

Improving Supply Chain Management: A Comparative Study on Internet of Things Adoption in SMEs of Philippines and Asian Countries

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ABSTRACT

The study examines how adoption of IoT in SMEs in the Philippines and other Asian countries can significantly improve SCM. The study's objective is to understand present state of IoT adoption in Philippines, its benefits and challenges, and how it can impact SCM. This paper's key findings include IoT's significant impact on SMEs, specifically in the SCM sector. This paper also highlights the challenges SMEs face such as resistance to change and limited resources. Considering these challenges, this study recommends policies to address these and at the same time enhance the successful adoption of IoT in the Philippines. The study used comparative analysis and thematic analysis to evaluate the gathered data finding valuable insights such as the importance of policies and strategies to successful adoption of IoT.

Keywords: Key Features of IoT in SCM, Benefits & Challenges of IoT Adoption, Utilization of IoT in SCM, Maintaining Green Image through IoT, Policy Recommendation for IoT

INTRODUCTION

Imagine living in a place where your coffee maker would communicate with your car and your clothes, exchanging data by themselves to give you a superb user experience. This is what Internet of Things (IoT) is about – connecting different technologies possessing ability to interact with one another using sensors and software as well as require an internet connection. According to Pal and Yasar (2023), IoT is a system of different technologies that are inserted with sensors wherein they can send and receive data to other technologies and internet. Examples of these are smartphone, appliance, thermostat, lighting system, irrigation system, security camera, and vehicle (Greengard, 2024).

According to Congressional Policy and Budget Research Department, SMEs in Philippines contribute to economic growth and job creation greatly, accounting for 99% of business establishments and 65% of employment in 2022 wherein they generate 40% of the country's GDP, making them the "backbone of the Philippine economy." The emergence of IoT brings both benefits and challenges to businesses, individuals, society, and for small and medium enterprises (SMEs) which pertain to businesses that have low investment and turnover. In Malaysian manufacturing, challenges are being faced in IoT adoption because of a lack of education and training. However, on the other hand, those Malaysian SMEs that adopt IoT have seen positive impacts such as improved communication, reduced errors, and enhanced product quality (Abdulaziz et al., 2023).

In connection with this, improving the traffic and relieving congestion through IoT significantly impacted

mobility and transportation. For instance, Singapore embraced IoT-enabled EV charging infrastructure to encourage environmentally friendly mobility, showing how IoT integration may transform mobility and transportation, improving the effectiveness of urban transportation, and opening the door to a more sustainable future (Khan, 2023). Consequently, it also positively impacted the general advancement of supply chain management (SCM). In a study in Karachi, Pakistan, it was found that IoT adoption affects SCM positively (Zafar, 2024). One industry that IoT has greatly impacted is logistics, way back 2019, it had a 34 billion dollars global IoT logistics market size and is expected to achieve a value of 63.7 billion dollars by 2026, with approximately 12.4% as its Compound Annual Growth Rate (CAGR) (Forbes, 2023).

As IoT significantly impacts industries such as Logistics, having our government have initiatives to further improve various sectors and its entrepreneurs, with the help of digital in general, is a big step towards a more connected and improved nation. Department of Trade and Industry of Philippines signed a Memorandum of Understanding (MoA) in partnership to Amazon Web Services in February 2023 that aims on providing Filipino entrepreneurs with competitive edge when it comes to digital services and solutions, and at the same time offer training for up-skilling and re-skilling the Filipino workforce. In addition to this, there is also a bill called Regional Comprehensive Economic Partnership (RCEP), aiming to create a contemporary, comprehensive, greater, and mutually advantageous economic alliance that will promote regional trade and investment growth and development as well as worldwide economic growth and development (Senate of the Philippines, 2022).

Transforming the Philippine landscape in the emerging trend of IoT in SCM, enhances productivity and competitiveness on a global scale, specifically in the logistics industry. According to Maheshwari (2024), the logistics industry in the Philippines is advancing to digital transformation, with the emergence of technologies wherein the IoT is revolutionizing the tracking of assets and management of fleets. Integrating IoT sensors in containers, transportation, and cargo enables logistics providers to have real-time data, route optimization, improve asset utilization, and develop strategies such as preventive maintenance. Therefore, creating a connected logistics network across archipelagic countries.

LITERATURE REVIEW

Key features of IoT on Supply Chain Management

There are various essential features that IoT can offer to SCM, some of these are connectivity, AI tracking inventory, and improved inventory management. These key features help for real-time tracking and monitoring, helping to enhance SCM. Firstly, the connectivity enables IoT devices to link with other devices. Hence, strong connectivity is essential for IoT applications to work well, including wearable fitness trackers that monitor activity levels, wireless IoT sensors that transfer data, and IoT alarm systems that offer long-term security (Alsen, 2017). Furthermore, as key features introduce how important IoT on SME's are, Artificial Intelligence (AI) will enter as a medium for tracking as AI can predict equipment failures and plan maintenance plans, reducing the possibility of costly downtime (Kothari, 2023). Relatively, real time data processing and analysis is possible with AI algorithms, businesses can benefit from a better understanding of their data. It contributes to the improvement of decision-making process which helps in minimizing the time of processes, and increases the efficiency rate (Poljanec, 2024). Moreover, inventory management plays a crucial part when it comes to keeping the records accurate (Zimon et al., 2021). Utilization of IoT technologies has ushered control of the inventory and real-time visibility. It also allows management of inventory system leverages sensor, RFID tag, and other interconnected technology for continuous monitoring of location, good and product's movement, and status throughout the process of supply chain (Sallam et al., 2020).

