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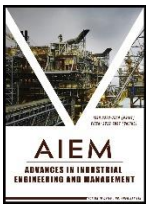

REVIEW ARTICLE

VALUE ENGINEERING AND VALUE ANALYSIS: UNEXPLORED POTENTIALS IN PROCUREMENT AND SUPPLY CHAIN MANAGEMENT

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ABSTRACT

This paper delves into the intricacies of Value Engineering (VE) and Value Analysis (VA) and their transformative impacts on procurement and supply chain management. As organizations navigate the complexities of the modern business landscape, VE and VA emerge as pivotal methodologies, guiding them towards optimal value realization. The research underscores the multifaceted benefits of integrating these methodologies, ranging from cost savings and efficiency improvements to enhanced stakeholder relationships and risk mitigation. However, the journey of VE and VA integration is not devoid of challenges. Organizational resistance, technical hurdles, and the complexities of change management often pose significant barriers. Yet, the promise of transformative impacts, reshaping the contours of procurement and supply chain management, remains undeniable. The paper also highlights the future directions of VE and VA, emphasizing the potential synergies with emerging technologies like artificial intelligence, the Internet of Things, and machine learning. As the global emphasis on sustainability intensifies, the research probes how VE and VA can be tailored to prioritize sustainable practices. The exploration concludes with recommendations for further research, illuminating areas ripe for deeper investigation. In the vast landscape of organizational processes, VE and VA stand out as potent tools, promising a profitable, sustainable, innovative, and value-driven future.

KEYWORDS

Value Engineering, Value Analysis, Supply Chain Management, Sustainability.

1. INTRODUCTION

1.1 Background of Value Engineering and Value Analysis

Value Engineering (VE) and Value Analysis (VA) have emerged as pivotal methodologies in the realm of procurement and supply chain management. Historically, these techniques were developed to optimize costs while ensuring that quality and performance were not compromised. Over the years, their significance has only amplified, especially in the context of procurement and supply chain management, where the balance between cost, quality, and timely delivery is paramount.

The evolution of supply chains has been a topic of considerable interest among scholars and industry experts alike. Supply chains have undergone significant transformations, changing in size, shape, configuration, and the manner in which they are coordinated, controlled, and managed (MacCarthy et al., 2016). As these supply chains matured and evolved, the role of VE and VA became increasingly crucial. These methodologies provided the tools and frameworks necessary to navigate the complexities of modern supply chains, ensuring that organizations could achieve efficiency, reduce costs, and maintain quality standards.

Technological advancements are one of the primary drivers behind the evolution of supply chains. The integration of technologies such as Big Data, cloud computing, and the Internet of Things (IoT) has given rise to the concept of Supply Chain Management 4.0 (SCM 4.0). This new paradigm emphasizes the importance of leveraging communication and technological advances to build adaptive, efficient, and transparent supply chain networks (Frazzon et al., 2019). In this context, VE and VA play a pivotal role in helping organizations harness the potential of these technologies to optimize their procurement and supply chain processes.

Furthermore, the dynamics of markets and competition, policy and regulation, procurement and sourcing strategies, and supply chain re-engineering have also influenced the trajectory of supply chain evolution (MacCarthy et al., 2016). As these factors interact and shape the supply chain landscape, the principles of VE and VA provide the necessary guidance to ensure that organizations can adapt, innovate, and remain competitive.

The application of digital twins in operations and supply chain management is another burgeoning practice that has gained traction in recent years. Digital twins can optimize operations and supply chain functions, providing a more streamlined and efficient approach to managing resources and processes (Bhandal et al., 2022).

Moreover, the rise of B2B e-commerce and the integration of the Internet of Things (IoT) in sustainable supply chain management have further underscored the importance of VE and VA. These technologies have revolutionized the way businesses operate, offering new avenues for cost

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savings, efficiency improvements, and sustainability (Prajapati et al., 2022).

In conclusion, the importance of Value Engineering and Value Analysis in procurement and supply chain management cannot be overstated. These methodologies have been instrumental in guiding organizations through the challenges and opportunities the evolving supply chain landscape presents. As supply chains continue to evolve, the principles of VE and VA will remain at the forefront, ensuring that organizations can achieve their objectives in an efficient, cost-effective, and quality-driven manner.

1.2 Importance in Procurement and Supply Chain Management

In the intricate web of modern business operations, Value Engineering (VE) and Value Analysis (VA) have emerged as quintessential tools, particularly in the domains of procurement and supply chain management. Their significance is underscored by the pressing need for organizations to optimize costs, enhance quality, and ensure timely delivery, all while navigating the complexities of global supply chains.

The realm of procurement has always been a critical component of organizational operations. It involves the strategic acquisition of goods and services at the best possible cost, which meets the company's quality, quantity, time, and location criteria. In this context, VE and VA play an instrumental role by offering methodologies to evaluate products, projects, and services to ascertain if they meet the desired function at the lowest life cycle cost (Amiri Ara et al., 2021). Such an approach ensures that procurement processes are cost-effective and aligned with the organization's long-term objectives.

