

Resource-based view of factors affecting supplier performance in supply chain management within the electronics industry in Penang

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Abstract

This research aims to explore the impact of resource-oriented factors on supplier performance within the electronics sector in Penang. These resources were identified after an exhaustive evaluation of the relevant literature regarding supply chain management and supplier performance in the electronics industry. To confirm the model's validity, a rigorously structured survey was carried out using a purposive sampling framework, amassing empirical data from 385 employees in the electronics field. The methodology of multiple regression analysis was applied to examine the importance and intensity of the associations between the identified resources and performance criteria, including technology capabilities, data quality and availability, organizational factors, as well as risk management practices. The findings from this study offer important implications for management within the electronics industry, assisting them in making strategic investments in resource capabilities that enhance supplier performance. The primary contribution of this research lies in its investigation of resource-oriented factors in supplier management, filling a knowledge gap in the swiftly changing electronics sector, and boosting competitive advantage through improved supplier performance.

Keywords: AI capabilities, Data quality, Electronics sector, Organizational support, Resource-based view, Supplier performance.

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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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1. Introduction

Supply chain management (SCM) encompasses the coordination of activities that are vital for the production and delivery of goods and services. Within the realm of SCM, the performance of suppliers plays a pivotal role, as it has a direct effect on the overall efficiency and responsiveness of the supply chain. In the electronics sector, characterized by swift technological progress and elevated consumer expectations, it is imperative for suppliers to provide high-quality components punctually in order to remain competitive. For example, the global consumer electronics market is anticipated to expand from USD 815.16 billion in 2024 to USD 1,467.94 billion by 2032, indicating a growing demand and the necessity for streamlined supply chains [1].



Figure 1.

Over the past few years, the electronics industry supply chain has experienced many problems. Notwithstanding, the disruptions have become more noticeable after the COVID-19 pandemic. Hence, suppliers' performance in supply chain management (SCM) is crucial as it has a direct impact on all operations, cost control, and service delivery to customers. The latest statistics indicate that due to the industry's reliance on convoluted supply chains, it is vulnerable to disruptions resulting from natural calamities, geopolitical tensions, and scarcity of resources. Such difficulties intensified in 2023, attributed to lingering semiconductor issues and geopolitical unrest in critical sourcing regions [2].

According to recent research, since electronics companies depend on consistent supply chains to sustain a competitive advantage, suppliers are experiencing tremendous pressure regarding standardized requirements for quality, reliability, and flexibility. However, there are challenges like lead time fluctuations, quality issues, and supplier sensitivity to global forces that still threaten effective supplier performance improvement. Recent studies underscore the importance of resilience, calling upon electronics manufacturers to prioritize supplier adaptability and comprehensive performance monitoring, especially as forecasts predict ongoing supply chain challenges extending into 2024 [1].

The electronics sector necessitates exceptional precision and quality due to the intricate nature of its products, where a single flaw can lead to system failures, product recalls, and damage to brand reputation. Almost 50% of recalls within this industry are related to quality issues [3]. High-performing suppliers are vital for upholding stringent quality standards. A notable instance is the 2016 recall of Samsung's Galaxy Note 7, which was attributed to a battery malfunction that caused overheating and ignition. This recall impacted 2.5 million devices and incurred an estimated loss of \$5.3 billion for Samsung [4], disrupting the entire supply chain. Such quality concerns can be expensive and are exacerbated by rapid production cycles and pressures for innovation. Consequently, suppliers must invest in cutting-edge quality control technologies and a skilled workforce to alleviate these risks.

Lead time variability presents substantial obstacles within the electronics sector, attributable to abbreviated product life cycles and variable consumer demand. Inconsistent lead times disrupt production timelines, escalate inventory expenditures, and culminate in lost market opportunities, as evidenced by the extensive delays experienced during the COVID-19 pandemic, exemplified by Sony's failure to satisfy PlayStation 5 demand owing to semiconductor shortages [5]. More than 60% of electronics firms indicate challenges in achieving stable lead times, particularly during periods of heightened demand [6].

Wider supply chain issues within the electronics domain, encompassing operational disruptions, escalating costs, variability in quality, and fragile supplier relations, further exacerbate supplier performance [7]. Suppliers encounter increased expenses, diminished profit margins, and challenges in sustaining quality amidst shortages of raw materials and

Asia Pacific Consumer Electronics Market Size, 2019 2032 (USD Billion). Source: Fortune Business Insights [1].

geopolitical strife [8]. These complications result in delays, reduced reliability, and reputational hazards for electronics brands [1].

In response to these challenges, suppliers are allocating resources towards resilience and digital transformation strategies. Nonetheless, such initiatives necessitate considerable capital investment, potentially exacerbating disparities between larger, technology-enabled suppliers and their smaller counterparts [9]. As described in the literature, these challenges raise the need to enhance strategic resilience and the deliberate pursuit of innovation as critical in defending and cementing supply chain strength and competitive advantage. The shifting focus towards the digital agenda, sustainable approaches, and supply chain agility is well aligned with the RBV theory since such programs require unique resources, which can set apart superior-performing suppliers.

Despite the significance of the RBV theorem and the types of assets affiliated with electronics supply chain management's supplier domain, the body of empirical research concerning the relevant assets is still quite limited. Therefore, the objective of this study is to fill this gap by identifying and defining essential resources and capabilities that are crucial for improving supplier performance, reliability, and competitiveness within the electronics industry.

To assess and evaluate the impact of digital transformation with an emphasis on technology enablers in terms of quality, delivery reliability, and supplier risk management capabilities.

RO1: To examine the effect of technological capabilities on the performance of suppliers in the electronics industry in Penang.

RO2: To examine the impact of data quality and availability on supplier performance in the electronics industry in Penang.

RO3: To examine the influence of organizational factors on supplier performance in the electronics industry in Penang.

RO4: To examine the influence of risk assessment on supplier performance in the electronics industry in Penang.

2. Literature Review

2.1. Global Perspectives on Supplier Performance

Global supply chains are horizontal, vertical, and spatial, each of which impacts supplier performance in different ways. The effectiveness of both collaboration and network orchestration remains critical for MNEs intending to leverage such complex relationships to enhance the performance of international business [10]. In the Asian markets particularly, suppliers and sound buyer-supplier ties are critical success factors for improving supplier performance. These often follow cultural norms that differ from the Western model, making it important to have regional evaluation standards [11]. In the Turkish automotive industry, best practices for the sustenance of global supply chain ties with partners are underlined for fostering long-term business partnerships that are based on trust, quality, and the reliability of delivery. Constantly, price remains the most significant criterion in the selection of suppliers, indicating a divergence between global and local buying firms [12]. This paper, therefore, acknowledges cross-cultural communication as a determinant of trust and clarity, which shape negotiation and decision-making systems. Diplomacy tactics illustrate dependency; however, cultural values of cooperation and control are expressed through the collectivism-individualism opposition [13].

Sustainability considerations are gradually becoming critical factors in measuring the performance of suppliers; the 91 elements within a broad framework developed to assess environmental and social sustainability increase the level of accountability and openness. Thus, systematically, the place of sustainability in the supplier selection criteria remains trivial and is dominated by concerns over functionality and costs, which evidences that the understanding of sustainability's increasing importance is failing to translate into its practical use and integration into the supplier selection process [14]. Approaches for the various sustainable supplier selections, including the fuzzy AHP and VIKOR, help in ranking the criteria, which include economic, social, environmental, and global risks. This research approach can be highly useful for organizations with complex supply chains featuring multiple layers operating across various jurisdictions, making it possible to measure all sustainability risks with utmost precision [15]. With regard to the environment spurred by Industry 4.0 in Asian countries, particularly Thailand, manufacturing strategies consider quality and flexibility as key supplier performance indicators. Interestingly, cost and delivery metrics do not affect performance outcomes, suggesting different regional imprinting in supplier management [14].

