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Technological factors influencing e-invoice: Qualitative insights from Malaysia's early implementation

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Abstract: This paper applies the Technology-Organization-Environment (TOE) framework to examine e-invoicing adoption during Malaysia's early implementation phase. Using a single case study involving large and small companies, along with accounting firms, tax freelancers, and consultants, the study identifies six key factors influencing adoption. It highlights three core technological drivers: system integration, middleware/Application Programming Interface (API) usage, and automation, aligning with TOE components and extending Rogers' Diffusion of Innovation (DOI) attributes. Challenges faced by adopters include system changes, validation delays, format incompatibility, and internet/server limitations. These issues particularly affect smaller enterprises with limited digital readiness. The findings underscore the need for targeted policy interventions and technical support to accommodate varying levels of digital maturity. Regulatory bodies and system providers are urged to simplify integration, offer affordable middleware solutions, and enhance user support. Addressing these technological hurdles is vital to improving compliance, inclusivity, and effectiveness within Malaysia's digital tax infrastructure. This study contributes uniquely by identifying and analyzing the technological drivers and challenges to e-invoicing adoption, emphasizing practical implications for policymakers, developers, and organizations. By integrating insights from the TOE and DOI frameworks, it offers a comprehensive understanding of the technological landscape shaping Malaysia's e-invoicing ecosystem.

Keywords: *Diffusion of innovations (DOI) Theory, Digital transformation in Malaysia, E-invoicing adoption, Middleware and system integration, Technology-organization-environment (TOE) framework.*

1. Introduction

1.1. Background

E-invoicing is a crucial digital transformation tool that enables automated processing, tax compliance, and operational efficiency. It has been adopted internationally for public administration such as by France, Italy, Germany, Spain, Portugal, Belgium, Netherlands, Luxembourg, Denmark, Norway, Sweden, United Kingdom, United States, Canada, Australia, New Zealand, United Arab Emirates (UAE), Saudi Arabia, China, India, Indonesia, Japan, Pakistan, Philippines, Singapore, South Korea, Taiwan, and Vietnam. Its implementation varies across organisations due to different models, targeted taxpayers, scope, timeline, formats, and standards. E-invoice scope has different types of transactions, which are Business-to-Business (B2B), Business-to-Consumer (B2C), and Business-to-Government (B2G). The implementation also has three different models: clearance, post-audit, and real-time models.

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It also involves different formatting processing of electronic invoices with Extensible Markup Language (XML), JavaScript Object Notation (JSON), and Pan-European Public Procurement Online - Business Interoperability Specifications (PEPPOL BIS).

In Malaysia, e-invoicing is currently in the early stages of implementation for B2B and B2G according to income threshold using XML and JSON format through MyInvois Portal or Application Programming Interface (API). In the first sector of implementation that began on 1 August 2024 are taxpayers with an annual turnover of revenue of more than RM100 million. The second sector was implemented on 1 January 2025 for taxpayers with annual turnover or revenue of more than RM25 million and up to RM100 million., The third sector will begin on 1 July 2025 for taxpayers with annual turnover or revenue of more than RM500,000 and up to RM25 million. The final implementation will be on 1 January 2026 for taxpayers with an annual turnover or revenue of up to RM500,000. This staggered adoption timeline means that businesses will have different preparation periods and adoption experiences, depending on their size, resources, and operational complexity. As Malaysia moves toward full e-invoice integration, businesses will need to navigate these challenges while leveraging the efficiency and compliance benefits of digital invoicing.

Although e-invoicing is not considered an innovation globally, Lian [1] suggested that e-invoice adoption continues to evolve as organisations assess both its benefits and challenges in Vietnam. Tiwari, et al. [2] suggested that many businesses adopt e-invoicing for its advantages, such as innovation characteristics, compatibility, complexity, relative advantage, and trialability, which are found to be significant in influencing the adoption of e-invoicing. In addition, others face challenges such as legal framework and government policies, IT infrastructure, and the market's psychology and habits [1].

Globally, Western countries and parts of Asia have implemented e-invoicing due to its recognised benefits, such as improved financial transparency and tax compliance. However, implementation differs between countries and organisations, influenced by regulatory frameworks, technological infrastructure, and phases. Comparative studies highlight both challenges and benefits that organisations encounter when transitioning any technology, particularly in terms of technological, organisational, and environmental factors, that impact adoption decisions, as suggested by early research such as Asender and Sapkota [3] in Finland, Harianto, et al. [4] in Indonesia, Hoblos, et al. [5] in Australia and Tiwari, et al. [2] in European Union. Research has identified several advantages, including enhanced transparency, where taxpayers are required to declare actual income and expenses, benefiting both businesses and individuals [6]. Additionally, e-invoicing has been acknowledged for its benefits, offering greater efficiency and regulatory compliance across different sectors of business and sizes. The primary goal of e-invoice is to ensure that data submitted to regulatory authorities is accurate, reliable, and sufficient to facilitate more precise tax audits. Unlike some countries that apply e-invoicing uniformly, Malaysia has introduced a phased implementation approach based on company revenue levels with varying financial capabilities and technological readiness.

1.2. Problem Statement

Despite its numerous benefits, e-invoicing adoption presents challenges related to system integration, data processing, and regulatory compliance from various countries, such as Vietnam [7] Romania [8] Indonesia [9] Croatia [10] Taiwan [6] Finland [3] and Egypt [11]. These technological factors affect businesses differently, depending on their size, industry, and readiness. While many studies highlight the advantages of e-invoicing, others emphasize the drivers and obstacles encountered during the preparation and adoption stages. The experience of adopting e-invoicing varies across companies, taxpayers, and countries, particularly from a technological standpoint, such as with different sizes of businesses.

For organisations, the adoption process requires system upgrades, appropriate tools, and adjustments in submission procedures to ensure a smooth transition. Technology-related challenges are not unique to e-invoicing; they are also common in the adoption of data analytics, cloud computing, XBRL, and robotic process automation (RPA) that have been done before, such as in Malaysia XBRL

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[12]. These challenges arise due to differences in technical requirements, which have been widely discussed in past research on technology adoption. Therefore, this study aims to identify the key technological factors influencing e-invoice adoption among different organisations in Malaysia. This research sought to provide insights into the technological drivers and challenges affecting the adoption process by examining businesses' experiences during the early stages of implementation.

