technologies may help organization to overcome barriers and smoother transition into AI-driven operations. Then, this study contributes to bridging research gaps by investigating the influences of AI Literacy on organization acceptance of Artificial Intelligence Technologies within organizations. Also, the study will be based on manufacturing industries which focus on Electric & Electrical Manufacturing companies. By identifying key challenges and opportunities, this study provides valuable insights for organizations, policymakers, and researchers to enhance AI integration through education, strategic planning, and leadership development. It also serves as a reference for future research, which highlights the need of AI education, training programs, and strategic implementation framework to drive AI business transformation.

4.0 SCOPE OF THE STUDY

This study aims to investigate the influence of AI Literacy on organization acceptance and readiness which directly impacts AI integration and organization success. It investigates the influence and challenges of the organization to integrate AI Technology to increase organizational performance. Data will be collected based on previous research by using PRISMA Diagram for inclusion in selecting related research. A literature review will contextualize the study from previous studies on the challenges selected. The findings will be discussed and implications for practice and future research.

5.0 LITERATURE REVIEW

In literature review we will discuss the overview of the challenges that influence AI Literacy on organization acceptance and readiness which directly impacts AI integration and organization success. Then, the literature review for the previous studies will be conducted

through summarization and description. In addition, to construct and give a clearer picture about the challenges that influence of AI Literacy on organization acceptance and readiness which directly impacts AI integration and organization success, the conceptual framework will be constructed and depicted. Finally, this study's hypothesis will be outlined and necessary to relate with previous study.

5.1 Overview on Knowledge Gap & lack of Training

The success of AI Integration in an organisation is depends on the level of management knowledge known as AI Literacy. It is one of the factors that influences management decision-making. According to Smith et al., (2024) states that AI Literacy consists of knowledge, skills, and ethical understanding as it is important for the effectiveness of AI Integration in organization. In a study by Ding,Kim and Allday (2024) it was also emphasize that lack of AI literacy among management creates resistance to AI Integration, leading to inefficiencies in technology implementation. However, organization with AI training programs implementation reported a higher rate of AI Integration (Markos, Prentzas, and Sidiropoulou, 2024). Addition, AI Literacy shows positive impact on management with knowledge and were more likely to incorporate AI-driven decision-making tools, as leading to better organizational performance (Pinski et al., 2024). Thus, it indicates that AI literacy plays a significant role in enhancing organization performance.

5.2 Overview on Misinformation & Resistance to Change

Lack of management readiness due to misinformation about AI, were driven by media exaggeration or lack of technical knowledge. It leads to unrealistic fears or misconceptions about AI’s role in workplace. Many managers are resistant to implementing AI as they see as a threat rather than a tool for optimization to their jobs (Glikson & Woolley, 2020). According to a survey in 2024, more that 75% of Malaysian businesses consider applicants who are proficient in AI and highlighting the need for an employee who are knowledgeable about AI.

However, managers unfamiliar with AI's potential may resist integration as they fear job loss and have doubts about the long-term impact of the technology on corporate operations or lack trust. To increase management acceptance and encourage an initiative-taking approach to AI adoption, it is important to address these concerns through appropriate AI education and literacy initiatives.

5.3 Overview on Ethical Concern & Resistance to Change

Algorithmic bias, data privacy, and regulatory compliance are the impact of poor awareness of AI ethical concern as management does not invest in AI Literacy (Jobin et al.,2019).
In the electrical and electronics industries, AI performance shows increasingly used for automation and predictive maintenance. However, misuse of AI due to ethical misunderstandings has led to legal and reputational risks. Lack of knowledge, management may fail to recognize ethical risks and lead to unintended consequences like discriminatory AI-driven hiring practices, biased automation, or cybersecurity threats (Heinrich, 2023). For example, according to Wang, Yuan, & Li (2024) indicate that if AI-powered predictive maintenance systems in power grids shows failures if management are educated on biased or incomplete data sets. Additionally, AI increasing demand in industry as organizations may prioritize cost-saving measures over equitable energy distribution and disproportionately affecting low-income communities (Baek, Kim, & Kim, 2024).

Other than that, another issue is data privacy and security compliance. To improved efficiency, industries often need large-scale of data collection through AI system such smart meters, industrial IoT sensors, and customer databases. However, lack of AI Literacy from

management lead to poor data governance and the risk of data breaches are increase. Besides, regulatory violations and unauthorized surveillance become the risk (Chuang et al., 2024). With that, it shows that AI Literacy is needed for management to interpret AI-generated insights transparently. Lack of AI Literacy may result in ethical concern related to decision making and accountability (Grassini, 2024).

Besides, other than ethical concern, resistance to change among managers become a major challenge to AI integration as it has slowed down AI Integration in the industries. With that, some of the executives may prefer traditional methods over AI-driven processes (Raisch & Krakowski, 2021). The resistance consists of fear of job displacement where AI Integration may replace human jobs. So that, unmanageable of AI Literacy training provide a failure for organisation to see AI as a complementary tool for decision-making. Besides, it also leads to lack of trust in AI decision-making. Without AI literacy, management are struggling to make decision as they need to access for the long-term benefit and contribute to delay in investment towards AI infrastructure, training programs and technology upgrades.

6.0 DATA AND METHODS

This study explores the Literature on influence of AI Literacy on organization acceptance and readiness which directly impacts AI integration and organization success by employing integrative literature analysis methods. This method will focus on the keywords by searching for a specific journal. This paper will select the journal from 2018 to 2025 as AI become increasing by the year.

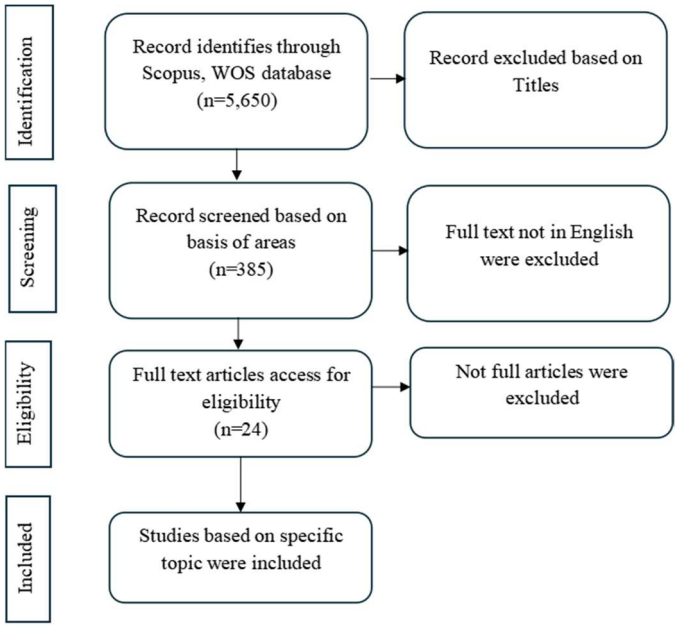

Figure 1: PRISMA Diagram for Inclusion

Firstly, relevant studies are searching by keyword in Scopus and WOS databased were collected. The final keyword includes AI Literacy, Artificial Intelligence, Management Acceptance and AI Technology. The paper considered peer-review journal articles through mykmuitm from Scopus Journal and Web of Sciences Journal from 2018 to 2025. The first search of articles resulted in 5,079 related papers of the areas. However, after refining specific issues, a total of 24 papers were refined.

As indicated in table 1, a literature summary of 24 papers is being constructed. Each article includes a set of 1-2 keywords specific to the relevant papers. The most frequent keyword was “AI Literacy,” Artificial Intelligence, and AI Technology. These keywords highlight

the related issues on AI Literacy towards AI Technology. A previous study addresses the challenge of limited AI Literacy among public (Smith, Sadek, Wan, Ito, & Mougenot, 2024). Besides, in this study examines cognitive and affective perceptions about AI. It shows mixed views on development, job loss, privacy invasion, and potential harm. However, they emphasize the voice in AI Literacy. Addition, Heinrich, S, (2023) investigate in the study to measure technology related concepts using Artificial Intelligence (AI) technology. Then, in the study concerning its ethical implications towards AI (Baek, Kim, & Kim, 2024). Furthermore, the research explores how human perception and emotional reaction are affected in AI-generated art. However, improvements in perception and emotion were modest and diminished (Grassini, 2024).

In the study of Wang, Z et al, (2024) explores on the impact of AI characteristics on technology well-being in systems. It found that higher levels of information optimization, predictability, human likeness, and customizability lead to higher intuitiveness. As a result, it helps business practitioners understand consumer beliefs and engagement with AI characteristics. Overall discuss related to the keywords selected as per below.

Table 1: Literature Summary (Open access from2020-2025)

No	Key Words	Author/Year	Journal
1	AI Literacy	Smith, F., Sadek, M., Wan, E. C., Ito, A., & Mougenot, C. (2024)	WOS
2	Artificial Intelligence	Walan, S. (2024)	WOS
3	AI Technology	Heinrich, S. (2023)	WOS
4	AI Technology	Baek, T. H., Kim, J., & Kim, J. H. (2024)	WOS
5	AI Technology	Grassini, S. (2024)	WOS
6	AI Technology	Scarbrough, H., Chen, Y. R., & Patriotta, G. (2024)	WOS
7	AI Technology	Xia, H. S., Sun, Z. L., Wang, Y., Zhang, J. Z., Kamal, M. M., Jasimuddin, S. M., & Islam, N. (2023)	WOS
8	AI Technology	Wang, Z., Yuan, R. Z., & Li, B. Y. (2024)	WOS
9	Artificial Intelligence (AI) Technology	Liu, H. R., Li, H. Q., Yu, X. Y., Wang, Z. Y., & Chen, Y. P. (2024)	WOS
10	AI Technology	Chuang, S. F., Shahhosseini, M., Javaid, M., & Wang, G. G. (2024)	WOS
11	AI	Jeremiah, F. (2025)	SCOPUS
12	AI Literacy	Ding, L., Kim, S., & Allday, R. A. (2024)	SCOPUS
13	AI Literacy	Markos, A., Prentzas, J., & Sidiropoulou, M. (2024)	SCOPUS
14	AI Literacy	Macdowell, P., Moskalyk, K., Korchinski, K., & Morrison, D. (2024)	SCOPUS
15	AI	Zhu, A. Y. F. (2024)	SCOPUS
16	AI literacy	Yang, H., Zhang, D., Guo, W., & He, Y. (2024)	SCOPUS
17	AI, AI Literacy	Lee, Y.-J., Oh, J., & Hong, C. (2024)	SCOPUS
18	AI Literacy	Pinski, M., Hofmann, T., & Benlian, A. (2024)	SCOPUS
19	AI Literacy, Artificial Intelligence	De Silva, D., Jayatilleke, S., El-Ayoubi, M., Issadeen, Z., Moraliyage, H., & Mills, N. (2024)	SCOPUS
20	Artificial Intelligence (AI), AI Literacy	Garcia Valencia, O. A., Thongprayoon, C., Jadlowiec, C. C., Mao, S. A., Miao, J., Leeaphorn, N., Suppadungsuk, S., Csongradi, E., Budhiraja, P., Khoury, N., Vaitla, P., & Cheungpasitporn, W. (2024).	SCOPUS
21	Artificial Intelligence	Li, Y. (2024)	SCOPUS

22	AI Literacy	Moon, W., Kim, B., Kim, B., & Kim, J. (2024)	SCOPUS
23	AI Literacy	Celik, I. (2023)	SCOPUS
24	AI Literacy, Artificial Intelligence (AI)	Lee, J., & Park, J. (2023)	SCOPUS

6.1 AI LITERACY

AI Literacy defines as knowledge, skills, and competencies for individuals to interact with AI systems effectively (Smith et al., 2024). It has huge impact on decision-making, AI-governance, and organizational strategy in industries. According to Ding, Kim, & Allday (2024) and Markos, Prentzas, & Sidiropoulou (2024) show that demand for Leaders with high level of AI Literacy have increasing by the year and resulted in better rates of AI Integration. However, challenges occur which lead to resistance of AI Integration, lack of understanding of the benefit, and contribute to ethical concerns such data privacy violations impacting from low of AI Literacy from the management.

According to Yang et al. (2024) elaborate that, organization which lack of AI Training in enhancing AI Literacy may hinder innovation and efficiency. For example, in a study reported AI Literacy has given impact for the effectiveness through statistical analysis, electricity plant management and automated troubleshooting systems in the industries. Companies that invest in AI literacy programs give better contributions from employees and improve success rate for AI Integration.

As conclusion, these studies show that, greater level of AI literacy may reduce resistance and increase chances of better AI Integration. In fact, it also has a positive influence on decision-making, job performance, and organizational AI readiness. Besides, Training programs and AI education become important for the organization to learn and educate for future success of AI Integration. However, organizations with low AI literacy may face several significant issues of knowledge gaps, misinformation, ethical concern, resistance to change and lack of training.

6.2 ARTIFICIAL INTELLIGENCE (AI)

Artificial Intelligence (AI) refers to a system that can learn, give a reason, and make decisions and it becomes important nowadays in business. Walan (2024) described AI as an industrial automation, consumer interaction and a catalyst for data-driven innovations. AI improves industries in increasing automation, decision-making, and data analytics. In addition, research states that an organization needs to address challenges to improve efficiency and innovation such bias, privacy concerns and transparency Walan (2024) and Zhu (2024). AI also has a big impact on consumer interaction through chatbots, virtual assistance, and personalized confirmation which enhances customer satisfaction. Besides, AI serves as a catalyst for data-driven innovations. A catalyst analyzing huge amounts of data to find correlations and make predictions that give a better result in decision-making.

Other than that, organization also must be well-known on the critical challenges related to AI Implementation. In the study of Walan (2024) and Zhu (2024) highlight those issues. Besides, transparency of AI decision-making is important to ensure accountability and build user trust. In addressing this challenge, it is crucial for business to fully potential while maintaining ethical and responsible AI Usage.

6.3 AI TECHNOLOGY

AI Technology is a main research focus regarding the advancements and industrial applications. According to Heinrich (2023), Baek et al., (2024), and Grassini (2024) examine several issues on AI Technology, consist of development, integration, and real-world use cases. Several paper highlight AI technologies as its significance in shaping industries such healthcare, finance, and manufacturing.it shows that AI Technology is growing in role modern of innovation. thus, drive for future technological breakthroughs.

7.0 DISCUSSION

Based on the findings highlighted the challenges of AI literacy is influencing management views towards AI Technology. Most businesses use AI in productivity to improve organization performance, including decision making which leads to its effectiveness. This discussion highlights the influence of the results and links with existing literature and outlines the future research directions.