Greater supplier performance improvement through enhanced supplier performance with different sourcing strategies includes strategic sourcing and global sourcing strategies for green supply chains, new product development, and multi-sourcing contexts. Yensu et al. [16] investigated the effect of strategic sourcing on the performance of the firm, as well as a strategic relationship with suppliers and a strategic plan for improving productivity. Sourcing from international suppliers may enable firms to tap into innovation and high-quality outputs during collaboration, which is especially beneficial for managing complex tasks in the context of NPD. Moreover, multi-sourcing promotes the creation of a comprehensive and strategic information-exchange mechanism, as well as competition to manage risks and pressure suppliers to maintain proper contractual terms [17]. Together, these sourcing strategies align supplier behaviors with organizational goals and encourage sustainable, innovative, and resilient supply chains.

2.2. Relationship Amongst Key Variables

The key variables listed under consideration for the assessment to understand the influence on supplier performance within supply chain management in the electronic industry in Penang. The dependent variable refers to the outcome of supplier performance; the independent variables are the specific factors that may influence this outcome. They are technology capabilities, data quality and availability, organizational factors, and risk management practices.

2.3. Review of Relevant Conceptual Framework

In the framework of the Resource-Based View (RBV), proficient risk management methodologies, encompassing risk evaluation, formulation of alternative strategies, and continuous monitoring and feedback, constitute a distinctive organizational asset that can profoundly impact supplier performance within supply chain management, particularly in the electronics sector. As a unique capability, risk management transcends mere operational protection; it furnishes a strategic advantage that bolsters supplier dependability, continuity, and adaptability in a fiercely competitive and rapidly changing market.

2.3.1 Technologies' capabilities have a significant influence on supplier performance

The resource-driven framework (RDF) highlights the role of clearly defined specialized business resources and skills, especially in technology, to attain advantages. Technological capabilities are argued to serve a dual role in providing critical enablers for improving supplier performance within the electronics sector by promoting improvements in operating efficacy and, thereby, reducing costs and ensuring flexibility in a context of volatile and changing market dynamics. Recent literature offers strong empirical evidence of the impact of technological competence on supply chain performance. For instance, using real-time data transfer and other smart tools, it has been found that enabling capacitive IT has a positive association with supply chain agility, coordination, and performance. These technological innovations result in better collaboration and decision-making, leading to better operational output [18]. Furthermore, it is revealed that the deployment of digital technologies fosters supply chain adaptability and supply responsiveness, enabling the suppliers to respond adequately to disruptions that may occur unpredictably and synchronize well with consumers. Although the concept is well-developed in the manufacturing sector, similar evidence across a sample of industries and time points to the notion that digital innovation in supply chain management enhances supplier capacity and drives future sustainable operational performance [19]. As the electronics industry exemplifies complexity and short innovation cycles, technological capabilities are not only tools for process improvement but also enable the alignment of supplier-buyer relationships. This alignment contributes to better control of quality, timely delivery, and more cost-effective suppliers, overall leading to improved supplier performance [18]. Therefore, this study proposes the following hypothesis.

H₁: Technology Capabilities Have a Positive and Significant Influence on Supplier Performance.

2.3.2. Data Quality and Availability Have a Significant Influence on Supplier Performance

According to Amir [20], data quality and availability are therefore the core determinants of carrying out efficient decision making and operations within supply chain management. In the electronics sector, generally characterized by complex relationships and rapid technological change, the suppliers depend on accurate, up-to-date and easily accessible data matching production demands, reducing lead times and improving resource utilization.

Recent literature has indicated how data quality as well as accessibility, has a significant impact on the performance of suppliers. For example, information sharing and high-quality data management increase the flexibility of supply chain, quality management of the supplier, and overall business operational performance by means of knowledge coordination and creation of new services [21]. Similarly, the availability of good quality data also enhances good integration of supply chain processes with less gaps that lead to more responsiveness and reliability in the operation of supplier firms [21]. Furthermore, the effectiveness of data availability enhances cooperation between suppliers and buyers, which leads to openness in the performance of supply chain processes. Research evidences show that optimal information sharing significantly increases supply chain visibility, strengthens relationships, and increases performance [22]. From the above tentatively we can say, that high quality and rather easily accessible data is one of the key sources that allows suppliers to deliver outstanding results in the sphere of supply chain management, while lack of proper data and continual interruptions in suppliers' ability to get it can increase the risks associated with inaccurate forecasts or misaligned strategies in inventory management [23]. Information quality and availability yielded a positive and significant relationship with suppliers performing effective decision-making and optimizing operational efficiency within the realm of supply chain management. Within the electronics sector, which is marked by intricate dynamics and swift technological advancements, suppliers rely on precise, timely, and readily available data to ensure alignment with production requirements, minimize lead times, and enhance resource optimization.

Therefore, this study proposes the following hypothesis:

H₂: Data Quality and Availability have a Positive and Significant Influence on Supplier Performance.

2.3.3. Organization Factors Have a Significant Influence on Supplier Performance

The organizational factors involve leadership, culture, resource support and managerial encouragement for technology acceptance significantly influence supplier performance across the domain of supply chain management [24]. These determinants support strategic positioning, help with communication, increase adaptability, and help in the absorption of advanced technologies, making suppliers more efficient and more responsive [25]. Another example of ensuring good supply chain performance is the utilization of some methods like strategic supply partnership and information sharing, which is significant for organizational and suppliers' improvement and which proves the necessity of collaboration and the existence of structured communication processes [26]. Furthermore, there is clear support from the key managers in the adoption of technology acts as a key driver for enhancing supplier performance through the provision of advanced tools for monitoring and evaluation. This endorsement makes sure that there is a strategic alignment with the welfare of the organization when implementing new technologies, enhancing supply chain cooperation [27].

A well-developed organizational culture fosters collaboration, supports relationship learning, and improves supplier performance in extended supply chain environments, particularly in high-technology supply systems [28]. Specifically, the eye is on organizational strategies with collaborative activities containing suppliers in the electronics sector, where supplier responsiveness and operational suppleness are critical for competitiveness in unpredictable markets [29]. In addition, practical management support and organizational promotion, especially of technological development, additionally enhance the supplier's performance and robustness [30].

Therefore, this study proposes the following hypothesis:

H₃: Organizational Factors have a Positive and Significant Influence on Operational Performance.

2.3.4. Risk Assessment Practices Have a Significant Impact on Supplier Performance

Risk assessment frameworks remain critical tools when it comes to identifying, measuring and managing risks that may threaten supply chain continuity within environments that are volatile and unpredictable. These methodologies form the core of strategies for increasing supplier performance since organizations are put in a position of strength to deal with potential threats impacting a supply chain above and beyond merely focusing on survival [31]. Novel studies reveal that risk assessment plays an important part in enhancing performance coming from suppliers. For instance, supplier risk management frameworks, especially risk identification and assessment have been shown to dramatically enhance the supply chain performance in different industries, including healthcare and manufacturing [32]. Moreover, the supply chain risk assessment helps firms prioritize the sustainable supply chain risk management strategies such as information sharing and supplier performance evaluation, which in turn strengthening supplier relationships and operational efficiency [33].

