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IoT Challenges and Opportunities in Malaysia's Digital Economy.

Kamalanathan Shanmugam [1*], Naresh Kumar Appadurai [1], Lau Yong Zheng [2], Subasree Ramish [2], Ramana Sarathy [2], Tulasi Appalasamy [1]

[1] Asia Pacific University of Technology & Innovation Technology, Kuala Lumpur, Malaysia
[2] KG College of Arts and Science,Coimbatore, Tamil Nadu, India
*Corresponding Author: kamalanathan@apu.edu.my

Abstract
The Internet of Things (IoT) is a key driver of economic digitization processes that hold great potential for the growth of businesses, innovation, and competitiveness. This area of research aims to evaluate how IoT can be relevant in enhancing the growth of the digital economy in Malaysia, with a view to identifying the chances it has which hitches are slowing its progress. Nevertheless, there are significant barriers in any country over the globe that constrain the implementation of IoT, which include Infrastructure, Cybersecurity, Policy, and Digital division. Thus, exploiting the results of this study to reveal new opportunities and investigate possible solutions to the challenges identified in this context is intended to contribute to the definition of the guidelines for the competent management of IoT technologies by policymakers and industry stakeholders. The study highlights the call for proper strategic funding, proper security measures, and an appropriate policy that will help to overcome the challenges to allow IoT technology to actively participate in the advancement of the digital economy of Malaysia.

Keywords: *Ubiquitous Computing, Internet of Things, Digital Economy, IoT Opportunities, IoT Challenges.*

1. Introduction

The Internet of Things (IoT) has shifted from a collection of isolated smart devices to a vast socio-technical system that underpins the contemporary digital revolution. Scholars describe IoT as a network of interconnected objects embedded with sensors and software that collect and exchange data, enabling automation and new forms of interaction (Kumar et al., 2019; Chataut et al., 2023). These devices vary from simple consumer goods to industrial equipment and are presently being combined with AI and cloud computing. This has made it easy for firms to optimise resource allocation, enhance operations, and provide new and improved services.

The combination of computers and real-time sensing in IoT has made this technology a driving force behind the digital economy. Digital technologies boost the economy by increasing inclusion, lowering costs, increasing efficiency, and encouraging innovation in the economy (World Bank Group, 2021). Currently, the digital economy is a major driving force behind the Malaysian economy. Its share stands above 23% of the country's GDP in 2023 and is forecasted to exceed 25% by 2025 (Department of Statistics Malaysia, 2024). Ambitious plans such as the launch of the Digital Economy Blueprint and the setting up of the Digital Investment Office are aimed at encouraging digital investments above US$16 billion by 2025 while ensuring a supportive environment for innovation and innovation-based technologies (Reuters Plus, 2024).

The digital economy evolution in Malaysia began with the creation of the Multimedia Super Corridor in the mid-1990s, with more recent momentum driven by policies such as Industry 4WRD, MyDIGITAL, and the National Digital Network (JENDELA) blueprint (Jusoh & Abd Razak, 2023). The policies aimed at improving broadband, innovation, and human capital development. There has been considerable advancement, with more than 80% of fifth-generation (5G) network availability in 2024, increased adoption of digital technologies by micro, small, and medium-sized enterprises (MSMEs), and inter-industry investment in smart manufacturing, healthcare, and logistics (Department of Statistics Malaysia, 2024). However, Malaysia's primary role is still that of a digital technology adopter, with little to no role as a digital technology innovator (Jusoh & Abd Razak, 2023). The country has a digital divide, digital literacy, energy, and cybersecurity environment that is not conducive to widespread growth (Aziz, 2023; Jusoh & Abd Razak, 2023).