IoT adoption's possible benefits and challenges in Philippines' SMEs

When it comes to IoT technology implementation, Philippine SMEs can possibly face both obstacles and opportunities. In a study conducted in Mapua University, it was found that the benefits that Philippines manufacturing SMEs can gain from IoT adoption are profitability or return on investment (ROI), easy management, and visibility in supply chain wherein these factors significantly influenced the willingness in adopting IoT. On the other hand, the challenges that negatively influenced the willingness in IoT adoption include resistance for change, dislike for technology, and complicated management style (Norona et al., 2021). It was no doubt that some SMEs in the Philippines face significant barriers to effective IoT implementation, including a limited source of money, technical skills, and poor ICT infrastructure. In the presence of these challenges, fortunately the Philippine government put effort in assisting businesses. For instance, the Senate of the Philippines decided to support businesses during the pandemic by approving Corporate Recovery and Tax Incentives for Enterprises (CREATE) Bill for tax relief measure for business organizations hence leading to reduced burden of paying taxes on revenue made by such firms. It aimed at lowering corporate profit taxes and making economic stimulus regimes better than before (Senate of the Philippines, 2020).

IoT's Utilization in SCM

Implementing IoT in SCM significantly improved responsiveness, efficiency, and transparency by enabling real-time tracking and data collection on inventory, shipping, and manufacturing processes (Taj et al., 2023). An Industry 4.0-specific IoT framework from Malaysia successfully addressed challenges, maximized resources, and expedited procedures, which are crucial for maintaining competitiveness for their SMEs (Abdulaziz et al., 2023). Manufacturing SMEs in the Philippines are ready to implement IoT to reduce costs and enhance efficiencies, increasing competitiveness (Norona et al., 2021). In research, IoT adoption enhances supply chain performance, notably in demand forecasting, logistics, and inventory management, by minimizing errors and delays (Zafar, 2024). In addition, integrating IoT into SCM develops an automated, intelligent, and adaptive ecosystem, improving operational efficiency and supporting innovation in the digital era (Korte et al., 2021; Greengard, 2024).

Government initiatives for future improvement of SMEs in the Philippines

The Philippine government has taken positive steps to strengthen the growth and sustainability of SMEs in the country. Through a range of programs, including the Agreement on the Regional Comprehensive Economic Partnership (RCEP), wherein it aims to expand and deepen the economic ties between the countries in the ASEAN to foster equitable economic development, boost economic growth, and create transparent, mutually beneficial regulations that facilitate trade and investment, including involvement in regional and international supply chains (DTI Philippines, 2020). It was stated by DTI Secretary, Alfredo Pascual, that RCEP have a significant contribution in Philippines when it comes to broadening our trade or transactions with the country's partners for RCEP. Speaking of IoT, it is important that we improve cybersecurity to have a safe adoption of IoT and this can be achieved by developing a national IoT strategy that embedded with best practices and protocols (Norona et al., 2021). Fortunately, in the Philippines, President Marcos signed the Internet Transactions Act in 2023, wherein this aims to promote a safe implementation of IoT by improving the e-commerce and providing a regulatory framework to establish a clear environment for IoT adoption and secure SMEs to fully utilize benefits of IoT and maintain their competitiveness. This initiative of government will promote positive impact on SMEs as he also states that his office would be active in promoting to Philippine-based enterprises, particularly the SME (The LawPhil Project, 2023).

Future implementation of Internet of Things in the Philippines

The IoT is being increasingly applied not only in the services of the shops but also in warehouses and factories. It is being applied in inventory management where labelling of component parts for faster identification and confirmation of their installment in the automobile assembly line industry. As of 2018, the market capacity is yet to be fully utilized. As per Department of Trade and Industry Philippines (2019), the world's apparel industry utilizes around 8 billion tags which is only 10% of the market capacity. Relatively, RFID labels are being widely implemented in the logistics industry to ensure real-time monitoring, traceability of the production inventory, and the improvement of logistical efficiency through the reduction of manual paperwork. In the Philippines, some project concept has already incorporated the IoT, including New Manila Bay, which has the goal of transforming the city and improving its economy. Furthermore, Packetworx in partnership with ThingsPH, a Division of Packetworx Technologies Incorporation, with the support and participation of ADNU MAGIS TBI, Technology Business Incubators, in funding the concept creation of assistance request applications and disaster preparedness solutions from various colleges within the university has taken a great stride in the advancement of Naga City by elevating it to a Fully Fledged Smart City in disaster management solutions (Naga City Government, 2024).

Through extensive research for different studies, the researchers were able to understand what IoT is and how it can be used to improve the Philippine SMEs, specifically in the SCM sector. During research for related literature, the researchers found gap that must be fill in such as limited comparison on IoT adoption between Philippines and its Asian countries to better look at how IoT is adopted in other Asian countries and how we can use this information to apply IoT in our country. In addition to this, the study will fill the gap of limited comprehensive analysis on the driving and restraining force of implementing IoT in SCM to help the country in maximizing the benefits of IoT and addressing its challenges. Lastly, they will also fill the gap in limited policy adoption regarding IoT implementation in SMEs of Philippines to leverage IoT for economic and social benefits.

In line with the research gap, the paper intends to examine current state of adopting IoT in Philippines in comparison to adjacent Asian countries to evaluate the factors IoT influencing the SCM. Therefore, this will reveal the Philippines' current position in the regional IoT landscape, helping to discover best practices and areas where the Philippines may boost its IoT goals. Upon filling the gap in limited comparative analysis, this will help researchers to analyze the driving and restraining forces of IoT SCM to discover the factors that facilitate or hinders IoT integration in supply chains. Understanding these constraints is crucial for enterprises and authorities looking to optimize the benefits of IoT while limiting possible hazards. Hence, this study also provides suggestions for the IoT application in the Philippines to design policy options which will be useful in ensuring that the nation leverages IoT for socio-economic benefits. It is important that such policies are from comprehensive perspective in terms of guiding principled economy.

Problem Statement

This paper aims to address the need to compare IoT adoption between Philippines and other Asian countries, comprehensive analysis of driving and restraining force of IoT, and suggestions of policy to better improved the IoT adaptation in the Philippine SMEs, specifically in SCM sector. Hence, the following study objectives are goal to be achieved:

1. What are insights of IoT adoption in SMEs between the Philippines and Asian countries into improving supply chain management?
2. What are the motivations in utilizing IoT in supply chains specifically in product quality, reliability, maintaining a green image, meeting economic factors, and survival needs?
3. What challenges in implementing IoT in supply chain management involve issues in terms of data

security, privacy concerns, technological challenges, and trust issues?