7.1 AI LITERACY

The main issue that has been concerned is lack of AI literacy on management. However, in the study of (Pinski, Hofmann, & Benlian, 2024) concluded that AI Literacy positively influences Top management Team (TMT) on AI adoption and implementation ability. However, in the startups levels are more affected as a result and AI Literacy represents skill-oriented on TMT towards value the AI implementation in an organization. Addition, AI Literacy is a capability of an individual's knowledge towards AI Technology not only in an organization but also in any industry which have implementing AI Technology. By enhancing AI Literacy management may adapt to AI-driven environments and avoid job displacement due to insufficient knowledge (Marinas, Paun, Diaconescu, & Smira, 2024). Many organizations also highlight to adopt AI in an organization the requirement if AI competency for an individual is needed to transform operations, improve efficiency and decision-making process.

Furthermore, AI is predicted to have 15.7 trillion global economic impact. Despite this, a lack of knowledge leads to difficult in achieving AI Literacy among individuals (Ding.L;Kim,S;Allan Allday,R, 2024). As a result, it indicated in the services of professional performed significantly better with a moderate Level of AI Literacy. Moreover, Artificial Intelligence (AI) Technology has an impact beyond individuals in AI education as it becomes interesting towards advancement of world technology. As a result, it shows that Ai Literacy significantly improves ethical awareness and have enhance attitudes towards AI (Yang,E,Choi,J,Goo,E, 2024). This study emphasizes the importance of ethical awareness in AI. In addition, with the purpose of innovation and changes in society, AI Literacy is important. Based on the study, Ai Literacy is significantly affected by several aspects consists of gender, grade level, interest, and experiences. It shows that, man is stronger to increase grade level of Ai Literacy.

7.2 AI TECHNOLOGY

Management Acceptance, which influences AI Technologies and manager's level of AI Literacy, plays a significant role in the success of AI Integration in an organization. When managers sufficient with AI literacy, better understanding, trust, and confidence in implementing AI Technologies. Furthermore, with skills of AI will give a positive impact on organizational performance (Heinrich, S, 2023). However, without knowledge, the used and implementation of AI Technologies also does not give meaning. Moreover, the advancement of Ai Technology has raised several concerns on the ethical implication, transparency, and

societal impact. As highlighted in study, the success of AI Integration is not only dependent on technological capabilities but also on the ethical practices and operations (Baek, Kim, & Kim, 2024). Besides, Grassini (2024) emphasizes the rapid growth of AI which has led to discussion regarding the implications towards individuals' capabilities and perceptions. Meanwhile, AI integrated systems can enhance efficiency and decision-making. For instance, these concerns underline the need for AI strategies that ensure AI remains a supportive tool with the purpose of data analysis, decision making, and operational efficiency.

According to Heinrich (2023) and Baek et al. (2024) illustrate that AI's predictive capabilities can drastically improve organizational performance. However, without understanding of AI the fundamentals of AI cannot be trusted. AI Technology provides managers actionable insight by processing large data sets, reducing uncertainty in decision-making. Besides, it allows managers to focus on strategic priorities.

8.0 CONCLUSION

Enhancing AI capabilities and raising managers' level of AI Literacy are important for integrating AI technologies into business. AI literacy guarantees that managers can understand, trust, and effectively use the transformative tools in AI technologies. Thus, AI technologies and AI literacy give a favorable combination to increase trust and knowledge. As a result, AI literacy has a positive influence on management acceptance towards AI Technology.

For future research, AI literacy being important to be discussed more to complement technological advancement and ensuring the acceptance of management towards AI technologies and keep maintain with the rapid evolution of AI Technologies. However, researchers may focus on industries since there is a gap in the acceptance of AI adoption.

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VENDOR-MANAGED INVENTORY (VMI) APPROACH TO MINIMIZE BULLWHIP EFFECT AT PT BRILIANT THINK CENTER

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ABSTRACT

PT. Briliant Think Center is a company that has sold health products and several other fashion products lately, PT. Briliant Think Center has experienced obstacles, namely differences in information related to demand and orders for fashion and health products obtained by the company for fashion goods and other items at PT. Brilliant Think Center. This has disrupted the company's supply chain, which causes variability or uncertainty in demand, more commonly known as the Bullwhip Effect phenomenon. The purpose of this study is to determine the effectiveness of the Vendor Managed Inventory (VMI) method in minimizing the bullwhip effect. The method used is the Vendor Managed Inventory (VMI) method. The calculation results show that the application of the Vendor Managed Inventory (VMI) method is effective in minimizing the bullwhip effect at PT. Brilliant Think Center. The value of bullwhip effect I (the company's actual condition) on the Wookey weight product is 1.2323 and the Nikey jersey product is 1.2284. However, when the VMI method was applied, the bullwhip effect results decreased drastically to 0.5145 for the wookey weight product and 0.4970 for the Nikey Kaos product.

Keywords: *bullwhip effect, forecasting, vendor-managed inventory.*

1.0 INTRODUCTION

In this modern era, every company has a unique business strategy and method to increase competitiveness with existing competitors. One way to strengthen competitiveness is to manage financial resources effectively, both from income received and expenses incurred to support business operations. The creative industry is one of the businesses that is currently growing rapidly, especially in the fashion or clothing sector. In the 21st century, the role of the supply chain has become a crucial element in corporate strategy, especially with increasingly tight competition and consumer demands. To formulate this strategy, it is necessary to consider aspects such as suppliers, distribution networks, finished products. All of these elements are part of the Supply Chain Management approach (Yunitasari, Wardana, & Nurhayati, 2022). The application of managing the network from upstream (suppliers) to downstream (customers) while still taking into account various aspects including cost, time, quality, and customer needs is known as supply chain management. The supply chain generally consists of several components, such as distributors, retailers, suppliers, logistics, and customers. In supply chain management, it is important to understand that demand fluctuates over time and is cyclical, intermittent, and requires careful attention (Industry, 2024). The Bullwhip phenomenon Effect, or where there is a real difference between the amount of remaining inventory and the amount of demand caused by variations or uncertainty in demand, is a problem that often occurs in the supply chain (Muzady & Ernawati, 2021).

1.1. BACKGROUND

PT. Brilliant Think Center is a company that sells health products and several other fashion products. In running its business, PT. Briliant Think Center gets fashion items from suppliers from various cities on the island of Java and health products (milk and honey) are sent directly from the factory owned by PT. Brilliant Think Center which produces milk and honey is also located on the island of Java.

Recently, PT. Briliant Think Center has experienced obstacles, namely differences in information related to demand and orders for fashion and health products obtained by the company for fashion goods and other items at PT. Brilliant Think Center. This has disrupted the supply chain for the company, which causes variability or uncertainty in demand or what is more commonly known as the Bullwhip Effect phenomenon. The demand factor in each supply chain is what drives the emergence of the bullwhip effect, which is characterized by consumer demand that can rise or fall based on conditions (Arfian, Prabowo, Industry, Adhi, & Surabaya, 2021)The uncertainty of existence encourages companies to make decisions to make orders or reservations based on estimates that cause existing inventory so that companies experience stockouts and overstocks.

Based on the problems that occur in PT. Brilliant Think Center, an effective solution to reduce the value of the bullwhip effect is to make improvements in the form of information sharing. There is a concept called CPFR (Collaborative, Planning, Forecasting, and Replenishment) which is a mechanism that allows all entities in the supply chain to manage their information appropriately. Vendor Managed Inventory (VMI) is a strategy for implementing the CPFR concept (Collaborative, Planning, Forecasting, and Replenishment) which emphasizes collaboration between producers and retailers(Muzady & Ernawati, 2021)

Vendor Managed Inventory (VMI) method is a system that allows demand from distributors and retailers to be controlled by the company (vendor). Responsibility for product delivery in the right amount and time is carried out by the vendor to avoid stockouts and overstock. Implementing Vendor Managed Inventory (VMI) is expected to minimize the bullwhip effect that occurs in the supply chain at PT. Brilliant Think Center, especially at the company level (vendor) so that the company can receive accurate information. In addition, by using the VMI method, it is also expected that an optimal inventory control determination policy can be implemented, especially in the company. Thus, the business process at PT. Brilliant Think Center can run optimally.

From the background above, the problem in this study is identified as follows: The bullwhip effect occurs when there is a significant difference caused by variance or uncertainty of demand. Uncertainty of demand makes it difficult for companies to take the right policy so that stockouts and overstocks occur. Ineffective communication can cause errors in meeting consumer demand, thus worsening the bullwhip effect situation.The formulation of the problem arises due to demand uncertainty causing stockout and overstock and ineffective communication between suppliers and retailers (PT. Briliant Think Center) thus worsening the bullwhip effect situation. As a solution, the researcher will use the Vendor Managed Inventory (VMI) method which implements the concept of Collaborative, Planning, Forecasting, and Replenishment (CPFR). What are the products that play an important role in the company, How to minimize the bullwhip

effect by using the Vendor Managed Inventory (VMI) method that can reduce stockout and overstock and what are the proposed recommendations for improvement to overcome the bullwhip effect?

The purpose of this study is to find out which products have an important role for the company, to find out the effectiveness of the Vendor Managed Inventory (VMI) method in minimizing the bullwhip effect, and to provide recommendations for improvements on how VMI implementation can improve communication and inventory optimization in the supply chain.

2.0 LITERATURE REVIEW

Literature review is a summary or abstract of several theories, findings, and other research materials from scientific works that have previously been conducted or published to strengthen researchers in determining theories and solving problems within the scope of the research.

In conducting this research, it must include previous research on previous research that discusses Vendor Managed Inventory (VMI) to Minimize Bullwhip Effect at PT. Brilliant Think Center. The following is a literature review used by researchers as a reference:

1. Research by (Industry, 2024) focuses on managing the bullwhip effect in acoustic guitar manufacturing through the Vendor Managed Inventory (VMI) approach. The purpose of this research is to assess the effectiveness of VMI in managing the bullwhip effect in the acoustic guitar manufacturing process, as well as its impact on supply chain efficiency and inventory management. The method used was the application of VMI to improve coordination between suppliers and manufacturers. The results of the study showed that the implementation of VMI can significantly reduce the bullwhip effect, by improving communication and collaboration between suppliers and manufacturers. In addition, the study also noted that VMI contributed to reducing excessive demand fluctuations and helped optimize inventory management and distribution, thus improving operational efficiency in acoustic guitar manufacturing.
2. Research by (Muzady & Ernawati, 2021) examines the application of the Vendor Managed Inventory (VMI) method to reduce the bullwhip effect in a supply chain system involving one vendor and several retailers at PT Magnesium Gosari International Gresik. This study aims to evaluate the effectiveness of VMI in reducing information distortions that cause unstable demand fluctuations or what is known as the bullwhip effect phenomenon. The method used is the application of the VMI system in the company's supply chain management. The results show that the implementation of VMI can significantly reduce the bullwhip effect by improving coordination between vendors and retailers, as well as optimizing inventory management. In addition, VMI is also able to stabilize the flow of demand and minimize unnecessary fluctuations, thus creating efficiency in the company's supply chain.
3. Furthermore, research by (Yunitasari et al., 2022) analyzed the impact of implementing Vendor Managed Inventory (VMI) in reducing the bullwhip effect in Marrone MSMEs. This study aims to evaluate how VMI can improve demand accuracy and inventory management in these MSMEs. The method used includes the implementation of the VMI system in MSME supply chain management. The results of the study show that the implementation of VMI successfully reduces the bullwhip effect, improves demand accuracy, and increases overall supply chain efficiency. In addition, VMI is also proven to help reduce excessive demand fluctuations and improve the relationship between suppliers and MSMEs, thus creating a more stable and efficient business environment.

In previous studies it was proven that the Vendor Managed Inventory (VMI) method can reduce the value of the bullwhip effect that occurs in the company. This study also uses Vendor Managed Inventory (VMI) to minimize the bullwhip effect but by adding another method, namely the Activity Based Costing (ABC) method which is used to determine products that play an important role in company operations.

A. Supply Chain Management

Supply chain management is a series of related business activities ranging from product planning to distribution to buyers. In practice, the supply chain system always involves many parties consisting of various components of industry players, including factories or sellers, transportation companies, suppliers, distributors, and stores or retailers, which are integrated to improve performance together(Muzady & Ernawati, 2021). In practice, collaborating with various stakeholders is very difficult. All parties involved in the supply chain must communicate and work together well. Due to the lack of good coordination in the supply chain, the implementation of SCM (supply chain management) often fails.

One of the difficulties in implementing supply chain management (SCM) is the need for good coordination of the various activities involved in the supply chain, which involve various actors with various systems. Effective coordination must cover from the beginning of the supply chain, namely customer demand, to the end of the supply chain, namely production and manufacturing(Retnowo & Waluyo, 2022). The main purpose of SCM is to increase value creation, maximize profits, and meet customer needs, to meet customer demands and needs, products are delivered immediately, which reduces costs, shortens time, and centralizes planning activities. Companies can ensure that products are delivered according to delivery requirements by implementing supply chain management. Because the goods are not excessive or defective, the last step is to reduce costs.

B. Activity Based Costing (ABC)

The concept of activity-based costing (ABC) explains that when a business becomes more complex, it can no longer use a conventional expense system because the overhead costs allocated become larger so the use of a conventional system will produce inaccurate data. Activity-based accounting systems focus on the activities carried out when creating a product or service(Sondakh, Sabijono, & Gerungai, 2023). Classification of groups A, B, and C in ABC analysis is divided into 3 large groups that are the company's priorities. The groups are named A, B, C. :

1.) Class A: The number of goods represents between 15-20% of the total number of goods, and it represents 75 to 80% of the total sales value.
2.) Class B: The number of goods between 20-25% of the total goods, or 10-15% of the total sales value.
3.) Class C: The number of goods is 60-65% of the total goods and 5-10% of the total sales value.

To find out the level of importance of each product or item, the product is divided into three classes, namely class A, class B, and class C. The process of grouping goods using the ABC method is as follows:

1. Identifying products available at PT. Brilliant Think Center.
2. Determining the price per unit with the volume of needs per year.
3. Multiplying the price per item and the volume of needs to determine the total rupiah value of each item.
   Annual volume (in units) x price per item (1)
4. Arranging the order of the types of goods based on the total rupiah value, with the first order of the type of goods with the largest total rupiah value.
5. Calculating the cumulative value of goods.
6. Calculating the cumulative percentage of rupiah value.

$$\frac{Annual\ volume\ in\ unit\ value}{Jumlah\ pence\ amount\ of\ fund\ absorption\ in\ a\ year}\ x\ 100\% \quad (2)$$

7. Determining inventory into classes A, B, and C

C. Bullwhip Effect

In the warehousing industry, the term “bullwhip effect” is used to describe how demand moves through the supply chain(Mera & Ernawati, 2023). When orders to suppliers differ from sales to customers, the bullwhip phenomenon occurs. The bullwhip effect reduces supply chain efficiency, because each part of the supply chain requires more inventory, so that part must bear higher inventory costs(Hamim, Hm, Junianto, & Mahsun, 2024). In addition, due to inaccurate demand information, production planning will

become increasingly difficult. The value of the bullwhip effect in a company's supply chain will be positively correlated with the level of performance optimization. The bullwhip effect, also known as amplification, occurs when the variability of demand upstream (producers) is greater than the variability of demand downstream (consumers). Thus, it can be concluded that the bullwhip effect is an increase in variability or fluctuation in demand from upstream to downstream of the supply chain caused by information distortion. In a bullwhip effect situation, there is an increase and decrease in demand.