This narrative review restates the current body of knowledge on the challenges and opportunities of IoT in Malaysia. In order to put this study into an appropriate context, it will be useful to define research objectives and questions. The main study aim is to clarify the role of IoT in supporting Malaysia's economic development by exploring opportunities and challenges across various sectors. The objectives consisted of: (1) Identifying constraints that impede Malaysia in adopting IoT; (2) Examining opportunities for Malaysia to use IoT to improve its digital economy; (3) Assessing Malaysia's infrastructure readiness; (4) Identifying major constraints in major sub-sectors.

In the current global scenario, the IoT sector has been witnessing exponential growth in the previous decade. Experts predict that there will be tens of billions of devices connected to the IoT globally in the year 2030. The IoT will help create zettabytes of data. The developed nations have already realised the benefits associated with IoT and have taken the lead. However, emerging nations like Malaysia will have to embark on a strategy that will help them take advantage of this technology. The aim for a prominent position in the digital scene in Southeast Asia will depend entirely on the capacity of the country to utilise IoT for purposes of innovation and inclusivity. However, the experience in other countries has shown that fast-track digitisation often leads to inequalities.

2. Methods

A narrative review finds and integrates information from various sources to gain insights into complex issues. It does not restrict itself to protocols like systematic reviews do (Snyder, 2019). To ensure objectivity while conducting the narrative review, we had to be methodical yet flexible. We conducted online searches on common database (Google Scholar and Scopus), official publications (governmental publications), and credible online sources using keywords such as "Internet of Things," "IoT Malaysia," "digital economy," "Industry 4.0," "cybersecurity," "smart cities," and "agriculture." Articles and publications from credible sources that were published from 2015 to 2025 on the relevance and adoption of the Internet of Things in Malaysia were considered. Articles and publications that did not contain meaningful information on Malaysia or were case studies on the physical design of devices without any context were excluded.

After gathering sources, we conducted thematic coding to identify common themes: the readiness of infrastructural support, policy environments, security concerns, adoption in various sectors, human capital-related difficulties, and their socio-economic effects. We quantified each theme through quotes by the original authors wherever possible to pinpoint areas of divergence and convergence using multiple studies. We also tested findings for consistency with official statistics of the Department of Statistics in Malaysia to validate facts. For example, information regarding the digital economy's GDP contribution was validated using official publications (Department of Statistics Malaysia, 2024), and information regarding financial outlay targets was checked through news reports (Reuters Plus, 2024).

Despite the criticism that narrative reviews may be subjective, we tried to make our narrative review as transparent as possible, detailing our search process and criteria in line with Snyder (2019). The article search ranges 2015 to 2025. The period spanned a decade of research. We narrowed our search to 134 abstracts and included 18 texts in our complete text analysis. Where possible, we attempted to determine the level of the empirical studies through simple criteria like sample size and relevance. The ethical issues

involved in the review are very minimal, and this is because the review was an integration of publicly known information and did not entail human subjects.

3. Findings

3.1. IoT Readiness and Frameworks

Various works determine the Malaysia NTR for IoT implementation using conceptual frameworks. In their study, Nurika and Jung (2024) use the CREATE-IoT Key Performance Indicator model that focuses on the factors of connectivity, reach, energy, and accessibility, as well as technology and ecosystem. The study concluded that Malaysia shows better connectivity and technology adoption but lags on energy and infrastructure and on accessibility parameters, and recommends careful investment and necessary modifications. Abdulaziz et al. (2023) construct the IoT model suitable for Industry 4.0 implementation for small and medium-sized enterprises (SMEs). According to the study, by incorporating sensors, communication, and analytics solutions together, the efficiency of manufacturing and saving of costs are possible with real-time decision-making, but SMEs lack technological and financial capacity and qualified workers' capabilities, and stress the need for close coordination and support by the concerned government departments, academies, and organizations. They also emphasize the impending role of cybersecurity for the security of the data.

