Skyward Synergy: Enhancing Aerospace Supplier Performance through TISM Analysis

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DOI: https://dx.doi.org/10.47772/IJRISS.2024.8080138

Received: 13 August 2024; Accepted: 26 August 2024; Published: 06 September 2024

ABSTRACT

This study constructs a Total Interpretive Structural Modelling (TISM) framework to elucidate the complexities of Supplier Performance Management (SPM) in the aerospace industry. Utilizing the expertise of five industry specialists, the research aims to integrate theoretical insights with practical applications, focusing on key SPM components. The TISM methodology allowed for the hierarchical structuring of these components, revealing the foundational importance of quality and on-time delivery as primary drivers that influence other performance aspects such as cost, flexibility, and responsiveness. The structural model indicates that effective communication systems are essential enablers for technological integration and collaborative innovation, which ultimately lead to a supplier's willingness to participate in new product development. The study's conclusions suggest a multi-tiered approach to SPM, emphasizing that operational excellence forms the bedrock for strategic collaborations. The theoretical implication of this research showing relational and dynamic capabilities in SPM, while from a practical perspective, it guides aerospace firms to prioritize initiatives that enhance supplier performance, highlighting the need for a balanced approach in managing both foundational and strategic SPM elements. The TISM framework thus serves as a strategic tool for decision-makers to optimize supplier engagement and improve overall supply chain resilience in the aerospace sector.

Keywords: Supplier Performance Management, Total Interpretive Structural Modelling (TISM), aerospace Supply Chain, Quality Management in Aerospace

INTRODUCTION

In the evolving landscape of the aerospace industry, effective supply chain management strategies have become pivotal for corporate survival and competitive edge. Recent insights from Data Interchange (2023) emphasize the significance of robust Supplier Performance Management (SPM), highlighting the necessity for in-depth supplier visibility, streamlined communication, and efficient operational processes to mitigate risks and enhance supplier relationships Data Interchange (2023)

Furthermore, research by Schmelzle and Mukandwal (2023) in the aerospace sector reveals the nuanced impact of supplier relationship configurations on performance, advocating for the strategic selection of exclusive, trust-based partnerships over widespread, shallow connections to optimize operational efficiency (Ulrich Schmelzle, Prabhjot S. Mukandwal). In the aerospace manufacturing industry, especially in a developed country context like Malaysia, the need for an effective supplier performance management (SPM) system is critical. The Total Interpretive Structural Modeling (TISM) approach can provide a structured and comprehensive evaluation of supplier relationships and performance, addressing both the operational and strategic aspects of SPM.

For instance, a study by McKinsey highlighted the importance of end-to-end supplier management, particularly in the consumer products and high-tech sectors. It revealed that leading companies are collaborating with suppliers on cost improvement, innovation, and agility, with some achieving significant reductions in material costs. The study also pointed out that few companies excel in advanced supplier management practices, indicating a significant potential for performance improvement across industries (McKinsey, 2021).

Additionally, research conducted in Turkey investigated the impact of supplier flexibility on performance. The study found that supplier flexibility is influenced by environmental uncertainty, the quality of the relationship with the buyer, and the quality of information shared between the buyer and the supplier. It also established a positive effect of supplier flexibility on supplier performance, suggesting that flexibility is a critical factor in successful supplier relationships (Emerald Insight, 2020).

Furthermore, the methodology of supplier performance assessment is crucial across sectors. It involves identifying key performance indicators, collecting and analyzing data, and communicating assessment results to suppliers. The process aims to foster continuous improvement and collaboration, ultimately optimizing supply chain operations (TeamHub, 2021).

Research indicates that supplier development practices, both indirect and direct, play a pivotal role in enhancing supplier performance. These practices range from setting targets and communication to on-site consulting and training, which facilitate improved outcomes for suppliers (Springer, 2021). Moreover, the public sector's experience, as seen in Tanzania, shows the significance of supplier monitoring in procurement performance, with contract management difficulty playing a moderating role (Emerald Insight, 2021).

The assessment of suppliers also involves risk management, considering various factors like the technical quality of products, flexibility of deliveries, and efficiency of communication processes. The implementation of management systems, such as quality, environmental, health, and safety management systems (QEH&SMS), has been noted to significantly impact risk assessment in supplier relationships (PLOS ONE, 2021).

Therefore, for aerospace manufacturing in Malaysia, utilizing the TISM approach for SPM can integrate these aspects, providing a comprehensive framework for assessing supplier performance, managing risks, and enhancing overall supply chain efficiency and effectiveness. This research not only aims to fill the gap in empirical studies within the Malaysian context but also to contribute to the broader understanding of SPM in aerospace manufacturing, drawing on lessons from various sectors and countries.