The concept of the bullwhip effect is when customer demand changes, either more or less, and this change causes demand distortion at each stage of the supply chain. The overall effect of this situation, namely increasingly inaccurate demand data, is influenced by this distortion (Supply & Management, 2024).

The bullwhip effect was chosen as the main problem in this study because this phenomenon directly affects the occurrence of stockouts and overstocks which are major problems in the supply chain. The bullwhip effect causes distortion of demand information from downstream to upstream, where small changes in consumer demand can result in large fluctuations in production planning and inventory at the supplier level. As a result, companies often experience excess stock which increases storage costs or shortages which hamper product availability in the market. If not handled properly, this can have an impact on operational efficiency, customer satisfaction, and company profitability. Although there are many other problems in the supply chain, such as late delivery and logistics efficiency, the bullwhip effect was chosen because it is a fundamental problem and is directly related to inventory imbalance. Therefore, this study focuses on how to reduce the bullwhip effect so that companies can optimize inventory, ensure products are available on time, and avoid losses due to excessive or insufficient stock.

How to Reduce the Bullwhip Effect

The following are some approaches that can be taken to reduce the bullwhip effect:

1.) Information Sharing
The CPFR (Collaborative, Planning, Forecasting, and Replenishment) collaboration model is a great solution to synchronize information between all parties involved. VMI (Vendor Managed Inventory) is a CPFR concept that involves close collaboration or coordination between manufacturers and retailers(Deniarsyah, Silviana, & Putri, 2023)

2.) Changing the Supply Chain Structure
Companies can see consumer demand quickly with a shorter supply chain structure(Deniarsyah et al., 2023).

3.) Measuring Fixed Costs
It is impossible to sell products in small quantities due to high fixed costs. Innovation is needed in sales and transportation, reducing the number of orders, and shortening production preparation time(Deniarsyah et al., 2023)

4.) Creating Price Stability
To create price stability, discounts given to retailers must be reduced. All parts of the supply chain must understand the terms when conducting promotions(Deniarsyah et al., 2023)

1. Bullwhip Effect Calculation

In the calculation of the Bullwhip Effect at a level in the supply chain, it can be calculated if the coefficient of variance of the order made is compared to the coefficient of variance of the demand received. The results of the bullwhip effect that produce a value of more than 1, then it can be ascertained that there is a bullwhip effect from the variance of demand. The measurement of the bullwhip effect value can be calculated using the following equation formulation(Muzady & Ernawati, 2021)

1.) Calculation of coefficient of variance

$$\mu\ (Demand) = \frac{Total\ Demand}{Periode} \quad (3)$$

$$\mu\ (Order) = \frac{Total\ Order}{Periode} \quad (4)$$

$$\sigma = \sqrt{\sum(x1 - x)2\ /n - 1} \quad (5)$$

$$CV\ (Order) = \frac{\sigma\ (order)}{\mu\ (order)} \quad (6)$$

$$CV\ (Demand) = \frac{\sigma\ (demand)}{\mu\ (demand)} \quad (7)$$

Description:

μ (Demand) : Average demand
μ (Order) : Average order
σ (Demand) : Standard deviation of demand
σ (Order) : Standard deviation of order
CV (Request) : Coefficient of variance of demand
CV (Order) : Coefficient of variance of orders

2.) Calculation of the bullwhip effect using the following formula:

Bullwhip Effect= $CV\frac{(Order)}{(Demand)}$ (8)

Calculation of the bullwhip effect using correlation parameters to obtain significant sources of constraints on the reduction of the bullwhip effect that occurs. By using the formula:

$$\frac{Var\ (Order)}{Var\ (Demand)} + \geq 1 + \frac{2L}{P}\frac{2L^2}{P} \quad (9)$$

Description:

L: lead time

Q: Period

D. Vendor Managed Inventory (VMI)

Vendor Managed Inventory (VMI) is a collaboration strategy between vendors to ensure products are available, affordable, and beneficial to both parties(Al Farih & Ernawati, 2020).(Undariyanto, 2023)that inventory is an idle resource whose existence is waiting for further processing. As an idle resource, the existence of inventory must be managed effectively and efficiently. VMI is one way to manage inventory of goods. By using Vendor Managed Inventory (VMI), companies or suppliers can combine the amount needed by distributors or retailers. This allows sellers to avoid stockouts by sending the right amount of product at the right time, which has an impact on distributors and retailers(Muzady & Ernawati, 2021)

Vendor Managed Inventory (VMI) consists of two main components: information exchange and control transfer(Al Farih & Ernawati, 2020)Effective vendor-supervised inventory management can improve supply chain performance by reducing inventory levels and increasing product replenishment frequency. Vendor-Managed Inventory (VMI) improves customer service, reduces inventory costs, and increases inventory replenishment frequency or turnover. Suppliers can leverage the sharing of information about inventory levels and customer demand from retailers to better plan production and delivery schedules,

fulfill retail inventory, plan purchases, and perform other logistics processes using Vendor Managed Inventory (VMI).

Therefore, an evaluation and analysis of the problems related to the bullwhip effect that occurs in the supply chain are carried out. The purpose of the Vendor Managed Inventory (VMI) method is to improve the smoothness of the production process and reduce the level of excess or shortage of raw material inventory(Pasha & Kholidasari, nd). The CPFR (Collaborative, Planning, Forecasting, and Replenishment) collaborative model is a good way to ensure that all parties in the supply chain have synchronized information or what is commonly called information sharing(Al Farih & Ernawati, 2020). Vendor Managed Inventory (VMI) is one of the ideas of CPFR that implements cooperation or coordination between producers and retailers. The VMI method is a system that is monitored and managed by the company or supplier to meet the needs of distributors and retailers. Vendors are responsible for delivering goods in the right quantities and at the right time to avoid stockouts that can affect customer service at the retail and distribution levels.

So far, there are several options that can be used to reduce the occurrence of the bullwhip effect, such as the just in time (JIT) method and Material Requirement Planning (MRP). One of them, as suggested in the research conducted(Lemadi, 2022), explains that the bullwhip effect can be reduced by using the vendor managed inventory approach. VMI provides many benefits, including reducing the bullwhip effect which will improve service, availability of goods, utilization, flexibility and reduce costs(Undariyanto & Bahagia, 2024). These benefits are the result of transparency of customer demand/needs information so that the characteristics of the inventory system from being uncertain or probabilistic to deterministic. The purpose of implementing VMI is to ensure product availability with low logistics costs and maintain inventory levels as low as possible throughout the supply chain(Lufika, Izzaty, Suhendrianto, Arifin, & Hamidah, 2023)Therefore, the author is interested in implementing Vendor Managed Inventory to minimize the bullwhip effect that occurs in retail companies in the fashion and herbal product sectors.

This study also includes the EOQ inventory formula used for vendors (PT. Briliant Think Center) to determine the ideal order quantity policy. This is included in the CPFR (Collaborative, Planning, Forecasting, and Replenishment) model in the replanning section (Yunitasari et al., 2022).

3.0 METHOD

3.1. DATA COLLECTION

In processing this data, the data required includes information on purchasing goods, inventory of merchandise for the last 1 year in the period from September 2023 to October 2024 and the cost of ordering goods. The data used in this study includes demand and order data in a period of 1 year in the period from September 2023 to October 2024.

3.2. ACTIVITY-BASED COSTING (ABC)

Using ABC classification to know the level of importance of each product or item, products are divided into three classes, namely class A, class B, and class C.

3.3. CALCULATION OF BULLWHIP EFFECT I (ACTUAL COMPANY CONDITIONS)

To calculate the bullwhip effect based on the company's actual data, where the vendor (PT. Briliant Think Center). If the bullwhip effect value > 1 then the company is identified as having a bullwhip effect phenomenon and will be resolved further. However, if the bullwhip effect value < 1 then the company is identified as not having a bullwhip effect phenomenon and is immediately continued to the results and discussion.

3.4. FORECASTING

Winter's forecast and moving average forecast are used and then the forecasting method that produces the lowest level of MAD, MSE, and MAPE forecasting errors is selected. The forecast is used to forecast data 1 year ahead and determine the bullwhip effect value in the current period using winter's forecast and moving average.

3.5. VENDOR MANAGED INVENTORY (VMI)

EOQ is used by vendors (PT. Briliant Think Center) to determine the ideal order quantity policy that will be used to inform suppliers.

3.6. CALCULATION OF BULLWHIP EFFECT II RESULTS FROM THE PROPOSED VMI METHOD

At this stage, the calculation of the bullwhip effect II value is carried out based on the results of the proposed VMI method.

3.7 COMPARISON OF BULLWHIP EFFECT I (ACTUAL) WITH BULLWHIP EFFECT II PROPOSED BY VMI

After calculating the bullwhip effect value using the proposed method (VMI), the next step is to compare the bullwhip effect II value from the proposed method with the bullwhip effect I value from the company's actual data. If the BE I value > BE II, then the bullwhip effect reduction method uses the proposed method (VMI).

3.8 DETERMINING THE COMPANY'S INVENTORY CONTROL POLICY

The purpose of calculating the inventory value is to determine the maximum stock capacity, safety stock value, and when to reorder. The calculation of the inventory value in Vendor Managed Inventory (VMI) is carried out by the vendor (PT. Brilliant Think Center) and is based on data from each item.

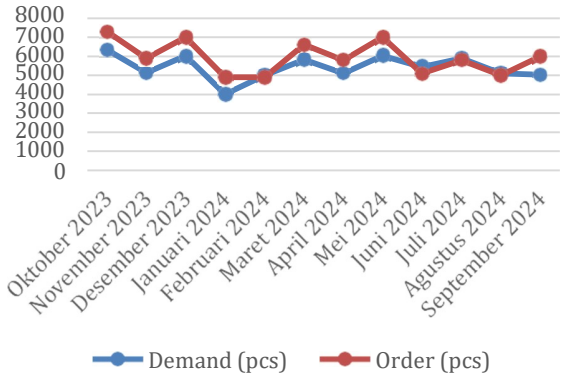
4.0 RESULTS AND DISCUSSION

4.1. DATA COLLECTION

In this study, the collection was carried out, namely primary data and secondary data. Primary data was obtained through observation and interviews. In the warehouse staff and employees are placed according to their fields, while secondary data is obtained from companies that are ready to process the data including demand and order data from vendors (PT. Brilliant Think Center). The products used in this study are products that are included in class A which included Wookey Weight and Nikey T-shirts after being grouped using ABC analysis because they are considered products that play an important role for the company.

Table 1 Data*Demand and Order Wookey Weight PT. BTC*

Period	*Demand*(pcs)	*Order*(pcs)
October 2023	6350	7300
November 2023	5125	5900
December 2023	6008	7000
January 2024	4012	4900
February 2024	5018	4900
March 2024	5827	6600
April 2024	5112	5800
May 2024	6027	7000
June 2024	5439	5100
July 2024	5908	5800
August 2024	5116	5000
September 2024	5029	6000



Picture1 *Wookey Weight Demand and Order in 1 year*

(October 2023-September 2024)

Table 2 Data*Demand and Order Nikey T-shirt PT. BTC*

Period	*Demand*(pcs)	*Order*(pcs)
October 2023	1050	1105
November 2023	1000	1050
December 2023	980	1020
January 2024	970	1010
February 2024	990	1030
March 2024	960	1005
April 2024	985	1025
May 2024	975	1015
June 2024	965	1000
July 2024	1005	1070
August 2024	990	1035
September 2024	980	1020

Source: Company Data

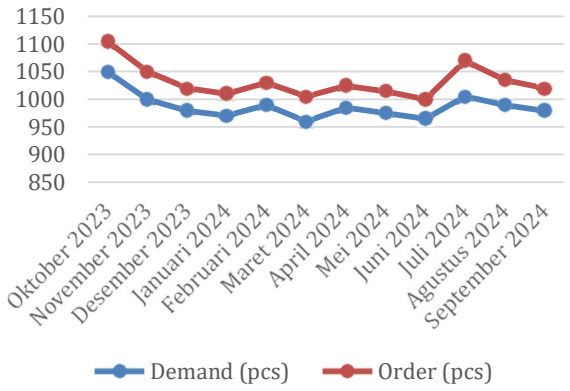


Figure 4.2 *Demand and Order Nikey T-shirts in 1 year*

(October 2023- September 2024)

4.2. DATA PROCESSING

1. Calculation of Bullwhip Effect Value I

In this study, the calculation of the bullwhip effect I value was carried out on the vendor (PT. Briliant Think Center). The following is the calculation of the bullwhip effect I value at PT. Brilliant Think Center.

1.) Calculation of average demand and orders

$$\mu\,(demand) = \frac{Total\,\frac{demand}{Order}}{Periode}$$

$$\mu\,(demand) = \frac{(6350 + 5125 + 6008 + 4012 + 5018 + 5827 + 5112 + 6027 + 5439 + 5908 + 5116 + 5029)}{12} = 5{,}414\ pcs$$

$$\mu\,(order) = \frac{(7300 + 5900 + 7000 + 4900 + 4900 + 6600 + 5800 + 7000 + 5100 + 5800 + 5000 + 6000)}{12}$$

$$= 5{,}941\ pcs$$

2.) Calculation of standard deviation of demand and order

$$\sigma = \sqrt{\sum \frac{(x1 - x)\hat{}2}{n - 1}}$$

$$\sigma(Demand) = \sqrt{\frac{(6350 - 5{,}414)^2 + (5125 - 5{,}414)^2 + (6008 - 5{,}414)^2 + \cdots + (5029 - 5{,}414)^2}{12 - 1}} = 643{,}435\ pcs$$

$$\sigma(Order) = \sqrt{\frac{(7300 - 5{,}941)^2 + (5900 - 5{,}941)^2 + (7000 - 5{,}941)^2 + \cdots + (6000 - 5{,}941)^2}{12 - 1}} = 870{,}170\ pcs$$

3.) Calculation of coefficient of variance

$$Cv(Demand) = \frac{\sigma\,(demand)}{(demand)} = \frac{643{,}435}{5{,}414} = 0{,}1188$$

$$Cv(Order) = \frac{\sigma\,(Order)}{\mu\,(Order)} = \frac{870{,}170}{5{,}941} = 0{,}1464$$

4.) Bullwhip effect calculation I

$$BE\ I = Cv\,\frac{(Order)}{(Demand)} = \frac{0{,}1464}{0{,}1188} = 1{,}2323$$

5.) Calculation of correlation parameters to determine whether there is a bullwhip effect on the wokey weight product at the vendor level of PT. Brilliant Think Center

$$\frac{Var(Order0}{Var(Demand)} \geq 1\frac{2.1}{12} + \frac{2.1^2}{P^2}$$

$$1{,}2323 \geq 1 + \frac{2.1}{12} + \frac{2.1^2}{12^2}$$

$$1{,}2323 \geq 1{,}18$$

Information:

L = Lead time

P = is the range of observation data, namely 12 (periods)

Table 3 Measurement Value of BE I PT. Brilliant Think Center

Item	MD	μo	σd	σo	Cvd	Cvo
Wookey Weight	5,414	5,941	643,453	870,170	0.1188	0.1464
Nikey T-shirt	987.5	1032.08	23.78	30.11	0.0240	0.0291

Source: Researcher 2024

Table 4 BE I Values and BE Parameters

Item	Am I	Parameter
Wookey Weight	1.2323	1.18
Nikey T-shirt	1,2110	1.18

The BE value for the Wookey weight product is 1.2323 and the Nikey Kaos is 1.2110 which is greater than 1, this occurs because the increase in order variance to the supplier is greater than the increase in demand variance at the retailer (PT. Brilian Think Center) so that it shows an increase in demand variability on the supplier side or demand fluctuations. To minimize the bullwhip effect, it is necessary to carry out Vendor Managed Inventory (VMI) by implementing the CPFR (Collaborative, Planning, Forecasting, and Replenishment) concept.