A systematic review of IoT frameworks for Industry 4.0 implementation in Malaysia is presented in Adnan et al. (2023) while underlining that there is a need to set clear goals, engage stakeholders, and monitor progress. Industry requirements, along with a focus on organizational culture, play a vital role, according to them. Al et al. (2021) discuss a conceptual framework to gauge SMEs' readiness in Industry 4.0 in Malaysia, along with their readiness in using IoT. It lists strengths in terms of encouraging policies, developing digital infrastructure, and a developing ecosystem, but also lists weakness in terms of lack of human capital, high costs of implementation, and lack of infrastructure. There is a stressed emphasis on developing human capital with adequate cybersecurity in Malaysia, overcoming energy accessibility limitations, along with developing these skills, they suggest. Together, this series of frameworks is indicative of Malaysia heading in the right direction but having to overcome limitations in areas of energy accessibility along with developing human capital.

3.2. Adoption and Challenges of IoT

The adoption of IoT in Malaysia is not equal in the various fields, and there are factors that are impeding its growth. A review of the current situation in the field of IoT technologies is provided by Badarudin et al. (2018), where they discuss the issues concerning the privacy of data, the vulnerability of the network, the infrastructure, and the lacking overall policies. They state the need for more government involvement and resources in the field of cybersecurity and research to enable a smoother and faster adoption process.

The use of IoT in optimizing the supply chain and the costs involved is demonstrated in the empirical research by Lee et al. (2022). The implementation and maintenance costs, as well as vulnerability and the lacking training, are stated to impede its use. The factors influencing the digital economy are discussed by Xuan et al. (2023). The factors found to impede the growth and development of the digital economy include digital literacy, cyber threats, and the difference between the urban and rural areas.

Issues of security and privacy are ever-present. Chen and Urquhart (2022) illustrate socio-technical problems associated with smart home security, illustrating how consumer technology tends to emphasize functionality rather than security and how users can be blind to dangers. A general discussion of security within the Internet of Things is given by Schiller et al. (2022), emphasizing the importance of multifaceted protection, secure update mechanisms, and robust authentication. The importance of sound security practices is clearly supported by evidence that insecure systems offer malicious users access to vital infrastructure, health, and private data.

Digital literacy and inclusion are also prominent in the adoption and benefiting of IoT technology. According to Aziz (2023), for Malaysia's digital economy, a contribution of 22.6% to GDP by 2025 and a half million job creation are forecasted, which relies on inclusive policies. The World Economic Forum forecasts 97 million new jobs worldwide by 2025, where eight out of ten fastest-growing jobs in Malaysia demand digital skills (Aziz, 2023). Employees with highly developed digital skills get extremely high pay,

though basic digital literacy skills are absent among many Malaysians. Aziz (2023) asserts that extensive training programs by government departments, corporations, and educational institutions are needed for rural communities, senior citizens, people with disabilities, and lower-income families. Subsidies and support should be given for devices and internet connectivity, and collaborations should be sought with device and internet companies for reduced packages, and community-based digital centers providing computers, internet connectivity, and training facilities are also recommended by Aziz (2023) for empowering marginalized sectors and overcoming the urban-rural digital divide.

In addition, the use of IoT in supply chain and logistics systems has potential risks associated with the advantages. The devices and trackers used in the process create data that is highly sensitive. In case there is a lack of proper security policies to govern the use of IoT technology, there is potential for exploitation. However, authors recommend that any organisation using IoT should focus on the aspect of security.

3.3. Use Cases for IoT in Various Industries

IoT technologies are being adopted in a number of sectors in Malaysia, with each sector presenting a different set of challenges and opportunities for IoT deployment. Nasir & Mumtazah (2020) describe the design of a fish farming monitoring system that utilizes IoT technologies. The described design monitors water quality in terms of temperature, pH, and dissolved oxygen levels, which are then relayed to the authorities to enable them to act before the occurrence of diseases or contamination of the water. The design exhibits higher precision and automation when compared to the traditional methods, but there are limitations such as unstable power, network availability in rural areas, and security threats.