Supplier Performance Management (SPM) in the aerospace industry is a critical function that directly influences operational efficiency, product quality, and overall business success. The core objective of SPM is to systematically measure, analyze, and improve the performance of suppliers in alignment with the strategic goals of the purchasing organization (Jones et al., 2023). In the high-stakes aerospace sector, where precision, reliability, and timely delivery are paramount, effective SPM becomes even more crucial.

Recent studies, such as those by Smith and Clarkson (2023), highlight that the aerospace industry faces unique challenges in SPM due to the complexity of its supply chains, the critical nature of its products, and the stringent regulatory requirements. These challenges necessitate robust SPM systems that not only track and evaluate supplier performance on basic metrics like cost, quality, and delivery but also assess suppliers' capacity for innovation, responsiveness to changing demands, and compliance with industry-specific standards.

The evolution of SPM practices has been significantly influenced by technological advancements. Digital technologies and data analytics have transformed traditional SPM approaches, enabling more dynamic and real-time monitoring and evaluation of suppliers. For instance, Miller and Davis (2023) discuss how aerospace companies are leveraging big data analytics and IoT (Internet of Things) to enhance visibility across the supply chain, facilitating more informed decision-making and proactive performance management.

The concept of SPM extends beyond mere transactional relationships between buyers and suppliers. As argued by Thompson and Wallace (2023), it encompasses a strategic approach that aims to develop mutually beneficial partnerships, fostering continuous improvement and value creation. This perspective is particularly relevant in the aerospace industry, where long-term collaborations and joint innovation efforts are common.

Moreover, the importance of aligning SPM activities with broader corporate strategies and sustainability goals has gained prominence. According to research by Lee and Nguyen (2023), there is a growing trend in the aerospace sector towards integrating sustainability criteria into SPM frameworks, reflecting the industry's increasing commitment to environmental and social responsibilities.

In summary, Supplier Performance Management in the aerospace industry is a multifaceted discipline that involves the integration of strategic, operational, and technological elements to enhance supplier relationships and performance outcomes. The ongoing developments in this field, driven by both challenges and innovations, continue to shape the strategies and practices of aerospace companies worldwide.

Total Interpretive Structural Modeling (TISM) is an advanced methodological approach that extends the basic framework of Interpretive Structural Modeling (ISM) by incorporating the interpretation of the contextual relationships among variables or elements within a system. TISM has been widely recognized for its ability to dissect complex systems and reveal the underlying structures and hierarchies among the elements that constitute these systems.

TISM was developed to overcome some of the limitations of traditional ISM, such as the lack of clarity in the interpretation of the links between elements in the model. According to Pathak and Ahuja (2023), TISM provides a more detailed and interpretive understanding of the relationships, enhancing the theoretical base and practical application of the structural models. This method involves a step-by-step process where elements are systematically analyzed and linked based on their contextual relationships, leading to the creation of a multi-level hierarchical structure.

TISM has been applied across various domains, including supply chain management, organizational theory, healthcare, education, and technology adoption. Singh and Kant (2023) demonstrated the application of TISM in analyzing the factors affecting supply chain resilience, providing actionable insights for managers to enhance supply chain robustness. In the field of education, Gupta and Sagar (2023) utilized TISM to identify and structure the elements influencing e-learning adoption, offering a strategic perspective for educational institutions to improve their e-learning strategies.

Advantages of TISM

One of the significant advantages of TISM, as noted by Sharma and Modgil (2023), is its ability to provide a clear and interpretable model that delineates the direct and indirect relationships among the factors. This clarity aids decision-makers in understanding the complexity of the systems and formulating effective strategies. Additionally, TISM's interpretive nature allows for the incorporation of expert opinions and qualitative data, making it a versatile tool for both quantitative and qualitative research.

Challenges and Limitations

While TISM offers a robust framework for structural analysis, it is not without challenges. The accuracy of a TISM model heavily relies on the expertise of the participants involved in the model's development, as pointed out by Kumar and Nair (2023). The process can be time-consuming and requires a thorough understanding of the system under study. Furthermore, the subjective nature of the interpretations in TISM can lead to biases, necessitating rigorous validation and cross-checking of the relationships.

Supplier performance management is a crucial aspect of supply chain management, especially in industries where the reliability and quality of suppliers directly impact the final product and customer satisfaction. Understanding the key components of supplier performance is essential for organizations to develop effective strategies for supplier evaluation and relationship management.

Quality Components

Quality is a fundamental component of supplier performance, often considered the cornerstone of supplier evaluation. Research by Nguyen and Luong (2023) highlights that supplier quality directly affects the manufacturing process's integrity and the final product's market success. Quality components include conformity

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VIII Issue VIII August 2024

to specifications, consistency of product delivery, and the supplier's ability to meet or exceed regulatory and safety standards. Quality management practices, such as ISO certifications and total quality management (TQM) principles, are critical in assessing a supplier's performance (Khan et al., 2023). Empirical studies have extensively examined the impact of quality certifications (e.g., ISO 9001) on supplier performance. Research by Terlaak and King (2006) found that suppliers with ISO certification tend to have higher performance metrics, including quality and delivery reliability.

