Available Online at www.e-iph.co.uk
Indexed in Clarivate Analytics WoS, and ScienceOPEN

E-B
Environment - Behaviour
Proceedings Journal

AQoL2023Bali
https://www.amerabra.org

e-IPH
e-International
Publishing House Ltd.,
United Kingdom

07th Asia-Pacific International Conference on Quality of Life
Wina Holiday Villa, Kuta, Bali, Indonesia, 30 Sept - 02 Oct 2023

Unlocking Nanotechnology Adoption Intention in the Malaysian Food Industry

Siti Norida Wahab[1*], Salini Devi Rajendran[2], Yeap Swee Pin[3], Albert Tan[4]

[1] Department of Technology and Supply Chain Management Studies, Faculty of Business and Management, University Teknologi MARA, Puncak Alam Campus, 42300 Selangor, Malaysia
[2] School of Food Studies and Gastronomy, Faculty of Social Sciences and Leisure Management, Taylor's University, Lakeside Campus, 47500 Subang Jaya, Selangor, Malaysia
[3] Department of Chemical & Petroleum Engineering, Faculty of Engineering, Technology & Built Environment, UCSI University, Kuala Lumpur 56000, Malaysia
[4] Graduate School of Business, Asian Institute of Management, 123 Paseo de Roxas, Makati City, Philippines 1229

sitinorida23@uitm.edu.my; Salini.Rajendran@taylors.edu.my; yeapsw@ucsiuniversity.edu.my; atan@aim.edu
Tel:+601023976911

Abstract
The purpose of this study is to investigate the factors that motivate nanotechnology adoption in the food industry. The study collects 101 responses from food industry operators in Klang Valley, Malaysia, via a quantitative field survey. The data was analysed using Structural Equation Modelling (SEM). The findings show that effort expectation, price value, and trust have no statistical impact on nanotechnology adoption, whereas performance expectancy and top management support have positive effects. Given that this study is one of the few that investigates factors influencing nanotechnology adoption, it should give useful information for future studies on the food industry and nanotechnology adoption among researchers and practitioners.

Keywords: nanotechnology, food industry, food supply chain, sustainability

DOI: https://doi.org/10.21834/e-bpj.v8i26.4973

1.0 Introduction

Nanotechnology is a branch of science and engineering concerned with the utilisation of materials on atomic, molecular, and supramolecular scales for industrial purposes. It is often referred to as nanotech. It is a rapidly developing technology with the potential to disrupt the food industry through some incredible applications that may change traditional methods of food production, processing, packaging, transportation, and consumption. Nanotechnology is one of the most promising technologies for revolutionising the traditional food industry (Khan et al., 2022). According to Derviş (2019), nanotechnology was discovered as a research focus in the mid-1990s and swiftly became a significant research agenda for scientists from a wide range of scientific fields. Recently, nanotechnology is a top research priority for both developed and developing countries. Globally, the total number of publications on nanotechnology-related topics and their application has steadily increased throughout the years, particularly in the food industry.

Nano-silver oxide (nano-AgO) is a common nanomaterial utilised in the food industry. The nano-AgO has antibacterial activity which can disrupt and harm the cell integrity of bacteria by producing reactive oxygen species. Because of these distinct features, nano-AgO

eISSN: 2398-4287 © 2023. The Authors. Published for AMER & cE-Bs by e-International Publishing House, Ltd., UK. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/). Peer–review under responsibility of AMER (Association of Malaysian Environment-Behaviour Researchers), and cE-Bs (Centre for Environment-Behaviour Studies), College of Built Environment, Universiti Teknologi MARA, Malaysia.
DOI: https://doi.org/10.21834/e-bpj.v8i26.4973