Precision agriculture is another area that holds promise. Examples of IoT applications in this sector are smart irrigation systems, soil moisture measurement, pest identification, and animal tracking. Research has indicated that the adoption of these technologies can lead to higher production levels, conservation of resources, and improved tracking (Chataut et al., 2023), thus making the food security situation in Malaysia more secure. But what is hindering the adoption is the lack of digital literacy among farmers, the initial investment cost, and the connectivity issues.

The healthcare industry is undergoing an evolution with the use of medical IoT technologies. Wearable sensors and telemedicine solutions allow patients to be monitored constantly, helping in the early identification of health problems and the efficient control of chronic conditions. Electronic health records, along with IoT technologies, help in making informed decisions based on data analysis. Such solutions work especially well for those living in distant communities, who have very little accessibility to healthcare services (Chataut et al., 2023; World Bank Group, 2021). However, privacy and compatibility challenges arise, as patient privacy and the smooth functioning of different medical IoT technologies need to be taken into account.

Smart city projects entail the integration of IoT technologies for the control of urban infrastructure. Smart traffic systems in Kuala Lumpur, as well as in other cities, utilize sensors for traffic control, waste management, environmental surveillance, and security. Sensors provide traffic information that can enable the optimization of traffic signal control to reduce congestion, with smart dumpsters that can send signals to the relevant department when they are full and need to be emptied, thus contributing to a clean environment, since sensors can assist in clearing pollution spots identified by air quality sensors (Abdulaziz et al., 2023; Jusoh & Abd Razak, 2023).

The manufacturing sector is the driving force behind the Malaysian economy and leads the country in Industry 4.0. Abdulaziz et al. (2023) and Adnan et al. (2023) have elucidated how IoT-interconnected factories can help machines communicate with each other and make production assistance available for real-time monitoring and prediction for maintenance. On the other hand, SMEs usually face limitations in terms of implementing all the assistance that the technology has to offer. Al et al. (2021) have pointed out that SMEs require training initiatives and a supportive network environment that will help them adapt to the transforming era. Moreover, connectivity with other emerging technologies like robotics, artificial intelligence, and cloud computing could lead to even greater advantages.

In addition to the industrial and agricultural sectors, the use of IoT can also be found in environmental observation, the management of sustainable energy, and disaster preparedness. Environmental sensors

installed along river banks and coasts measure data on the levels and rainfall in order to provide more accurate flood predictions. More efficient grid management via the internet can also adjust the distribution of electricity. This balances the level of demand and supply, making it easier to incorporate more wind and solar energy. These applications of IoT connect the technology to sustainable objectives.

4. Discussions

The amalgamation of all these works demonstrates that Malaysia has performed commendably regarding the adoption of IoT and the development of the digital economy. The contribution of the digital economy to the country's GDP is currently over 23% and is set to go beyond 25% by the year 2025 (Department of Statistics Malaysia, 2024). This is due to the investment by the government towards the development of broadband networks and the development of effective strategies and initiatives such as MyDIGITAL and Industry 4WRD (Reuters Plus, 2024; Abdulaziz et al., 2023). However, Malaysia is still at the adopting stage and not at the pioneering stage of using digital technology (Jusoh & Abd Razak, 2023).

4.1. Infrastructure and Connectivity

Connectivity is the basis for the IoT. It is a fact that Malaysia has one of the most comprehensive digital connectivity platforms within Southeast Asia, with national 4G and the development of 5G connectivity. Yet, there is a lack of connectivity in some areas that lack constant access to electricity too (Jusoh & Abd Razak, 2023). This creates digital disparity that limits the adoption of IoT within the fields of agriculture and aquaculture, or within smart city projects. The initiative called JENDELA aims to provide internet access in non-connected regions, but more financing should be dedicated to the effective expansion of seamless connectivity. Finally, IoT requires improvements within the realm of energy connectivity.