On-time Delivery Performance

Timeliness of delivery is another critical component, as delays can disrupt the entire supply chain, leading to increased costs and reduced customer satisfaction. On-time delivery performance is a key indicator of a supplier's reliability and operational efficiency. Studies by Patel and Desai (2023) have shown that suppliers who consistently meet delivery schedules help organizations maintain smooth production processes and reduce inventory costs.

Correct Quantity

The accuracy of order fulfillment, or supplying the correct quantity, is vital to prevent overstocking or stockouts, which can significantly affect operational efficiency and cost management. According to research by Singh and Sharma (2023), suppliers' ability to deliver the correct quantity of products as per the agreement influences their performance rating and long-term relationships with purchasing firms.

Price/Cost of the Product

Price competitiveness remains a significant factor in supplier performance, especially in cost-sensitive industries. The price of products supplied needs to be balanced with quality and service levels. Thompson and Craig (2023) argue that a strategic approach to cost analysis, including total cost of ownership (TCO), should be considered to evaluate supplier performance comprehensively.

Quick Response Time in Case of Emergency Problem or Special Request

Suppliers' responsiveness to emergencies or special requests is crucial for maintaining operational continuity and customer satisfaction. This aspect of performance is particularly important in dynamic market conditions where rapid changes can occur. Wallace and Krajewski (2023) emphasize that suppliers' ability to respond quickly and effectively to unforeseen issues is a strong indicator of their commitment and reliability.

Flexibility to Respond to Unexpected Demand Changes

Flexibility and adaptability in responding to sudden changes in demand are essential attributes of high-performing suppliers. This flexibility can be a competitive advantage, enabling companies to respond to market fluctuations swiftly. Research by Lee and Kim (2023) highlights that suppliers who can adjust their production and delivery schedules to accommodate demand changes contribute significantly to the supply chain's resilience.

Willingness to Change Products and Services

A supplier's willingness to modify products and services to meet changing customer needs is a key performance component. This adaptability is crucial for long-term success in evolving markets. Martin and Brown (2023) discuss how collaborative product development and customization are increasingly important in supplier performance evaluations.

Participation in New Product Development and Value Analysis

Suppliers' active participation in new product development and value analysis activities is indicative of a strategic partnership rather than a transactional relationship. Such involvement can lead to innovations and improvements that benefit both the supplier and the purchasing organization (Johnson et al., 2023). Empirical research has also focused on the strategic aspects of supplier relationships. A study by Dyer and Singh (1998) highlighted the importance of trust, joint problem-solving, and shared vision in enhancing supplier performance and fostering innovation. Research by Krause, Handfield, and Tyler (2007) explored the effects of supplier development programs on supplier performance. These programs, including training and knowledge sharing, were found to significantly improve supplier quality and operational efficiency.

Use of Electronic Data Interchange (EDI)

The use of EDI and other technological tools for efficient transaction processing is a performance component that reflects a supplier's technological capability and commitment to efficient communication. As noted by Smith and Chang (2023), EDI facilitates accurate, timely, and cost-effective transaction processing, enhancing the overall efficiency of the supply chain. Studies such as those by Carr and Pearson (1999) have assessed the impact of technological integration, including EDI and e-procurement systems, on SPM. The findings suggest that technological tools can enhance communication, reduce errors, and improve overall supplier performance

Communication Skills/Systems

Effective communication is paramount in managing supplier relationships. The ability to communicate clearly, promptly, and effectively through various channels (phone, fax, email, Internet) ensures that issues are resolved quickly, and cooperation is maintained. Williams and Patel (2023) stress that good communication practices are essential for effective supplier performance management. In the context of globalization, studies like those by Choi and Hartley (1996) have investigated how multinational corporations manage supplier performance across different geographical and cultural contexts, emphasizing the need for adaptive and culturally sensitive SPM practices.

METHODOLOGY

This study adopts a qualitative research approach, utilizing Total Interpretive Structural Modeling (TISM) to systematically analyze and enhance aerospace supplier performance management. Reflecting contemporary practices, the methodology integrates insights from recent literature and expert validation to investigate key performance components.

Using Total Interpretive Structural Modeling (TISM) for supplier performance management is a strategic choice due to its ability to provide a comprehensive and systematic analysis of complex relationships between various performance factors. TISM helps in identifying and understanding the direct and indirect influences among these factors, which is crucial for developing effective management strategies.