1.3. Research Questions

1. What technological factors act as drivers or challenges for e-invoicing?
2. How do these factors impact large and small companies?

1.4. Research Objectives

1. To identify technological factors influencing e-invoice adoption.
2. To differentiate technological challenges between large and small companies.

2. Literature Review

2.1. TOE Framework and Technology Adoption

Existing research on technology adoption using the TOE (Technology-Organisation-Environment) framework presents mixed findings across different studies for technology adoption. The technological context in these studies commonly identifies key factors, such as relative advantage, compatibility, complexity, trialability, observability, stability, and standardisation [2, 13, 14]. Numerous studies have applied the TOE framework to understand the decision-making process for technology adoption. For instance, Tiwari, et al. [2] explored technological factors influencing e-government adoption, highlighting the role of both internal and external technologies.

The decision to implement technology was investigated by Depietro, et al. [15] in terms of the availability of technology and contemporary technology compatible with a company's current technology platform. The factors proposed by Rogers [16] including relative advantage, compatibility, complexity, trialability, and observability, are consistent with this context. These factors, which are elaborated upon below, can either facilitate or impede the adoption of electronic invoices. This ability indicates that the TOE framework is suitable for the analysis of organisational adoption and is considered a well-established framework for the identification of factors that influence e-invoice [8]. Similarly, this study focused on technological factors in e-invoice adoption with different business sizes and available systems and their impact on the adoption process. Furthermore, it examined the factors adopted within companies to determine how well they align with e-invoicing requirements. These technological factors may either serve as drivers or challenges to e-invoice adoption, depending on the organisation's size, industry, and user roles.

2.2. Benefits of E-Invoice

E-invoicing offers numerous benefits, including enhanced tax compliance, environmental sustainability, and savings in both time and financial resources. By using it, firms can promote sustainable business practices, enhance customer interactions, boost operational efficiency, and gain a competitive advantage. According to [4] e-invoicing in Indonesia enhances data accuracy and use, ensuring error-free tax filing. Furthermore, it optimises the procedure by conserving time and effort in reporting, submission, and billing. Fairchild [17] underscored the enhancement of financial operations through e-invoicing by optimising accounts payable and receivable processes. A 2009 Swedish study by Sandberg et al. indicated that 75% of enterprises reported a substantial reduction in costs due to e-invoicing. It also reduces paper handling, hence decreasing operational expenses and benefiting the environment. Research by Hesami, et al. [18] indicated that e-invoicing enhances tax efficiency by enabling tax return prefilling, boosting compliance, and ultimately reducing administrative costs. Similarly, Harianto, et al. [4] found that e-invoicing improves VAT collection in Indonesia, optimises tax revenue, and increases tax compliance among taxable entrepreneurs. E-invoicing provides firms

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with a competitive advantage by strengthening client interactions and loyalty [19]. Moreover, it allows organisations to enhance efficiency by reallocating personnel resources to alternative duties. Furthermore, a company's public image and public relations strategy are enhanced with the adoption of modern, environmentally sustainable technologies. Research indicates that e-invoicing diminishes financial reporting inaccuracies by 25% [19]. It also optimises transactions, hence enhancing operational efficiency.

2.3. Factors in E-Invoicing

Various factors, including organisational, technological, and environmental, influence the adoption of e-invoicing. Numerous studies have identified the key elements influencing firms' decisions to implement e-invoicing systems, ranking technological factors in the first place. Multiple studies highlight the role of technology in the adoption of e-invoicing. Tiwari, et al. [2] identified compatibility, complexity, relative benefit, and trialability as significant factors affecting adoption in India. Harianto, et al. [4] emphasised the importance of technological readiness, communication factors, and observability in ensuring a smooth transition to e-invoicing in Finland. Organisational factors rank second. The implementation of e-invoicing is significantly influenced by managerial endorsement and organisational readiness. Sandberg, et al. [19] asserted that external pressure, owner/manager characteristics, and organisational readiness significantly impact the adoption of e-invoicing in Sweden. Harianto, et al. [4] emphasised that managerial support is a crucial element for successful adoption. Behavioural and trust aspects rank third. The adoption process is influenced by perceived risks and faith in e-government. Lian [1] identified that in Taiwan, perceived risk, social influence, effort expectation, and trust in e-government greatly impact enterprises' readiness to use e-invoicing. In a similar vein, Qi and Che Azmi [10] underscored the importance of perceived benefits and trust in the adoption of e-invoicing.

In fourth place are external and regulatory pressures. The adoption of e-invoicing may be affected by external circumstances and governmental laws. Tiwari, et al. [2] examined the impact of regulatory pressure on company decision-making. Sandberg, et al. [19] emphasised the significance of external pressure in motivating enterprises to adopt electronic invoicing. In fifth place is behavioural control. Nguyen, et al. [7] found that a company's decision to implement e-invoicing in Vietnam is significantly affected by perceived behavioural control. This finding suggests that organisations are more inclined to implement e-invoicing successfully when they possess greater confidence in their capability. Several elements, including organisational readiness, trust, technological proficiency, regulatory obligations, and external influences, affect the implementation of e-invoicing. Businesses and legislators can formulate policies that facilitate the smooth adoption of e-invoicing systems across diverse industries by gaining a deeper comprehension of these factors.

2.4. Challenges in E-Invoice Technology Adoption

Even though e-invoicing has many advantages, businesses face many obstacles when implementing it. Numerous studies have outlined the main challenges that organisations encounter, which range from financial strains and regulatory complexity to technical problems. First, choosing appropriate e-invoicing solutions is a common challenge for small and medium-sized businesses (SMEs). In Australia, Hoblos, et al. [5] discovered that the adoption process is impacted by expenses, staffing limitations, and regulatory variances. The financial strain, poor technical assistance, and unreliable IT infrastructure were also cited by Soliman [11] in Egypt as significant obstacles, especially for companies with little funding. Issues with integration and technology come in second. When putting e-invoicing systems into place, many businesses run into integration issues. According to Soliman [11] inefficiencies are caused by technical errors in online systems and a lack of system integration with tax-related platforms. Interoperability is a major challenge, as noted by Harianto, et al. [4] in Finland, who also noted conversion issues between various e-invoicing operators. Third, challenges with adoption and user experience. Businesses' readiness to embrace e-invoicing technology is influenced by how easy it is to

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use. According to Qi and Che Azmi [10] businesses frequently deal with low usability, a challenging adoption phase, and a mismatch between e-invoicing and traditional invoicing methods.