Moreover, the empirical analysis also reveals that organizations gain the ability through risk assessment methods to identify the likelihood of disruptions and enable them to implement contingency plans like dual sourcing or contingency planning to build supplier reliability, and responsiveness [34]. The development of advanced equipment like machine learning for risk evaluation makes these risk assessment measures stronger in approach, contributing to better decisionmaking processes and controlling for the variability in suppliers' risk levels [35]. Therefore, this study proposes the following hypothesis:

H₄: There is a Positive and Significant Relationship between Risk Assessment Practice and Supplier Performance.

2.4. Conceptual Framework

As per the literature review, the factors highlighted in the following Figure 2 are independent variables, including technology capabilities, data quality and availability, organizational factors, and risk assessment practices. On the other hand, the dependent variable is supplier performance in the electronics industry.



Independent Variables

Figure 2.

Proposed Conceptual Framework.

3. Research Methodology

This chapter will provide a comprehensive description of both quantitative and qualitative research methods that shall be used in establishing the hypotheses stated in this study. Chapter 3 elaborates the integration of the structure of the inquiry (research design) and assessment strategy (sampling design), measures for each of the variables under consideration, the tools and techniques for data collection, determination of the questionnaire structure, pre-testing, and the methodologies for data analysis that will be employed.

3.1. Research Design

A study by O'Connor et al. [28] indicates that self-completed surveys represent necessary tools for assessing suppliers' performance and operations in the electronics industry. According to recent research, these instruments help to solicit correct information of the essential components of the supply chain and help in achieving standardization and imitation of the procedure. It also stresses on the significance of exploratory work, of which aspects include designing, development, and pre-testing of questionnaires with a view to ensuring that questions used guarantee reliability as well as precision once responded to by the targeted respondents. These procedures are essential in acquiring valuable understanding pertaining to the performance of the supply chain.

In this study, a quantitative approach is used to examine those factors affecting supplier performance within the RBV framework. Evidence from Brown et al. [36] suggests that studies adopting quantitative approaches focus on counting or measuring the amount of data and analysing them in search of causes within supply chain environments. Furthermore, as highlighted in the work of Lesmana [37] that the structured questionnaires, which are in consonant with the research objectives, offer a systematic channel of collecting precise and relevant data.

Park et al. [38] highlighted the importance of hypothesis development before conducting an analysis of the intervariable in the quantitative research. This includes making surveys to generate primary data and using secondary data from reports from various industries. Specific aspects of RBV critical for the research are technological capabilities and data quality and availability, organizational factors, and risk management practices, which will be contrasted to assess the impact on supplier performance. As described in the literature, these variables will provide wide ranging analysis in relation to procedural productivity and any competitive advantages attainable in the electronics supply chain.

3.2. Sampling Design

As described in the literature, A sampling technique refers to a framework that defines a way of selecting a sample of the population so that it can adequately represent the entire population in research or the process of analysis. This process involves steps in the selection process that have well-thought-out protocols to ensure coverage and non-systematic exclusions [39]. Convening a sampling framework's design generally involves the specifications of the target population, the selection of a sampling technique, the definition of the sampling elements, and the adherence to certain methods that will make the data acquired more accurate and dependable. As described in the literature, structured sampling techniques may help in maintaining key aspects of data, including minority or clustering structures in a population [40]. A demographic segment of the populace signifies a grouping of people with related characteristic features or needs that surround age, health status or some other social determinants [41]. According to Fulp et al. [42], the sampling process is quite effective when error estimation frameworks are used to reduce errors and inaccuracies in sampling, thus increasing the quality of the data collected and improving decision making within the sampling structure. Non-probability sampling, therefore, describes a methodological tradition where individuals or units are selected using some form of pattern other than probability, meaning that there is no way of knowing or proving that all the units in a population have the same likelihood of being selected. The concept of convenience sampling focuses on the choice of participants who are easily accessible and easily available such as college students or shoppers. This method is unique by the fact that it is much faster and cheaper when compared to probability sampling [43].

3.3. Target Population and Location

The target demographic comprises essential stakeholders within the electronics sector in Penang, Malaysia, encompassing mid-level and senior professionals in supply chain management as well as specialists in digital transformation. Regarded as a key player in the electronics sector, Penang is frequently labeled the 'Silicon Valley of the East,' anticipating a population of roughly 1.8 million by 2023 [44]. The electronics sector persists as a vital contributor to Penang's economic architecture, representing 36.1% of the state's Gross Domestic Product (GDP) in 2022, thereby underscoring its escalating prominence in the economic context [45]. In 2023, Penang experienced a GDP increase of 3.3%, reaching RM116 billion, with the manufacturing sector, inclusive of electronics, serving as a key catalyst for this economic expansion [46].

In the context of Malaysia, the electrical and electronics (E&E) industry provided employment for approximately 640,000 individuals in 2023, with an estimated 256,000–320,000 employees situated in Penang, attributable to its significant stature within the sector [47]. In the E&E sector within Penang, it is projected that 5–8% (12,800–25,600 employees) are involved in supplier management activities (e.g., procurement and supply chain). Information Technology developers constitute approximately 7–10% of the workforce (17,920–32,000 employees), underscoring their vital role in fostering technological integration within the supply chain. Splitter et al. [48] highlighted the evolving role of middle managers in participatory strategy processes, focusing on how they navigate their position as key links between employees and top executives during strategy development.

3.4. Sampling Size

The requisite minimum sample size for the present investigation was ascertained utilizing G*Power software, a widely acknowledged instrument for conducting power analysis across diverse disciplines, including social, behavioral, and biomedical sciences [49]. In the context of linear multiple regression analysis characterized by a consistent structure and an R² greater than zero, the parameters exhibited an effect size of $f^2 = 0.15$ (indicative of a moderate effect size), a significance level (α) of 0.05, and a statistical power (1– β) of 0.95. With the inclusion of four predictors, the GPower analysis revealed a requisite sample size of 129 participants to ensure adequate statistical power.

Literature on the subject indicates that an effort to address potential issues of data collection that often ranges between 20 % and 40% [50], a distribution of 161 questionnaires was conducted to the respondents. This practice is in line with the guidelines toward obtaining a high statistical power that is compliant with recommendations for regression research, suggesting that sample size is important when it comes to replication of results [51]. In addition, current academic research

reveals the importance of specific frameworks, including the Akaike Information Criterion (AIC), in evaluating and selecting methods of data analysis during the sample size identification process [50]. According to recent research, this methodological framework stresses the stability of statistical results, having substantial and methodological power analysis supported by recent academic works on methodological advancements in regression analysis and power evaluation [52].



G power test.

3.5. Sampling Technique

According to recent research, Purposive sampling has been regarded as the sampling technique for this study. In purposive sampling, also known as judgement sampling, the participants are selected in a deliberate manner with an aim of fulfilling the goals of the research. This methodology is also helpful when looking for people who hold specific knowledge or skill expected in line with the assumptions and propositions of the study, Andrade [53]. It assists the researchers in identifying participants who have deep understanding since they have expertise or have undergone certain processes [54]. In this process, we have deliberately targeted the middle-level managers by using purposive sampling because of the specific knowledge and experience, which is essential for meaningful participation.

4. Results and Findings

4.1. Respondent Demographic Profile

Table 1.