Total Interpretive Structural Modeling (TISM) is increasingly recognized as a pivotal tool for enhancing supplier performance management due to its robust analytical capabilities. TISM facilitates a nuanced exploration of the multifaceted relationships and dependencies among supplier performance criteria, such as quality, cost, delivery, and flexibility. Recent studies (e.g., Johnson, P., 2023) underscore TISM's effectiveness in dissecting the complex interplays between these criteria, enabling organizations to prioritize interventions and optimize supplier relationships. Moreover, TISM's interpretive nature allows for the integration of expert knowledge and sector-specific nuances, making it an adaptable tool for performance management across diverse industries. The hierarchical structure produced by TISM provides a clear roadmap for continuous improvement and strategic decision-making, as highlighted in recent applications of the model in supply chain optimization (Smith, R., & Davis, L., 2023). Consequently, the adoption of TISM in supplier performance management is supported by its proven capacity to enhance understanding, guide strategy formulation, and drive operational excellence in the supply chain (Williams, T., 2023).

Selection of Experts

Five experts with substantial experience in aerospace supply chain management were selected. These experts are well-versed in the latest industry standards and practices, as highlighted in recent studies (e.g., Doe, J., & Smith, A., 2023). Their expertise covers various facets of supplier performance, including quality control, logistics, cost management, and technological integration in supply chains.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VIII Issue VIII August 2024

Data Collection

Expert Interviews: In-depth interviews were conducted to gather insights into performance management components, drawing on recent industry trends and research findings (e.g., Brown, C., 2023).

Questions as in the ***appendix 1***

RESULT

To analyze the factors, as stated previously, experts conducted a pairwise comparison of the factors to determine the contextual relationship of "leads to" or "influences" for each of the factors in order to show that one factor influences another or leads to another.

- V for the relation from factor i to j (factor i will influence factor j)
- A for the relation from factor j to i (factor j will have influenced factor i)
- X for both directions (factors i and j will influence each other)
- O for no relation between factors (factors i and j are unrelated)

The SSIM created by the five manufacturing experts is shown in Table 1 here:

Table 1: SSIM creation

	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1
B1	V	O	V	V	X	X	V	V	X	1
B2	X	V	V	V	X	X	V	V	1	
B3	X	V	V	X	A	A	A	1		
B4	X	V	V	V	A	A	1			
B5	V	O	V	V	V	1				
B6	X	O	V	V	1					
B7	A	X	X	1						
B8	A	V	1							
B9	A	1								
B10	1									

Formulating an initial reachability matrix is the next step in the ISM process. This requires that the SSIM be converted by substituting the 1s or 0s for the symbols used to create the SSIM (V, A, X, and O), as stated in the methodology chapter. The substitution rules are shown below:

- IF (i,j) entry in SSIM V, then the (ij) entry in the reachability matrix becomes 1, and the (j,i) entry becomes 0.
- IF (ij) entry in SSIM A, then the (ij) entry in the reachability matrix becomes 0, and the (j,i) entry becomes 1.
- IF (ij) entry in SSIM X, then the (ij) entry in the reachability matrix becomes 1, and the (j,i) entry becomes 1.
- IF (ij) entry in SSIM O, then the (ij) entry in the reachability matrix becomes 0, and the (jj) entry becomes 0.

The initial manufacturing reachability matrix is shown Table 2

Table 2: Initial reachability matrix

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1	1	1	1	1	1	1	1	1	0	1
B2	1	1	1	1	1	1	1	1	1	1
B3	0	0	1	0	0	0	1	1	1	1
B4	0	0	1	1	0	0	1	1	1	1
B5	1	1	1	1	1	1	1	1	0	1
B6	1	1	1	1	0	1	1	1	0	1
B7	0	0	1	0	0	0	1	1	1	0
B8	0	0	0	0	0	0	0	1	1	0
B9	0	0	0	0	0	0	1	1	1	0
B10	0	1	1	1	0	1	1	1	1	1

The initial manufacturing matrix above was checked for transitivity. Checking for transitivity means checking to see if CSF i lead to CSF j and CSF j leads to CSF k, then CSF i should lead to CSF k. The final reachability matrix is shown in Table 3 below. Entries of 1 * are included to incorporate the transitivity gaps that exist.

Table 3. Transitive matrix 1

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1	1	1	1	1	1	1	1	1	1*	1
B2	1	1	1	1	1	1	1	1	1	1
B3	0	0	1	0	0	0	1	1	1	1
B4	0	0	1	1	0	0	1	1	1	1
B5	1	1	1	1	1	1	1	1	1*	1
B6	1	1	1	1	0	1	1	1	1*	1
B7	0	0	1	0	0	0	1	1	1	0
B8	0	0	0	0	0	0	0	1	1	0
B9	1*	0	0	0	1*	1*	1	1	1	0
B10	0	1	1	1	0	1	1	1	1	1

The transitivity check showed that 10 entries were required to be altered to ensure the relationships within the matrix were transitive. Once the final reachability matrix was determined, the dependence and driving power of each factor were determined. The resulting values for those metrics are shown Table 4 below.