Similarly, Soliman [11] noted that some users struggle with the system's lack of customisation to their work environment, feel powerless over it, and find it time-consuming. Fourth, issues with data protection and security. Data protection and security threats continue to be major obstacles to the adoption of e-invoicing. According to Soliman [11] companies are reluctant to embrace e-invoicing fully because they are concerned about security flaws and inadequate data protection measures. Fifth, a company's readiness and external factors determine whether or not it adopts e-invoicing. Sundström [20] highlighted that the decision to adopt is influenced by managerial attitudes, perceived benefits, and outside pressures. Adoption may be slowed down or met with resistance if a company lacks a supportive management style or is not technologically ready. Therefore, Financial expenses, integration problems, usability issues, security threats, and organisational preparedness are some of the obstacles to the adoption of e-invoicing. Businesses can make a more seamless transition to e-invoicing by addressing these challenges with better system compatibility, increased IT support, and clearer regulations.

3. Research Methodology

3.1. Research Design

This study applied an interpretive approach to understand the early stages of e-invoice adoption among stakeholders in Malaysia. It adopted the TOE framework to examine the technological, organisational, and environmental contexts influencing the adoption process. The study focused on the preparation and initial stages of adoption to identify key factors that impact readiness for e-invoice implementation. It gathered insights from accounting practitioners, business organisations, small businesses, taxation consultants, and freelance practitioners, all of whom provided perspectives on the adoption of e-invoicing.

This study explored the experiences and perspectives of small and large companies in Malaysia operating in different industries. Different types of companies must comply with varying regulations, which influence their approach to e-invoicing adoption. Additionally, company size affects their capability to implement e-invoicing solutions. By incorporating insights from various stakeholders, this study aimed to enhance understanding of how e-invoicing can be effectively integrated into different organisational contexts. The comparative analysis highlights technological factors that impact adoption experiences in large and small businesses.

When investigating the implementation of a technology, the interpretive approach may employ the case study method [21]. The objective of a case study, as emphasised by Ryan, et al. [22] is to explain the comprehensive nature of the observation of social systems and the behaviour of human actors. This objective suggests that explanatory case studies are relevant. Therefore, the present investigation can comprehend a real-world scenario and make the assumption that this comprehension is likely to encompass critical contextual factors associated with the adoption of e-invoices. As Benbasat, et al. [23] suggested, a case study approach is advantageous for this type of investigation during its initial and formative phases. Additionally, they underscored the importance of employing a case study to investigate a phenomenon in its natural environment and employing multiple data collection methods to collect information from a single or a limited number of entities. In the same manner as e-invoice research, the researchers investigated related phenomena in their natural environment and acquired a comprehensive comprehension of the details and nature of the adoption scenario.

3.2. Data Collection

This study conducted semi-structured interviews with representatives from various sectors, including accounting practitioners, taxation consultants, freelance practitioners, and professionals specialising in tax and financial reporting from large and small companies. The participants listed in Table 1 were selected based on their experience and expertise in invoice preparation, ensuring that their insights represent key stakeholder perspectives effectively.

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The interview instrument was developed using the Technological, Organisational, and Environmental (TOE) framework to explore factors influencing technology and innovation adoption. Examples of interview questions are *What is your understanding of e-invoicing, how does it work in the context of your business?, What preparations does your company make before using e-invoicing (e.g., training or system updates)?, What internal challenges, such as cost constraints or employee resistance, did you face during the transition to e-invoicing?, How does your business's existing technology system support the use of e-invoicing?, Is the pressure from government regulations a major factor for you to use e-invoice?, Do vendors or technology providers play a significant role in helping your company implement e-invoicing? What are the main challenges your company faces in complying with e-invoicing requirements in terms of regulations and taxes?* Data collection took place from November 2024 to February 2025. Each interview session lasted approximately one hour and was recorded with permission for accuracy. All interviews were conducted online.

The first interviewee was T, a representative of a large company in the energy industry, followed by J, a representative of a large healthcare company, and R and A, accounting practitioners representing small companies in the trading and plantation industries, respectively. Participant H is a freelance tax practitioner, while M is a tax consultant. Both participants represented small and large companies in the service industry.

Table 1.
Participants for Interview.

Interviewee	Interview Duration	Representative for Large Company	Representative for Small Company
T Large Company	45 minutes	X	
J Large Company	1.5 hours	X	
R Accounting Firm	1.5 hours		X
A Accounting Firm	2 hours		X
H Tax Freelance	45 minutes		X
M Tax Consultant	2 hours	X	X

3.3. Data Analysis

Data analysis was conducted using qualitative methods. First, the interview responses were transcribed verbatim to capture the adoption and preparation process for e-invoicing. The analysis followed the approach of Miles, et al. [24] which consisted of preparation and analysis of the data, beginning with coding, followed by description and identification of relevant themes aligned with the TOE and e-invoice concept as shown in Table 2. These themes were categorised into technological drivers and challenges, highlighting the factors that either facilitate or challenge e-invoice adoption. To ensure alignment with existing research, the analysis was guided by prior studies and structured within the TOE framework. This approach helped to identify key factors relevant to the adoption process.

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Table 2.
Sample for Thematic Analysis.

Theme	Sub-code
E-Invoice System Integration	Integration_Efficiency
	Adoption_Support_Regulators
	Cloud_Storage_Benefit
	Manual_vs_Auto_Entry
Middleware & API Integration	Use_of_Middleware
	API_Effectiveness
	Custom_Integration_Challenges
	Cost_of_API_Middleware
AI & Automation	Automation_Data_Entry
	AI_Record_Validation
	Efficiency_Gain_AI
	Knowledge_Gap_AI
System Changes & Validation Delays	System_Upgrade_Need
	Validation_Process_Delay
	Adjustment_Period_Impact
	Organisational_Adaptation
Format Compatibility	XML_JSON_Format_Limitations
	Format_to_System_Issues
	Multiple_Format_Handling
	Learning_Curve_Format
Internet & Server Limitations	Internet_Stability_Issues
	Server_Downtime_Effects
	Access_Delay_Risk
	Digital_Readiness_Gap

The identified factors were further analysed through a comparative lens, examining differences between large and small companies as shown in Figure 1. Insights were drawn from respondents representing both business sizes, providing a nuanced understanding of how company scale influences the adoption of e-invoicing. This comparison helps to highlight varying challenges and enablers within different organisational contexts.