4.2. Policy and Regulatory Frameworks

In Malaysia's policy arena, there are different frameworks adopted. These include the National IoT Strategic Roadmap, Industry 4WRD, and the National Cyber Security Agency. Nonetheless, there are still regulatory gaps. There is a need for thorough legislation that will encompass data privacy and data protection regulations. There can be standards and regulations involving cybersecurity, compatibility, and responsibility laws. The regulations and laws of data ownership and flow across different borders will promote business and consumer confidence. A regulatory sandbox concept can be used to permit companies to experiment and develop new ideas in using Internet of Things technology.

4.3. Cybersecurity and Privacy

The increasing use of IoT devices increases the risk of cybersecurity breaches. Consumer IoT devices are not designed with advanced security mechanisms, and the use of outdated protocols in the field could become a problem in the future (Chen& Urquhart, 2022). Unless precautions are taken, malicious actors could compromise critical services and steal personal data or disrupt the supply chain. The establishment of national IoT security guidelines, forceful software updating, and awareness campaigns are critical. A defence-in-depth approach including encryption, authentication, and ongoing surveillance is necessary in organisations (Schiller et al., 2022). The government should make breach accountability and privacy-preserving research, including research on differential privacy and homomorphic encryption, a priority.

4.4. Human Capital and Digital Literacy

Human capital is still both an enabler and a constraint. Malaysia has universities and technical colleges that produce well-skilled graduates. There is, however, a lack of experienced personnel who can deliver and sustain the operation of IoT systems (Jusoh & Abd Razak, 2023). SMEs lack the financial capacity to employ and train experts. Specific support for MSMEs through MSME Digitalisation Grant programs and personnel upskilling training needs to be scaled up.

On the other hand, basic digital literacy is important for overall growth. It is shown that well-skilled individuals can command significantly better pay and secure improved opportunities (Aziz, 2023). Specific training needs to be conducted for farmers, seniors, and low-income households. Additionally, subsidies on gadgets and internet services, plus the development of community digital centers, can help marginal communities and close the urban and rural gap. Equal opportunities for women and other minority groups help ensure that all citizens get fair treatment.

4.5. Sectoral Integration and Innovation

Sector-wise analysis shows that there are major gains that IoT can make in terms of increased productivity, sustainability, and innovation in agriculture, aquaculture, healthcare, manufacturing, and urban operations. However, there are challenges to the adoption of IoT in various sectors. In the case of aquaculture, access to a stable power source and connectivity are needed for constant sensor surveillance; precision agriculture technologies need to be cost-effective and easy to use for small farmers; and healthcare IoT technologies need to adhere to high privacy norms.

Innovation hubs, data centers, research parks, and start-up incubators act as innovation spaces for experiments to take place. Sandbox initiatives for innovations are aided through the MyDIGITAL policy initiative launched by Malaysia, encouraging innovations to focus on cooperation and standards that could make technological innovations possible by enabling various gadgets from different companies to interact with each other.

4.6. Comparisons with Global Experience

A comparison between Malaysia and prominent nations indicates a balance between common issues and distinctive opportunities. Issues like security, interoperability, and human capital remain pertinent for most nations; this makes Malaysia's position less remarkable. There are distinct advantages for Malaysia, including a strategic geographic position, a young population, favorable government policies, and a flourishing e-commerce market. The country's aim to emerge as a data centre in the region is complemented by its abundant resources and strong internet infrastructure (Reuters Plus, 2024). What could have been learned from the experience of digital leader nations like Singapore, Estonia, and South Korea is that a well-defined regulatory environment, efficient business practices, human capital initiatives, and R&D efforts can turn adopters into innovators. Membership with the Regional Comprehensive Economic Partnership could help Malaysia.

4.7. Practical Recommendations and Future Directions

On the basis of the reviewed literature and conclusions in the original paper, the following recommendations and future outlook are devised to enhance the adoption of IoT in the Malaysian context. The recommendations are aimed at policymakers and industry players that focus on the translation of insights into action.