has found widespread use in the food industry predominantly in food packaging. The use of nano-AgO in food packaging, in particular, can enhance the shelf life of foods without affecting their quality. Nonetheless, other nanomaterials, such as zinc oxide, titanium oxide, gold and copper oxide have been widely used in the food industry (Venkatasubbu et al., 2016). Moreover, the nanotechnology-based sensor has recently received a mountain of attention which acts as rapid detection of food contaminants to deal with the food crisis issue. Excessive effort is being devoted to the application of nanotechnology in the food industry. These efforts have become even more important in recent years, as ensuring food safety against the COVID-19 virus has become critical. With substantial technical developments, concepts, and technologies that have the potential to revolutionise all aspects of consumers' daily lives, its application began to grow rapidly in the twenty-first century. The global nanotechnology market is anticipated to be valued at more than US$126.8 billion by 2027 (Dobrzański et al., 2021). This illustrates that nanotechnology is commonly regarded as an important driver of economic growth. However, Malaysia is still in the early stages of nanotechnology adoption (Hasmin et al., 2022). Hence, investment in nanotechnology is critical for a developing country like Malaysia to remain competitive in the global market and pave the path for a future industry growth that can provide economic benefits.

From an academic standpoint, nanotechnology adoption in the food industry is limited in Malaysia in both scholar and practitioner contexts. A low rate of nanotechnology adoption and a lack of knowledge about the benefits of nanotechnology are factors influencing Malaysian nanotechnology adoption (Yeap et al., 2022). Furthermore, the lack of studies related to nanotechnology, particularly in the food industry from a consumer point of view, renders this field less investigated when compared to other technological advancement studies (Al-Waeli et al., 2018). Thus, the author's intention is to bridge the gap by focusing on the factors influencing nanotechnology adoption. The second version of the Unified Theory of Acceptance and Use of Technology (UTAUT2) serves as the foundation for this study. It appears to be the first attempt to investigate factors influencing nanotechnology adoption in Malaysia's food industry. Subsequently, the findings of this study can be utilised as a parameter for Malaysian food manufacturers to consider when adopting nanotechnology.

This paper is divided into several sections. It begins by reviewing previous literature on nanotechnology and then moves on to the grounded theory, hypothesis and research framework development. The research methodology is described in the following section. Following that, in the fifth section, the data analysis of this study is discussed, and the author elaborates on the research implications in the following section. Finally, the study discusses the paper's limitations and future research agenda before concluding with a broad annotation for both scholars and practitioners.

2.0 Literature Review and Hypotheses Development

2.1 Malaysia Nanotechnology Initiatives in Food Industry

Malaysia is among the developing countries that have made considerable investments in nanotechnology advancement throughout the years. With the goal of extending nanotechnology's application to strengthen the nation's economy and to commercialise nanotechnology operations throughout Malaysia, Malaysia through the Ministry of Science, Technology and Innovation (MOSTI) began investigating nanotechnology in 2005 as part of the 8th Malaysia Plan (8MP) (Karim et al., 2017). Through that, the National Nanotechnology Initiatives were launched in 2006. Subsequently, the NanoMalaysia programme was established to foster the development of nanotechnology in Malaysia. Similarly, NanoMalaysia Bhd (NMB) was founded in 2011 to commercialise nanotechnology. In 2014, the Malaysia Nanotechnology Industrial Group (MNIG) was then established, which resulted in the National Nanotechnology Policy and Strategy 2021-2030. Besides, Nanopac is an ISO 9001 accredited manufacturing company with trained nanotechnology experts in charge of providing Malaysian manufacturers with nanotechnology expertise and approvals for design, testing, and certification. Additionally, Malaysia established Nano Silver Manufacturing Sdn Bhd (NSM) in 2004 to focus on the research, development, and commercialization of nanotechnology goods in order to improve productivity and efficiencies, resulting in lower production costs. Apart from that, the Malaysia Nanotechnology Association and National Nanotechnology Initiative (NNI) are among the nanotechnology-related organizations in Malaysia responsible for strengthening Malaysian nanoscience as well as promoting the future of nanotechnology development including its application in the food industry (Hasmin et al., 2022).