2. Calculating Forecast Value

Table 5 Comparison of Forecast Error Levels

Method	MAD	MSE	MAPE
Winter's	1,007.01	1,450,605.09	19.8
Moving Average	535.9	521,002	10.71

From Table 3, it can be seen that the smallest value for MAD Moving Average is 535.9, the smallest value for MSE is 521.002, and the smallest value for MAPE is also found in forecasting with the moving average method with a value of 10.71. Of the three accuracies used to compare the winter's and moving average methods, it turns out that all the smallest accuracy values are found in the moving average method. This proves that the moving average forecasting method is the best method in Wookey weight forecasting.

3. Calculating the Optimal Order Quantity Value in VMI

The calculation of the optimal order quantity policy is obtained by using the help of the EOQ formula for wookey weight PT. BTC with a storage cost of Rp. 16,000 (month), an ordering cost of Rp. 400,500. The calculation is as follows:

$$EOQ = \sqrt{\frac{2 \; x \; S \; x \; D}{H}}$$

EOQ = $\sqrt{\frac{2\ x\ 400.500\ x\ 5737,5}{16.000}}$

EOQ = 535,942

Table 6 Wookey Weight Optimum Order Quantity Values

Period	Demand Forecast	Q*
Oct 23		
Nov 23		
Dec 23	5737.5	535,942
Jan 24	5566.5	527,895
Feb 24	5010	500,812
Mar 24	4515	475,428
Apr 24	5422.5	521,022
May 24	5469.5	523,275
Jun 24	5569.5	528,037
Jul 24	5733	535,732
Aug 24	5673.5	532,944
Sep 24	5512	525,304
Oct 24	5072.5	503,927
Nov 24	5072.5	503,927
Dec 24	5072.5	503,927
Jan 25	5072.5	503,927
Feb 25	5072.5	503,927
Mar 25	5072.5	503,927
Apr 25	5072.5	503,927
May 25	5072.5	503,927
Jun 25	5072.5	503,927
Jul 25	5072.5	503,927
Aug 25	5072.5	503,927
Sep 25	5072.5	503,927

Source: Researcher 2024

4. Calculate the Bullwhip Effect II VMI Value

1.) Calculation of average demand and orders

$$\mu\ (demand) = \frac{Total\ \frac{demand}{Order}}{Periode}$$

$$\mu\ (demand) = \frac{(5737,5 + 5566,5 + 5010 + 4515 + 5422,5 + 5469,5 + 5569,5 + 5733 + 5673,5 + 5512)}{10} = 5420,9$$

$$\mu\ (order) = \frac{(535,942 + 527,895 + 500,812 + 475,428 + 521,022 + 523,275 + 528,037 + 535,732 + 532,944 + 525,304)}{10}$$

$$= 520,63$$

2.) Calculation of standard deviation of demand and order

$$\sigma = \sqrt{\sum \frac{(x1 - x)\hat{}2}{n - 1}}$$

$$\sigma(Demand) = \sqrt{\frac{(5737,5-5420,5)^2+(5566,5-5420,5)^2+(5010-5420,5)^2+\cdots+(5512-5420,5)^2}{10-1}} = 380,77$$

$$\sigma(Order) = \sqrt{\frac{(535{,}942 - 520{,}63)^2 + (527{,}895 - 520{,}63)^2 + (500{,}812 - 520{,}63)^2 + \cdots + (525{,}304 - 520{,}63)^2}{10 - 1}} = 18{,}81$$

3.) Calculation of coefficient of variance

$$Cv(Demand) = \frac{\sigma\,(demand)}{(demand)} = \frac{380{,}77}{5420{,}9} = 0{,}0702$$

$$Cv(Order) = \frac{\sigma\,(Order)}{\mu\,(Order)} = \frac{18{,}81}{520{,}63} = 0{,}0361$$

4.) Bullwhip effect calculation I

$$BE\ I = Cv\frac{(Order)}{(Demand)} = \frac{0{,}0361}{0{,}0702} = 0{,}5145$$

5.) Calculation of correlation parameters to determine whether there is a bullwhip effect on Nike T-shirt products PT. Brilliant Think Center

$$\frac{Var(Order0}{Var(Demand)} \geq 1\frac{2.1}{12} + \frac{2.1^2}{P^2}$$

$$0{,}5145 < 1 + \frac{2.1}{12} + \frac{2.1^2}{12^2}$$

$$0{,}5145 < 1{,}18$$

Table 7 Measurement Values of BE II PT. Brilliant Think Center

Item	μd	μo	σd	σo	Cvd	Cvo
Wookey Weight	5420.9	520.63	380.77	18.81	0.0702	0.0361
Nikey T-shirt	985	215.20	16.37	1,777	0.0166	0.0008

Source: Researcher 2024

Table 8 BE II Values and BE Parameters

Item	BE II	Parameter
Wookey Weight	0.5145	1.18
Nikey T-shirt	0.4970	1.18

Based on the results of the bullwhip effect calculation after the Vendor Managed Inventory (VMI) which implements the CPFR (Collaborative, Planning, Forecasting, and Replenishment) concept, it can be concluded that there is no bullwhip effect, the bullwhip effect produced after the Vendor Managed Inventory on wookey weight is 0.5145 and Nikey t-shirt is 0.4970 or less than the parameters that have been set. The VMI method is also effective in reducing the original bullwhip effect value from the company for Wookey weight which is 1.2323 and Nikey jersey is 1.2110.

5. Calculating Inventory Value

The calculation of inventory value in the Vendor Managed Inventory (VMI) method is carried out by the vendor (PT. Briliant Think Center) which includes safety stock, reorder point and maximum stock.

1.) Calculating Safety Stock:

$$SS = Zx\sigma x\sqrt{\bar{L}} \qquad (4.10)$$

2.) Calculating Re-Order Point:

ROP = (D x 1) + SS (4.11)

3.) Calculating Maximum Inventory:

MS = SS + Q*

Table 9 Wookey Weight Inventory Control Recap Results PT. Brilliant Think Center

Period	SS	ROP	MS
Oct 23			
Nov 23			
Dec 23	628,274	6365.77	6901.72
Jan 24	628,274	6194.77	6722.67
Feb 24	628,274	5638.27	6139.09
Mar 24	628,274	5143.27	5618.7
Apr 24	628,274	6050.77	6571.8
May 24	628,274	6097.77	6621.05
Jun 24	628,274	6197.77	6725.81
Jul 24	628,274	6361.27	6897.01
Aug 24	628,274	6301.77	6834.72
Sep 24	628,274	6140.27	6665.58
Oct 24	628,274	5700.77	6204.7
Nov 24	628,274	5700.77	6204.7
Dec 24	628,274	5700.77	6204.7
Jan 25	628,274	5700.77	6204.7
Feb 25	628,274	5700.77	6204.7
Mar 25	628,274	5700.77	6204.7
Apr 25	628,274	5700.77	6204.7
May 25	628,274	5700.77	6204.7
Jun 25	628,274	5700.77	6204.7
Jul 25	628,274	5700.77	6204.7
Aug 25	628,274	5700.77	6204.7
Sep 25	628,274	5700.77	6204.7

From the calculation table of safety stock, reorder point, and maximum stock, it can be seen that the Z score is 1.65 or a safety factor of 95%. With a safety stock of 628,274 pcs. And for different reorder points each month, the average reorder point for wookey weight is 5859.14 pcs. The maximum stock at different wookey weights each month is obtained with an average maximum stock of 6370.66 pcs.

Table 10Comparison of BE Wookey Weight and Nikey Kaos Before and After VMI

Item	Parameter	Before	After
Wookey Weight	1.18	1.2323	0.5145
Nikey T-shirt	1.18	1,2110	0.4970

Based on the VMI method, it can reduce stockout or overstock, because accurate forecasting calculations are carried out in each period by the vendor (PT Briliant Think Center), this is also a benchmark for PT. Brilliant Think Center to provide order data to suppliers by taking into account the order quantity policy. The results of the vendor-managed inventory (VMI) method, the BE value can be minimized for

stockout and overstock problems where before VMI the BE value was still above the parameter, but by implementing Vendor Managed inventory (VMI) the BE value decreased from before VMI so that the bullwhip effect can be eliminated/minimized. The following is a comparison of BE parameters before and after VMI.

5.0 CONCLUSION

Based on the research results on the vendor-managed inventory (VMI) approach to minimize the bullwhip effect at PT. Brilliant Think Center, the following conclusions were obtained:

a. The Vendor Managed Inventory (VMI) approach by implementing the Collaborative, Planning, Forecasting, and Replenishment (CPFR) concept can help inventory efficiency and reduce stockouts or overstocks on Wookey weight and Nikey t-shirt products. The CPFR concept is an information collaboration strategy between vendors (PT. BTC) and suppliers, where vendors know the actual demand from consumer demand and predict more accurate demand, in addition, the addition of safety stock can anticipate an increase in demand that is not known with certainty. After forecasting consumer demand, the vendor will inform the supplier to send goods in a predetermined quantity, and the goods are sent according to the agreed schedule.
b. The results of the comparison of the bullwhip effect values show what happened at PT. Brilliant Think Center in the period October 2023-September 2024 before the implementation of the Vendor Managed Inventory (VMI) Method by implementing the Collaborative concept. Planning, Forecasting, and Replenishment (CPFR) for wookey weight products was 1.2323 to 0.5145 and nikey jersey products were 1.2110 to 0.4970 where previously the bullwhip effect value at PT. Brilliant Think Center was more than 1 due to the variance of orders to suppliers which was still greater than the variance of demand before the safety stock. However, with the Vendor Managed Inventory (VMI) Method, this can be minimized because the variance of orders after the implementation of VMI can be adjusted to forecasts and safety stock compared to the company's initial policy.

Suggestion

From the conclusions that have been obtained, suggestions can be made for the company and further researchers with the same problem, then what should be done next:

1. For the Company:

1.) Data limitations: This study was conducted in only one company, so the results may not be fully generalizable to other industries.

2.) Limited duration of the study: This study only covered a period of one year, so it was not possible to observe the long-term impact of implementing Vendor Managed Inventory (VMI).

3.) Limitations of the research method: This study only used the VMI and EOQ approaches as inventory management strategies without comparing them in depth with other methods such as Just-In-Time (JIT) or Material Requirement Planning (MRP).

2. For Future Studies:

1.) Investigating the implementation of VMI methods in different industries, such as manufacturing, pharmaceuticals, or retail to understand their effectiveness in different sectors.
2.) Comparing more complex demand forecasting methods, such as the use of Machine Learning or AI-based forecasting to improve demand prediction accuracy and reduce the bullwhip effect.
3.) Analyzing the integration of digital technologies in supply chain management, such as the use of the Internet of Things (IoT) or Blockchain to increase the transparency and efficiency of VMI systems.

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Innovative Water Management System for Service Apartment: Greywater Recycling for Sustainability

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ABSTRACT

Residential development projects often face serious issues related to water source scarcity, which can pose risks to public health and lead to high costs for water supply. In this context, the main objective is to create a system capable of recycling greywater without the risk of contamination that can be used locally. To achieve this objective, an innovative water management system will be implemented, including the use of advanced technology to treat greywater for toilet flushing and plant irrigation. With this it is hoped to reduce potable water usage and ensure the availability of clean and safe water sources for all. Research findings indicate that greywater treatment systems such advanced filtration systems, Ultraviolet disinfection, and hybrid treatment systems are not only effective but also cost saving and making them an attractive option for future development projects.

Keywords: *water management system, greywater treatment, greywater recycling, water security.*

1.0 INTRODUCTION

Innovative water management systems are becoming essential to sustainable living considering growing water scarcity and environmental concerns, especially in service apartments. These technologies, which improve water usage efficiency can make a substantial contribution to environmental sustainability, through the greywater recycling technology. Effective water management systems are becoming more and more necessary as urbanization keeps growing. The need for sustainable water management systems has grown in importance due to urbanization and water shortages, especially in service apartments where water usage is high. Greywater recycling is the main component of this cutting-edge water management system, which are crucial for advancing resource efficiency and sustainability.

Overview Water Management Issue			
WATER CONSUMPTION	**WATER LOSS**	**ECONOMIC IMPACT**	**FUTURE DEMAND**
Malaysians typically consume between 205 and 245 liters daily, which is much more than the WHO's suggested daily intake of 165 liters (Malaysia Voluntary National Review (VNR), 2021).	Malaysia has a high Non-Revenue Water (NRW) rate of over 36.4%, which means that leaks and other inefficiencies cause almost a third of treated water to be lost (Malaysia Voluntary National Review (VNR), 2021).	Significant economic consequences result from interruptions in the water supply; Selangor alone is dealing with serious water-related problems that affect its GDP. (Raihan et al., 2023)	By 2050, it's expected that water consumption would have increased by 103%, increasing the demand on available resources (WWF, 2023).

Table 1: Overview Water Management Issue (Author's Research, 2025)

In any service apartment complex, water is one of the most important resources since it supports everyday operations and ensures tenants' comfort and well-being. Unfortunately, growing urbanization, water scarcity, and rising utility bills are making it harder and harder to manage water resources with efficiency. As a result, there is now a greater need for creative water management solutions that maximize use, cut waste, and improve sustainability.

Adopting a creative water management solution can have several advantages for service apartments, as utility management has a direct impact on operational expenses and resident satisfaction. These include cutting water costs, adhering to environmental regulations, and improving the property's standing as a sustainable one. Service apartments can help create a more environmentally friendly future while offering residents better living conditions by using modern solutions.