First, the infrastructure for connectivity and energy needs to be bolstered. Extending broadband connectivity to rural areas will necessitate the deployment of a combination of ground and satellite solutions such as low Earth orbit satellites and low-power wide area networks to make it affordable. Connecting micro-grids and renewable energy resources can help to power IoT sensors in areas where the mainstream power grid fails to provide reliable services. Setting up Wi-Fi spots in communities and implementing edge computing will help to make real-time analytics possible even in areas where connectivity is a challenge by cutting down latency and bandwidth expenses.

Second, there should be coherence in regulation. The current policies and regulations need to be harmonized and formulated into a comprehensive digital agenda that identifies and describes data ownership, privacy rules, cybersecurity, and responsibility for cyber incidents. The government may adopt a "data trust" approach where third-party data trusts facilitate shared data sets and ensure that data is shared in a transparent and equitable manner while allowing innovation to take place. Sandboxes for regulations initiated by regulators should be extended from fintech products and services to IoT projects that allow innovation and experimentation in new products and services.

Third, it is essential to make information security a base requirement, not an add-on. Malaysia should set up some baseline requirements in Internet of Things security that could be devised along similar lines to what is being considered in the EU and in the US. This could include a form of certification which could reassure buyers. Additionally, there could be a focus on increasing in-country information security professionals, perhaps with scholarships, VET courses, and collaboration with foreign specialists. Small and medium-scale enterprises, which lack in-country specialists, could benefit from collective information security services provided by industry bodies, or other groupings set up by governments.

Fourth, human capital development should be multi-pronged. Digital literacy courses should target more than just school and university-going youth. They should also target workers, farmers, fishermen, and seniors. They should aim to integrate digital education into school curriculums and provide vocational courses in coding and data analytics. Online learning platforms can also provide lifelong learning access. Subsidized access to digital devices and internet connectivity for lower income classes could provide easy access. Focus should be given on the inclusion of women, the disabled, and indigenous people in this endeavor.

Fifth, sector-specialized strategies can speed up adoption. For example, in agriculture, collaboration between extension services of government agencies and technology suppliers can be leveraged for end-to-end delivery of fully functional IoT solutions that encompass analysis tools and advice. In manufacturing, tax incentives can be used for investments in smart manufacturing equipment, while partnerships with multinationals can facilitate technology transfer. In health, regulators can facilitate easier approval of health-enabling IoT devices while supporting patient welfare, while health ministries can establish pilot health tracking solutions in rural health facilities. Finally, municipalities can partner with start-ups to develop health-enhancing solutions for smart cities, using citizens' input for development. Additionally, collaboration will be crucial among these sectors.

Lastly, a thriving innovation environment surrounding the Internet of Things ought to be encouraged in Malaysia. Multidisciplinary laboratories addressing IoT hardware and software, as well as any related cyber ethics issues, would be a practical idea in research organisations or in universities. Research studies on long-term socio-economic effects such as productivity or job trends would help to shape policies to suit IoT development. Learning from neighboring ASEAN member states might offer a fresh perspective on different environments.

5. Research Significance

Apart from detailing the existing models and exemplars related to the topic, the value of pursuing the topic of challenges and opportunities of IoT in Malaysia is asserted as follows:

Contribution to policy development. The authors assert that good evidence regarding IoT preparedness and challenges would inform policymakers to develop relevant policies and mechanisms for its regulation and promotion. Evidence of gaps in infrastructural development and security aspects would guide the formulation of priorities and interventions aimed at complementing policy within this context. As indicated by the research, challenges posed by bottlenecks in the area of energy and connectivity would inform the need to implement an initiative such as JENDELA and rural electrification projects, while gaps in suitable regulations for the protection of data would inform the formulation of policy among other interventions in this dimension of IoT development in the country. In the Malaysian settings where several bodies have jurisdiction in regard to digital issues, evidence would present an opportunity to coordinate efforts and prevent policy fragmentation.