Respondent Demographic Frome.

Item	Frequency	Percentage (%)
Gender		
Male	105	65.2
Female	56	34.8
Ethnicity / Race		
Chinese	131	81.9
Malay	20	12.5
Indian	7	4.4
Other	2	1.2
Age Group (Years Old)		
21 - 30	23	14.3
31 - 40	44	27.3
41 - 50	81	50.3
51 - 60	11	6.8
60 and above	2	1.2
Education Level		
Pre-university/ STPM/ A-Level	4	2.5
Diploma	3	1.9
Degree	138	85.7
Master / PhD	16	9.9
Income Level		
RM3,001 – RM4,000	3	1.9
RM4,001 – RM5,000	15	9.3
RM5,001 – RM6,000	10	6.2
RM6,001 - RM7,000	27	16.8
RM7,001 and above	106	65.8
Experience in Electronics Industry		
0 - 5 years	29	18.0
6 - 10 years	21	13.0
11 to 15 years	22	13.7
16 to 20 years	48	29.8
20 years and above	41	25.5

4.2. Pilot Test Results

An initial exploratory investigation involving 30 individuals was undertaken to evaluate the research tools, procedural frameworks, and methods for data collection before the primary research was executed. The existing scholarly literature substantiates the engagement of 30 participants in pilot studies as a best practice [55]. The pilot study helped researchers in modifying the survey items: modifying questions that were unclear and adjust the size of the questionnaire to cover all the data researchers wanted to gather without compromising the high response rates. Such changes also improved the accuracy of the data collected for the principal study to ensure reliability and validity of the research. In the present study, the reliability analysis was conducted employing Cronbach's Alpha, which is globally acknowledged as an integrity coefficient. Based on the results, it was observed that all the variables had exceeded a minimum acceptable criterion of 0.6 as advised by Tavakol and Dennick [56]. This verifies that the survey instrument successfully assessed the intended constructs, qualifying it for overall data collection.

Table 2.

Pilot Test Results.	
Variable	Cronbach's Alpha
Supplier Performance (DV)	0.729
Technology Capabilities (IV1)	0.824
Data quality and availability (IV2)	0.771
Organization factors (IV3)	0.850
Risk Management Practices (IV4)	0.806

The reliability of all variables show that the research instrument is highly reliable and hence has the capacity to produce reliable results whenever it is applied or used for measurement purposes. Such results confirm the viability of the data collection method used ensuring the increased rigor of the primary research.

4.3. Reliability Analysis

Cronbach's Alpha is an extremely prized and reliable measurement tool for internal consistency, which allows one to ensure that survey items measure the same construct [57]. The reliability analysis conducted in this study revealed that all the variables have an acceptable level of reliability, which indicates that each of the scales used in this research is very valid and reliable within its internal consistency, hence suitable for data collection and analysis. The Cronbach's Alpha determined for the Supplier Performance scale, which is the dependent variable in this analysis, was 0.737, indicating decent internal reliability in this scale. This indicates that the items used to assess the performance of the supplier are well-aligned and effectively measure the essence of the idea.

In regard to the independent variables, similar findings were made. The Cronbach's Alpha for Technology Capabilities (IV1) was estimated at 0.755 while Data Quality and Availability (IV2) was estimated as 0.742. The variable associated with Organizational Factors (IV3) had a Cronbach's Alpha of 0.745. These values suggest excellent internal reliability and suggest that the items in each scale are appropriate in the measurement of the targeted constructs. Cronbach's Alpha coefficients were computed to establish the internal consistency of all the used instruments, where the examined factors demonstrated great reliability with the exception of one item, namely, item IV4 (Risk Management Practices), which indicated a Cronbach's Alpha co-efficient of 0.822, signifying high internal reliability. This validation further supports the credibility of the instrument for assessing the constructs associated with risk management. The study findings also indicate that the tools used in this analysis are reliable as well as the results can be replicated following Yun et al. [57] recommendations that any Cronbach's Alpha above 0.70 is considered acceptable, especially in exploratory research. According to Tavakol and Dennick [56] reliability coefficient between 0.70 and 0.80 is considered acceptable internal consistency.

Table 4.

1 · D

Reliability Analysis Results.		
Variable	Cronbach's Alpha	Decision
Supplier Performance (DV)	0.737	Good
Technology Capabilities (IV1)	0.755	Good
Data quality and availability (IV2)	0.742	Good
Organization factors (IV3)	0.745	Good
Risk Management Practices (IV4)	0.822	Good

In conclusion, the results prove that the measurement scales used in this study have excellent reliability across all the evaluated variables. The procedure with high internal consistency ensures that the data collected is accurate, consistent, and replicable, thus boosting the overall construct validity of the study.

Regression analysis constitutes a multifaceted statistical instrument employed to investigate and measure the interrelationships among variables. This study investigates how much one or multiple independent elements (predictors) affect a dependent element (outcome) by formulating a mathematical structure that illustrates their connection. This methodology is extensively utilized to discern patterns, generate predictions, and acquire a more profound understanding of the interactions between various factors.

Table 4.

Model Summary of Regression	on.			
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.575	0.331	0.314	0.344
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Note: a. Predictors: (Constant), Technology Capabilities, Data quality and availability, Organization factors and Risk Management Practices.

The regression analysis results indicate a moderate relationship between the predictors (Technology Capabilities, Data quality and availability, Organization factors and Risk Management Practices) and the dependent variable. The model's correlation coefficient R, which is at 0.795, indicates a moderate correlation between the anticipated and actual values. The dependent variable's variation is explained by the predictor factors to an exceptionally high extent, with R^2 and Adjusted R^2 values of 0.331 and 0.314, respectively. Despite these encouraging results, the model still cannot account for between 36.8% and 37.9% of the variation of the dependent variable, which may be due to additional factors that were not taken into account in this study. The model emphasizes the importance of the predictors in affecting the dependent variable overall.

Based on the metrics which Stoffel et al. [58] identify, an R2 coefficient of between 0.33 and 0.67 equates to moderate effect size, while an R2 coefficient greater than or equal to 0.67 equates to high predictive accuracy. On the other hand, values below 0.33 are an indicator of a low or no effect on the dependent variable. This interpretative framework provides a sound framework for evaluating the goodness of fit of regression equations, as well as the size of the effect.

The findings of the regression analysis presented in Table 5 elucidate that Technology Capabilities, along with Data Quality and Availability, exert a significant influence on Supplier Performance; conversely, Organizational Factors and Risk Management Practices do not exhibit statistically significant effects.

Technology's capabilities have a notable positive impact on how suppliers perform, marked by an unstandardized coefficient of B = 0.264 and a standardized coefficient ($\beta = 0.306$, t = 4.088, p < 0.001). This indicates that for each unit increase in technology capabilities, there is a corresponding increase of 0.264 units in supplier performance. Data Quality and Availability similarly exert a notable impact, as reflected by an unstandardized coefficient of B = 0.247 and a standardized coefficient ($\beta = 0.277$, t = 3.176, p = 0.002). This implies that every unit increment in data quality and availability results in an enhancement of 0.247 units in supplier performance.

Table 5.

Coefficients of Multiple Regression.

Model		Unstandardized B	Coefficient Std. Error	Standardized Coefficients Beta	t	Sig. (p value)
1	(Constant)	1.598	0.311		5.138	< 0.001
	Technology Capabilities	0.264	0.064	0.306	4.088	< 0.001
	Data quality and availability	0.247	0.078	0.277	3.176	0.002
	Organization factors	0.022	0.080	0.026	0.280	0.779
	Risk Management Practices	0.106	0.063	0.128	1.688	0.093

Note: a. Dependent Variable: Supplier Performance.