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Table 3.
Sample of Data Analysis.

A Accounting Firm				**H Tax Freelance**		
Integration of Accounting System with e-Invoice	**Use of Middleware for Data Synchronization**	**Automation and Real-Time Processing**	**The Importance of APIs in System Integration**	**Limited Data Format (XML & JSON) as a Technology Requirement**	**Technological Capability Enhancement with SQL for Invoicing**	**Use of Cloud SQL for Integration with IRB Systems**
The main technological factor discussed was the need to ensure that the accounting system can be integrated with e-Invoices operated by IRB. Excerpt: "One, we have to make sure that the system we use can implement e-invoice." (19:56 - 24:04)"Right now, I'm still using the word counting. Okay. And we're still not obligated to do so, but we're already practicing using my invoice." (24:05 - 26:22)	Technology solutions such as middleware are used to connect the accounting system with the IRB e-Invoice system. For example, Sofos software serves as a link between QuickBooks and IRB. Quote: "Sofos is a Malaysian app that he made, but he can sync with QuickBooks." (24:05 - 26:22)" So he's in the middle of this, which means he's taking data from the accounting system for him to give to HDM." (24:05 - 26:22)	The e-Invoice process is now happening in real-time, which is changing the way businesses record and send invoices to the IRB. Quote: "Now when we make invoices, we also put them in the LHDM system. Because it's like real time." (18:26 - 19:56)"That's why it's like when you say that if you want to understand this invoice, you have to know the process first." (18:26 - 19:56)	The API enables the direct integration of third-party accounting systems with the e-Invoice system, ensuring smoother data processing. Quote: "Either we use my invoice, or we use API. This API means that it is an accounting system that we can integrate with e-invoices." (24:05 - 26:22)"So like I said earlier, QuickBooks is what XXX said is the system that he works with the accounting system." (24:05 - 26:22)	"Because Invoice has its own formats, especially the format that has been set, is XML with JSON only, which is AI. So, if we send a PDF, we don't get it." (07:55 08:10) Implications: Users need to adapt their systems to meet XML or JSON formats to ensure that data is received by the Invoice system.	"So, how to solve it, I upgraded SQL. What SQL offers is close to its users, close to its customers. So, they provide a function for invoicing." (08:11 - 08:25) Implications: Users upgrade their SQL systems to support e-invoicing functionality to improve invoice processing efficiency.	"But I use SQL, I use cloud SQL. I verified, he will auto enter near the Cloud " (08:40 - 08:50) Implications: Cloud SQL enables automatic synchronization between user systems and IRB systems, reducing the need for manual input and speeding up processing.

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4. Findings and Discussion

4.1. Technological Drivers of E-Invoice Adoption

4.1.1. E-Invoice System Integration

First, one of the key drivers identified in this study is the integration of the e-invoice system, which has been implemented by regulatory authorities to ease the adoption process, particularly for small businesses. The regulatory framework provides an automated system that filters and validates submitted data, ensuring accuracy, and minimizing errors in taxpayer submissions. This feature is particularly beneficial for small enterprises that may lack the resources for advanced data verification.

As a representative of a large company, T mentioned that "*Large companies already have well-functioning systems, therefore the implementation of e-invoicing does not have a significant impact on their operations. For large companies, the existence of organised documentation as well as a good system is very helpful in document storage and management. Large companies can easily adapt to the implementation of e-invoicing because they already have a robust document management system in place. The implementation of e-invoicing helps maintain records for a long time through cloud-based storage methods. The use of e-invoicing ensures that the recorded data is cleaner, organised, and easier to manage.*" Meanwhile J, representing another large company, believed that "*e-invoicing is more focused on the financial operations themselves as it involves the process of issuing invoices digitally. When we engage a system, the party directly involved is the digital department, which is our information technology (IT) division. The implementation of e-invoicing in our company requires changes to the existing system because our organisation is large-scale, with a high volume of transactions and large value. We are also financially able to improve our system to support the automatic withdrawal of invoice data into the system.*"

Comparatively, R, from accounting firm representing small businesses mentioned that "*What I thought at first was that I didn't need to do anything because the auto-account system for clients was already automatically generated. I remind you that when I receive an expense invoice, I just need to download it and it will be automatically included in the item. This means that the expenses will have their own code under the 'self-billing' method. However, in my auto-account system, I had to create the entry manually. In addition, all expenses incurred must be accompanied by an e-invoice that has been verified by the IRB to ensure that the expenses can be claimed and recognised.*" A, from another accounting firm stated that "*first, we need to ensure that the system used is able to support the implementation of e-invoicing. Currently, I am still using the basic accounting system. Although our organisation is not yet required to implement e-invoicing fully, we have started to practice its use through the MyInvoicing platform. Sometimes, there are systems that are not suitable for use. There are companies that have purchased a certain system, but the system is not really suitable for their type of business. Therefore, the implementation of e-invoicing is not just a financial initiative. It requires the involvement of all organisational entities, including sales network management and logistics departments, to work together comprehensively. Organisations need to ensure readiness in terms of systems, data, and human resources to enable comprehensive and effective compliance with e-invoicing requirements.*"

There is another view from a tax freelancer H and a tax consultant M. H mentioned, that "*with the e-invoicing function, the party concerned can monitor the revenue stream more easily and regularly. Through this system, the government can find out the amount of income recorded and make a comparison to see whether it is in line with the audited financial statements. Indirectly, invoice records entered into the system will be kept in an orderly manner, thus reducing the risk of fraud among merchants. Indirectly, all invoice records recorded in the system will be kept transparently. This allows taxpayers to see clearly where their spending is going.*" This opinion aligns with M, who is concerned that "*when it comes to the implementation of e-invoicing, it is not just a financial initiative, but also involves all aspects of business operations. Once the e-invoice data is entered into the system, the information can be adjusted as needed for reporting and analysis purposes. Organisations need to ensure readiness in terms of systems, data, and human resources to enable the comprehensive and effective implementation of e-invoicing. Improve commercial efficiency and promote more open information sharing in the business ecosystem.*"

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4.2. Middleware and API Integration

Second, for large companies, regulatory authorities have introduced middleware applications and API integrations to facilitate seamless connectivity between the e-invoice system and the existing Enterprise Resource Planning (ERP) systems. Many large organisations, such as those using SAP, can automate invoicing through ERP integration, thereby reducing manual effort and improving operational efficiency. This capability enables businesses to streamline their invoicing processes, ensuring compliance while minimising administrative workload.