One of the most common applications of nanotechnology is in the food industry. Nanotechnology has been utilised to improve manufacturing efficiency, packaging, shelf life, and nutritional bioavailability. Besides, Nile et al. (2020) found that using nanoparticles in food products can improve sensory qualities such as flavour, colour, and texture. Furthermore, the application of nanotechnology to food products may improve nutritional absorption and targeted administration of bioactive chemicals. It may also enable the stabilisation of active compounds such as nutraceuticals within food structures. Furthermore, nanotechnology enhances the shelf life of packaging while also improving food safety and downstream processes such as protein extraction of large molecular weight proteins such as bovine serum albumin. Aside from the tremendous lineup of nanotechnology applications in the food industry, Kamarulzaman et al. (2019) reported in their study that nanotechnology is viewed as a key component of national economic development, with innovation in this field seen as holding significant potential for groundbreaking scientific advancements and improving overall human life quality. The contribution of nanotechnology is gradually increasing, and the entire nanotechnology market size and expected value in the food industry will be greater than RM1.31 (US$0.31) billion in 2025 (Dardak, 2023). Despite market trends indicating that Malaysia's nanotechnology application capabilities are expanding, the application of nanotechnology in the food industry in the Malaysian context is very new, and more research is needed. However, it has gained traction as the government recognised this technology as a potential source of economic growth. Hence, improvements in development strategies are required to significantly expand and strengthen nanotechnology applications in a variety of industries, particularly the food industry. This initiative may increase nanotechnology commercialization, and position Malaysia as a leader in the rapidly growing field of nanotechnology.

2.2 Theory

The UTAUT2 model established by Venkatesh et al. (2003) serves as the underpinning theory to investigate the factors influencing nanotechnology adoption and to develop a study framework and research hypotheses. UTAUT2 was chosen as the guiding principle because it has been used to understand technology adoption in a variety of industries, including healthcare (Bile Hassan et al., 2022), e-learning (Osei et al., 2022) and e-commerce (Dutta & Shivani, 2020). The UTAUT2 model, according to Addy et al. (2022), is often employed as a theoretical framework for predicting technology adoption within an organisation. This is due to the fact that the UTAUT2 model is a high-level theoretical model for describing organisational decisions regarding new technology adoption. Thus, it is believed that the UTAUT2 model would aid the organisation in establishing the applicable components that will stimulate the adoption of new technologies, including nanotechnology.

2.3 Performance Expectancy

The level to which individuals use a specific technology in their day-to-day activities is referred to as performance expectancy (Al-Rawashdeh et al., 2022). Performance expectancy is the degree to which employees believe that the use of nanotechnology will improve food industry operations, productivity, and performance. Nanotechnology has capable aspects in terms of food supply chain developments to improve overall food quality, increase product shelf life, improve food safety, and promote human health through creative and inventive ways. Several studies have found that performance expectations have a major impact on behavioural intention(Nile et al., 2020). Moreover, performance expectancy influences an individual's behavioural intention on the acceptability of nanotechnology. Moreover, Francisco and Swanson (2018) in their study emphasized that performance expectancy is one of the most important factors to consider when studying technology adoption and behavioural intentions. Hence, this study hypothesizes that:
H1: Performance expectancy positively affects nanotechnology adoption

2.4 Effort Expectancy

Venkatesh et al. (2003) define effort expectancy as the ease with which technology may be used. It can also be defined as the level of acceptance for new technology adoption. When it comes to examining the use of technology behavioural intention in the context of technology adoption, effort expectancy is the most important factor. Furthermore, it is one of the factors influencing the efficiency of food supply chain operations and a determinant of the organization's competitive advantage. Nanotechnology enables the use of ‘smart systems’, which allow the organisation to operate with little or no human interaction(Aithal & Aithal, 2022). Comparable, the simplicity of use for any related technology can influence the adoption of nanotechnology in the food industry (Siddiqui et al., 2022). Hence, effort expectancy can be seen as a significant factor that can influence nanotechnology adoption among Malaysian food manufacturers. As a result, the following theory is proposed:
H2: Effort expectancy positively affects nanotechnology adoption

2.5 Price Value

Price value is the user's perception of a trade-off between cost and benefits. The propensity of food manufacturers to embrace any new technology is heavily influenced by price. Since nanotechnology is used in various aspects of the food industry, including food production, processing, storage, and distribution, price will be the main concern since an organisation is concerned about the return on investment. Moreover, the cost of nanotechnology adoption in food manufacturing and production is quite expensive which also comprises productivity, labour, and efficiency. Thus, the key factor determining whether or not a food manufacturer would adopt new technology is cost (Yeap et al., 2022). Previous research has found that price value is important in new technology adoption decisions and influences behavioural intentions to adopt new technology (Khan et al., 2022; Meng et al., 2023). As a result, the following hypothesis is established based on previous research:
H3: Price value positively affects nanotechnology adoption