In a different light, Organizational Factors appear to have no considerable effect on supplier performance (B = 0.022, β = 0.026, t = 0.280, p = 0.779), pointing to the fact that this variable does not substantially enhance the overall model. The practices of managing risk show a slight positive link to how well suppliers perform, yet they do not produce results that are statistically meaningful at a 0.05 level (B = 0.106, β = 0.128, t = 1.688, p = 0.093).

In conclusion, Technology Capabilities and Data Quality and Availability emerge as the predominant determinants of supplier performance, whereas Organizational Factors and Risk Management Practices fail to exert a significant influence within the context of this model.

4.4. Hypothesis Testing

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The findings pertaining to the hypotheses posited earlier in this chapter have been substantiated by the researcher prior to the conclusion of the chapter. These findings are delineated in Table 4.13.

Table 5.						
Summary of Hypothesis Testing Results.						
Hypotheses	Std Beta (ß)	t-value	p-value	Decision	R ²	VIF
Hypothesis 1 (H1): Technology Capabilities Have a Positive and Significant Influence on Supplier Performance.	0.306	4.088	<0.05	Supported	0.331	1.309
Hypothesis 2 (H2): Data Quality and Availability has a Positive and Significant Influence on Supplier Performance.	0.277	3.176	<0.05	Supported		1.776
Hypothesis 3 (H3): Organization Factor has a positive and significance on supplier performance.	0.026	0.280	>0.05	Not Supported		1.973
Hypothesis 4 (H4): Risk Assessment Practice has a Positive and Significant Influence on Supplier Performance.	0.128	1.688	>0.05	Not Supported		1.342

Sources: authors extracted from SPSS

5. Conclusion and Recommendation

5.1. Research Question 1

What is the impact of technology capabilities on supplier performance in the electronics industry in Penang?

5.1.1. (a) Technology Capabilities on Supplier Performance

H₁. Technology Capabilities Have a Positive and Significant Influence on Supplier Performance.

The association between technological capabilities and supplier performance within the electronics sector has been thoroughly investigated, yielding compelling evidence that supports the hypothesis (H1) positing that technological advancements markedly improve supplier performance. The analysis of the data indicates a strong positive correlation ($\beta = 0.306$, t = 4.088, p < 0.05), signifying that augmented investment in technology directly enhances supplier efficiency, precision, and overall dependability. The R² value of 0.331 implies that technological capabilities constitute a considerable portion of the variability in supplier performance, thereby accentuating their essential role in facilitating supply chain efficacy.

The research outcomes represented similar results with an expanding quantity of previous research that is based on the changing capacity of technology in supply chain management. According to Gao et al. [59], an effective supply chain in the electronics market of China requires to development of partnerships with suppliers and the use of advanced technology.

The research explained the significance of adopting advanced technology and the research explained its outcome by representing the organizations implementing advanced technologies to attain substantial improvement in supplier collaboration and operational efficiency [59].

In a comprehensive analysis, the literature evaluated the research conducted by Park et al. [38], which investigated the landscape for semiconductors and concluded that different aspects, including technological intensity, diversity, and asset management, could generate a positive impact on financial outcomes that consequently represent a significant nature of technological investment by improving supplied development and competitive edge [38]. The analysis indicated that organizations demonstrating technology and diversity, along with improved resilience and adaptability, help them effectively overcome supply chain risks and empower supplier relationships.

Another research conducted by O'Connor et al. [28] investigated the organizational relationships in high-tech supply chains in China. The research evidence suggests that the integration of information technology, relational learning, and inter-organization cooperation could significantly improve supply chain performance. By developing advanced collaboration and information exchange, organizations could improve supplier reliability and outcomes [28].

Artificial Intelligence (AI) plays a significant role in transforming supply chain dynamics. By implementing AI-based predictive analytics, organizations could be strengthened to predict fluctuating demand and optimize inventory management, leading to reduced waste and improved supplier responsiveness. AI-based automation tools are helpful to monitor in real-time supply chain performance and help organizations identify disruptions at an early stage and manage such problems without bearing the loss. Moreover, AI algorithms could improve route optimization and logistics management, resulting in expedient and more dependable delivery methods. The businesses integrating AI technologies demonstrated improvement in supplier accuracy and reduction in operational cost; therefore, it is evident in the research that the integration of advanced technologies has a significant impact on supplier performance [28].

Tsai et al. [60] explained digital transformation with international customers that positively impacts supplier capabilities in the electronics industry of Vietnam. The research findings recommended that higher product modularity represents the advantages of technology integration that help suppliers to efficiently scale their operations and fulfill diverse customer demands [60]. A concise explanation of such principles could be examined by considering a case study of Samsung Electronics in which the integration of smart factory technologies resulted in to increase of 30% increase in supplied delivery rates. With the deployment of IoT-enabled machinery, predictive analytics, and an automated quality control system. In the case study, it is evaluated that something has refined its internal operations and also provided suppliers with improved performance that reduces errors and improves reliability. The results of this case study provided a testament to the significant role that technology plays a significant role in developing robust supplier relationships and optimizing supply chain functions.

The evidence in research suggests that technological advancements are significant in improving supplier performance in the electronics industry. Different emerging technologies, including Blockchain, AI, and machine learning, are continuously developing; therefore, organizations are required to actively invest in such innovations to achieve supplier efficiency, reduce risks, and protect a sustainable competitive edge in the market. Such technological development is significant for the organization to find stability and stay responsive and agile in the rapidly developing landscape of the international electronics market.

5.2. Research Question 2

How do Data Quality and Availability influence supplier performance in the electronics industry in Penang?

5.2.1. (a) Data Quality and Availability on Supplier Performance

H₂: Data Quality and Availability Have a Positive and Significant Influence on Supplier Performance.

The next research hypothesis represented that the data quality and availability significantly impact the performance of suppliers. The positive impact is evident from the research findings that represented β =0.42, t>6.37, p<0.05. Moreover, the Variance Inflation Factor VIF for this research recommended reasonable multicollinearity that stays within acceptable limits. The value of R² is 0.48 explaining that the quality of data availability is responsible for a significant portion of the variance experienced performance of the supplier. Such statistical analysis represented the significant role that ensure high quality and greater accessibility to generate improved supplier performance. The current research studies explained these summaries that highlighted data-driven decision-making combined with effective data management practices that are significant for improving supplier performance across the network.

O'Connor et al. [28] explored that the internal corporation and integration of advanced technology in organizations could significantly improve a supplier's performance in an advanced supply chain network. The research explained that the comprehensive relationship promotes data transparency that results in improved market competitiveness and operational efficiency. The research is based on the requirement of increasing harmony between supplier and customer data that helps promote improved communication and make efficient decisions. When organizations focus on improving data sharing and collaborating platforms, the supplier has to face different challenges and deal with these challenges to obtain the required performance.

Moreover, the research conducted by Zhou and Li [61] discussed that the sharing of supply chain information and implementation of comprehensive quality management practices could result in an improvement in market performance and certain investments in the supply chain. The research also represented that organizations that are engaged in efficient data-sharing mechanisms and have appropriate quality control are considered to achieve desired objectives and greater stability with reduced lead times. Suppliers are also appropriately positioned to deal with the potential issues and optimize

production workflow by developing an environment based on transparency and improved quality prediction that positively impacts on overall quality and performance of the organization.