The view sand experiences of small and big companies differ based on how they use either middleware or API. J stated "*One option is to use the MyInvois portal provided by the Inland Revenue Board (IRB). This portal is more suitable for companies with low transaction volume. To use SAP DRC, we first need to subscribe to the software license. In addition, the existing SAP system also needs to be upgraded and improved to allow effective integration with SAP DRC modules. However, the vendors or consultants appointed for the system upgrade process differ between the parent company and the subsidiary. For example, if the parent company uses Consultant A, the subsidiary may choose another consultant.*" They also see that "*other companies in the same group may use middleware because they have multiple accounting systems. Middleware is used to facilitate integration between these systems and e-invoicing systems. This system acts as a facilitator for companies or related parties to submit their sales reports to the Inland Revenue Board.*"

R believes that "*Even with ERP, companies still need to add intermediaries, as the process and requirements remain the same. The function of Auto Account is solely to transmit data. It does not carry out other processing; instead, it only serves as a channel for transmitting information to the relevant system. As a solution step, I upgraded the SQL system I was using. SQL has offered e-invoicing functionality to its users and customers. Currently, I am using an SQL system that provides the e-invoice function. If I have a regular customer, I no longer have to manually enter the information every time a transaction is made.*" Meanwhile, A highlighted that "*XXX is a local application developed in Malaysia, and it is capable of syncing with the QuickBook system. This middleware acts as an intermediary that takes data from the accounting system and channels it to the IRB. These companies have systems that are suitable for the retail sector, hence the use of middleware is the main choice for streamlining these systems.*"

The tax practitioner freelancer, H, and consultant, M, have their own views. H mentioned that "*I'm using the cloud version of SQL (cloud SQL). Once the information is verified, it will be automatically entered into IRB's cloud system. I have upgraded the SQL system to meet the requirements of e-invoicing. In one SQL system I use, there are 10 users, and all of them have been upgraded.*" While M believed that "*Middleware has the ability to send invoices directly to customers on your behalf. If your organisation uses an ERP system, you have the option to determine the appropriate middleware company for integration purposes. As mentioned, there are more than 50 middleware providers on the market at the moment. Organisations can choose a middleware provider from over 50 companies available to customise according to the needs of their respective systems.*" Therefore, this study found that the existence of middleware could ease the adoption of e-invoices in terms of cost utilisation. A also raised the issue "*Due to the need for the implementation of e-invoicing, companies have had to spend around hundreds of thousands of ringgits to ensure that their systems can be integrated with the e-invoicing system. Therefore, they choose to use a third-party software solution, i.e., middleware, which was mentioned earlier.*"

Besides the middleware, API integration is also one of the options for e-invoice implementation. This method provides the option to either a small or a large company, which impacts the integration of their existing system. J mentioned, "*For a small company, only need to do the initial setup in the MyInvois portal, and the system can then automatically pull the data from the UBS system. For a big company, the high cost of the API. The cost involved in upgrading the entire system can reach almost one million ringgits. Without adequate financial allocation, it can be difficult to implement integrations using APIs or middleware.*" This issue is also different from the subsidiaries, which may adopt different options. J highlighted that "*Additionally, this is because not all subsidiaries have enough budgets. The best solution is actually the use of a specific API, which can be customised according to the organisation's daily needs and procedures. However, not all subsidiaries have that luxury in terms of finances and resources.*" This view aligns with A who believed that the variety

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option might be easier for small companies. He stated "*Therefore, we need to use APIs as well as appropriate accounting systems, and plan investments in new technologies related to business operations. Whether using the MyInvois portal or API, an API refers to an accounting system that can be integrated directly with an e-invoicing system. As mentioned earlier, QuickBooks is a system that can work with accounting systems for the purpose of e-invoicing integration.*"

4.3. AI and Automation

Additionally, the use of Artificial Intelligence (AI) in tax monitoring and fraud detection serves as another important technological driver. AI-powered validation mechanisms help ensure compliance by detecting discrepancies and preventing fraudulent transactions. This automated oversight enhances the reliability and security of the e-invoice system, making it a valuable tool for businesses of all sizes.

Based on the respondents' view, e-invoice is believed to provide benefits from automation and detection. Besides that, the automation could minimise the manual process of issuing the e-invoice, which can be integrated with the monitoring of tax operations. J believed that "*The system will only read and review the required 55 data fields. If all the fields are complete and eligible, the system will automatically approve the e-invoice. It does not evaluate the type of goods or services sold. Only when all 55 data fields are filled in completely will the e-invoice be approved by the IRB system. No manual checks are done by individuals; All checks are done by the system automatically.*"

The representatives of small companies also raised concerns with the same issues regarding this factor. As A mentioned, "*Now, when an invoice is issued, it is entered into the IRB system immediately as the process takes place in real-time. Therefore, to understand e-invoicing, one first needs to understand the entire invoicing process itself. Because the e-invoicing process is in real-time, IRB can see transactions immediately. With this implementation, manual processes can be significantly reduced.*" H also believes that e-invoices can indirectly reduce the risk of fraud among traders, such as undeclared profits, which ultimately impact consumers. According to H. "*For example, if it involves an insurance company, when they enter an e-invoice, the amount paid will automatically appear in my personal record. So, there is no room to run away from tax liability. In my view, this system will ensure better compliance after this. Situations such as selling at different prices or creating hidden markups can be reduced as these systems help control the transparency of transactions. Authorities can monitor transactions as a whole, comparable to a full set of account statements*". M also mentioned manual work and reducing errors in his view "*The system will check for file formats, including errors such as unauthorised use of characters. The data collected through this system has great potential to significantly reduce the need for manual work.*"

4.4. Technological Challenges of E-Invoice Adoption

Despite the advantages of e-invoicing, several challenges hinder its adoption. One major challenge is the system changes and validation process, which requires users to wait for their submitted invoices to be verified. Respondents highlighted that this delay could slow down business operations, especially for companies that require immediate invoice processing for cash flow management.