2.6 Trust

Trust is a multifaceted term that is intertwined with user security and privacy. It has been discovered that trust can be viewed as a significant component that determines behavioural intention to adopt technology and has a substantial impact, particularly on the privacy issue (AlHogail, 2018). Trust is necessary to inspire individuals to readily adopt modern technologies in the face of unforeseen circumstances. Furthermore, authenticity is the primary factor influencing trust in technology adoption. The stability and readiness to adopt nanotechnology are critical to overcoming potential uncertainties that may emerge whenever a malfunction occurs throughout the food supply chain. The adoption of nanotechnology should be demonstrated to be capable of producing better results, including enhanced food production, food quality and, safety as well as creating a competitive advantage (Eleftheriadou et al., 2017). Based on the preceding arguments, we hypothesise:
H4: Trust positively affects nanotechnology adoption

2.7 Top Management Support

Top management support denotes the total commitment, dedication, and effort that enables the adoption of modern technology and is required for disruptive technology to be widely accepted. Top management is responsible for providing proper mechanisms for the development, integration, and emergence of bottom-up tactical initiatives. Accordingly, top managerial abilities and cumulative knowledge of nanotechnology deployment are required. Continuous commitment and support from top management are required to improve knowledge and capacities in order to adopt new technology (Wahab et al., 2020). To ensure that all staff are ready to adopt new technologies, personal development, training, and workshops are essential. Nanotechnology knowledge should extend throughout the organization's value chain. They are in charge of ensuring that every member completely understands how to operate and apply nanotechnology, notably in the food industry (Lowry et al., 2019). The following hypothesis is offered based on these justifications:
H4: Top management support positively affects nanotechnology adoption

Figure 1 depicts the research framework based on the discussions and hypotheses proposed.

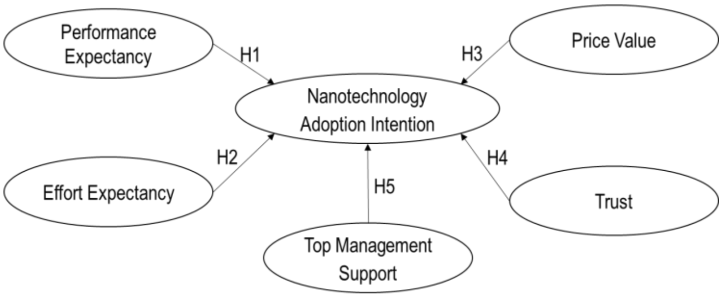

Fig 1. Research framework

3.0 Methodology

The measurements for each construct were constructed based on a thorough examination of the literature and were adapted from the research of previous scholars (Nguyen & Petersen, 2017; Wahab et al., 2022). All of the measures used a five-point Likert scale, with 1 (strongly disagree) and 5 (strongly agree). The link between the independent and dependent variables was investigated using a quantitative methodology in this study. It is used to generate numerical data to quantify attitudes, views, behaviours, and other specific factors and generalise outcomes from a broader sample population. Data were collected using the questionnaire method. Food manufacturers in Klang Valley who are members of the Federation of Malaysian Manufacturers (FMM) were chosen to test the research framework and hypotheses. The minimum sample size, according to Faul et al. (2009), is 92, which is comparable with a good practice analysis utilising G*power 3.1 statistical analysis. As a result, the sample size of 101 in this study is consistent with preceding practices. The SmartPLS technique was used to validate the relationship between several latent constructs as described in the framework in the preceding section.

4.0 Findings

4.1 Sample Distribution

Table 1 reveals that the majority of respondents (43.6%) held the post of senior manager/manager and the majority of the respondents (n=47) have already been in the industry for around 11 to 15 years. Most of them have been in the food industry for 16 - 19 years and come from various food industry operations including food manufacturing (26.7%), new product development (8.9), food packaging (22.8%), and food distribution (41.6%).