4. What are the policy recommendations that can enhance the implementation of IoT in the Philippines?

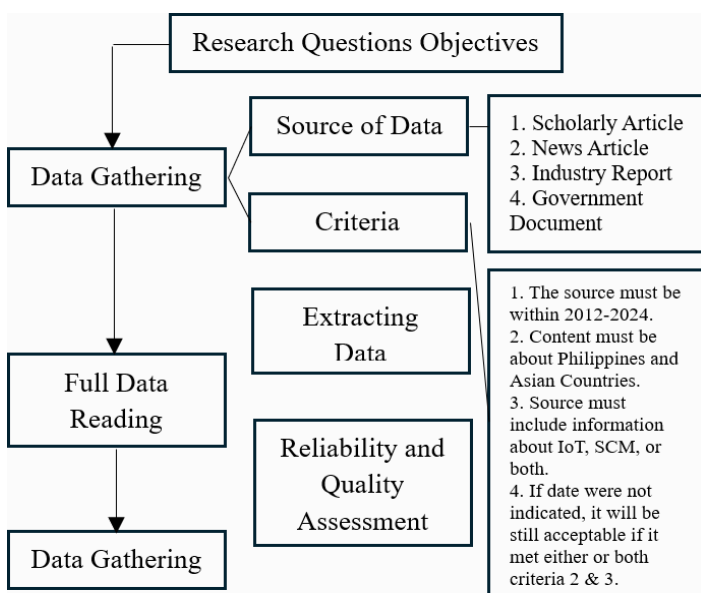
METHODS

To provide an appropriate and relevant answer to the statement problem, the researchers collected raw data from sources such as scholarly articles, news articles, industry reports, and government documents. Keywords such as “IoT”, “SCM”, “Asian Countries”, and “Philippines” were used to extract the appropriate sources of information easily. Content analysis is a way to study different forms of communication, like text, images, or audio, by looking for patterns, themes, and important features. This helps researchers conclude based on what they find (Hassan, 2024). In this research, to understand the meaning of language or text based on the relationships between words or phrases from various sources, the researchers will use Comparative Analysis and Thematic Analysis because these methods suit the paper.

A comparative analysis is a two-side comparison to find out how they are similar and different. It can look at ideas or theories, or it can compare real data sets (Dovetail, 2023). Aside from Comparative Analysis, the researchers will also utilize Thematic Analysis. According to Flick (2022), a Thematic Analysis includes principles which are data coding, creating themes, double-checking the themes, and stating findings. Conversely, it’s a method of analyzing qualitative data that involves identify and extract patterns to a set of data for interpretation of their definition (Braun & Clarke, 2006). Using this analysis, the researchers will extract raw data from each source wherein they will be based if they meet certain criteria which are: sources must be within 2012-2024, content must be about Asian Countries, including information about IoT, SCM, or both, and if the date were indicated, it will be still acceptable if it met the criteria 2 & 3. Then, researchers will generate a code in each raw data to narrow down the context. Lastly, they generate themes on which all the codes will be categorized.

Through this, researchers will be able to gain insights into IoT adaptation between the Philippines and Asian Countries to determine what challenges and motivations SCM experience in IoT adoption, providing them with valuable information that will be the basis for policy recommendations for enhancing IoT adoption in the Philippines. The researchers intended to use this design for this study to formulate an interpretation of data, then answer the statement problem, and lead to a conclusion.

Fig. 1. Data Collection and Preparation



Source: (Delmo et al., 2023)

RESULTS AND DISCUSSIONS

After gathering the necessary data, researchers created the tables below, visualizing how these extracted codes from sources are generated and categorized through themes, and how data relate with each other. Hence, enabling the researchers to appropriately interpret each table, satisfying the needs of researchers to achieve their objectives.

Table I. Adoption of IoT in SMEs of SCM

Adoption of IoT in SMEs of SCM in Asian Countries	Adoption of IoT in SMEs of SCM in Philippines	Themes and Description
<p>In Malaysia, the IoT readiness of SMEs in information and communication technology (ICT) and non-ICT services holds a strong case to be investigated in future studies. Furthermore, the government of Malaysia introduced the National IoT Strategic Roadmap in 2014 where the SME Corporation Malaysia was appointed as one of the key players (Zaidi, 2017).</p>	<p>The ‘Internet of Things’ and RFID technology in the Philippines make daily life easier for businesses, governments, families, and schools. There are numerous solutions for health, smart homes, logistics, agriculture, and other areas, all of which contribute to technology’s success. Devices gain new capabilities when connected, allowing communication between humans and robots (IoT Philippines Inc., n.d.).</p>	<p>Communication – Based on these two data, Communication refers to information exchange between systems, devices, or humans which enables them to interact and coordinate.</p>
<p>Online applications that are IoT-based is use by Sleman SMEs, like Shopee and Tokopedia. In addition, the government itself has an E-SME application which can be used by SME owners. It is a concept about the product marketing system of Indonesian SME products in penetrating the free market based on smartphone applications (Fridayani & Atmojo, 2021).</p>	<p>Focusing on embracing IoT technology advances, FWD Philippines is the new, rapidly growing life insurance company that is keen on making improvements to the organizational processes and cutting on operational expenses. The company is also effectively implementing Mobile tools & tablets, restricting paper use and engaging the Social Media Wrapper (Newsbytes PH, 2017).</p>	<p>Control and Automation – Based on these two data, Control is referred to as monitoring and managing devices and systems, while automation involves using technology to carry out tasks without human intervention.</p>