4.4.1. System Changes and Validation Delays

This factor is related to changes in system integration and the period used for validation. E-invoices may be considered new to most companies in Malaysia. It will also impact the restructuring of the companies before the e-invoice is implemented. According to T, for large companies, "*changes in work processes require adjustments in terms of organisational structure as well as increased understanding among staff. Changes in processes also involve challenges in terms of system configuration, which can affect the mapping and processing of data in the system. To implement changes such as system integration, organisations need to structure and restructure processes more carefully.*" J believed that "*any upgrade or improvement work needs to go through an appointed consultant. However, since the system is still new, some consultants may be less experienced in its implementation. Gap assessment includes an examination of the company's current financial systems and*

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DOI: 10.55214/2576-8484.v9i7.9094

procedures to identify gaps in technical requirements and e-invoicing guidelines. This assessment also involves reviewing the current system to ensure that it is in line with the requirements of the e-invoicing system."

The representatives of small companies also raised the issue of the existence of a system that might not exist in the long term. This issue was raised by A, "*there are cases where, after a few years, the system is purchased. When it comes time to be reviewed, the system no longer exists or can no longer be used.*" H also mentioned, "*there are aspects of the system that are not user-friendly and need to be improved to ensure its suitability and ease of use. After the details are entered into the system, the user is given a period of three working days (72 hours) for customer verification. If not confirmed within that period, the e-invoice will be rejected, and the transaction will be considered non-existent.*" He also raised concerns about how the system needs to comply with the current law and the company needs to engage with the consultant to ensure the quality of services. He is supported by M, who mentioned that, "*most aspects of e-invoicing are closely related to the tax laws that companies need to comply with. It is important to appoint a consultant who is truly qualified and experienced in the implementation of the e-invoicing system in order to fit with the existing system. Whenever there is an update from the ERP system provider, the company has to bear the additional costs associated with the software update.*"

4.4.2. The Need for Format Compatibility

Another significant challenge is format compatibility, particularly for small and medium-sized enterprises (SMEs). Many SMEs face difficulties integrating their existing systems with the mandated e-invoice formats, such as XML and JSON. Upgrading their systems to support these formats often requires additional investment, which can be costly and technically challenging for businesses with limited resources.

Based on his experience, J mentioned that the format and the data cannot be directly keyed into the company's system if the company does not have system integration. He also stated, "*E-invoices are actually not like traditional invoices that we usually print or store in PDF form. It is digital transaction data in a specific format that is understood by the system and can be translated back into a more human-readable display form if necessary. The e-invoice must be provided in a specific digital format, i.e., XML or JSON, according to the technical stipulations specified by the authorities. Don't get me wrong — an e-invoice is not just a soft copy of a regular invoice but refers to a digital transaction that is recorded and transmitted in the form of data that can be read by the system. E-invoices are provided in a technical format (system language) that cannot be directly read by humans; instead, they are only understood and processed by computer systems. When we download the e-invoice data, it will not automatically enter the system. On the other hand, the data has to be re-entered (key in) manually if there is no system integration. As a payer (not a supplier), we need to complete the required details such as supplier ID, registration number, as well as tax details before the e-invoice can be sent.*"

The small company representative A mentioned, "*We need to come across as professional advisors to clients since there is involved technical format, identify what they don't understand, and offer support through training and implementation guidance.*" Additionally, tax freelancer H believed that clients need to understand better the format of e-invoice and not only PDF. He said "*Systems such as E-invoice only accept files in XML or JSON format as specified. If sent in another format, such as PDF, it will not be accepted by the system.*"

4.5. Internet and Server Limitations

Additionally, internet connectivity issues present a challenge, particularly for businesses. Slow or unstable internet connections can cause inefficiencies in the invoicing process, as taxpayers may experience delays when submitting data for validation. The participants expressed concerns that these infrastructure limitations could further complicate the adoption of e-invoicing, leading to operational disruptions and compliance challenges.

This limitation is raised by T, who highlighted "*The main problem lies in the system itself, where technical glitches can cause glitches in operations. If the system is in a stable state, most technical issues can be*

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avoided. System efficiency is a key factor that affects the smooth running of operations, especially for large-scale companies." The representatives for small companies also emphasised that internet access needs to be stable when generating e-invoices and storing data via a server. R also mentioned that "*Not all users have stable internet access. Therefore, e-invoices cannot be generated without an adequate internet connection. Once the e-invoice is generated, it needs to be sent immediately to the customer and also reported to the Inland Revenue Board (IRB), usually before or on the 7th of the month. The information sent by the supplier to our company's tax number will be stored in IRB's cloud system for 365 days. Only documents for the last 31 days can be displayed, and the selection of date ranges is limited to a maximum of 10 days at a time.*" The issue of internet, data storage, and technical systems related to the government system was also raised by A, "*The IRB system sometimes experiences technical problems that are difficult to predict. For example, during the e-filing process, there is a delay due to server problems. This is more complicated in e-invoicing systems as it involves coordination with APIs, accounting systems, middleware, and even third parties. Systems operated by government agencies sometimes experience slowdowns or 'hangovers' at certain times with high traffic.*" H added that "*Other problems may stem from poor internet connections or unstable system servers. For example, if the MyTax site is open for too long, the system will display a notification to continue the session and sometimes cause usage interruptions. The IRB portal has a specific time limit for each session. If it is inactive for too long, you still want to continue, a notification will appear, and sometimes the system will automatically exit, causing interruptions.*"
Figure 2 below summarises the technological drivers and challenges of e-invoice adoption.