Table 1. Respondents profile information

Variables	*Frequency*	*(%)*
Position in the organisation		
Owner	8	7.9
CEO/President	11	10.9
Director/Deputy Director	26	25.7
Senior Manager/Manager	44	43.6
Assistant Manager/Supervisor	12	11.9
Managerial experience		
Less than 5 years	2	2.0
6 - 10 years	11	10.9
11 - 15 years	47	46.5
16 - 19 years	22	21.8
More than 20 years	19	18.8
Years in the food industry		
Less than 5 years	16	15.8

6 - 10 years	21	20.8
11 - 15 years	17	16.8
16 - 19 years	28	27.7
More than 20 years	19	18.8
Type of business operations		
Food manufacturing	27	27.0
New product development	9	9.0
Food packaging	23	23.0
Food distribution	42	42.0

4.2. Measurement Model

The psychometric assessments are tested using the Structural Equation Modelling (SEM) technique with SmartPLS 3.0 to confirm that the measurements are valid and reliable, as recommended by Ringle et al. (2015). Following Anderson and Gerbing (1988), this study also conducted a two-stage analytical procedure comprising a measurement model analysis to validate the instruments and a structural model analysis to analyse hypothesised correlations. Confirmatory factor analysis (CFA) was used to determine the factorial and discriminant validity of the constructs. Furthermore, the measurement model's internal consistency reliability, convergent validity, and discriminant validity of key constructs were assessed. Internal consistency evaluates whether the measures consistently embody the same latent construct, whereas convergent validity examines the average variance extracted (AVE) of each construct from its indicator to determine the degree to which items representing the same construct correspond. The composite reliability (CR), AVE and factor loadings of the five components employed in this study are listed in Table 2. The measurement model will be evaluated using convergent and discriminant validity. The measurement's convergent validity is determined by assessing the loadings, AVE, and CR. All loadings for this study are greater than 0.7. Similarly, the AVE and CR values for all of the constructions are greater than 0.5 and 0.7, respectively. As a result, the constructs measure what they are designed to measure, and the set of items measures what it is supposed to measure (Hair et al., 2017).

Table 2. Construct validity

Constructs	Loadings	CR	AVE
Performance Expectancy (PER)		0.930	0.768
"Nanotechnology can provide us with better performance"	0.829		
"Nanotechnology enables us to complete tracking tasks more efficiently"	0.899		
"Nanotechnology allows us to improve product quality"	0.935		
"The use of nanotechnology boosts our productivity"	0.838		
Effort Expectancy (EFF)		0.911	0.721
"It is easy for us to learn how to use nanotechnology"	0.885		
"It is easy for us to understand nanotechnology"	0.898		
"It is easy for us to become skilful in using nanotechnology"	0.732		
"It is simple to incorporate nanotechnology into existing activities"	0.871		
Price Value (PRI)		0.906	0.763
"Nanotechnology is a good investment"	0.984		
"Nanotechnology provides good value"	0.943		
Trust (TRU)		0.876	0.702
"I have confidence in the use of nanotechnology"	0.824		
"Nanotechnology is a robust technology"	0.913		
"Nanotechnology is a safe technology"	0.771		
Top Management Support (TOP)		0.963	0.929
"Our top management actively participates in nanotechnology adoption"	0.897		
"Our top management supports adequate resource allocation for nanotechnology adoption"	0.825		
"Our top management always encourages us to learn nanotechnology knowledge"	0.897		
Intention to Adopt Nanotechnology (INT)		0.823	0.608
"We intend to adopt nanotechnology in the future"	0.841		
"We predict we will adopt nanotechnology in the future"	0.735		
"We plan to adopt nanotechnology in the future"	0.759		

4.3. Discriminant validity

As demonstrated in Table 3, the square root of the AVE of each construct surpasses its correlation with other constructs, and each item loading is much higher on its assigned construct than on the other constructs. All of the values meet the discriminant validity requirement, which requires *r* values to be smaller than 0.9 (Gold et al., 2001) and that the average variance shared by each construct and its measures must be greater than the variance shared by the construct and another construct (Henseler et al., 2015). As a result, the statistical data give sufficient support for discriminant validity. Alike, multicollinearity is also not an issue since the VIF values are constantly less than 5 (Hair et al., 2017).