1.1. BACKGROUND

According to Asian Water Development Outlook, (2013) water scarcity and water supply limitations are a pressing problem in many cities mostly because of poorly developed piped water systems. This has been worsened by unregulated industrial development that has introduced rivers as the sources of water, more pollution. According to Bouguerra (2006), water sources are increasingly becoming at risk of being polluted or dried up, misused, or being exploited by International Oil Companies that are involved in environmentally unfriendly practices.

Water supply is essential, so water pricing and billing policies need to be fair and reasonable, as argued by Siwar and Ahmed (2014). Academy of Sciences Malaysia. (2022) state that some low-income earners have to reduce their usage of water for personal activities due to high charges for water. The water problem is made worse by the fact that many Malaysian towns continue to rely on outdated water delivery networks, which result in increased Non-Revenue Water (NRW), pipe bursts, leaks, and decreased internal pressurization, according to WST2040. Siwar and Ahmed (2014) noted that due to the ageing of water systems in urban and suburban regions, a higher percentage of NRW and service interruptions occur.

Primary Sector	Secondary Sector	Service Sector
• Groundwater mapping and abstraction • Rainwater harvesting • Desalination of brackish / saline water • Alternative water	• Water reuse and recycling systems for agriculture and aquaculture • Urban farming • Livestock waste treatment system • Hydropower development • Water-efficient design and buildings • Water transportation • Water and ecotourism • Commercialisation of technology and expertise	• Tertiary treatment for sewage to reduce eutrophication in public waters • Smart water network monitoring systems for non-revenue water reduction • Improve stormwater management • Pollution monitoring and control at source • Flood mitigation and forecasting

Research	Institutional and Legal Framework
• Establish a: o Water Research Consortium o National Water Research and Development Centre o Centres of Excellence or research institutes for water, green technology, tropical biological diversity, timber, o Global Warming Research Centre • Conduct and fund water research into 21 themes and 96 research topics • Encourage research into water and water-related sectors (i.e., energy, agriculture, tourism, urban development)	• Review, update, and introduction of existing/new policies: o Optimisation of government bodies and agencies o Institutionalising IWRM o Toughened regulation and enforcement of IWRM o Privatisation / Corporatisation of the water supply sector

Source: Analytics by Sunway Institute for Global Strategy and Competitiveness (2021)

Table 2: Findings on Policies and Strategies that Address Water Related Issues

The lack of greywater recycling systems in service apartments causes serious problems, especially when it comes to sustainability and water saving. A significant amount of home water

use is comprised of greywater, which is wastewater produced by household tasks like laundry, dishwashing, and bathing. In fact, studies indicate that greywater can account for 50-70% of total residential wastewater (Soon Hui Ni, 2021). Water shortages are made worse by the absence of greywater systems, which also increases reliance on freshwater supplies, which are frequently limited and under strain from expanding urban populations.

Due to population increase and shifting consumption habits, the demand for freshwater is still increasing in many places, especially cities. The lack of greywater recycling equipment in service apartments leads to the depletion of water resources in the area. This is particularly concerning in places where there is a lot of water scarcity for instance, in Malaysia, it has been reported that domestic usage accounts for approximately 67% of total water consumption (Roshartini Omar, 2021). By allowing the reuse of water for other purposes like landscaping and toilet flushing, greywater recycling might significantly reduce this demand.

1.2 RESEARCH OBJECTIVES

1. To identify suitable greywater treatment technologies for service apartments.
2. To determine the challenges in implementing greywater recycling systems.
3. To examine the economic and environmental benefits of greywater recycling.

1.3 RESEARCH QUESTIONS

Water scarcity is becoming a growing concern, especially in high-density residential developments like service apartments. Malaysia's daily per capita water consumption (205–245 liters) exceeds the WHO-recommended 165 liters, increasing reliance on potable water sources (Malaysia VNR, 2021). With rapid urbanization and rising water demand, there is a need for effective water management solutions to reduce dependence on treated water.

Greywater recycling is one possible solution, as it allows the reuse of non-potable water for applications such as toilet flushing and irrigation. However, the adoption of greywater recycling in Malaysia is still limited due to various factors, including technology selection, cost, public perception, and regulatory barriers. This study focuses on the potential of greywater recycling in service apartments by addressing the following questions:

1. What are the main greywater treatment technologies used in service apartments?
2. What challenges hinder the implementation of greywater recycling systems?
3. What are the economic and environmental benefits of greywater recycling?

1.4 ABBREVIATIONS AND ACRONYMS

ICBIV – International Conference on Business Management and Innovation
NRW – Non-Revenue Water
MBR – Membrane Bioreactor
UASB – Upflow Anaerobic Sludge Blanket
RBC – Rotating Biological Contractor
UV – Ultraviolet
VOC – Volatile Organic Compounds
TDS – Total Dissolved Solids

2.0 LITERATURE REVIEW

2.1 GREYWATER TREATMENT TECHNOLOGIES

(a) Definition of Sources of Greywater in Residential Settings

Greywater is often referred to as lightly polluted household water and it originates from various everyday activities such as laundry, kitchen, bathroom sinks, showers, and baths. It is important to distinguish greywater from wastewater, which typically contains more harmful contaminants like urine and feces from toilets. Despite being classified as “used water”, greywater is usually clean enough to be treated and reused for non-potable purposes such as toilet flushing and irrigation. This presents significant opportunities for conserving water. The potential of greywater to reduce the consumption of freshwater is particularly impressive. As noted by Pradhan et al. (2019), greywater from less contaminated sources, like hand basins and laundry requires minimal treatment, especially when it is kept separate from water with higher organic loads like from the kitchen. By recycling greywater effectively, households can realize considerable water savings, reduce environmental pollution, and decrease the overall costs associated with freshwater supply (Knutsson & Knutsson, 2021).

In practical terms, greywater recycling systems are designed to filter and treat greywater and allow it to be reused without any direct contact with users. The treated water is especially beneficial for non-potable applications, such as toilet flushing, where it can effectively replace potable water. While this paper specifically highlights the innovative use of greywater for toilet flushing. It is important to recognize the broader potential of greywater recycling in promoting residential water sustainability. Despite its potential, the adoption of greywater recycling systems in countries like Malaysia is still limited. Oh et al. (2018) pointed out that although Malaysia is rich in greywater resources, the lack of resources and knowledge regarding their implementation has prevented widespread adoption. This is particularly relevant in urban areas such as service apartments, where it has larger roof areas and higher densities of residents can generate

significant volumes of greywater thus presenting a valuable opportunity for sustainable water management

(b) Common Technologies for Greywater Treatment

Greywater Treatment uses a variety of technological methods that combine physical, biological, and chemical processes. Each stage of treatment is important to ensure that greywater is adequately purified for safe and effective reuse, especially for non-potable applications like toilet flushing.

Figure 1 : The process of greywater treatment

(i) Physical Treatment

The treatment process usually begins with physical treatment, which acts as the first line of defense in greywater recycling systems. Two widely used in this phase are filtration and sedimentation, both of which help to reduce suspended solids in the greywater. There are several filtration techniques such as sand filters, metal mesh, and membrane filtration. Membrane filtration is recognized for its ability to effectively remove both dissolved and suspended solids, along with pathogenic bacteria that make it a vital component in advanced greywater treatment systems (Oh et al., 2018).

(ii) Biological Treatment

Biological treatment methods play a crucial role in breaking down organic pollutants found in greywater. These systems can be divided into two main categories: aerobic and anaerobic processes, each with its own strengths and limitations. Anaerobic treatments, like the Upflow Anaerobic Sludge Blanket (UASB), are often used as preliminary steps in the treatment process. They utilize microorganisms to decompose organic matter in environments devoid of oxygen. However, these processes can be slower and less effective in completely breaking down pollutants unless they are properly insulated and disinfected. In contrast, aerobic treatment relies on oxygen to facilitate the breakdown of organic pollutants, making it a more efficient choice for greywater applications. Techniques such as Membrane Bioreactors (MBR) and Rotating Biological Contractors (RBC) are commonly used to improve treatment efficiency in this phase. Typically, biological treatment is positioned between sedimentation or filtration stages to maximize the removal of biosolids and sludge.

(iii) Chemical Treatment

Chemical treatment represents a more advanced stage of greywater recycling, focusing on further refining the water quality. Methods like coagulation, advanced oxidation processes, and adsorption using activated carbon are frequently employed to tackle more complex pollutants. One innovative approach is photocatalysis, especially when paired with ultraviolet (UV) light, which not only breaks down organic contaminants but also disinfects the water by eliminating harmful pathogens. Among the various disinfection methods, ozone and UV disinfection are prominent options. UV disinfection is often favored due to its accessibility, cost-effectiveness, and ease of implementation compared to ozone systems.

(c) Innovation in Greywater Treatment Technologies.

(i) Advanced Filtration Technologies.

(a) Membrane Filtration: Membrane filtration technologies such as nanofiltration and reverse osmosis can remove water pollutants effectively. These membrane filtration systems force water through semi permeable membranes which act as barriers that physically remove harmful microorganisms, such as bacteria and viruses. Moreover, nanofiltration will be able to filter out particles as small as 0.1 microns. On the other hand, reverse osmosis can eliminate sediments and bacteria in dissolving state. According to Hourlier et al. (2010) membrane filtration can remove 90% of total dissolved solids (TDS) from water. Also, the compact design of the filtration system makes it easy to install in service apartment recycling grey water.

(b) Activated carbon filters : The volatile organic compounds (VOCs), can be removed by adsorption. The porous nature of the activated carbon helps to trap contaminants in the greywater. In Malaysia, this technology has been introduced in several types of property development. In addition, the filter is environmentally safe and produces less waste and uses less chemicals (Hourlier et al., 2010).

(ii) Ultraviolet (UV) Disinfection

Ultraviolet (UV) disinfection systems are systems that inactivate microorganisms by using ultraviolet light in water. Basically, water is exposed to UV light at a particular wavelength, generally at 254 nm. The process will rupture the DNA of bacteria, viruses, and protozoa. As a result, microorganisms with ruptured DNA cannot replicate. The UV disinfection technology also works well against waterborne contaminants, making it a solid technology to treat greywater. Also, the UV disinfection process does not include any toxic chemicals into the water system (Juiani, 2023). UV systems can be installed at points of entrance as well as in service apartments to add one more layer of protection against microbiological contamination.

(iii) Hybrid Treatment Systems

The hybrid treatment system includes several treatment systems, such as membrane filtration and UV disinfection. Consequently, these increase the assurances of the safety of the reuse of greywater in service apartments. These systems offer great flexibility and efficiency of greywater treatment in the service apartment. For example, the process starts with membrane filtration to

remove impurities such as TDS and VOC. The microorganism then is killed and removed with the UV disinfection system (Tortajada & Nambiar, 2019). Hybrid systems have been shown to enhance the overall efficiency of water treatment operations, thus making them suitable for residential application.

(d) Effectiveness of Greywater Treatment

Greywater Treatment is a smart and sustainable way to manage water resources and offers significant advantages in reducing water consumption and minimizing environmental impact. According to Pradhan et al. (2019), greywater is considered lightly polluted which means it requires far less treatment compared to wastewater, which is heavily loaded with organic materials. By treating and recycling greywater, households can cut down their water usage anywhere from 10% to 50% thus making it a valuable asset in urban greywater management. In the studies by Cureau & Ghisi (2019), the combination of greywater reuse with rainwater harvesting can reduce the consumption of potable water by 46.3%. Prasad et al. (2022) stated that the implementation of a greywater recycling system can help to save 29% to 47% of potable water. Findings from several studies indicate the potential of greywater recycling as a good innovation to ensure water sustainability.

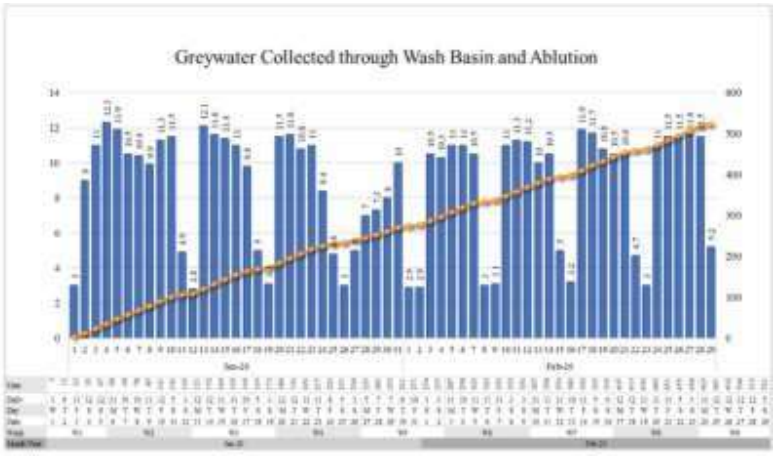

Figure 2 : The volume of greywater collected in Jan 2020 and Feb 2020 (Journal of the Malaysia Institute of Planners, 2023)

Research has shown that the main sources of greywater in both residential and commercial buildings are wash basins and ablution facilities. These sources contribute significantly to the overall volume of greywater that can be recycled. For instance, data from the study “Integrating Rainwater Harvesting and Greywater Recycling to Increase Water Efficiency in Office Buildings” highlights on greywater collection volumes. The study recorded daily greywater collection from wash basins and ablution for January and February 2020, which included weekends and public holidays. In January 2020, the total greywater collected from these sources was 27.09 cubic

metres, while in February 2020, it slightly decreased to 249.7 cubic metres. The cumulative volume of greywater collected over these two months reached 520.6 cubic metres. It highlights the significant role that washing basins and ablution facilities play in generating greywater. This data emphasizes the importance of implementing effective greywater recycling systems in building that consume a lot of water. The consistent daily collection, even on holidays, showcases the potential for reliable water savings if such systems are put into place. The study also demonstrates the possible cost savings from a greywater recycling system. The implementation of greywater recycling systems in existing urban infrastructure not only saves potable water but also leads to a reduction in sewage generation, which decreases sewage's impact on the environment (Zavala et al., 2016).

However, greywater recycling still not widely practice in Malaysia. As compared to other countries, Malaysia is in its infancy for greywater recycling. According to Ntibrey et al. (2020), public acceptance of the idea of greywater recycling initiatives depends on the community experience. The studies indicate that communities that experience water issues such as water shortage or water pollution are more accepting of the practice of recycling and reusing greywater. Greywater is not commonly reused in Malaysia due to the limited resources and knowledge on the implementation and management of greywater recycling and is conventionally treated together with wastewater from toilets in a centralized treatment facility (Oh et al., 2018). Nonetheless, Malaysia has opportunity to kickstart greywater recycling initiatives by concentrating on lighter sources of greywater such as water from ablution, sinks, and bathrooms. These sources require less intensive treatment and are perfectly used for things like toilet flushing and garden irritation. These small-scale projects could serve as a foundation for the broader implementation of greywater recycling systems across the country. In the long term, integrating greywater recycling with rainwater harvesting systems can yield even greater benefits. Such dual systems not only enhance water efficiency but also provide significant returns on investment for building stakeholders by greatly reducing the consumption of potable water. For service apartments and other high occupancy residential areas can adopt these systems represent a forward-thinking strategy to achieve water sustainability while tackling the challenges posed by urban water demand.