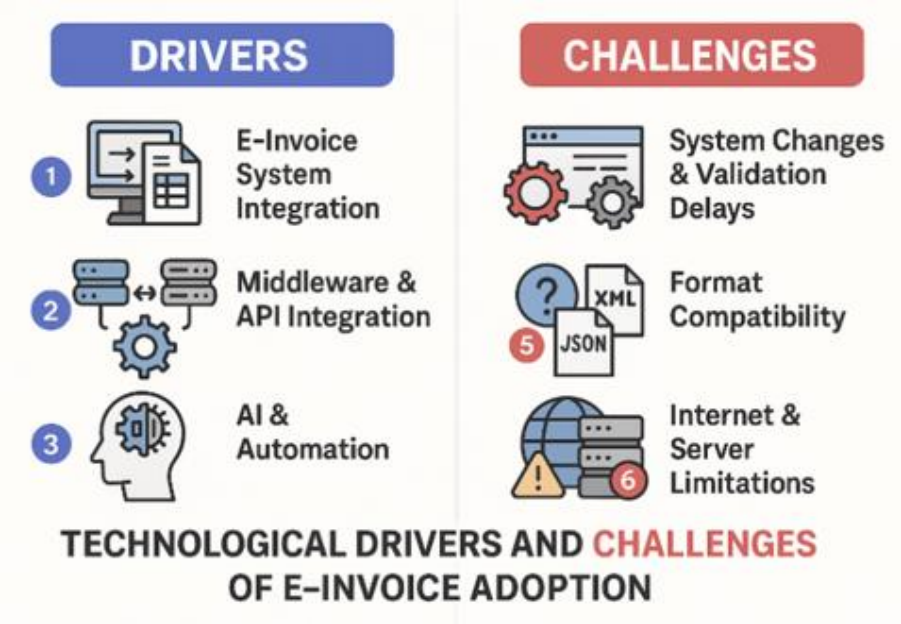

Figure 1.
Technological Factors that Influence the Adoption Process Framework.

4.6. Comparison of Large and Small Companies

The perception of e-invoice adoption varies depending on the type of company. The participants from the large companies believe that the ability to adopt e-invoicing largely depends on the integration of ERP systems, middleware, and APIs, as shown in Figures 1 and 2. Since these companies can afford advanced ERP solutions, such as SAP, they can seamlessly integrate invoicing systems with their existing infrastructure. Additionally, large organisations have dedicated IT teams that can resolve technical issues related to system compatibility, middleware integration, and API adoption. As a result, validation delays are not a major concern for them, as their well-integrated systems ensure fast and efficient invoice processing.

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In contrast, the interviewees representing small companies, including accounting practitioners, tax consultants, and freelancers, emphasised the challenges faced by SMEs in e-invoice adoption, as shown in Figure 2 and Table 4. One of their primary concerns is system integration, as many of their clients rely on manual data entry instead of automated API-based invoicing. The high cost of API integration makes it unaffordable for small businesses, forcing them to depend on government-provided invoice portals.

Another challenge for small businesses is the lack of technical support. Unlike large companies with dedicated IT teams, small businesses often have limited resources, making it difficult for them to troubleshoot system issues or upgrade their software. Additionally, validation delays become a significant concern for SMEs relying on invoice portals, as these delays can impact their financial operations. As a result, small businesses must carefully manage their tax submissions to avoid potential compliance issues in the future.

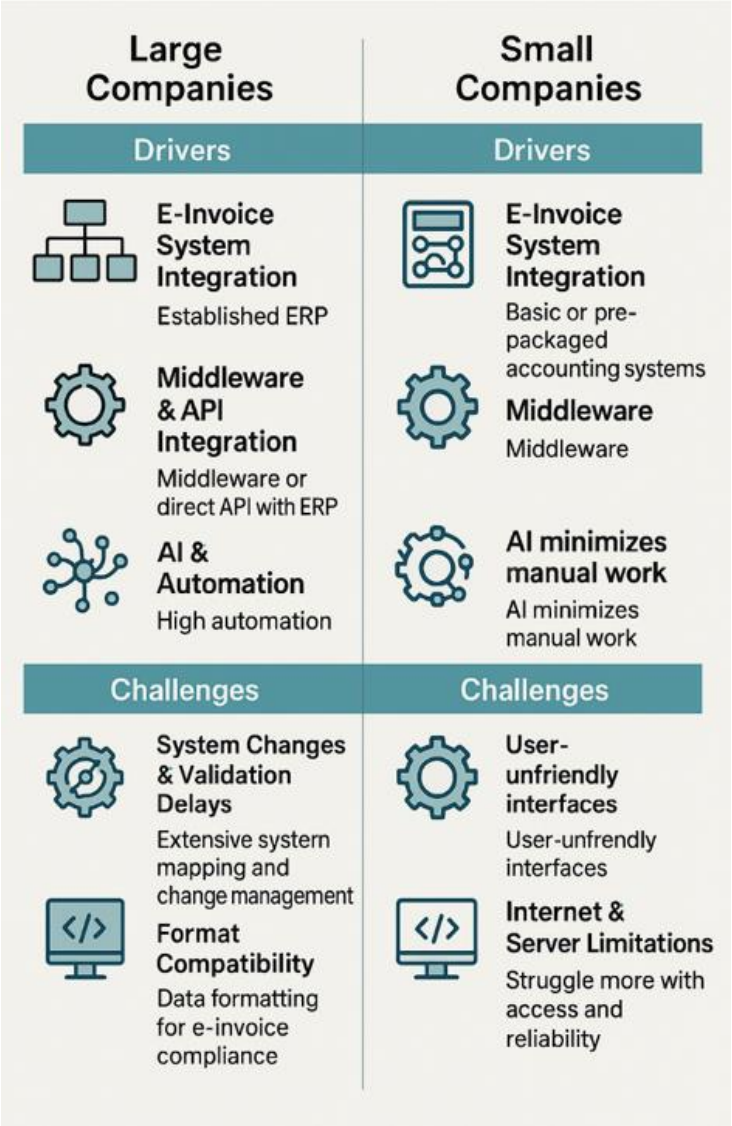

Figure 2.
Technological Factors that Influence the Adoption Process Framework for Large and Small Companies.

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Table 4.
Technological Factors that Influence the Adoption Process Framework for Large and Small Companies.

	Large Companies	**Small Companies**
E-Invoice System Integration	Established ERP	Basic or pre-packaged accounting systems
Middleware & API Integration	Middleware or direct API with ERP	Middleware
AI & Automation	High automation	AI minimises manual work
System Changes & Validation Delays	Extensive system mapping and change management	User-unfriendly interfaces
Format Compatibility	Data formatting for e-invoice compliance	Middleware that handles data transformation
Internet & Server Limitations	Emphasise system stability	Struggle more with access and reliability

4.7. Discussion

This study shows how technological factors of companies affect the possible successful acceptance of e-invoicing. It found that the three important factors considered driving factors for adoption are E-invoice system integration, middleware and API Integration, and AI and automation. System changes and validation delays, format compatibility, and internet and server limitations are the challenges that adopters experience.