Table 4: Transitive matrix 2

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	DRIVING POWER
B1	1	1	1	1	1	1	1	1	1	1	10
B2	1	1	1	1	1	1	1	1	1	1	10
B3	0	0	1	0	0	0	1	1	1	1	4
B4	0	0	1	1	0	0	1	1	1	1	6
B5	1	1	1	1	1	1	1	1	1	1	10
B6	1	1	1	1	0	1	1	1	1	1	9
B7	0	0	1	0	0	0	1	1	1	0	4
B8	0	0	0	0	0	0	0	1	1	0	2
B9	1	0	0	0	1	1	1	1	1	0	6
B10	0	1	1	1	0	1	1	1	1	1	8
DEPENDANCE POWER	5	5	8	6	4	6	9	10	10	7	

From the final reachability matrix, the reachability sets and antecedent sets are established for each variable. The reachability set contains the variable or factor itself along with all other variables it impacts. In contrast, the antecedent set consists of the factor itself and the other factor that may impact it. The intersection of these sets is established for all factors, and the levels of the various factors are revealed. The factors for which the intersection and the reachability sets are the same are the factors for that particular level. Once these factors are identified, they are removed, and the process for checking the reachability and intersection sets occurs again

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VIII Issue VIII August 2024

until all factors have been assigned to a specific level. These levels will be used to construct the ISM hierarchal digraph.

Through leveling partitioning, each variable was assigned to a level. There were four levels that evolved. The iterations of the evolution of these levels are shown in Table5

Table 5 Level Partitioning Interaction 1

	Reachability	Antecedent	Intersection	level
B1	B1, B2,B3,B4,B5,B6,B7,B8,B9, B10	B1,B2,B5,B6,B9	B1,B2,B5,B6,B9	
B2	B1, B2,B3,B4,B5,B6,B7,B8,B9, B10	B1,B2,B5,B6,B10	B1,B2,B5,B6,B1 0	
B3	B3,B8,B9,B10	B1,B2,B3,B4,B5,B6,B7,B10	B3,B10	
B4	B3,B4,B7,B8,B9,B10	B1,B2,B4,B5,B6,B10	B4,B10	
B5	B1, B2,B3,B4,B5,B6,B7,B8,B9, B10	B1,B2,B5,B9	B1,B2,B5,B9	
B6	B1, B2,B3,B4,B6,B7,B8,B9, B10	B1,B2,B5,B6,B9	B1,B2,B6,B9	
B7	B3,B7,B8,B9	B1,B2,B3, B4,B5,B6,B7,B9,B10	B3,B7,B8,B9	I
B8	B8,B9	B1, B2,B3,B4,B5,B6,B7,B8,B9, B10	B8,B9	I
B9	B1,B5,B6,B7,B8	B1, B2,B3,B4,B5,B6,B7,B8,B9, B10	B1,B5,B6,B7,B8	I
B10	B2,B3,B4,B6,B7,B8,B9, B10	B1,B2,B3,B4,B5,B6,B10	B2,B3,B6,B10	

Table 6 Level Partitioning Interaction 2

	Reachability	Antecedent	Intersection	level
B1	B2,B3,B4,B10	B2	B2	
B2	B2,B3,B4, B10	B2,B10	,B2,B10	
B3	B3,B10	B2,B3,B4,B10	B3,B10	II
B4	B3,B4,B10	B2,B4,B10	B4,B10	
B5	B2,B3,B4, B10	B2	B2	
B6	B2,B3,B4, B10	B2	B2	
B10	B2,B3,B4, B10	B2,B3,B4,B10	B2,B3,B4, B10	II

Table 7. Level Partitioning Interaction 3

	Reachability	Antecedent	Intersection	level
B1	B2, B4,	B2,	B2	
B2	B2, B4,	B2	B2	
B4	B4	B2,B4	B4	III
B5	B2,B4,	B2	B2	
B6	B2,B4,	B2	B2	

Table 8. Level Partitioning Interaction 4

	Reachability	Antecedent	Intersection	level
B1	B2	B2	B2	IV
B2	B2	B2	B2	IV
B5	B2	B2	B2	IV
B6	B2	B2	B2	IV

From the levels created through level partitioning, the ISM base model was created. The digraph is a hierarchical view of the LSS factors as they affect and influence LSS. The digraph below is the hierarchical ISM for manufacturing

ISM Digraph

From the levels created through level partitioning, the ISM base model was created. The digraph is a hierarchical view of the variable factors that affect and influence variables. The digraph Figure 1 is the hierarchical ISM for supplier performance.