(e) The Challenges of Greywater Recycling System

The implementation of greywater recycling systems faces several challenges which arise from financial, technical, legal, and social factors. These systems have the potential to address water scarcity issues and promote sustainability and achieving widespread adoption especially in countries like Malaysia. It is a complex task that requires a careful balance between environmental, economic, and political consideration (Oh et al., 2018).

One major challenge is the financial constraints associated with implementing greywater recycling systems. The high initial costs for installation and maintenance pose a significant barrier. This issue is particularly pronounced in existing buildings were modifying the existing plumbing

systems to accommodate greywater recycling requires extensive redesign and construction work. For example, in a residential building, it need to configure plumbing layouts to separate greywater from sewage can lead to substantial expenses. Oh et al., (2018) emphasize that creating new plumbing systems for greywater in already established structures further increases costs and makes such projects less chance economically viable.

Another important challenge is the absence of standardized guidelines for greywater recycling in Malaysia. This lack of clear standards makes it difficult for construction professionals to effectively treat greywater and remove contaminants which is crucial for the success of these systems (Soong Hui Ni, 2021). Because of this knowledge gap, industry players often have to depend on external expertise which can drive up implementation costs. In developing this system in countries like Malaysia, this challenge of limited knowledge and resources is common when trying to adopt advanced green building technologies.

Moreover, legal limitation introduces additional challenges to scaling up greywater recycling systems. As noted by Rescke (2013), regulatory obstacles frequently hinder the integration of these systems into standard construction practices. Governmental oversight and experience in greywater recycling are also limited in Malaysia. Oh et al. (2018) noted that while state governments oversee the approval process for these systems and their lack of experience in managing and maintaining greywater recycling systems slows down progress. The current focus of wastewater and greywater treatment is still on the development of centralized systems handled by the Malaysian government.

Next, public perception towards greywater recycling systems is another challenge to the successful implementation of greywater recycling systems (Soong Hui Ni, 2021). Many people have concerns regarding the safety and cleanliness of recycled greywater, often viewing it as unhealthy and potentially dangerous. Additionally, there is a prevalent fear that storage tanks for greywater could serve as breeding grounds for mosquitoes, which may worsen health issues like dengue fever. To address these misconceptions, it is essential to conduct public education campaigns and foster transparent communication about the safety and advantages of greywater recycling systems.

3.0 RESEARCH METHODOLOGY

This paper is conducted using a systematic literature review approach, relying on secondary data from peer-reviewed journals, government reports, and industry publications. The study examines existing greywater treatment technologies, their effectiveness, and their feasibility for service apartments. The methodology follows a structured process to analyze how greywater recycling systems function and how they can be implemented efficiently.

The research focuses on understanding the greywater treatment process, which typically involves several key stages which are physical treatment, biological treatment, and chemical treatment. Through an extensive review of literature, this study explores various technologies, including filtration, biological treatment, membrane systems, and disinfection methods such as UV and chlorination. The analysis helps identify the most suitable approaches for service apartments, considering factors like cost, space limitations, and regulatory compliance.

By reviewing case studies and previous research, this study also highlights the challenges in implementing greywater recycling systems, including technical, financial, and social barriers. The findings contribute to a better understanding of how greywater systems can be integrated into service apartments to promote sustainable water management.

4.0 DISCUSSION

The proposed water management system can be seen as a viable and feasible way to overcome the problems of water scarcity and water consumption, especially in residential properties such as service apartments. The innovative greywater recycling technologies allow up to 47% of potable water to be conserved (Prasad et al., 2022). Additionally, the reuse of greywater for plant irrigation, toilet flushing, and other non-potable uses can reduce the cost for water supply and alleviate the pressure and burden on the potable water supply (Zavala et al., 2016).

Moreover, the study shows that membrane filtration and UV disinfection technologies are reliable as an innovation for greywater treatment technologies. Hybrid systems, which include multiple filtration systems, were used to improve system efficacy and flexibility in providing solutions for various types of residential settings. They not only ensure the safety of recycled greywater but also lessen the environmental impact of using potable water in urban areas.

The implementation of the greywater recycling system in Malaysia is also hindered due to the high cost of installation, the limited technological ability, and the absence of established regulations. Moreover, the social acceptance of the system is also a challenge, where the public perceptions of greywater recycling are low. The public is skeptical about the safety of greywater treated and whether the system is properly maintained. To encourage the use of these technologies, public education and regulatory support will be needed.

The implications of this proposed system are extensive and practical. This can increase the sustainability of service apartments, reduce operational costs, and contribute to the worldwide water conservation goal. Furthermore, the system is modular and may be scaled and adapted to other property types, whether in urban or rural locations, becoming a model for sustainable water management in underdeveloped countries.

While this study provides valuable insights, it does have certain limitations. One key limitation is that it relies heavily on past research and literature reviews, which may not fully capture the latest technological advancements, or the specific challenges faced in implementing greywater recycling in different apartment service settings. Additionally, the study does not include a detailed cost-benefit analysis, which is crucial for understanding the economic feasibility of such systems for both property developers and residents.

Another limitation is the lack of real-world implementation data. Without pilot projects or case studies specific to Malaysia, it is difficult to determine how well these hybrid filtration and disinfection technologies would perform in practical settings. This lack of empirical data makes it challenging to accurately predict long-term maintenance costs and overall system efficiency.

Finally, the current study focuses on specific greywater treatment technology. For instance, future research should conduct a comparative study of various greywater treatment technologies, considering their effectiveness in removing contaminants, their energy consumption, and their cost effectiveness and also overcoming the financial and regulatory problems identified in the study. Additional benefits could be obtained when the application of rainwater harvesting is integrated with greywater recycling, which increases water efficiency and reduces consumption on potable water sources. This will provide valuable insights into the optimal treatment technology for different service apartment or high-rise building settings and contribute to the development of more efficient and sustainable greywater recycling systems.

Aspect	Key Findings
Greywater Treatment Technologies	Membrane filtration, UV disinfection, hybrid systems combining physical and biological treatment. (Hourlier et al., 2010), (Juiani, 2023), & (Tortajada & Nambiar, 2019)
Benefits of Greywater recycling	Reduces potable water consumption, lowers utility costs, supports sustainability, minimizes wastewater generation. (Prasad et al., 2022), (Zavala et al., 2016), & (Cureau & Ghisi, 2019)
Challenges in Implementation	High installation and maintenance costs, lack of public awareness, limited government regulations. (Oh et al., 2018), & (Soong Hui Ni, 2021)

Table 3: Summary of Literature Review Findings (Author's Research, 2025)

5.0 CONCLUSION

This study emphasizes the important role of innovative water management systems, especially greywater recycling in tackling water scarcity and promoting sustainability in residential especially service apartments. Rapid urbanization increasing water demand and aging infrastructure have worsened the challenges related to water security and making it essential to implement efficient systems like greywater recycling. The research highlights how these systems can convert greywater, which constitutes a significant portion of household wastewater into a reusable resource for non-potable uses such as toilet flushing and landscaping.

Exploring greywater treatment technologies reveals the potential of physical, biological, and chemical processes with advancements like membrane filtration, UV disinfection and hybrid systems greatly improving the quality and safety of treated water. These systems are not only environmentally sustainable but also cost-effective for future because potentially reducing potable water usage by up to 50% and lowering operational costs for buildings.

Furthermore, this study also highlights the importance of community involvement and government support in promoting the acceptance and implementation of these technologies. Last but not least, the proposed system provides a viable pathway for achieving sustainable water management in residential areas. By reducing reliance on potable water and minimizing environment impact, greywater recycling can assist urban areas in meeting their increasing water demands while advancing global sustainability goals Future research should focus on optimizing costs, assessing long term environmental impacts, and expanding the application of these systems in various residential and commercial settings and also paving the way for a more resilient water infrastructure.

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Innovative Strategies for Smart Residential Buildings: Advancing Sustainability Goals in Real Estate Business

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ABSTRACT

In recent years, the development of smart residential buildings has gained significant attention as a key strategy to achieve sustainability goals. Integrating smart building technologies in the real estate business offers a transformative approach to the real-time data and networked systems used in smart buildings to maximize energy efficiency, lower carbon emissions, and enhance the comfort and well-being of residents. However, one of the problems of smart buildings is dealing with systems, which involves navigating a complex web of interconnected functional entities across various aspects of a building. This method offers practical solutions for developers to implement smart residential buildings successfully, balancing the need for advanced technologies with practical feasibility and gaining a competitive edge in the real estate business. This study explores innovative strategies for implementing smart systems in residential buildings, particularly landed properties by conducting a systematic literature review (SLR). The findings indicate that smart buildings can create healthier living environments and enhance the branding and marketing of smart residential buildings as innovative and business models.

Keywords: *Smart building, Sustainability goals, Real estate business, Eco-Friendly building.*

1.0 Introduction

Most of these gadgets are smartphones, which are equipped with applications that allow users to monitor and control their remote work in real-time. In other words, people have reached a point where they can embrace new and innovative solutions. (Andersson et al., 2018; Caputo et al., 2018; Wang and Seidle, 2017). In the REC-sector, digitalisation is redefining the built and digital spheres and merging them into one coherent environment, and a smart building has been introduced as one embodiment of it in the traditional sector. According to (Säynäjoki et al, 2017), intelligent buildings create a new ecosystem within the sector that has a potential to enhance the value of the external data exchange, especially regarding smart communities and smart cities. However, the value of smart buildings is not well defined yet, as the significance of the external data is not yet completely recognized (Säynäjoki et al., 2017). Moreover, it is the imprecise value attached to the concept of smart buildings that has its roots in the lack of a clear, widely accepted definition, which introduces vagueness into the very term. Considerable improvements in energy efficiency across the built environment are expected for the coming years by the European Union, and the potential digitalization contribution in achieving these goals under the banner of smart buildings has drawn significant policy attention.

2.0 Literature Review

Many cities seek to establish long-term and mutually beneficial relationships with their local real estate communities when it comes to the development and implementation of commercial or multifamily building performance policies. These relationships allow cities to more effectively advance legislation that ensures a flourishing, resilient community for all and reaps the maximum benefits. However, it can be hard to make and follow policies when neither building owners nor tenants have full control over how much energy they use and aren't rewarded for making changes to the building's performance. It is crucial for policymakers to comprehend the business aspect of real estate in order to surmount this obstacle. Building performance policies will be unable to realise their maximum potential until that time.

2.1 Definition of Real estate business

Alfonsius (2020) states, Business is the process of generating income or sustaining oneself by producing, purchasing, and selling goods and services. Business can be defined as any activity or enterprise undertaken with the aim of generating profit. It includes various forms, such as sole proprietorships, partnerships, corporations, and cooperatives, each possessing unique characteristics and legal structures.

Real estate encompasses the definition of land along with all natural and artificial enhancements that are permanently affixed to the land (Chen, 2024). The phrase "real estate" refers to land, enhancements, rights, and aspects of ownership. The real estate business includes the acquisition, disposition, leasing, administration, or development of properties, including land, residential dwellings, commercial structures, or industrial facilities. This sector is essential to the economy, enabling property transactions and development to address societal housing, business, and infrastructural requirements.

2.2 Definition of Smart building

The concept of smart buildings has evolved significantly due to advancements in technology. The integration of these technologies facilitates more intelligent resources and processes, enhancing the building's ability to operate efficiently, flexibly, interactively, and sustainably. Smart buildings encompass various aspects, but are briefly defined by Vattano (2014) as architecture that employs building technology systems to facilitate services and enhance the operation of a building for the benefit of its occupants and management.

A smart building incorporates modern technology, including sensors, Internet of Things (IoT) devices, and automated systems. These structures use intelligent technologies to oversee and regulate many functions, such as lighting, heating, ventilation, air conditioning (HVAC), security, and energy usage, frequently via a centralized or cloud-based platform. They are frequently utilised in residential, commercial, and industrial environments, influencing the path of urban growth and modern infrastructure.

Matrix Table						
Authors	**HVAC System**	**Smart Lighting**	**Permeable pavement**	**Smart Window**	**Energy management system (EMS)**	**Building Automation System (BAS)**
Jeniffer King & Christopher Perry	☑	☑	☐	☐	☐	☐
Héctor F. Chinchero 1 , J. Marcos Alonso1, Hugo Ortiz T2	☐	☑	☐	☐	☐	☐
J. Aguilar	☑	☐	☐	☐	☐	☐
Antunes, L. N., Ghisi, E., & Severis, R. M.	☐	☐	☑	☐	☐	☐
Guan, X., Wang, J., & Xiao, F.	☐	☐	☑	☐	☐	☐
Aliero, M.S. Asif, M. Ghani, I. Pasha, M.F. Jeong, S.R	☐	☐	☐	☑	☑	☐
FE Doukouré Charles	☑	☐	☐	☑	☑	☐
Bonetto, S.; Fowler, T.	☐	☐	☐	☐	☐	☑

1) HVAC System

HVAC systems can account for more than 40% of energy consumption in commercial buildings (EIA, 2016), and many are oversized, which reduces their efficiency. Smart HVAC systems optimize energy use through real-time data from sensors and cloud-based software while maintaining occupant comfort. The system can adjust its operation with regard to occupancy and other factors; it can also detect faults and lower energy use during peak demand.

Some of the basic elements of smart HVACs include sensors, which include duct static pressure sensors that measure resistance to airflow to help save energy. The decreasing costs of sensors have made these technologies more accessible. Advanced smart controls enhance efficiency further by adjusting airflow based on variables such as CO2 levels, temperature, and occupancy.

Intelligent control mechanisms can easily be incorporated into the HVAC system for better efficiency of operations. This is because with smaller structures, intelligent systems allow full analytical capabilities, which provide insightful information on energy consumption and system efficacy to make informed decisions toward savings in energy.

2) Smart Lighting

Advanced smart lighting control has developed beyond infrared motion sensors, manual dimming, and timer switches, which have faced issues of poor design, improper setup, and very low user adoption. These now aim at improving energy efficiency and enhancing the user experience of a building. By 2014, 12% of all U.S. commercial buildings had adopted advanced lighting controls, with the education sector leading all at 2.43%. However, market penetration remains limited with 15% of systems featuring occupancy-type controls, 6% dimming controls, 4% lighting management systems, 3% demand response, and 2% daylighting. Globally, smart lighting systems are installed across 600 million to 1 billion square feet of commercial space. The base of installed units is forecast to grow from 46 million units in 2015 to 2.54 billion units by 2020.