Table 3. Discriminant validity

Variables	EFF	INT	PER	PRI	TOP	TRU
Effort Expectancy (EFF)	**0.849**					
Intention to Adopt Nanotechnology (INT)	0.519	**0.780**				
Performance Expectancy (PER)	0.782	0.749	**0.876**			
Price Value (PRI)	-0.072	-0.062	-0.088	**0.964**		
Top Management Support (TOP)	0.662	0.513	0.594	-0.026	**0.874**	

Trust (TRU)	0.135	0.085	0.132	0.676	0.064	**0.838**

Note: Diagonals in bold represent the square root of AVE

4.4. Hypotheses Testing

Table 4 shows the findings of the PLS-SEM method to the hypothesised correlations. Specifically, performance expectation has a substantial impact on users' adoption of nanotechnology (β1 = 0.0848, $p<0.05$). As a result, H1 is supported. Users' intention to adopt nanotechnology is insignificantly influenced by effort expectancy (β2 = -0.0268, $p>0.05$), and so does not sustain H2. Furthermore, the link between price value (β3 = 0.001, $p<0.05$) and trust (β4 = -0.004, $p>0.05$) on users' intention to adopt nanotechnology is insignificant, showing that H3 and H4 are not supported. H5 is supported, as evidenced by top management support having a significant impact on consumers' intentions to adopt nanotechnology (β5 = 0.187, $p>0.05$).

Table 4. Hypotheses results

Hypotheses	Relationship	β	SE	t-value	*p-value*	*Decision*
H1	PER → INT	0.848	0.173	4.895	0.000*	Supported
H2	EFF → INT	-0.268	0.216	1.293	0.216	Not supported
H3	PRI → INT	0.001	0.086	0.017	0.986	Not Supported
H4	TRU → INT	-0.004	0.118	0.033	0.974	Not supported
H5	TOP → INT	0.187	0.086	0.088	0.033*	Supported

Note: *p < 0.05

5.0 Conclusion

The results of this study allowed the authors to gather important information pertaining to the nanotechnology adoption intention in the food industry. In a society that is becoming increasingly concerned about food safety, quality, and security, the relationship between nanotechnology adoption in the food industry will need to be investigated further in the future. Therefore, researchers should examine (i) how the food industry may sustainably convert their food processes through the adoption of nanotechnology, (ii) how the nanotechnology adoption may be influenced by the increase in demand for both quality and sustainable food, and (iii) how the use of nanotechnology in the food industry may increase food sustainability. Furthermore, the Sustainable Development Goals (SDGs) and their significance in raising awareness of long-term food safety, quality, and security are also infrequently discussed. Therefore, in order to investigate the role of nanotechnology in the food industry in ensuring long-term food safety, quality, and security, future research should embrace the primary driving forces of SDGs 9 and 12 on industrial innovation and infrastructure, responsible consumption, and production.

This study's findings are critical as they provide theoretical and practical implications for nanotechnology adoption in the setting of the food industry in an emerging market economy, which has been disregarded in previous studies. In terms of theoretical contributions, this is the first study to analyse users' intentions to use nanotechnology in the food industry in an emerging economy using the UTAUT2 model. The empirical findings of the PLS-SEM technique show that, among the five factors investigated, performance expectancy and top management support influence users' intentions to adopt nanotechnology in the food industry in an emerging economy. In contrast to previous research, this study reveals that effort expectation, price value, and trust have no substantial impact on users' intention to adopt nanotechnology in the food industry. Hence, these findings contribute to the advancement of research in the food industry and nanotechnology.

This research has a number of practical implications. Food producers should put more effort into adopting nanotechnology in order to improve day-to-day business operations and customer service through better information technology integration and effective food safety management. Food producers should examine nanotechnology adoption and foster collaboration among all stakeholders of the food supply chain network (Makanyeza & Mutambayashata, 2018). Food producers should reassess their operational skills and use them to build appropriate food safety management policies, allowing them to attain and sustain a competitive advantage.