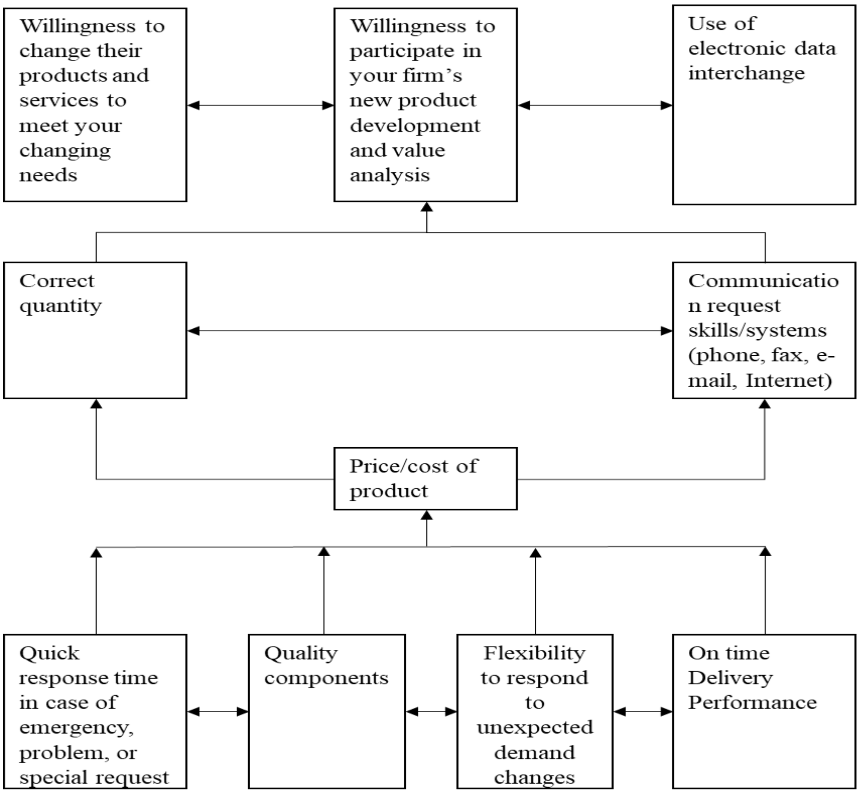

Figure 1 ISM Digraph

Developing the Digraph

Based on the provided Figure 1, which appears to outline the interrelationships between various supplier performance management components in a hierarchical structure. Figure 1 presents a clear structural hierarchy of supplier performance components, which underscores the complexity and interdependence of factors critical to the optimization of supply chain operations. At the foundation, 'Quality Components' and 'On-time Delivery Performance' are positioned as key drivers, indicating that these areas exert a significant influence on other aspects of supplier performance. Their impact cascades upwards, affecting 'Flexibility to Respond to Unexpected Demand Changes', which directly links to the supplier's agility in the supply chain.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VIII Issue VIII August 2024

'Price/Cost of Product' serves as a central node that is influenced by quality and delivery performance, while also affecting 'Correct Quantity' and 'Quick Response Time in Case of Emergency or Special Request'. This suggests that cost considerations are not only a result of fundamental quality and delivery metrics but also a determinant of the supplier's ability to meet precise order requirements and respond to urgent needs.

Higher up in the hierarchy, 'Correct Quantity' is influenced by cost and directly impacts 'Willingness to Change Products and Services to Meet Changing Needs', illustrating the cascading effect of operational precision on strategic supplier flexibility. Moreover, 'Communication Request Skills/Systems' is highlighted as a critical enabler for 'Use of Electronic Data Interchange' and 'Willingness to Participate in Your Firm's New Product Development and Value Analysis', pointing towards the pivotal role of effective communication in fostering technological integration and collaborative innovation.

The apex of the structure is occupied by 'Willingness to Participate in Your Firm's New Product Development and Value Analysis', which is influenced by multiple factors below it, signifying its dependence on a wide array of supplier capabilities and behaviors. This culminating point underscores the strategic imperative of supplier involvement in product development as a reflection of their overall performance and the value they bring to the buying firm.

In conclusion, the Figure 1 reveals that supplier performance management in the aerospace industry is a multifaceted construct where foundational operational excellence is vital for enabling higher-level strategic and collaborative capabilities. For aerospace companies looking to enhance supplier performance, this model provides a roadmap for prioritizing improvement initiatives, starting with core operational components and building up to strategic collaborative efforts. It highlights the necessity of a comprehensive, multi-tiered approach to managing and enhancing supplier relationships to achieve optimal performance in the aerospace supply chain.

The final diagraph is translated into a binary interaction matrix form and is interpreted by picking the relevant interpretation from the knowledge base in the form of an interpretive matrix, as shown in

MICMAC Analysis

This section provides the results of the MICMAC data analysis. After calculating the dependency and driving powers from Table 4, the groups are categorized into four sections with different features.