Adoption of IoT in SMEs of SCM in Asian Countries	Adoption of IoT in SMEs of SCM in Philippines	Themes and Description
<p>Malaysia’s transportation goal is to be one of the top five in Asia Pacific container and container trails. Malaysia also wants the opportunity to improve trade facilities and strengthen Malaysia’s competitive edge in supply chain management methods. E- parking, taxi reservations, bus transportation information, and, most significantly, travel and train information recommendations with real-time information for convenient traveling are all suggested apps (Tiwari, 2022).</p>	<p>Some of the issues that have been met when SMEs are adopting IoT technologies during the outbreak of COVID-19 are being dealt with by the Philippines as well as other Asian nations. An understanding of the factors including management, cost of entry, and willingness to embrace IoT is important in IoT market success. Nonetheless, respondents still hold a lukewarm attitude easily recognizable towards full-blast IoT technologies such as sensors, cloud systems, big data analytics (BPO Philippines, 2024).</p>	<p>Self-Configuration – Based on these two data, Self-configuration refers to the automatic adaptation and optimization of systems or technologies without human intervention.</p>
<p>Despite the halal industry primarily focusing on religious needs and requirements, integrating the Internet of Things (IoT) into firm management is essential to enhance business performance. The emerging global technology demands halal food-based SMEs to adapt to remain competitive in both local and global markets. To achieve this, these SMEs must understand the benefits of IoT in managing halal supply chain activities (Tarmizi et al., 2019).</p>	<p>Philippine manufacturing SMEs have a disposition to meld IoT for proliferation yet are indifferent about high impact IoT tools such as sensors and cloud systems. The research carried out highlights ease of management as well as initial investments when it comes to adoption of IoT technology. Subsequent studies should examine how it can contribute to the efficiency of output, quality regulation, and the minimization of expenses, which will give the SMEs a higher chance of success in the industry (De Vera, 2022).</p>	<p>Efficient Business Processes – Based on these two data, Efficient Business Processes Means streamlining operations with minimal waste, enhanced output, and optimized quality through IoT integration.</p>
<p>The challenges faced by halal agro-food SMEs in accessing trusted halal information through information networks and the high cost of installing IoT devices in business premises are significant. However, despite these obstacles, it is concluded that Malaysian halal agro-food SMEs can benefit from technological advancement with proper training and knowledge transfer programs on IoT (Tarmizi et al., 2019).</p>	<p>IoT can upgrade return on equity, assets’ returns, and cost reductions for a company to get a competitive edge and provide more growth, as well as fulfill customers’ demand and optimize the supply chain (Norona et al., 2021).</p>	<p>Cost-Saving – Based on these two data, Cost-savings refer to the reduction of expenses that result from the integration of IoT in SMEs. This can include lowering operational costs, optimizing the supply chain, and improving asset returns, thus providing a competitive edge and enhancing growth potential.</p>

Source: Processed by Authors

This table reveals that based on a comparison of how small businesses in Malaysia, the Philippines, and Indonesia are adopting IoT technology for managing their supply chains, clear differences emerge. Malaysia focuses on government plans like the National IoT Strategic Roadmap to help small businesses get ready for using these technologies through partnerships and policy (Zaidi, 2017). In contrast, the Philippines uses IoT in specific areas such as healthcare, logistics, and farming to make the operations smoother and even allow devices to communicate with people (Garde, 2022). Conversely, Indonesia is integrating IoT into popular online platforms such as Shopee and Tokopedia, using government apps like E-SME to help small businesses sell more using smartphones (Fridayani & Atmojo, 2021). Meanwhile, in the Philippines, companies like FWD Philippines are showing how IoT can cut costs and make things more efficient, especially in sectors like insurance (Newsbytes PH, 2017). Both regions face challenges like managing these technologies and the costs involved, and they are cautious about using advanced IoT tools like sensors and cloud systems (BPO Philippines, 2024; Ian, 2022). Despite these challenges, the possible benefits of IoT such as better efficiency, quality control, and cost savings, are evident for small businesses in both Malaysia and the Philippines (Tarmizi et al., 2019; Norona et al., 2021). This comparison shows how different countries in Asia are using and benefiting from IoT in their supply chain management.

Table II. Motivation in Utilizing IoT

Existence Needs	Relatedness Needs	Growth Needs	Themes and Description
Sensors and RFID tags enhance product quality by facilitating efficient monitoring and investigation of supply chain steps (Yesodha et al., 2023).	Silver Spring started collaboration with Singapore Power with the aim to improve product and market development, and the goal to unlock creativity and innovation in the IoT of Singapore in academic and commercial institutions (Lago, 2018).	IoT technologies improve quality control in manufacturing by applying sensors to monitor important characteristics like temperature, pressure, and humidity, which have a direct impact on product quality. Real-time monitoring allows for fast correction of errors, guaranteeing constant quality (Sapot, 2024).	Product Quality – Based on these three data, product quality is a multifaceted concept that encompasses meeting customer expectations, conforming to requirements, ensuring reliability and performance, and continuously improving processes to deliver high-quality products in IoT of supply chain. It requires a combination of collaboration, robust design, effective monitoring, and data-driven process to improve IoT adaptation.

Existence Needs	Relatedness Needs	Growth Needs	Themes and Description
<p>AI, a powerful IoT technology, can automate supply chain management (SCM) processes, aiding major stockholders like managers, suppliers, and retailers in predictive analytics and defect detection of their products and goods (Taj et al., 2023).</p>	<p>Internet Initiative Japan has signed a (MoU) with Indonesian partners to advance IoT research and technology in areas like transportation, map information, data analysis, and algorithm development (IoT Now, 2024).</p>	<p>Monitoring products from raw ingredients to the final sale of products, an RFID-enabled IoT-driven system ensures food quality and transparency all the way through the SCM. RFID tags collect all the information at the very last stages, which facilitates logistics management, monitoring, and inspection. Integration of Blockchain enhances security by providing tamper-proof digital documents (Taj et al., 2023).</p>	<p>Reliability – Based on these three data, reliability pertains to the consistent and accurate capture, processing, and transmission of data essential for operations.</p>
<p>Green logistics technology, including climate measurement tools, real-time data-gathering, electric vehicles, green cold chain solutions, electric cargo delivery drones, and logistics resource management platforms, can reduce waste, simplify processes, improve competitiveness, and be environmentally friendly. Companies like Spencer, Bigbasket, Amazon, Licious, Myntra, and Flipkart have partnered with Zypp Electric for last-mile delivery through e-vehicles and e-vehicle fleet management (Bhardwaj, 2023).</p>	<p>ABB and China Telecom have established a joint digitalization and industrial IoT laboratory in Hangzhou, focusing on developing end-to-end industrial IoT solutions for Chinese industrial companies (ABB News, 2023).</p>	<p>Companies are focusing on the importance of energy-efficient and sustainable measures to gather the social, economic, and environmental gains of IoT deployments. Energy-efficient hardware and software need to be produced to lower the carbon impact of the IoT. Refrain from consuming more power and measuring the real-time performance of systems assists in promoting sustainability through IoT. Where green IoT comes into play, emissions of carbon by these devices should not stall the move towards using IoT for ecological solutions (Glickman, 2023).</p>	<p>Maintaining a Green Image – Based on these three data, survival needs, maintaining green image operationalizes as companies strategically integrate green logistics technologies such as electric vehicles, green cold chain solutions, and IoT-driven logistics management platforms to reduce carbon emissions and enhance operational efficiency.</p>