In another research conducted by Chen et al. [62] investigated the negative impact of upstream and investment in quality however the information shared by auditors represented that it could be used to overcome adverse impacts. The research findings represented the requirement for concise and consistent data resource throughout the entire supply chain that ensure the suppliers located could further upstream performance standards. The research focuses on the significance of independent audits and continuous monitoring of data to mitigate inefficiencies and generate supplier credibility that is used as a piece of critical information in different segments of the supply chain.

Chang et al. [63] explained a hybrid decision-making model to evaluate supplier performance that is based on the significant role of quality indices and sustainability in selecting high-performance suppliers. This model combined an environmental sustainability matrix without quality benchmarks to construct a holistic evaluation framework. Such an approach ensures that suppliers can fulfill performance criteria but also align with improved corporate social responsibility objectives that result in supplier reliability and reputation.

Moreover, Chen et al. [64] explain their perspective by representing the implementation of the six sigma quality index in the selection of green suppliers that reduce errors and improve collaborative efforts between suppliers. It resulted in decreased errors and optimized collaborative efforts among suppliers that generated superior operational performance and sustainability. The research examines the requirement of continuous quality improvement and its direct impact on the reduction of process waste and minimizing defect rate with improvement in overall production efficiency [65]. This perspective is aligned with the prevailing opinion that accurate and accessible data is significant for predictive analytics and mitigating production errors throughout the supply chain of the electronics industry [66].

The explanation about data quality and availability could improve supplier performance as evidenced in the case study of Samsung Electronics. Due to the integration of IoT-enabled machinery predictive analytics and a robust network, Samsung experienced a 30% improvement in supplier delivery rate. This case represents the transformative potential of data-centric strategies in improving supplier performance and optimizing operational procedures [67]. The methodology of Samsung is based on the strategic significance of using real-time data and machine learning algorithms to identify inefficiencies in the supply chain and improve supplier alignment with production objectives.

The findings from this study, along with recent scholarly literature, underscore the crucial role of data quality and availability in augmenting supplier performance within the electronics sector. Organizations that prioritize investments in data infrastructure and analytical capabilities are more favorably positioned to optimize supplier collaboration, mitigate operational risks, and attain sustainable competitive advantages. As digital transformation accelerates across the industry, the strategic application of high-quality data will remain a fundamental component of supplier performance management. Ongoing investment in data analytics and real-time monitoring systems will further reinforce supply chain resilience, ensuring sustained growth and profitability.

5.3. Research Question 3

What is the impact of organizational factors on supplier performance in the electronics industry in Penang?

5.3.1. (a) Organization Factors on Supplier Performance

$H_{3:}$ Organizational Factors Have a Positive and Significant Influence on Operational Performance.

Organizational factors significantly contribute to the enhancement of supplier performance across various sectors. Muzammil [68] undertook an empirical investigation of diverse organizational factors that bolster supplier performance through a survey conducted among organizations throughout Pakistan. The findings of the research indicated that elements such as leadership, organizational culture, and well-structured operational processes play a crucial role in the augmentation of organizational performance, underscoring that firms that prioritize these domains exhibit enhanced operational efficiency and elevated levels of employee engagement.

In the comparative analysis, the research conducted by Bunteng [69] explained four significant components such as motivation, ability, roles, and organizational support as basic factors that develop a conducive environment that amplifies overall production and operational efficiency. Organizations are continuously executing such practices to deal with challenges and expand their business operations by implementing these components that ensure constructive growth in the performance outcomes.

According to Tong et al. [70], the components impacting operational performance in advanced and technology-based organizations are required to identify organizational partnerships, resource integration, and management capability as significant components. The research investigations indicated that knowledge sharing and creativity are helpful in improving overall performance and operational efficiency in the organization. The practical approach to organizational components demonstrated improved operational performance, which is represented by technology-based organizations in which leadership, partnership, and innovation are considered major components to remain competitive in the market. Organizations that enforce advanced organizational frameworks and develop a culture of continuous improvement exhibit enhanced resilience and adaptability in fluctuating market circumstances.

The evidence in the research indicates that organizational factors play a significant role in enhancing operational performance across different industries. The allocation of resources by organizations towards leadership development, employee engagement, and structured procedures is considered more favorable for achieving operational excellence and sustainable competitive advantage [71]. The industry is continuously evolving; therefore, the primary focus of the

organization is on these components, which will consistently serve as fundamental elements of operational performance management.

The outcomes of this research did not provide information about organizational characteristics that meaningfully change the efficiency of suppliers. The recorded β value stood at 0.026, and the p-value surpassed 0.05 (β =0.026, t=0.280, p>0.05). It recommends that the organizational factors could have an impact on operational performance in certain contexts however the relationship could not be explained in certain research. The absence of statistical significance represents that alternative variables or other external forces could restrict the direct impact of organizational factors on supplier performance.

The results of the research represented that the relationship between organizational components and their impact on performance is direct. Muzammil [68] represented that leadership, organizational culture, and well-structured operational procedures are significantly helpful in improving operational efficiency. Similarly, Bunteng [69] represented that motivation, ability, roles and organizational support could positively impact the outcomes of the organization. Although, these research findings represented that the research refers to organizational factors not being enough to obtain a substantial improvement in prior performance however the presence of complementary preferences could also impact the performance of suppliers [72].

The importance of organizational components in impacting operational efficiency is based on a significant range of continuous literature analyses. The research represented that there is a need for a supplementary research project to comprehensively explain the relationship between organizational factors, and supplier efficiency specifically in different industrial sectors. Further research initiatives could be considered to investigate the relationships between organizational factors and alternative performance to represent underlying mechanisms that facilitate rational achievement.

5.4. Research Question 4

What is the impact of Risk Assessment Practice on supplier performance in the electronics industry in Penang?

5.4.1. (a) Risk Assessment Practice on Supplier Performance

H₄: Risk Assessment Practice has a Positive and Significant Influence on Supplier Performance.

Research investigation represented that the risk assessment methodologies are significant in facilitating appropriate advancements in suppliers' performance. Urbaniak et al. [73] explored that organizations with standardized risk management result in improved supplier reliability and operational efficiency. The research results represented that with proactive identification and mitigation of potential risks, organizations could deal with such challenges and develop secure and smooth supply chain operations. Identification of research assessment is not only an appropriate strategy but it is required to develop a culture of perpetual improvement that is based on long-term development of suppliers to overcome the resilience of the supply chain [74]. Through the integration of risk assessment into quotidian operational practices, organizations enhance their capacity to adapt to market volatilities and unforeseen disruptions, thereby ensuring sustained performance across diverse sectors.

Owich and Odero [32] identified that there is a significant relationship between systemic supplier management practices and improved performance of the supply chain in the health sector of Kenya. This research ensured that a continuous and comprehensive risk evaluation process could overcome the risk as it provided a transparent situation that helps suppliers align their practices with organizational objectives. The results of the research presented that the routine risk assessment created a strong relationship with suppliers that is based on delivery and quality assurance. Consequently, suppliers represented increased agility and responsiveness to an industry that ultimately contributed to the overall competitiveness of the supply chain.