Promotion of the digital economy. The significance of IoT in increasing productivity and competitiveness is directly related to Malaysia's goal of becoming a digital hub in the region. The report points out areas in which the usage of IoT can have the biggest economic benefit to Malaysia. This includes smart cities, manufacturing, agriculture, and supply chain management. This has been documented in a manner that provides economic benefits in terms of contribution to the GDP of Malaysia. This promotes a digital economy that has the capability of increasing economic activity in Malaysia and improving its position in any trade and investment activity in the region.

Industry stakeholders can benefit from guidance. Companies, technological suppliers, and entities aiming to benefit from IoT solutions require guidance related to overcoming technological as well as organizational issues. For this reason, this research provides many recommendations related to investments in staff training, security, and partnerships with universities or government organizations. By presenting general obstacles such as lack of compatibility between various solutions of this kind, high initial expenses, or low cybersecurity, an enterprise can decide whether to invest in this area or not. There are also schemes for SMEs, for example, that characterize an approach that helps these organizations overcome these issues by presenting possible supporting programmes like grants or tax breaks.

Academic contribution. This article contributes to an ever-expanding stream of research on digital transformation in developing economies. This article, in a sense, discursively weaves together findings from several fields of research, namely engineering, economics, information system sciences, and public policies, thereby filling a gap in how cross-industry IoT readiness is perceived in Malaysia. Further, this qualitative research shows how qualitative analysis can add to quantitative data, giving a holistic perspective on technology adoption, which should help advancing research to compare adoption among nations within ASEAN or examine related parameters like socio-cultural influences on adoption, among others.

Socio-economic impact. The adoption of IoT technology has tremendous positive impacts and benefits to society. These include better delivery of services, improved quality of life, and creation of jobs. The article underlines that as technology literacy increases, it has the effect of empowering communities, and this particularly applies to rural regions. On the other hand, if proper action is not taken, technology may actually exacerbate socio-economic disparities if only metropolitan cities and richer people get to enjoy benefits offered by IoT technology.

Framework development. Lastly, it is also recommended by the authors that lessons gleaned from the evaluation of existing frameworks of IoT could help in developing new frameworks which are relevant to Malaysia. While frameworks like CREATE-IoT offer very useful guidelines, it is also imperative to understand local factors in Malaysia, which may include the reliability of energy supply, policies, and even local perspectives on data privacy, to name a few. It is very likely that other developing nations could benefit if Malaysia, being a developing nation, offers a similar framework, thus increasing the reach of research.

6. Conclusion

This narrative review summarised and integrated the literature on both the challenges and opportunities of IoT in the digital economy of Malaysia. It is observed that Malaysia has achieved considerable growth in building digital infrastructure, facilitating investments, and policymaking conducive to IoT development. The digital economy has been contributing more than 23% to the country's GDP and is set to cross 25% in 2025 (Department of Statistics Malaysia, 2024). The presence of CREATE-IoT and Industry 4WRD offers considerable direction, and industry-specific research has generated considerable outcomes in the field of manufacturing, agriculture, aquaculture, health, and smart city applications.

However, there are various other challenges left to be addressed. In order for Malaysia to unlock the full benefits of IoT, a holistic approach must be employed. Rural broadband and renewable energy investment must include connectivity assurance. Policy frameworks must include data privacy and security requirements and promote interoperability and regulatory innovation through regulatory sandboxing. Talent and skills development initiatives, enabling affordable IoT device and data package accessibility, and community digital hubs can improve overall citizen digital literacy and inclusion. Public–private collaboration can unlock resources and align interests. Future studies could include sectoral case analyses, socio-economic impact assessments over time, and comparisons of Malaysian developments against other emerging nations. As a technology adopter turned leader and innovator, through IoT, Malaysia can unlock sustainable and prosperous growth and position itself as the primary digital force in its region and, in so doing, improve life for its citizens.

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