Existence Needs	Relatedness Needs	Growth Needs	Themes and Description
<p>IoT can significantly improve supply chains (SCs) by automating product identification and tracking, facilitating smooth information sharing, and overcoming challenges. However, COVID-19 pandemic disrupted SCs across various areas such as economic and social, making IoT crucial for supply chain resilience and responsiveness to unexpected situations. Therefore, IoT plays a vital role in unexpected situations like COVID-19 as well as in post-COVID-19 days (Ali et al., 2023).</p>	<p>The Fira de Barcelona event has signed a collaboration agreement with China, a leader in IoT development in the Asian country of Wuxi. The agreement aims to facilitate investment and cooperation between China and the European Union, promoting the development of IoT technology and facilitating knowledge exchange (IoT Solutions World Congress, 2024).</p>	<p>Significant economic growth is expected to be supported by the IoT. McKinsey projects the better pricing and delivery performance might increase efficiency by 20–30%. Beyond just improving operational efficiency, this wide spread adoption of IoT technology is expected to significantly increase GDP and attract large investment in IoT advances. Significant economic growth is expected to be supported by the IoT (Dahlqvist et al., 2019).</p>	<p>Meeting Economic Factors – Based on these three data, meeting economic entails leveraging technology to enhance economic performance and resilience, particularly evident in supply chains.</p>
<p>Cloud computing technology is crucial for the success of the IoT. Connected IoT devices need integrated communications, which rely on advanced cloud technology for connectivity at a central point. Hence organizations must gear up in terms of accommodating these changes by adopting this technology (IEEE Innovation at Work, n.d.).</p>	<p>The Japanese government is collaborating with Germany and the US to enhance IoT development through skills training and knowledge sharing, aiming to boost consumer confidence and drive IoT spending and innovation (Glade, 2017).</p>	<p>IoT has a critical role in increasing efficiency, production, and consumer happiness, particularly in meeting necessities. However, it also introduces major challenges such as cybersecurity threats, cultural challenges, infrastructure issues, and scaling concerns. To overcome these difficulties, it is essential to develop strong IoT designs, use big data analytics, and ensure the security of IoT (Kumar et al., 2019).</p>	<p>Survival Needs – Based on these three data, survival needs encompass the essential adaptations and strategic initiatives that organizations and countries must undertake to thrive in a rapidly evolving technological landscape.</p>

Source: Processed by Authors

The table emphasizes how technological advancements, collaborative innovation, and sustainable development play a vital role in motivating IoT adoption of the supply chain management. Innovations in IoT such as sensors and RFID tags have proved important in improving product quality by monitoring the supply chain processes in real time and at the same time analyzing the data collected. Furthermore, the technologies presented in IoT, like RFID and sensors, help in securing data capture, process of data, and data transmission which provides transparency and information integrity in logistics management (Taj et al., 2023). The table also reveals that IoT contributes to the enhancement of environmentally friendly processes by promoting green logistics. Furthermore, IoT enables cost reduction without loss in environmental

sustainability through technological advancements like electric cars (Bhardwaj, 2023). The environmental efficiency of Supply Chain (SC) grows with aid from IoT, such an extent that it brings higher GDP and investments into this technology (Dahlqvist et al., 2019). On the other hand, international collaborations also show the development and formation of IoT like how Japan collaborated with Germany and the US to boost innovation and enforce global lead in competitiveness for IoT technologies (Glade, 2017). To summarize, the said motivations significantly influence the IoT adaptation on Asian countries' supply chain management playing a vital role in improving their product quality, reliability, maintaining a green image, meeting economic factors, and survival needs.

Table III. Challenges in Utilizing IoT

Wealthy Asian Countries	Middle Class Asian Countries	Themes and Description
<p>Singapore is a leader when it comes to smart city development across the globe. For enhancing the quality of life, economizing, and progressing toward environmental sustainability, the state looks to the IoT. Not wanting to become a victim of cyber-attacks and managerial aberrations affecting public trust and data privacy, much has gone into its cybersecurity infrastructure, building the Cyber Security Agency in 2015. It put in stringent measures such as the Cybersecurity Act of 2018 and the NCSC (Caburn Telecom, n.d.).</p>	<p>Security and privacy in IoT and supply chain management are very critical because devices will be transmitting data. Strong protection measures are needed by companies, including encryption methods, authentication, and frequent updating of gadgets to protect them against cyber-attacks. The security of data is important because breaches can cause financial losses, lead to loss of reputation, and legal liability (Miller, 2024).</p>	<p>Data Security – Based on these two data, data security refers to the protection measures and practices implemented to safeguard digital information from unauthorized access, breaches, and cyber-attacks. This involves employing encryption methods, authentication protocols, and regular updates to devices and systems to ensure the confidentiality, integrity, and availability of data.</p>
<p>The increasing connectivity and data sharing in IoT in Asia raises the risk of data breaches and cyber-attacks, necessitating supply chain companies to ensure secure devices and networks. Asian businesses are implementing next-generation connectivity technologies that have received considerable support from global governments. China and Singapore take the leading innovative role in these sectors (Osborne Clark, 2019).</p>	<p>The Vietnam IoT Security Market is making speedy development of advanced solutions that enhance cybersecurity in industrial automation and smart city perspectives in blockchain-based authentication, AI-powered threat detection, and secure firmware update, and so on, to combat rising cybersecurity concerns and sensitive data protection (Taiwan News, 2024).</p>	<p>Privacy Concern – Based on these two data, privacy concern refers to the apprehension and consideration regarding the potential risks and implications of unauthorized access, misuse, or exposure of personal or sensitive information in connected systems.</p>