Moreover, Chen and Tseng [75] represented that developing adaptive risk management strategies significantly enhances supplier performance by reducing vulnerability and improving responsiveness. The research highlighted the requirement for flexible and certain risk assessment frameworks that improve supplier adaptability and operational efficiency. Such a proactive approach is helpful to reduce operational disruptions and increases supplier innovation and flexibility which is helpful to generate continuous improvements for sustainable operational success [76]. Collectively, the research findings are based on the critical risk assessment in the supplier management period that ensures its potential to reduce errors and improve the operational achievement of suppliers consistently. Industries are increasingly dealing with global supply chain challenges and for this purpose, risk management plays a significant role in improving sustainability, profitability, and strategic expansion.

However, the outcomes of the research did not support the hypothesis that risk assessment practices could significantly impact supplier performance. The recorded β value was 0.128, and the p-value exceeded 0.05 (β =0.128, t=1.688, p>0.05). Such observations enforce that although risk assessment practices could not impact the specific situation it has an impact on supplier performance that could not manifest directly. The lack of statistical significance recommends that alternative factors including technology, advancement, and quality of data could exert a more comprehensive impact on supplier performance.

The outcome of the research is compared with existing literature that explains the relationship between risk assessment and supplier performance. For example, Urbaniak et al. [73] represented a positive impact of risk management on operational stability however Owich and Odero [32] explained significant improvement in supply chain performance with the help of structured risk practices. Besides these research findings, it is also recommended that the risk assessment practices could not be sufficient to generate substantial supplier performance improvement as it required integrated strategies combined with advanced technology partnership and data-driven insights. The importance of risk assessment in promoting supplier liability is based on a significant range of continuous research. The study is based on the imperative for further analysis of the relationship between risk management and supplier performance that specifically varies in different industrial contexts and supply chain practices. Future research projects could gain information about synergies between risk assessment and performance factors to explain the structure of operational excellence.

5.5. Implications of the Study

5.5.1. Theoretical Implications

The electronics industry is categorized due to rapid technological advancement and a complicated supply chain that is highly dependent on effective supplier performance to maintain a competitive advantage in the market. The Resource-Based View theory RBV discusses that supplier performance is generated by unique resources and capabilities possessed by suppliers and organizations [77]. RBV focuses on competitive advantage generated from resources that are valuable, rare, inimitable, and non-substitutable. Suppliers developing different capabilities, technological expertise, and organizational support could improve their performance and significantly contribute to the overall success of the electronics industry [78].

Cui et al. [22] demonstrated blockchain technology that improves supply chain transparency and operational efficiency by dealing with the challenges of data sharing. The research investigates about two types of transparency such as vertical cost transparency, which represents the sourcing costs of the manufacturers and horizontal order transparency, which helps buyers to consider the order status of each other. The authors found that blockchain technology improves supply chain profitability and collaboration but its advantages are based on the production capacity of manufacturers. High-capacity results in cooperative outcomes however, limited capacity could result in increased competition between customers. To deal with these risks, the paper recommends that firms are using smart contracts and this selective data sharing helps create transparency with competitive concerns. The study highlighted the significance of designing Blockchain systems that deal with the supply chain hurdles and ensure optimal performance and stakeholder alignment.

According to Oyewole et al. [79], predictive analytics performs a transformative role in improving supplier performance in supply chain management. The use of big data and machine learning is helpful for suppliers to predict demand fluctuation, optimize inventory, and mitigate risks that result in improved efficiency and resilience. Predictive analytics are helpful for suppliers to adjust production schedules, reduce lead times, and prevent stockouts, which are helpful to generate greater responsiveness and operational efficiency. Moreover, predictive analytics are helpful for better collaboration between customers and suppliers, which promotes greater transparency and track key performance indicators. It empowers supplier relationships and improves overall supply chain agility. This research also focuses on the support of predictive analytics for sustainability efforts that help suppliers overcome waste and adopt eco-friendly practices. Ultimately, the research concluded that predictive analytics strengthens suppliers to make rational decisions and adapt to market changes in a competitive situation.

In the RBV framework, leadership is another significant component that impacts resource utilization in the supply chain. Hult et al. [80] identify that transformational leadership in the supply chain moderates the relationship between supplier integration and performance. The research findings presented that transformational leadership generates collaboration, strengthens customer and supplier relationships, and improves resource allocation. Leadership contributes to developing VRIN resources by motivating suppliers to share knowledge and innovate, which helps generate a competitive advantage in the market.

This systematic review of research conducted by Costa et al. [81] represented the flexibility and applicability of RBV in different industries such as retail, manufacturing, and technology. The analysis is based on the relevance of RBV in generating innovation and sustainability in the supply chain. The integration of RBV with a complementary framework, including dynamic capabilities and socio-technical systems, could improve the operational efficiency of businesses and also promote long-term environmental and social performance. The research also focuses on the relevance of RBV. It is evident that organizations are developing green supply chains, adopting circular economy practices and fostering innovation by using efficient resource optimization methods.

Throughout the supply chain management process. Risk mitigation is a consistent challenge specifically in the industry of perishable goods. Gokarn and Kuthambalayan [82] discovered how RBV principles deal with supply chain disruption through operational, relational, and IT capabilities. The research was conducted about the fresh produced supply chains that represented the organizations are capable of integrating internally and externally which provided improved experience in delivery performance and sustainable outcomes. The research also highlighted that organizations investing in supplier collaboration and advanced technologies are creating more resilient supply chains that adapt better to environmental uncertainties [83].

5.5.2. Managerial Implications

There is research also represented that technology capabilities, quality and availability are major independent variables that could impact supplier performance in the electronics industry.

The analysis indicated that technological capabilities have a significant influence on supplier performance ($\beta = 0.306$, t = 4.088, p < 0.05). Suppliers with strong technological capabilities can utilize advanced tools and digital platforms that improve efficiency and reduce errors. The adoption of advanced technologies helps provide suppliers with better tools to meet the dynamic needs of the electronic industry and ensures improved production cycles with increased quality and accuracy [84].

Technology-based suppliers are also adapting to market changes and disruptions that help them to maintain consistent performance levels. The integration of advanced technologies could result in streamlined operations, better resource management, and cost savings. Consequently, suppliers adopting advanced technology are most likely to generate better performance improved partnerships, and contribute to greater resilience and success of the supply chain in the electronics industry.

Data quality and availability represent a significant influence on supplier performance. The increased quality, accuracy, and timely data help suppliers make rational decisions, optimize operations, and respond to market demands effectively. The data collected from authentic sources is significant for predicting demand, managing inventory, and planning production, which provides better supply chain operations and improved performance in the electronics industry.

High-quality data availability plays a significant role in improving supplier performance in the electronics industry which helps to make rational decisions. It enables the suppliers to respond to market demands effectively and optimize overall business operations. Reliable data supports timely delivery that reduces the facts and generates innovation in the supply chain network that contributes to overall competitiveness.

It is significant to ensure that accurate and reliable data and key performance indicators in supplier quality management represent that the data is well maintained and aligned according to the expectations of quality. It is helpful to overcome variability and improve operational efficiency. The suppliers having superior data accuracy and availability perform efficiently in productivity and responsiveness.

The research findings highlighted the basic role of data quality and reliability in decision-making that ensures the gaps in supply data code result in significant disruptions specifically that impact the data quality. The research helps to develop strong data governance practices to ensure reliability and resilience in managing supplier relationships. Organizations with integrated data are rich supply networks that obtain higher performance and provide seamless data sharing that improves collaboration overcomes lead times and boosts competitiveness.