Future studies could add a few hypotheses on technology adoption to broaden and improve the understanding of the elements influencing nanotechnology adoption. Similarly, this study only examines five variables; future research could examine the key proportions of the related theories in modern technology adoption to further analyse the focus area, develop a greater understanding, and produce better results.

Acknowledgements

The authors would like to acknowledge that this article is part of a research project funded by Universiti Teknologi MARA (UiTM). Project ID: 600-RMC/GPM SS 5/3 (077/2021).

Paper Contribution to Related Field of Study

This study offers future scholars simple access to data related to factors affecting modern technology adoption associated with the food industry, which is in accordance with the SDGs agenda. The authors anticipate that this study will have a substantial impact on practitioners, notably food producers and other relevant stakeholders about the potential benefits of nanotechnology adoption across the food industry, particularly in Malaysia.

References

Addy, M. N., Addo, E. T., Kwofie, T. E., & Yartey, J. E. (2022). Predicting the adoption of e-procurement in construction project delivery in Sub-Saharan Africa: an application of UTAUT2. *Construction Innovation*, *ahead-of-print*.

Aithal, P. S., & Aithal, S. (2022). Opportunities and Challenges for Green and Eco-Friendly Nanotechnology in Twenty-First Century. *Sustainable Nanotechnology: Strategies, Products, and Applications*, 31–50.

Al-Rawashdeh, M., Keikhosrokiani, P., Belaton, B., Alawida, M., & Zwiri, A. (2022). IoT adoption and application for smart healthcare: a systematic review. *Sensors*, *22*(14), 5377.

Al-Waeli, A. H. A., Kazem, H. A., Sopian, K., & Chaichan, M. T. (2018). Techno-economical assessment of grid connected PV/T using nanoparticles and water as base-fluid systems in Malaysia. *International Journal of Sustainable Energy*, *37*(6), 558–575.

AlHogail, A. (2018). Improving IoT technology adoption through improving consumer trust. *Technologies*, *6*(3), 64.

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin*, *103*(3), 411.

Bile Hassan, I., Murad, M. A. A., El-Shekeil, I., & Liu, J. (2022). Extending the UTAUT2 Model with a Privacy Calculus Model to Enhance the Adoption of a Health Information Application in Malaysia. *Informatics*, *9*(2), 31.

Dardak, R. A. (2023). Contribution of Nanotechnology of Food Security in Malaysia. In *Food and Fertilizer Technology Center*. https://ap.fftc.org.tw/article/2639
Dervi\cs, H. (2019). Bibliometric analysis using bibliometrix an R package. *Journal of Scientometric Research*, *8*(3), 156–160.

Dobrzański, L. A., Dobrzański, L. B., Dobrzańska-Danikiewicz, A. D., Dobrzańska, J., & Kraszewska, M. (2021). 8 Ethical imperatives towards the development prospects of the triad of Dentistry 4.0, dental engineering, and nanoengineering. In *Ethics in Nanotechnology* (pp. 157–248). De Gruyter.

Dutta, S., & Shivani, S. (2020). Modified UTAUT2 to Determine Intention and Use of E-Commerce Technology Among Micro \& Small Women Entrepreneurs in Jharkhand, India. *Re-Imagining Diffusion and Adoption of Information Technology and Systems: A Continuing Conversation: IFIP WG 8.6 International Conference on Transfer and Diffusion of IT, TDIT 2020, Tiruchirappalli, India, December 18--19, 2020, Proceedings, Part II*, 688–701.

Eleftheriadou, M., Pyrgiotakis, G., & Demokritou, P. (2017). Nanotechnology to the rescue: using nano-enabled approaches in microbiological food safety and quality. *Current Opinion in Biotechnology*, *44*, 87–93.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*(4), 1149–1160. https://doi.org/10.3758/BRM.41.4.1149

Francisco, K., & Swanson, D. (2018). The supply chain has no clothes: Technology adoption of blockchain for supply chain transparency. *Logistics*, *2*(1), 2.

Gold, A. H., Malhotra, A., & Segars, A. H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems*, *18*(1), 185–214.

Hair, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., & Thiele, K. O. (2017). Mirror, mirror on the wall: a comparative evaluation of composite-based structural equation modeling methods. *Journal of the Academy of Marketing Science*, *45*, 616–632.