Wealthy Asian Countries	Middle Class Asian Countries	Themes and Description
<p>The Japan Ministry of Economy, Trade and Industry (METI) has established a Study Group to establish an IoT Product Security Conformity Assessment Scheme, aiming to promote secure IoT products while considering similar efforts in other countries. The group aims to promote appropriate security measures for IoT products. To this end, METI established the “Study Group for Establishment of a IoT Product Security Conformity Assessment Scheme” (hereinafter referred to as the “Study Group”) in November 2022 and has since advanced discussions (Ministry of Economy, Trade and Industry, 2024).</p>	<p>Industry 4.0 is still in a developing ground in Malaysian SMEs, which face various tech hitches, of course IoT scale up. These problems are variations in standards, privacy problems; demands for secureness hence analytics errors in results. Because cloud and web-based infrastructures are heavily relied upon, cybersecurity becomes as significant area of concern, and the increasing amount of data being collected increases the danger of security breaches (Abdulaziz et al. ,2023).</p>	<p>Technological Challenges – Based on these two data, technological challenges refer to the difficulties and obstacles encountered in the development, implementation, and maintenance of advanced technological systems and solutions.</p>
<p>IoT devices are fabricated in high volume and their design should be secure to enable their functionality. This leads to the challenge, identified by ENISA187, and MITRE188 building a chain of trust based on a root of trust anchored within the device. As of 2018, IoT stakeholders will need to comply with GDPR and other such privacy regimes, including Singapore’s PDPA. That entails no-escape clauses for establishing legal liability for the processing of a person’s personal data in line with their respective interventions (Staalduinen & Joshi, 2019).</p>	<p>Cloud computing services are likely to bring flexibility to SMEs while reducing their costs. However, trust issues with potential losses of sovereignty over data, uncertainty regarding its location, and a lack of standard operations among cloud providers, are very significant impediments. This revolution in cloud computing is here to stay despite the above-mentioned challenges. No control very often goes with a high degree of uncertainty about data location. Moreover, there is no standard way by which the cloud providers operate hence making the shift from one service provider to another hard for the user (Cueto et al., 2022).</p>	<p>Trust Issues – Based on these two data, trust issues refer to the concerns and apprehensions regarding the reliability, security, and control over data and systems in technological environments.</p>

Source: Processed by Authors

The data in the table reveals that wealthy and middle-class Asian countries faces similar difficulties in developing IoT technology, wherein wealthier countries like Singapore and Japan are leading in cybersecurity and rules for protecting data, such as Singapore’s Cyber Security Agency and strict Cybersecurity Act, which aim to keep data safe and build public trust (Caburn Telecom, n.d.; METI, 2024). In contrast, middle-class countries like Vietnam and Malaysia are dealing with challenges in adopting and securing IoT technologies due to varying standards and concerns about privacy (Osborne Clark, 2019; Abdulaziz et al., 2023). Both groups emphasize the importance of secure IoT products and systems, following privacy laws like GDPR and PDPA, and addressing trust issues related to uncertainties in cloud

computing operations and risks to data security (Stalduinen & Joshi, 2019; Cueto et al., 2022). This highlights a shared focus on improving data security and managing complex technology issues, while also showing differences in regulatory maturity and readiness across different economic levels in Asia.

Table IV. Government Initiatives and Policies

Neighboring Asian Countries Government Initiatives and Policies	Philippines' Government Initiatives and Policies	Themes and Description
<p>Singapore's government is crafting a policy that enhances IT assets and citizen data defense through technology and community engagement, requiring a calibrated framework for cyberspace protection. Mr. Chai, government's chief information security officer, suggests segregating information into tiers, implementing access restrictions, and logging levels to promote a risk-based security approach, thereby enhancing cybersecurity efforts (GOVTECH Singapore, 2019).</p>	<p>The Data Privacy Act follows an international ethics for personal data protection, ensuring privacy, free information flow, and national development safeguarding fundamental human rights. It acknowledges the role of information and communications technology in nation-building and enforces state obligations (National Privacy Commission, 2012).</p>	<p>Perceived Privacy – Based on these two data, perceived privacy refers to the degree to which individuals feel their personal information is securely protected and appropriately managed, based on established frameworks and policies governing data defense and privacy.</p>
<p>Infocomm Media Development Authority and ITSC's IoT Technical Committee in Singapore had released a standard for IoT that focuses on the data exchange and cybersecurity wherein the standards aim to reduce deployment costs and support enterprises by promoting secure, open interfaces between devices and systems, lowering entry barriers for technopreneurs, and fostering a secure IoT system (Infocomm Media Development Authority, 2023).</p>	<p>The National Cybersecurity Plan 2024-2029 that aims to provide policy direction, operational guidelines, and cyberspace defense to online threats has been approved by President Ferdinand R. Marcos Jr. (Presidential Communications Office, 2024).</p>	<p>Perceived Security – Based on these two data, the perceived security is about how safe people feel their data and online activities are from potential threats, grounded in strong cybersecurity measures and policies.</p>
<p>In Malaysia, the National 4IR Policy aims to capitalize on growth opportunities and address risks from emerging technologies like robotics, AI, and the Internet of Things wherein it consists of four core thrusts that target people, businesses, and government. This prepare people with 4IR knowledge, developing digital infrastructure, providing flexible rules for technology change, and expediting innovation (Malaysian Investment Development Authority, 2021).</p>	<p>The Philippine government has enhanced its MSMEs program in order to boost competitiveness despite the emerging Industry 4.0 and the pandemic's impact, focusing on SETUP 4.0 strategies, including access to new technologies, technical support, and enterprise resilience. (Philippine News Agency, 2021).</p>	<p>Facilitating Conditions – Based on these two data, facilitating conditions refer to the supportive measures and infrastructure implemented by governments to enable and enhance the adoption of advanced technologies, particularly by micro, small, and medium enterprises (MSMEs).</p>