Intelligent lighting systems use networked LED and fluorescent luminaires with advanced sensors and control. These systems can detect faults, send alerts, and adjust lighting based on occupancy, ambient light, and activities. Features like dual-technology sensing, daylight harvesting, and continuous dimming enable fine-grained control, which can reduce artificial lighting by 40–80% while maintaining occupant satisfaction. Retrofitted advanced controls on lighting can help save as much as 45% in energy, and half of this comes from occupancy sensing and daylight harvesting. The vacancy sensing, based on user-activated lights, also improves energy efficiency through the ability to leave their lights off when they are not needed. All in all, smart lighting systems offer large energy savings and operational efficiency benefits while improving the user experience.

3) Permeable Pavement

Permeable pavement is a surface material engineered to facilitate the infiltration of water through its structure into the underlying soil or drainage system. In contrast with traditional pavements that generate runoff by impermeable sealing the ground, permeable pavements effectively manage stormwater by mimicking natural water cycles. Permeable pavement significantly affects hydrology and environmental outcomes due to its high porosity and permeability, which allow for the penetration and temporary accumulation of storm water. This minimises surface runoff while preserving the building's stability (Antunes et al., 2020). Permeable pavement was first developed in the 1800s in Europe, primarily aimed at creating porous paving stones to address stormwater runoff issues in congested urban areas.

China has led the way in the sponge city initiative. Initiated in 2015, the nation seeks to convert urban regions to capture a minimum of 70% of rainwater via green infrastructure and complex drainage systems. A sponge city consists of wetlands, forests, lakes, green roofs, biological retention systems, and permeable pavements. Permeable pavements infiltrate and purify water on the surface, subsequently retaining or draining it. In the absence of water, permeable pavements facilitate the evaporation of retained water, thereby supplying the outside environment (Guan et al., 2021). A sponge city demonstrates a shift in urban planning towards sustainability, facilitating the harmonious integration of urban environments with natural water cycles, thereby enhancing liveability, resilience, and environmental health.

Permeable pavements minimise urban heat islands through evaporative cooling and can incorporate smart technologies, such as sensors, for monitoring water flow and maintenance requirements. The water retained in the pavement can evaporate to supply the atmosphere during times of drought. Furthermore, evaporation has the capacity to absorb heat, thereby lowering pavement temperature (Guan et al., 2021). Pavements consist of porous materials, including previous concrete, porous asphalt, or interlocking pavers with gaps filled by gravel or grass. Commonly used in parking lots, sidewalks, driveways, and low-traffic streets, they represent a crucial component of sustainable urban planning, effectively addressing environmental and climate resilience issues.

4) Smart Window Systems

Smart window systems, which provide dynamic control over the amount of daylight and solar heat, are an advanced approach to building management. Smart window systems control the amount of daylight and solar heat that pass through the building (Saidu, 2022). Both passive and active elements are included in the window glazing of these creative systems. Low-emissivity (low-E) coatings and specialty glass types are examples of passive systems that naturally control the flow of light and heat through the window. Active systems, on the other hand, incorporate responsive components that actively adapt to shifting environmental circumstances. These components could be motorized blinds and shades that automatically extend or retract in response to temperature sensors and light levels, or electrochromic glass that can change its tint in response to the amount of sunlight.

Smart window systems make buildings more comfortable and energy-efficient by cleverly adjusting to these outside influences. The systems include active and passive window glazing systems that respond to changes in temperature or solar heat gain, and accordingly adjust shading devices to control light levels at specific times (Saidu, 2022). They prevent overheating and lessen the need for air conditioning by minimizing heat gain and glare during the hottest parts of the day. On the other hand, they optimize natural daylighting when the sun isn't shining as much, improving occupant comfort and lowering the demand for artificial lighting. In addition to improving occupant comfort, this dynamic control makes a substantial contribution to energy conservation and a lessened environmental effect.

5) EMS For Smart Building

Smart buildings use cutting-edge technology to improve sustainability and efficiency. Electricity Usage Metering and Submetering, which makes use of smart meters to provide comprehensive consumption data, is one essential component. A smart meter identifies consumption in more detail than a conventional meter, sends data back to the local utility for monitoring and billing purposes, and may provide information and data to the consumer directly (Doukoure, 2014). This information helps consumers make well-informed decisions, enabling them to monitor the effects of energy-saving initiatives, control consumption, and pinpoint areas for improvement. Additionally, smart meters improve grid resilience and reliability by offering insightful data on demand, outages, and power quality.

Smart buildings use a variety of integrated systems to improve safety and optimize operations in addition to energy management. Video surveillance systems improve security, while access control systems manage entry and departure. Occupant safety is given top priority by fire alarm and mass notification systems, which guarantee prompt alerts and coordinated emergency responses. Newer smart meters allow utility customers to monitor demand, power outages, and power quality in real time (Doukoure, 2014). These systems are supported by a strong data network that facilitates smooth communication, data sharing, and centralized control, all of which help to create a built environment that is more effective, safe, and sustainable.

6) Building Automation System (BAS)

One of the earliest elements added to smart buildings was automation, which made it possible to centralize, monitor, and control a number of services, including power, water, light, elevators, closed-circuit television (CCTV), HVAC, and access control systems, in a shared network that can be remotely monitored and automatically managed through the internet, in addition to offering users a comfortable working environment. Like automation, technology has advanced along with smart building development. Although the incorporation of new technologies, like ICT, was a major advancement, it also raised the risks associated with cyber security and resilience. Resulting from the integration of computer technologies and building systems.

Due to its potential to lower energy consumption, facilitate building operation, monitoring, and maintenance, and increase occupant satisfaction, building automation has been gaining more attention. These systems realize this potential through the use of a variety of sensors (such as those that measure temperature, CO2 concentration, zone airflow, daylight levels, and occupancy levels), which generate information that helps make decisions about how to control the building's equipment with the goal of lowering costs while preserving occupant comfort.

3.0 METHOD

The present research employed a systematic approach that encompassed keyword searches, screenings, and categorization to investigate the influence of smart technologies on the real estate sector. The keywords utilized included “Smart Building”, “Real Estate Business”, “Eco-Friendly Building” and “Sustainability Goals”, which were applied across various databases, including Google Scholar, Website, and others. The search process integrated semantic queries and term combinations to guarantee extensive coverage. Articles were filtered according to relevance, language, and date of publication, with 12 articles remaining for analysis. The screening process followed a stepped approach: results were screened to focus on most disruptive technologies in building. Four screens were used: limiting results to real estate business, smart building, technology aspects, and online dissemination. The present integrative review summarized and critiqued the selected studies by integrating qualitative and quantitative insights into establishing the most beneficial smart technologies.

The study also performed thematic content analysis to identify critical factors and superior benefits of smart technologies in real estate investment and development. Articles were read based on the frequency of occurrence of relevant factors, and elements that appeared more frequently were ranked as more critical.

4.0 FINDING DISCUSSION

Initially, the incorporation of modern HVAC systems, like heat pumps and variable refrigerant flow (VRF) systems, showed great energy savings when contrasted with conventional systems. In conjunction with Building Automation Systems (BAS), these systems optimized energy use and minimized environmental impact by dynamically adjusting operations according to occupancy, weather, and energy pricing. Comparably, smart lighting systems that used LED fixtures with built-in controls and daylight harvesting capabilities greatly decreased lighting energy use. In addition to optimizing energy use, these systems improved occupant comfort and well-being by dynamically modifying lighting levels based on occupancy, daylight availability, and time of day.

Additionally, a sustainable stormwater management solution was provided by the installation of permeable pavements in residential developments. These pavements improved water quality, decreased runoff volumes, and lessened the urban heat island effect by letting rainwater seep into the ground. In addition to reducing the negative effects of stormwater runoff on the environment, this made communities more sustainable and livable. Electrochromic and thermochromic windows, two types of smart windows, have shown great promise in controlling solar heat gain and enhancing energy efficiency. These windows significantly decreased the need for excessive heating and cooling by dynamically modifying their characteristics in response to variations in temperature and solar radiation.

Lastly, the research pointed out how important Building Automation Systems (BAS) and Energy Management Systems (EMS) are to maximizing building performance and accomplishing sustainability objectives. EMS platforms reduced peak energy demand and operating costs by identifying areas for improvement and implementing demand-side management strategies after tracking and analyzing energy usage across multiple building systems. As the smart building's central nervous system, BAS integrated and managed a number of building systems, such as security, lighting, and HVAC. BAS improved building performance, increased occupant comfort, and ultimately made living more sustainable and efficient by automating tasks, keeping an eye on system operations, and reacting to data and events in real time.

These results highlight the huge potential of combining these technologies to produce residential buildings that are both genuinely sustainable and energy efficient. A comprehensive approach that takes into consideration the mutual dependence of different building systems and their effects on the overall energy performance and environmental footprint is necessary for the successful application of these strategies.

But there are still a number of difficulties. When putting these technologies into real life, there may be substantial upfront costs. Furthermore, careful planning and expertise are needed to ensure proper connection and compatibility between various systems. In order to overcome these obstacles and encourage the broad implementation of these sustainable building practices, more cooperation between developers, technology suppliers, and legislators is needed.

5.0 CONCLUSION

In conclusion, Smart residential buildings, which combine technology with sustainability, comfort, and security, are an important step toward in the way of our life. The advantages and implications of smart building technology can be concluded from several in significant conclusions as we look to the future, especially in 2025 and beyond. Based on this study, various concepts can be applied such as functional intelligence in Heating, Ventilation, and Air Conditioning (HVAC) systems, smart lighting, smart windows, permeable pavement, Energy Management System (EMS) and Building Automation System (BAS). In addition, this concept Implementing green infrastructure and energy efficient practices further increases sustainability by improving air quality, preserving biodiversity, and reducing carbon emissions. Ultimately, the ultimate goal in sustainable urban planning is to create healthy, prosperous and vibrant urban areas that coexist in harmony with nature to ensure a comprehensively sustainable future for all.

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Kinetic Energy Tiles: Innovative Strategies for Sustainable Real Estate Management

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ABSTRACT

The increasing use of non-renewable energy sources drives the worldwide energy crisis and environmental degradation. This situation has prompted researchers to investigate alternative energy systems that may extract energy from the surrounding environment, such as renewable energy kinetic tiles. This research examines the advantages of energy kinetic tiles as an innovative and sustainable building management strategy in Malaysia. The design of energy kinetic tiles aims to capture the energy that human movement generates while walking on the floor. The building floor will absorb the force generated by the individual's weight and convert the dynamic compression of the floor into electrical energy, thus saving the usage of electricity bills. Reviewing previous studies revealed that kinetic energy tiles provide tangible and strategic benefits to management and businesses, particularly regarding sustainability, cost savings, innovation, and effective marketing. Therefore, using energy-kinetic tiles contributes to producing natural energy and helps save on property management operating costs. This innovation will bring Malaysia closer to an effective, efficient, sustainable property management practice.

Keywords: *Energy-kinetic Tiles, Property Management Cost, Efficient Management, Sustainable PracticeCitation:*

1.0 INTRODUCTION

As the world faces growing challenges related to environmental degradation and resource depletion, the search for more sustainable alternatives to traditional energy generation methods has become more urgent. The reliance on traditional power generation methods, including the burning of coal, diesel, and wood continuously depletes natural resources such as fossil fuels and leads to significant environmental pollution (Parisa et al., 2018). Global energy consumption is steadily rising, with the International Energy Outlook 2017 predicts an increase from 575 quadrillion Btu in 2015 to 736 quadrillion Btu by 2040 which is equivalent to a 28% growth (Shreeshayana et al., 2017; Moussa, 2019). Using fossil fuels to generate electricity has a negative impact on the environment from the production stage until the consumption. Relying solely on these energy resources will result in increased CO2 emissions and global temperature increases (Dawood et al., 2013). This pressing challenge emphasizes the need to shift toward clean renewable energy sources such as sound energy, vibration energy, wind energy, sea wave energy, and kinetic energy. Proper utilisation of such sources helps to reduce the strain of increasing demand for traditional energy sources while benefiting from sources that are always and freely available. Due to the global scarcity of energy resources, it is critical to actively seek alternative sources, such as harvesting the power generated by human footsteps, rather than viewing it as an option. One of these energy harvesting systems employs piezoelectric materials, which convert kinetic energy or mechanical vibrations in the surrounding environment into electrical power (Kyrillos et al., 2024). This idea includes the mechanical energy generated by moving limbs, body vibrations, and interaction between the foot and the ground (Mughal et al., 2023). Pedestrian energy harvesting specifically harnesses the piezoelectric effect to transform the kinetic energy produced by activities such as walking, jogging, or jumping into electricity (Kyrillos, et al., 2024). From a business and management perspective, this transition to green energy represents not just an environmental necessity but also a valuable business opportunity. Companies can gain a competitive edge by investing in energy harvesting technologies, which align with both corporate social responsibility objectives and growing demand for sustainable solutions. By exploring these emerging technologies, businesses can position themselves at the forefront of a rapidly evolving industry that ensures long-term success and profitability. Even a small contribution from green energy sources like this can help to alleviate the effects of climate change (Kyrillos et al., 2024).

1.1. BACKGROUND OF ENERGY KINETIC TILES

Nowadays, electrical energy is crucial and becoming more in demand. Many energy resources have been mismanaged and depleted. A new method of generating power utilising a human population has been developed to produce the eco-friendly sources of electrical energy.

Echeverry-Velásquez et al. (2020) introduced a piezoelectric energy harvester for pedestrian spaces, demonstrating how these systems can maximize energy capture from human activity in both indoor and outdoor environments . Hence, kinetic energy is one of the renewable energy technologies harvested from the environment. Devices that extract energy from vibrations and pressure convert kinetic energy into electricity (Kyrillos K. Selim,2023).

Piezoelectricity has several applications in architecture, notably the use of flooring tiles. Nevertheless, its use is currently limited due to factors including economic efficiency and service life to overcome its high capital cost (Anton & Sodano, 2007). From an environmental perspective, energy harvesting technologies such as piezoelectric tiles represent a promising innovation system. It does not require additional land space (Walubita et al., 2018) and is free of noise emissions with zero GHG emissions (Woodcock et al., 2009). Hence, it appears as a solution to the depleting trend of natural resources and the global energy problems (Andriopoulou, 2012). It is in phase with the actual adaptation strategies for global climate change (IPCC, 2014).