One of the central technological drivers of e-invoicing adoption is system compatibility and integration capability. Tiwari, et al. [2] identified compatibility as a critical innovation characteristic, influencing how easily e-invoicing solutions fit into existing business processes and supply chain systems. Hoblos, et al. [5] further argued that developing a marketplace using APIs enhances integration with financial services like accounting, logistics, and procurement. However, they noted that SMEs often face integration difficulties due to digital transformation complexities and misaligned systems. Similarly, Asender and Sapkota [3] found that inconsistent software platforms and incomplete invoice data (e.g., missing information or format issues) act as challenges. The current study aligns closely with these findings, highlighting system integration, middleware, and API connectivity as key enablers. However, it also reveals more granular challenges, such as system changes required for validation, limited format compatibility (XML/JSON only), and difficulty aligning with suppliers' platforms—especially when suppliers have not yet adopted e-invoicing. These issues reinforce the importance of not just having integration potential but also ensuring standardisation and readiness across the ecosystem.

Ease of use remains a critical determinant in technology adoption. Tiwari, et al. [2] reported that perceived complexity deters users, especially those unfamiliar with digital tools. Hoblos, et al. [5] and Ali [25] noted that SMEs and small vendors struggle with technical knowledge, increasing the perceived difficulty in navigating invoicing systems. The current study confirms these concerns, as the interviewees consistently report validation delays, system errors, and confusion around format requirements, which complicate system usability. These findings suggest that although technological solutions are available, the learning curve and lack of intuitive user interfaces continue to hinder smooth adoption, particularly among non-technical users.

Numerous studies highlight the perceived benefits of e-invoicing as strong adoption motivators. Asender and Sapkota [3] highlighted user perceptions, such as ease of payment tracking, reduced paper clutter, and environmental friendliness. Ali [25] and Harianto, et al. [4] pointed to benefits like faster processing, storage efficiency, transparency, and better tax compliance. Findings from the current study are consistent, especially regarding automation and efficiency gains through AI integration. Organisations see potential in automation to reduce manual entry and improve data accuracy. However, these advantages are often overshadowed by technical interruptions, such as server downtime or error-prone applications, emphasising the need for reliability to match the theoretical benefits.

Tiwari, et al. [2] argued that trialability, which is the ability to test, is essential for the gradual implementation of new systems that facilitate adoption. Sundström [20] added that organisational

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readiness, including leadership support and adequate digital infrastructure, plays a crucial role. However, SMEs often lack this readiness due to limited resources and support structures [5]. The current study reinforces this, particularly noting that smaller organisations in Malaysia express concerns about the cost of system upgrades, inadequate IT support, and a lack of preparatory training. These challenges hinder trial-based adoption and suggest that policy support or public-private collaboration may be necessary to ensure equitable implementation across organisation sizes.

Finally, external technological factors like internet connectivity, server reliability, and data format restrictions significantly impact e-invoicing adoption. Harianto, et al. [4] reported that internet disruptions and application crashes erode trust and delay transactions. The current study presents similar constraints, where server errors, internet limitations, and rigid format requirements (e.g., XML/JSON) are frequent issues. These findings underscore that the success of e-invoicing is not only dependent on organisational willingness but also on national digital infrastructure and vendor ecosystem readiness.

Additionally, this current study has also shown that large businesses have a chance to simplify invoicing procedures, ensure regulatory compliance, and improve data accuracy using integration with ERP systems that involve using APIs and middleware. Large companies also gain from their financial capability to fund system development and hire skilled professional consultants for implementation. Small and medium-sized businesses (SMEs), on the other hand, frequently encounter challenges because of low technology readiness and financial restrictions, especially in hiring expertise and software. Many depend on simple accounting tools that lack e-invoicing capability. Hence, middleware or system modification is necessary and requires extra expenses to ensure compatibility. Although government websites like MyInvois Portal provide streamlined responses, problems with real-time validation, system outages, and user-friendliness might compromise the effectiveness of E-invoicing.

The application of artificial intelligence and automation is one essential factor that is incorporated with the e-invoice to ensure the quality of data. Transparency and compliance are enhanced via automated validations, fraud detection, and real-time data synchronisation transforming data. Still, these advantages depend on system compatibility and correct data structure, which may depend on the type of middleware or system that they are capable of using, which still causes major issues for SMEs. Furthermore, this research shows that while the size and extent of their operations cause complicated integration problems for big businesses, SMEs struggle with fundamental challenges, including system incompatibility, lack of support, and file format constraints (e.g., XML and JSON). Although standardising calls for these formats, businesses without the required digital infrastructure or knowledge experience may struggle with them.

This current study contributed three core technological factors, which are system integration, middleware/API usage, and automation, as vital elements influencing adoption for the component in TOE and extends key innovation attributes from Rogers' DOI theory. The findings also show that digital infrastructure (e.g., internet reliability and format standardisation) serves as an environmental condition that interacts with internal technology capabilities.

5. Conclusion

System integration capabilities, middleware/API solutions, and AI-based automation are among the various technological elements driving e-invoicing adoption in Malaysia. Still, the degree to which companies may use these enablers will depend much on their resources and scale. Because of strong IT infrastructure and financial flexibility, large businesses are typically well-positioned to embrace e-invoicing; SMEs experience structural and financial difficulties that impede smooth adoption.

This study emphasises the need for varied policy strategies and technical support to fit different degrees of digital maturity. Particularly for smaller companies, regulatory bodies and system suppliers must try to simplify integration processes, give reasonably priced middleware choices, and improve user assistance. Addressing these technology issues will not only help achieve compliance but also help Malaysia's digital tax ecosystem to be more open, effective, and inclusive.

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This study was carried out with limitations. First, it primarily focused on technological drivers and challenges without addressing in-depth organisational and environmental factors that are part of the TOE framework. Future studies could explore how management support, regulatory pressure, and industry competition interact with technological drivers to influence adoption outcomes. Second, the study did not examine the progression of adoption of e-invoicing from voluntary to mandatory phase, particularly after the full implementation phase. Future research could gain more data from the pre- and post-implementation journey of both large companies and SMEs to observe changes in system efficiency, user experience, and compliance behaviour over time that may also involve various taxpayers and suppliers.

Institutional Review Board Statement:

This study followed ethical standards with human participants. All respondents were informed about the research's purpose, participated voluntarily, and provided informed consent. Confidentiality and anonymity were maintained throughout.

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Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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