Neighboring Asian Countries Government Initiatives and Policies	Philippines' Government Initiatives and Policies	Themes and Description
<p>The MyDIGITAL GovTech Innovation Partnership in Malaysia aims to equip civil service members with the digital skills and training for inclusive, responsible, and sustainable development through the help of Microsoft Skilling pilot program wherein this program provides workshops and self-learn platforms for learning Cloud, IoT, AI, and cybersecurity (My Digital, 2023).</p>	<p>The DOST has launched the Small Enterprise Technology Upgrading Program (SETUP) to encourage MSMEs in adopting the technology innovations, improving products, services, operations, productivity, and competitiveness. This program offers assistance in technology needs assessment, human resource training, consultancy, product standards, testing, packaging, and database management (Jur PH, 2015).</p>	<p>Effort Expectancy – Based on these two data, the effort expectancy refers to the perceived ease of use and the level of effort required to learn and implement new technologies or skills.</p>
<p>In Japan, they are focusing on the development of concrete solutions to societal challenges to create momentum and dominate large markets globally. In order to achieve this, METI has held meetings of the R&D and Innovation Subcommittee of the Committee on Industrial Science and Technology Policy and Environment since December 2015. The results of these meetings have been compiled into an interim report on efforts to promote innovation (Ministry of Economy, Trade and Industry, 2019).</p>	<p>According to the Department of Trade and Industry (DTI), they have signed a Memorandum of Understanding with the Amazon Web Services aiming to offers advanced digital services to every Filipino entrepreneur and innovator, aiming to improve workforce, encourage digital technology adoption, and collaborate with stakeholders for digital innovation (Department of Trade and Industry Philippines, 2023).</p>	<p>Social Influence – Based on these two data, the social influence refers to the impact of societal norms, government policies, and collaborative efforts on individuals' or organizations' decisions to adopt and use new technologies or innovations.</p>
<p>Japanese technology companies developed a system called, The Smart Cyber Operating Theater (SCOT), which integrates IoT technology in the medical practices wherein it connects medical equipment that allows comprehensive data processing for operation progress along with the patient condition. This system integrates surgical navigation system, MRI scanner, 4K3D microscope monitor, and diagnostic test system which improves the precision and safety during surgical procedures (Japan Gov, 2020).</p>	<p>In the Philippines, the Republic Act No. 11967, also known as the Internet Transaction Act of 2023, aims to foster trust between online merchants and consumers, improve competition and productivity, ensure effective regulation, protect consumer rights, and promote innovation, competition, secure transactions, intellectual property rights, product standards, environmental sustainability, and safety compliance (LawPhil Project, 2023).</p>	<p>Perceived Autonomy – Based on these two data, the perceived autonomy” refers to the extent to which individuals or organizations feel they have control and independence in their actions and decision-making processes.</p>

Neighboring Asian Countries Government Initiatives and Policies	Philippines' Government Initiatives and Policies	Themes and Description
<p>In March 2016, Japan's National Center of Incident Readiness and Strategy for Cybersecurity released a "General Framework for Secure IoT Systems" and IoT Security Guidelines in July 2016 that implement and maintain trust worthiness in IoT products and services. These guidelines supplement the international standard ISO/IEC/IEEE 15288:2015 which focuses on security, privacy, safety, reliability, and resilience (Ministry of Economy, Trade and Industry, 2021).</p>	<p>In the Philippines, the National Information and Communication Technology Environment (NICTEF) is a blueprint for collecting, managing, and developing national ICT data wherein it serves as a strategic compass in response to ICT-related challenges and an implementation plan for stakeholders. It also contextualizes the strategies based on the connectivity master plans and best practices, benchmarking the pace of development within the region. Furthermore, it provides avenues for synchronizing policy formulation, technology evolution, and regulatory regimes to promote ICT inclusion in government processes and society (Department of Information and Communications and Technology, n.d.).</p>	<p>Perceived Competence – Based on these two data, the perceived competence refers on the belief among stakeholders in the effectiveness of systems and frameworks in IoT and ICT initiatives that is influenced by established guidelines, frameworks, standards, and strategic implementation plans, which ensure robust and trustworthy systems for security, reliability, and strategic goals.</p>
<p>In Vietnam, the Department of Information Security and global cybersecurity company Kaspersky held a seminar on September 12 in Hanoi wherein they discuss the importance of securing IoT devices with cyber immunity. This event is part of a long-term cooperation between the two sides since cybersecurity becomes complicated because of the proliferation of IoT devices in everyday life. The Director of Government Relations and Public Policy (GRPP) for Japan, Asia-Pacific, Turkey, Africa, and Middle East highlighted the era of the IoT, where billions of IoT devices are used daily (Ministry of Information and Communications, 2023).</p>	<p>According to the Department of Trade and Industry (DTI), they have signed a Memorandum of Understanding with the Amazon Web Services aiming to offers advanced digital services to every Filipino entrepreneur and innovator, aiming to improve workforce, encourage digital technology adoption, and collaborate with stakeholders for digital innovation (Department of Trade and Industry Philippines, 2023).</p>	<p>Perceived Relatedness – Based on these two data, the perceived relatedness refers to the extent to which individuals feel a sense of connection and involvement with others through shared goals, collaborative efforts, and mutual understanding within the context of cybersecurity and digital transformation initiatives.</p>