According to Adnan Mohamed Elhalwagy (2017), piezoelectric energy harvesting as a sustainable clean energy is generating usable electricity depending on people's footsteps pressure, this valuable energy is wasted in spite of its available clean source (human movement). Public spaces piezoelectric floors can scavenge a reasonable amount of energy that can power electrical devices like lighting and screens. On the other hand, human footsteps are an important and sustainable energy source to investigate because of the high-power density of the ever growing population and places to walk along (Panu Thainiramit, 2022). It also may be one of the most effective non traditional renewable energy sources. Since they include energy in both kinetic and potential modes, human footsteps can generate electrical energy (Narayan S, 2019). It has been proposed to create power from human footsteps using an energy harvesting floor that employs a rotating electromagnetic approach (Jintanawan T, 2020).

So, whenever a person walks, they manage to lose energy towards the floor by means of influence, vibration, and audio and so on, a result of the move of excess weight to the floor. That energy may be used and converted into electrical energy.The actual electro-kinetic floor is really an approach to make electrical energy by using the kinetic energy of the person who walks on the floor. Producing this type of energy will be cost effective.The power floor does not need any fuel or perhaps any sort of energy resource, simply making use of kinetic energy (Parisa jahangiri Manesh, 2018). Because the energy conversion is based on the piezoelectric effect, there is no need for deflection of the ground. The efficiency of this energy conversion depends on the thickness and properties of the piezoelectric material, and the force affecting the piezoelectric material. Higher thicknesses and higher forces generate higher amounts of surface charges (Elham Maghsoudi Nia, 2017).

1.2. MECHANISM OF ENERGY KINETIC TILES

Kinetic energy tiles are innovative solutions designed to convert mechanical energy from footsteps, or other physical activities into electrical energy, promoting sustainability in real estate management. These tiles primarily rely on piezoelectric materials or electromagnetic generators. A piezoelectric material is a type of transducer used to detect vibrations, converting the kinetic energy into electrical energy (Adib, 2022). When pressure from a footstep or vehicle is applied to the piezoelectric material, the stress or force is transformed into electrical energy (Adib, 2022).

The advantages of piezoelectric materials include high achievable bandwidth, reliability, compactness, lightness, and ease of implementation (Abdelaziz, 2017). Kinetic tiles are capable of generating sufficient power (up to 702 mJ per step) to operate low-energy devices like IoT sensors (Thitima, 2020). When pressure is applied to the piezoelectric material in the tile, it causes a deformation in the material, which generates a small electrical charge through the piezoelectric effect. This electrical energy is then captured and stored in a battery or capacitor. The energy generated is typically low, but when many footsteps are applied over a large area of tiles, it can be harvested and used to power low-energy devices like sensors or smart IoT systems. as shown in figure below :

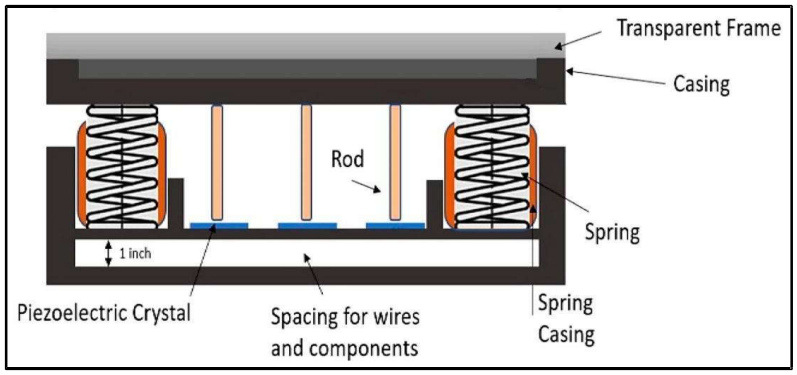

FIGURE 1: *Piezoelectric tiles diagram*

Source: *Visconti, P. (2021).*

2.0 ADVANTAGES OF ENERGY KINETIC TILES

Kinetic energy tiles provide tangible and strategic benefits to management and businesses, particularly regarding sustainability, cost savings, innovation, and effective marketing.

2.1 Sustainability

Energy kinetic tiles make a significant contribution to sustainability by converting everyday human movement into renewable energy. When a person walks, they lose energy to the floor through vibration, as a result of the movement of excess weight to the ground. The electro-kinetic floor is a method of producing electrical energy by harnessing the kinetic energy of the person walking on it (Jahangiri Manesh et al., 2018). By capturing kinetic energy from footsteps, these tiles reduce reliance on fossil fuels, lowering carbon emissions and mitigating the environmental impact of energy use. Many tiles are made from recycled or eco-friendly materials, which adhere to the principles of the circular economy. Their use in high-traffic areas improves energy efficiency and aligns with global sustainability goals like greener cities and affordable, clean energy. Aside from their functional benefits, these tiles promote environmental awareness by directly linking human activity to renewable energy production.

2.2 Cost Saving

Energy kinetic tiles may be expensive to install at first, but they provide significant long-term savings by lowering energy costs. These tiles can power lights, displays, or small devices in high-traffic areas, reducing reliance on grid electricity and utility costs. According to the findings of the paper Selim et al. (2024), two LEDs were successfully illuminated as an actual load using electrical energy collected from human footsteps. The maximum useful power that could be harvested successfully using the proposed floor tile (one tile) was 246 mW. Furthermore, their durability ensures low maintenance costs because they are designed to withstand heavy and continuous use. They gradually allow businesses or corporations to achieve partial energy independence, shielding them from fluctuating energy prices. When installed on a large scale, such as in airports or stadiums, the overall energy savings can have a significant impact on operational costs. Businesses can also reap indirect financial benefits from their sustainable practices, such as increased brand reputation and customer engagement.

2.3 Innovation

Energy Kinetic tiles represent a significant step forward in the integration of renewable energy into urban infrastructure. The function of building products is evolving to include not only functional requirements, but also environmental benefits (Moussa et al., 2021). Kinetic flooring tiles are among the most promising for indoor energy generation, particularly in public buildings with high occupancy rates and intensities (Moussa et al., 2021). These tiles convert sidewalks, floors, and other common surfaces into energy-generating platforms, thereby making cities or buildings that installed these kinetic tiles smarter and more sustainable. Aside from energy generation, the tiles have other applications, such as interactive displays that light up underfoot. Studio Roosegaarde's Sustainable Dance Floor®, a modular system measuring 65 × 65 × 30 cm3, generates 25 W per module to power lighting and a DJ booth. When a person dances on the tile, the springs drop, and the rack drives the pinion, which rotates the dynamo shaft (Visconti et al., 2022). Their modular and adaptable design allows for easy integration into existing structures with minimal disruption. The success of kinetic tiles encourages further innovation in energy harvesting, paving the way for other technologies such as capturing road vibrations or generating power during physical activities such as sports.

2.4 Effective Marketing

Eco-innovation (EI) is an innovation that aims to make significant and measurable contributions to sustainable development (Chen et al., 2024). This can be achieved by either reducing negative environmental impacts of increasing efficiency and responsible material utilization. For example, energy kinetic tiles provide unique marketing opportunities for businesses and organizations that are committed to sustainability. Installing these tiles not only demonstrates a commitment to renewable energy, but also strengthens a brand's eco-friendly image, attracting environmentally conscious customers. Businesses can use the tiles' interactive nature to create engaging customer experiences, such as powering real-time displays of energy contributions. Furthermore, data collected from these tiles, such as foot traffic patterns, can provide insights for improving customer experiences while also serving as a marketing tool. By adopting energy kinetic tiles, businesses can create a compelling narrative of innovation, environmental responsibility, and social impact, which resonates strongly with modern audience

3.0 RESEARCH FINDINGS

This study employed the desktop study method, a research approach that involves collecting and analysing secondary data from existing literature, reports, and case studies rather than conducting primary fieldwork. Desktop studies are typically used to gain comprehensive insights from previously published materials, making them a cost-effective and time-efficient method for exploratory research. It is particularly useful when investigating emerging technologies or concepts, where direct experimentation might not yet be feasible.

In this context, the desktop study was utilized to examine the viability of kinetic energy tiles as a sustainable innovation for property development in Sepang. Through an extensive review of academic journals, technical papers, and real-world applications, the researchers evaluated how kinetic tiles function, their benefits, limitations, and relevance to the Malaysian urban landscape. This method enabled a thorough understanding of the subject without the need for on-site installation or data collection, offering evidence-based projections to support future development planning.

Following this, piezoelectric technology offers a groundbreaking method for harvesting energy by converting mechanical pressure, such as that from human footsteps, into electrical power. Its potential application within Malaysia’s urban infrastructure highlights both practical functionality and promising contributions to long-term sustainability efforts.

3.1 Functionality and Mechanism of Piezoelectric Kinetic Tiles

Piezoelectric materials possess the unique ability to convert mechanical energy into electrical energy through the direct piezoelectric effect, which occurs when mechanical stress induces electrical polarization (Selim et al., 2024). This property is harnessed in kinetic tiles, where footstep-induced pressure generates electrical energy. As noted by Howells (2009), piezoelectric energy harvesting offers significant potential for small-scale energy systems, such as wearable and flooring applications. These systems capitalize on human motion to generate electrical power, emphasizing the adaptability of piezoelectric transducers.

The energy conversion process in piezoelectric systems can be enhanced through innovative mechanical coupling designs. Selim et al. (2024) discuss the use of optimized mechanical components to improve energy transfer efficiency. Additionally, Sharma et al. (2022) highlight advancements in piezoelectric tile designs that integrate efficient mechanical-to-electrical energy conversion mechanisms, achieving outputs suitable for powering low-energy devices. Such developments underscore the potential of piezoelectric systems for use in high-traffic areas to optimize energy capture.

3.2 Energy Efficiency and Sustainability

Piezoelectric tiles present a sustainable energy solution with zero operational carbon emissions, making them ideal for urban environments with high foot traffic (Chew et al., 2017). Unlike solar and wind energy systems, piezoelectric systems are not dependent on weather conditions, which is advantageous in tropical climates like Malaysia's, where frequent rain and cloud cover reduce solar efficiency (Rushdy Moussa et al., 2021).

Moreover, piezoelectric energy harvesting aligns with global initiatives to reduce dependence on fossil fuels and greenhouse gas emissions. Howells (2009) emphasizes that piezoelectric systems complement renewable energy strategies by providing localized, clean power sources. In Malaysia, integrating these systems into existing infrastructure—such as airports, train stations, and malls—supports national sustainability objectives (Chew et al., 2017).

3.3 Application in Building Construction in Malaysia

Malaysia's commitment to renewable energy adoption, particularly in urban infrastructure, reinforces the case for integrating piezoelectric tiles. For instance, Kuala Lumpur International Airport (KLIA) has adopted solar energy systems, and research indicates that piezoelectric technology could complement these initiatives (Chew et al., 2017). Studies at KLIA reveal that kinetic energy from high foot traffic areas, such as main entrances, can be effectively harnessed to power low-energy systems within the airport.

Rushdy Moussa et al. (2021) further support the applicability of piezoelectric systems in public spaces, noting their ability to enhance energy efficiency in high-density urban environments. By integrating these systems with power management circuits, the overall energy harvesting efficiency can be significantly improved. Sharma et al. (2022) also emphasize the scalability of piezoelectric systems, particularly when combined with smart building technologies, making them suitable for Malaysian urban settings.

3.4 Advantages Over Conventional Energy Sources

Piezoelectric systems offer unique advantages over traditional energy sources. Their ability to harness untapped mechanical energy from human movement provides an environmentally friendly alternative. Howells (2009) and Sharma et al. (2022) note that energy harvested from footsteps can power low-energy devices such as LED lighting and sensors, reducing overall energy demand in buildings.

Additionally, integrating piezoelectric tiles into existing infrastructure is minimally invasive, requiring no major structural modifications. This makes them an attractive option for retrofitting older buildings to improve energy efficiency. As Chew et al. (2017) argue, adopting piezoelectric systems in public spaces can enhance Malaysia's reputation for sustainable development and innovation in renewable energy.

3.5 Future Potential and Recommendations

The future of piezoelectric technology in building construction is promising. To maximize its potential, future research should focus on cost reduction, material durability, and integration with smart technologies. Pilot projects in high-traffic areas, such as airports, malls, and train stations, could provide valuable insights into the feasibility and scalability of piezoelectric systems (Chew et al., 2017; Sharma et al., 2022).

Moreover, public awareness campaigns and government incentives could play a crucial role in driving adoption. Chew et al. (2017) highlight that piezoelectric tiles, when showcased in high-profile locations like KLIA, can position Malaysia as a leader in green technology and sustainable innovation. By addressing existing challenges and leveraging public-private partnerships, piezoelectric systems can become a cornerstone of Malaysia's renewable energy strategy.

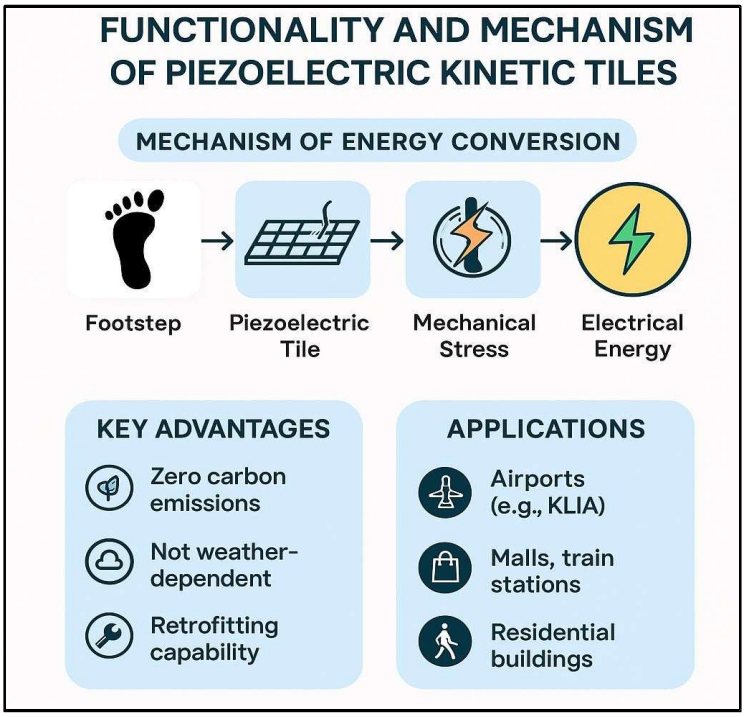

FIGURE 2: *Mechanism and application of piezoelectric kinetic tiles diagram*

4.0 CONCLUSION

The study emphasizes the transformative potential of kinetic energy tiles in promoting sustainable practices in Malaysia's property management industry. These tiles offer a novel solution to energy challenges by converting human movement into renewable energy, reducing reliance on nonrenewable resources and aligning with global sustainability goals. While there are some drawbacks to the technology, such as high initial costs and material durability, the benefits are significant, including environmental conservation, cost savings, and fostering an innovative culture. To fully realize the potential of piezoelectric technology, ongoing research, material advancements, and strategic partnerships between the public and private sectors are required. By embracing this innovation, Malaysia can establish itself as a green technology leader, promoting smarter and more sustainable urban infrastructure.

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