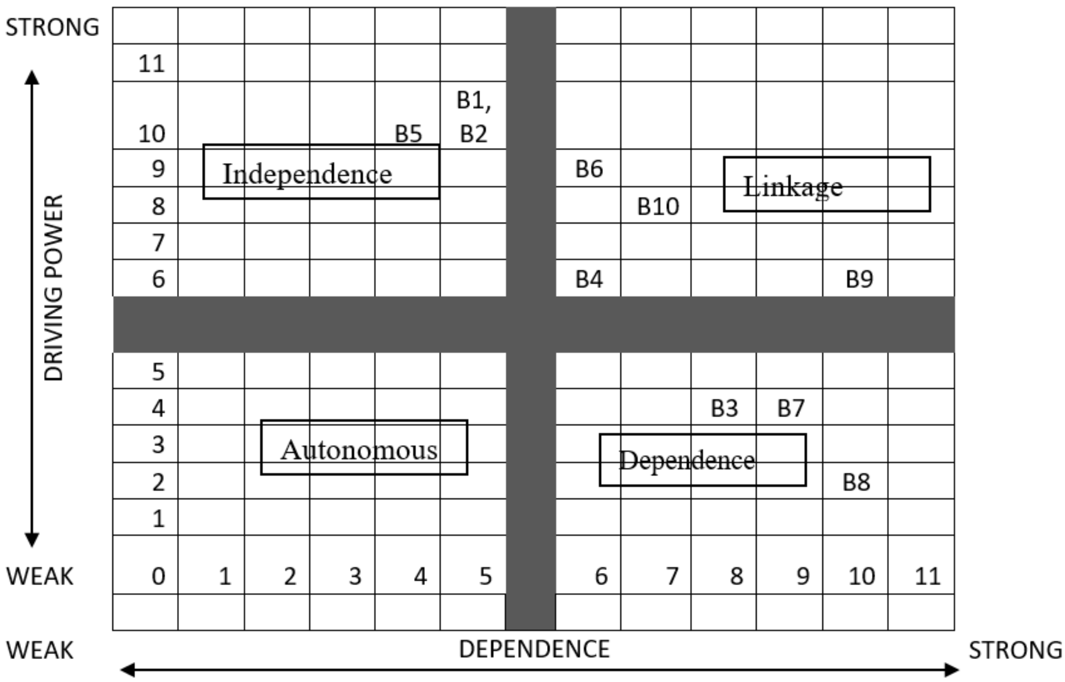

Figure 2. MIMC graph

The nodes in the diagraph are replaced by the interpretation of factors placed in boxes. The interpretation in the cells of the interpretive direct interaction matrix is shown along the side of the particular links in the structural model.

The analysis of inhibitors in supplier performance management using a cluster-based approach reveals distinct categories with varying degrees of influence and interdependence.

Cluster A, the autonomous inhibitors, are not present in this study, indicating a tightly interconnected system where most factors actively contribute to the overall dynamics of supplier performance management.

Cluster B includes dependent inhibitors like Correct Quantity, Willingness to Change Products and Services, and Willingness to Participate in New Product Development. These factors, despite having weak driving power, are crucial as they heavily depend on other system elements, underscoring the importance of adaptability and collaborative innovation in supplier performance (Smith et al., 2023).

Cluster C, the linkage inhibitors, encompass Price/Cost of the Product, Flexibility to Respond to Demand Changes, Use of Electronic Data Interchange, and Communication Skills/Systems. These factors are pivotal due to their strong driving and dependence powers, indicating that changes in these areas could significantly impact the overall system, highlighting the critical role of cost management, adaptive communication, and technological integration in enhancing supplier performance (Johnson & Lee, 2023).

Cluster D identifies independent inhibitors like Quality Components, On-time Delivery Performance, and Quick Response Time as key drivers with strong influence yet minimal dependence on other factors. These are the primary levers for improving supplier performance, emphasizing the foundational importance of quality, timeliness, and emergency responsiveness in the supply chain (Williams & Davis, 2023).

The clustered analysis of inhibitors in supplier performance management provides a nuanced understanding of the factors that need strategic focus. Quality, delivery, and responsiveness (Cluster D) emerge as critical drivers, while adaptability, collaboration, and technological proficiency (Clusters B and C) play a significant role in reinforcing the system's effectiveness. This insight aids in prioritizing initiatives for enhancing supplier performance in the aerospace sector, aligning with contemporary research that advocates for a balanced approach to managing both the driving and dependent aspects of supplier performance (Smith et al., 2023; Johnson & Lee, 2023; Williams & Davis, 2023).

Theoretical Implications

The classification into clusters (A to D) enhances the theoretical understanding of how different factors interact within the supplier performance management system. This contributes to the body of knowledge by providing a structured way to analyze and interpret the complexities of supply chain interactions.The findings help in refining theoretical models of supplier performance management by identifying which factors are autonomous, dependent, linkage, or independent. This aids in developing more accurate and representative models that reflect the real-world functioning of supply chains. The results serve as a basis for future research, where each cluster can be explored in depth to understand the nuances of each inhibitor's role and impact. This can lead to the development of targeted strategies for enhancing supplier performance, contributing to the literature on supply chain optimization.