HASMIN, N. O. R. A., MATMIN, J., & BASIR, S. A. (2022). NATIONAL NANOTECHNOLOGY POLICIES IN MALAYSIA, EUROPEAN UNION AND UNITED STATES: A COMPARATIVE ANALYSIS. *Quantum Journal of Social Sciences and Humanities*, *3*(3), 72–92.

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, *43*(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8

Kamarulzaman, N. A., Lee, K. E., Siow, K. S., & Mokhtar, M. (2019). Psychological and sociological perspectives for good governance of sustainable nanotechnology development in Malaysia. *Journal of Nanoparticle Research*, *21*, 1–21.

Karim, M. E., Akhter, S., Munir, A. B., Muhammad-Sukki, F., Hoque, K. E., Yasin, S. H. M., Abu-Bakar, S. S., Abu-Bakar, S. H., Bani, N. A., Wirba, A. V., & others. (2017). Malaysian tertiary level students and their understanding, knowledge and perception of nanotechnology. *Journal of Advanced Research in Social and Behavioural Sciences*, *6*(1).

Khan, F., Pandey, P., & Upadhyay, T. K. (2022). Applications of Nanotechnology-Based Agrochemicals in Food Security and Sustainable Agriculture: An Overview. *Agriculture*, *12*(10), 1672.

Lowry, G. V, Avellan, A., & Gilbertson, L. M. (2019). Opportunities and challenges for nanotechnology in the agri-tech revolution. *Nature Nanotechnology*, *14*(6), 517–522.

Meng, Y. U. E., LI, W., Shan, J. I. N., Jing, C., Chang, Q., Glyn, J., CAO, Y., YANG, G., LI, Z., & Frewer, L. J. (2023). Farmers' precision pesticide technology adoption and its influencing factors: Evidence from apple production areas in China. *Journal of Integrative Agriculture*, *22*(1), 292–305.

Nguyen, T., & Petersen, T. E. (2017). *Technology adoption in Norway: organizational assimilation of big data*.

Nile, S. H., Baskar, V., Selvaraj, D., Nile, A., Xiao, J., & Kai, G. (2020). Nanotechnologies in food science: applications, recent trends, and future perspectives. *Nano-Micro Letters*, *12*, 1–34.

Osei, H. V., Kwateng, K. O., & Boateng, K. A. (2022). Integration of personality trait, motivation and UTAUT 2 to understand e-learning adoption in the era of COVID-19 pandemic. *Education and Information Technologies*, *27*(8), 10705–10730.

Ringle, C., Wende, S., & Becker, J. (2015). SmartPLS 3. In *Retrieved from*. https://doi.org/http://www.smartpls.com

Siddiqui, S. A., Zannou, O., Bahmid, N. A., Fidan, H., Alamou, A.-F., Nagdalian, A. A., Hassoun, A., Fernando, I., Ibrahim, S. A., & Arsyad, M. (2022). Consumer behavior toward nanopackaging-a new trend in the food industry. *Future Foods*, 100191.

Venkatasubbu, G. D., Baskar, R., Anusuya, T., Seshan, C. A., & Chelliah, R. (2016). Toxicity mechanism of titanium dioxide and zinc oxide nanoparticles against food pathogens. *Colloids and Surfaces B: Biointerfaces*, *148*, 600–606.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly: Management Information Systems*, *27*(3), 425–478. https://doi.org/10.2307/30036540

Wahab, S. N., Hamzah, M. I., Khoo, Z. X., & Yau, W. S. (2022). An empirical study on warehouse automated materials handling equipment adoption in Malaysian warehousing sector. *International Journal of Services and Operations Management*, *42*(4), 539–563.

Wahab, S. N., Loo, Y. M., & Say, C. S. (2020). Antecedents of blockchain technology application among Malaysian warehouse industry. *International Journal of Logistics Systems and Management*, *37*(3), 427–444. https://doi.org/10.1504/IJLSM.2020.111414

Yeap, S. P., Rajendran, S. D., & Wahab, S. N. (2022). The microbial-killing Ag nanoparticles in food supply chain: How it was applied and what a consumer should know? *Food Frontiers*, 1–8.