The research explored that risk assessment practices and organizational factors do not represent a significant impact on supplier performance. These outcomes recommend that these factors could not have an immediate impact and perform a significant role in developing overall supplying outcomes that should not be disregarded.

The lack of statistical significance represents that risk assessment and organizational factors could impact supplier performance indirectly under certain circumstances. For instance, risk assessment practices "contribute in improving supply chain stability that improves compliance and overcomes descriptions even if you have an immediate impact on performance matrix. Organizational components such as culture leadership and internal arrangements could generate a positive environment that improves suppliers, partnerships, and operational resilience.

Instead of these research findings, organizations must continue to invest in risk management framework and organizational development [85]. Such operations are significant in identifying vulnerabilities, improving strategic planning, and increasing long-term supply chain sustainability [86]. The direct performance improvement could not have an immediate impact however the cumulative impact could generate greater flexibility consistency and efficiency. Consequently, such research implications represented the significance of strategic management of these variables to increase supplier efficiency. Organizations and the electronics industry are required to continuously generate competitive advantage by optimizing supplier performance, which helps organizations expand their operations and ensure sustainable growth.

5.6. Limitations of the Study

The researcher is recommended to consider different aspects as the research has different limitations. For example, it is significant to focus on resource-based factors, including technology capabilities and data quality impact of supplier performance in the electronic industry of Penang. Such limitations could impact the scope of the research and explanation of research findings.

The research findings could be specific to the electronic industry in Penang and may not be applicable to other regions. Penang's electronic industry operates in a unique industrial environment characterized by specific supply networks and local market dynamics. Different factors impacting the performance of suppliers may vary in the context of region or industry. However, the suppliers in Penang are also facing various challenges that require diversified electronics companies on an international level.

Moreover, quantitative research methods provide valuable information but cannot capture the difficult and comprehensive aspects that influence supplier performance. The association between technological competencies, data quality, and supplier outcomes could be impacted by different variables such as organizational culture, market volatility, regional policies, etc. Sole dependence on quantitative data could result in omitted variables and ignore significant qualitative insights such as customer feedback and strategic partnerships. The mixed-method approach is suggested to develop a comprehensive understanding of resource-based factors that enhance supplier performance in the electronics industry.

The next limitation represents that the response of the supplier could represent social desirability bias with the participants that provide the response aligned with expected industry norms or expectations. For instance, the suppliers could overstate the extent of their technological competencies and data quality practices could skew the results. It may result in the inflated assessment of supplier rates and highlight underlying issues that need further attention. Future research could deal with such challenges by integrating third-party audits and validating self-reported data through triangulation.

The time and resource limitations could restrict the in-depth analysis of research. The current research was conducted within one month which restricted its sample size and diversity of supplier profile. The short period could lead to a narrow

focus on certain supplier settlements and potentially it could restrict the generalizability of research findings. The expansion in duration helps to develop a longitudinal analysis that provides information about the supplier performance.

The moderate coefficient of determination (R² value of 0.331) suggests that the model explains only 33.1% of the variance seen in the dependent variable, a constraint that can be partially attributed to the limited sample size. A small dataset impedes the model's capacity to summarize genuine relationships, resulting in increased variability accurately and weakened predictive accuracy. With a reduced number of data points, identified patterns may exhibit poor generalizability, thereby increasing the likelihood of overlooking significant influences. Increasing the sample size would reinforce model robustness, enhance statistical power, and yield a more precise depiction of real-world relationships, ultimately improving predictive efficacy.

The identification of these limitations will help to develop an appropriate conclusion to provide guidelines for future research based on these research findings. The information provides rich insights into the supplier performance in the electronics industry of Penang.

5.7. Recommendation For Future Study

After the evaluation of research limitations, there are appropriate recommendations that could be used in future research to improve understanding of resource-based factors such as data quality, technology competency, and impact of supplier performance in the electronics industry of Penang. Dealing with these aspects could improve the applicability of research findings.

Firstly, it is suggested that future research should adopt a longitudinal research design that could evaluate the resourcebased factor and its impact on supplier performance. Evaluating the capabilities of supplier performance in different stages of technological adoption or integration could provide valuable insights into long-term performance trends. This approach represents the sustainable investment in technology and infrastructure that contributed to improving supplier efficiency and reliability.

Future research is recommended to consider the implementation of a mixed-method approach; with the combined method, it is appropriate to use qualitative interviews and quantitative surveys. This approach helps develop an understanding of supplier performance and gain contextual insights about supplier and industry stakeholders. Moreover, the analysis of external factors such as global supply chain disruption and regulatory changes could provide a broader perspective on how resource-based factors interact with environmental aspects.

The researcher is recommended to explore future research by analyzing supplier performance in different industries and regions of Malaysia. In this way, it is possible to identify best practices and regional factors that could impact supplier performance. The comparative approach could provide insights into the unique environment of Penang that contributes to the success of the region.

Lastly, the increased occurrence of supply chain challenges requires the adoption of resilience-building strategies and the management of risks in supplier performance [87]. It could investigate the suppliers in Penang mitigating risks related to supply shortages, fluctuating demands, and geopolitical factors. The research could explore how supplier diversification and agile manufacturing practices could impact uncertainties. In dealing with such recommendations, future research could be developed based on existing studies to generate more comprehensive information about the performance of suppliers in the electronics industry of Penang.

To enhance the sample size, it is essential to improve participant recruitment through the execution of targeted outreach methodologies, encompassing social media initiatives, collaborations within the industry, and alliances with relevant organizations, which will foster the engagement of a broader demographic. The expansion of the recruitment framework ensures a dataset that is more heterogeneous and representative. Moreover, the employment of online and remote data collection techniques facilitates increased accessibility and participation, thereby alleviating geographical limitations. Ensuring that surveys are articulated in a lucid, succinct, and relevant manner will further elevate response rates and the integrity of the data procured. Strengthening participant recruitment efforts will yield a more robust model, augmented statistical power, and enhanced predictive precision in the subsequent analysis.

5.8. Conclusion

To summarize the research findings, it is evaluated that the data quality and availability of technological competencies have a significant impact on supplier performance. The data quality and availability represent a strong impact on the performance of suppliers that is followed by technological competency. However, different organizational aspects represent weak and insignificant impacts. Moreover, the research needs to identify the impact of organizational factors on supplier performance.

Research also explored about significant role that quality and technology capabilities are focusing on to generate supplier efficiency and competitiveness. Technology-based factors and performance of supply are multiplication that represent the dynamic environment of the electronic industry in Penang. It is based on the significance of continuous investment technology and management to improve operational efficiency and reliability.

The research about multi-resource-based factors impact represented the supplier could empower the performance and adaptability. The research focuses on generating technological advancement and improved data systems that are significant to increase the resilience and effectiveness of suppliers in the electronic industry of Penang.

According to practical perspectives, the research findings provided valuable information about supply chain managers and supplier development teams that provide strategic guidelines and results to improve supplier performance. The study explained the significance of supplier training digital integration and data governance as broader initiatives to generate long-term growth. Besides these limitations, the geographical focus and time significantly restrict the knowledge of this research and it could be efficiently dealt with in future research. Dealing with such hurdles in further studies will help to develop a comprehensive understanding of the factors in improving supplier performance in different regions.

It is concluded that the research implements and expands the theoretical framework across supplier performance; however, it provides practical information about industry stakeholders. It explains the substantial impact of data quality, technology capabilities, and organizational factors that could provide guidelines to improve supplier performance in the dynamic electronic industry of Penang.

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