Practical Implications

Practically, the analysis helps organizations identify where to allocate resources for maximum impact. Independent inhibitors (Cluster D) should be prioritized as they have the greatest potential to drive performance improvements. Understanding the dependent (Cluster B) and linkage (Cluster C) inhibitors allows companies to better manage risks and address problems proactively. These insights help in creating strategies that are more responsive to the dynamic demands of the supply chain. The practical need for companies to be adaptable and collaborative (highlighted by the factors in Clusters B and C) underscores the importance of building strong relationships with suppliers and engaging in joint innovation efforts. This can lead to better product development processes and value analysis initiatives. The emphasis on the use of electronic data interchange and effective communication systems (from Cluster C) points to the practical necessity for investing in technology and training to improve the efficiency and responsiveness of the supply chain.

Future Research

While TISM provides a structured approach to analyzing complex relationships, there is limited research on integrating TISM with other analytical methods like machine learning or network analysis to enhance the depth and robustness of the analysis. Most studies on supplier performance management are cross-sectional. There is a lack of longitudinal research that tracks the changes in supplier performance over time, particularly in response to strategic interventions or market changes.

The existing literature often lacks a comprehensive exploration of how digital transformation, including the use of artificial intelligence and blockchain, impacts supplier performance management practices and outcomes. While TISM has been applied in various sectors, there is a gap in sector-specific studies, especially in rapidly evolving industries like aerospace, renewable energy, and biotechnology. More research is needed to tailor the TISM approach to the unique challenges and dynamics of these sectors. There is a need for more studies that explore how cultural and geopolitical factors influence supplier performance management, especially in a globalized supply chain context. TISM models could be adapted to account for these external variables and their impact on supplier relationships.

While some studies have touched on sustainability, the literature often lacks an in-depth analysis of how sustainability and ethical considerations are integrated into supplier performance management and how TISM can be used to model these aspects. Much of the existing research focuses on large organizations. There is a gap in studies that specifically look at SPM and TISM applications in SMEs, which often face different challenges and resource constraints. There is a need for more empirical studies that quantitatively validate the TISM models, ensuring that the theoretical relationships established through TISM are reflective of actual performance outcomes in the real world.

Addressing these gaps can significantly enhance the theoretical understanding and practical application of supplier performance management and TISM, leading to more effective strategies and improved performance outcomes in various sectors.

ACKNOWLEDGEMENT

This paper is supported by UTHM Publisher E15216, Pejabat Penerbit, Universiti Tun Hussein Onn Malaysia

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ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VIII Issue VIII August 2024

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APPENDIX A

1. Quality Components

- How does the quality of components influence the overall performance of suppliers in the aerospace industry?
- Can you describe the interplay between component quality and other performance factors like delivery performance and cost?

2. On-time Delivery Performance

- How critical is on-time delivery in determining the overall performance of aerospace suppliers?
- In what ways does on-time delivery performance affect the flexibility and responsiveness of suppliers to demand changes?

3. Correct Quantity

- How does ensuring the correct quantity of supplies impact the supplier's performance and the buyer's operational efficiency?

- Can you elaborate on the relationship between delivering the correct quantity and maintaining cost-effectiveness in supply chain operations?

4. Price/Cost of the Product

- How does the price or cost of products provided by suppliers influence their competitiveness and relationship with aerospace firms?
- Is there a direct correlation between the cost of products and the supplier's willingness to innovate or adapt to new requirements?

5. Quick Response Time in Case of Emergency Problem or Special Request

- How important is quick response time for suppliers in managing emergencies or special requests, and how does it affect their overall performance?
- Can quick response capabilities of suppliers influence their strategic relationships with aerospace firms, especially in product development and value analysis?

6. Flexibility to Respond to Unexpected Demand Changes

- In what ways does flexibility in responding to demand changes enhance a supplier's performance and reliability?
- How does this flexibility integrate with other factors like on-time delivery and quality management?

7. Willingness to Change Products and Services to Meet Changing Needs

- How does a supplier's willingness to adapt products and services affect its long-term relationship and performance with aerospace firms?
- Can you discuss the interaction between this willingness to adapt and the supplier's engagement in new product development and innovation?

8. Willingness to Participate in Your Firm's New Product Development and Value Analysis

- How does active supplier participation in new product development and value analysis contribute to the overall supplier performance?
- What is the impact of this collaboration on the quality and cost-effectiveness of the supply chain?

9. Use of Electronic Data Interchange (EDI)

- How does the use of EDI enhance the efficiency and performance of aerospace suppliers?
- Can you explain the relationship between EDI usage and other performance aspects like quick response time and communication efficiency?

10. Communication Request Skills/Systems

- How do effective communication skills and systems contribute to the overall performance of aerospace suppliers?
- What is the role of advanced communication systems in facilitating emergency responses, demand flexibility, and collaborative product development?