Source: Processed by Authors

Asian countries, especially Philippines, have their governments focus on digital transformation and cybersecurity. They're enhancing privacy by improving how they protect personal data (GovTech Singapore, 2019; National Privacy Commission, 2012) and boosting security through plans to defend against online threats (IMDA, 2023; Presidential Communications Office, 2024). They're making it easier for businesses to adopt technology with programs like Malaysia's National 4IR Policy and the Philippines'

support for small businesses (MIDA, 2021; Philippine News Agency, 2021). They're also helping people learn digital skills through initiatives like Malaysia's MyDIGITAL and the Philippines' SETUP program (My Digital, 2023; Jur PH, 2015). They are working together to make innovation for technologies (METI, 2019; DTI Philippines, 2023), and they are creating rules to ensure that new technologies such as IoT, are secure and effective (Japan Gov, 2020; METI, 2021; Department of Information and Communications Technology). Lastly, they are collaborating with global partners to tackle cybersecurity issues in IoT (MIAC, 2023). These efforts are shaping how technology develops and how safe it is for everyone to use across Asia, enhancing the successful implementation of IoT.

DISCUSSION

Adoption of IoT by SMEs from Philippines, Indonesia, and Malaysia shows different ways to improve supply chain management. It reveals that to have a successful IoT adoption in SMEs of SCM, there should be clear and strong government initiatives or policies that strengthen and make it accessible for SMEs to adopt IoT. It also indicates that integrating IoT with online store applications such as Shopee can boost digital interaction which can help these SMEs to broaden their market. Despite various challenges such as high costs and complex management, these countries show that formulating IoT strategies can significantly enhance efficiency, quality control, and cost savings in supply chain management.

In connection with this, technological advancements, collaborative innovation, and sustainable development play a vital role in motivating IoT adoption of the supply chain management, and at the same time address these challenges to have a safe and successful adoption of IoT. Findings reveal that innovation in IoT such as sensors and RFID improves product quality by monitoring supply chain processes. Conversely, technological advancement and sustainable development help cost reduction without loss in environmental sustainability. In addition, collaborative innovation such as international internships greatly boost the successful IoT adoption in supply chain management making SMEs globally competitive which can help them meet the demands in a digitally connected world.

However, implementing IoT in supply chain management faces challenges such as data threats, hackers, technology barriers, and trust issues. This paper's findings reveal that IoT adoption is also vulnerable when it comes to cyber threats as IoT is not just connected with other devices, but to the whole internet or cloud system making it prey for hackers. Hence, the trust issues of users for technology are heightened by knowing how these technologies can be a threat to their data. Therefore, highlighting a shared focus on improving data security and managing complex technology issues is essential to control these challenges.

To address these challenges, this paper recommends several policies that can also enhance IoT implementation in the Philippines. These policy recommendations are drawn from existing successful government initiatives and policies across Asia. First, the Philippines should broaden the spectrum of its cybersecurity framework knowing that there are now various types of technologies, establishing measures and guidelines to protect users from online threats, ensuring data integrity and privacy.

This paper also suggests our government to introduce a comprehensive program that will support small and medium enterprises (SMEs), providing them with financial incentives, technical assistance, and accessible processes for adopting IoT technologies, thereby facilitating digital transformation in businesses. To maximize and utilize the full potential of IoT. This paper also suggests a policy where every business owner, and even employees, have basic knowledge when it comes to IoT, requiring them to attend programs that will give them certification when it comes to digital literacy, giving them the eligibility for the safe and honest use of IoT, equipped to handle advances IoT systems. Furthermore, since the Philippines is not fully familiar with the IoT, as specific, knowing we have limited policies when it comes to IoT, it is a smart move that we collaborate with countries that are quite advanced when it comes to IoT, giving our country the

access to cutting-edge technologies and best practices, enhancing its IoT capabilities.

Lastly, in consideration of these suggested policies, the findings also suggest that the Philippines should develop a clear and comprehensive regulatory framework for IoT technologies wherein this framework will ensure the security, effectiveness, and ethical use of IoT, providing guidelines for deployment and maintenance that align with international standards. By adopting these policy recommendations, the country can enhance its IoT implementation, driving digital transformation and economic growth.

CONCLUSIONS

In conclusion, this paper provides significant information on IoT adoption in SMEs, especially in the SCM industry. This paper compares the Philippines with other Asian countries, highlighting the similarities and differences in implementing IoT to manage their supply chains. Based on the findings, this paper found that while the Philippines has made some advancements in IoT implementation, there is still room for improvement. Hence, this paper finds motivations that help in the successful implementation of IoT such as technological advancement, collaborative innovation, and sustainable development. However, in contrast to these motivator factors, there are also various challenges that IoT adoption inevitably faces such as data threats, hackers, technology barriers, and trust issues. Therefore, this paper also suggests policy recommendations to address these challenges and at the same time enhance the successful adaptation of IoT in the Philippines. These policy recommendations focus on helping to improve the literacy of Filipinos when it comes to IoT, assisting SMEs in SCM, and strengthening their cybersecurity framework to create a safe environment for adoption of IoT in Philippines.

RECOMMENDATIONS

In line with conclusion and findings, this study recommends policies for the Philippine government to boost its IoT use in SMEs of the SCM industry to help maintain a green image, leading to sustainable development. First and foremost, since we are discussing technologies, the government should improve its cybersecurity laws and data protection to build public trust in IoT. Then, implement various programs that offer incentives, technical assistance, and subsidies to aid SMEs in digital transformation, providing financial and technical support for SMEs in the Philippines since the country is not yet familiar and equipped when it comes to IoT as a general, improving business owners and IoT user's digital skills and literacy through training programs and partnerships with academic institutions to prepare for IoT adoption. To make these effective, the Philippine government should also consider collaborating internationally by creating global alliances with other Asian countries and take note of their successful IoT strategies to encourage innovation and widen implementation, especially in the topics of making IoT green friendly. With all these suggestions in consideration, the government should create clear regulations that will ensure IoT technologies are used safely, effectively, and ethically making it a safe space for SME owners in SCM to adopt and of course, for the environment. Therefore, the Philippine government can significantly improve the IoT implementation in the country which will lead to its digital transformation and economic growth.

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