On the other hand, supply chain management encompasses a broader spectrum of activities, from sourcing raw materials to delivering finished products to consumers. In today's globalized world, supply chains often span multiple countries and involve numerous stakeholders, making them inherently complex. This complexity is further exacerbated by factors such as fluctuating demand patterns, geopolitical uncertainties, technological disruptions, and evolving consumer preferences. Amidst these challenges, VE and VA offer a structured approach to dissecting supply chain processes, identifying inefficiencies, and implementing solutions that enhance value delivery (Bae, 2020).

The food industry is a testament to VE and VA's importance in supply chain management. With consumers becoming increasingly conscious of the quality, safety, and sustainability of the food they consume, there is a growing emphasis on ensuring transparency and efficiency in food supply chains. A study focusing on consumers from Korea, China, and Japan highlighted the significance of various food values, such as safety, taste, and environmental impact, in influencing consumer choices (Jo and Lee, 2021). Such insights underscore the need for food supply chains to be managed with a keen eye on consumer preferences, ensuring that the end product aligns with the values deemed important by the target market.

Moreover, technologies such as blockchain have opened new avenues for enhancing transparency and traceability in supply chains. For instance, in the oil and gas sector, a blockchain system design was proposed to improve the supply chain processes of engineering, procurement, and construction companies, aiming to mitigate cost and time inefficiencies (Amiri Ara et al., 2021). Such innovations, rooted in the principles of VE and VA, are set to redefine the way supply chains operate, making them more resilient, transparent, and value-driven.

In conclusion, the importance of Value Engineering and Value Analysis in procurement and supply chain management is profound. As businesses grapple with the challenges of a dynamic global environment, these methodologies offer a beacon of guidance, ensuring that organizations can deliver unparalleled value to their stakeholders, from suppliers to consumers.

1.3 Objective of the Paper

The rapidly evolving procurement and supply chain management landscape necessitates a comprehensive understanding of the tools and methodologies that can drive efficiency, reduce costs, and enhance value delivery. Among these tools, Value Engineering (VE) and Value Analysis (VA) are pivotal methodologies that have garnered significant attention in academic and industry circles. However, despite their evident importance, a gap in the literature delves into the unexplored potentials of VE and VA, especially in the context of procurement and supply chain management. This paper seeks to bridge this gap by elucidating the intricacies of VE and VA, their historical evolution, their significance in modern procurement and supply chain processes, and the untapped opportunities they present. The objectives for this paper are as follows.

1. To trace the origins and evolution of Value Engineering and Value Analysis. This will provide readers with a comprehensive understanding of how these methodologies have evolved over time, their foundational principles, and their significance in the broader context of business operations.

2. To delve into the importance of VE and VA in the realms of procurement and supply chain management. This exploration will focus on how these methodologies can drive efficiency, reduce costs, and ensure optimal value delivery in supply chain processes, highlighting their transformative potential in modern business contexts.

3. Shed light on the unexplored potentials of VE and VA. While these methodologies have been extensively applied in various industries, their potential has not been fully realized in several areas. This exploration will highlight opportunities for innovation, improvement, and the broader application of VE and VA in diverse sectors.

4. To present real-world case studies where VE and VA have been successfully implemented, leading to tangible benefits. These case studies will serve as exemplars, demonstrating the practical implications of these methodologies and offering insights into their real-world applications and benefits.

Through these objectives, this paper endeavors to serve as a comprehensive guide on Value Engineering and Value Analysis, catering to a diverse audience ranging from industry professionals, academic researchers, students, and anyone keen on understanding the transformative potential of these methodologies in procurement and supply chain management.

2. Historical Overview

Value Engineering (VE) and Value Analysis (VA) are deeply embedded in the annals of engineering and management practices. Historically, these methodologies were conceived as tools to optimize costs without compromising on quality and performance. Their inception can be traced back to the mid-20th century when industries, particularly in the post-war era, faced significant challenges related to resource scarcity and the need for efficient production (Giménez et al., 2020).

During this period, the primary focus was on ensuring that products and services were designed and delivered with optimal value. This meant that organizations had to critically evaluate every aspect of their operations, from product design to procurement and production processes, to identify areas where value could be enhanced or where inefficiencies could be eliminated. The methodologies of VE and VA provided the necessary frameworks for such evaluations, emphasizing a systematic approach to understanding the functions of a product or service and exploring alternative ways to achieve those functions at a reduced cost (Kettinger et al., 1997).

2.1 Evolution of Value Engineering and Value Analysis

The journey of VE and VA from their inception to their current status as pivotal tools in procurement and supply chain management is marked by continuous evolution and adaptation. These methodologies were initially applied in manufacturing, emphasizing product design and production processes. However, as industries evolved and the complexities of global supply chains emerged, the applicability of VE and VA expanded to encompass a broader range of operations, including procurement, logistics, and supply chain management (Espina-Agullo et al., 2016).

One of the significant milestones in the evolution of VE and VA was the integration of customer-centric approaches. The traditional methodologies, which were primarily focused on cost optimization, began to incorporate elements of customer satisfaction and value delivery. This shift was influenced by the growing recognition that value is not just about cost savings but also about meeting and exceeding customer expectations. The Kano model, for instance, provided insights into how different product or service attributes contribute to customer satisfaction, and these insights were integrated into the VE and VA frameworks to ensure that value optimization efforts were aligned with customer preferences (Giménez et al., 2020).

Furthermore, the advent of advanced technologies and data analytics brought about another significant transformation in the VE and VA methodologies. With the ability to capture and analyze vast amounts of data, organizations could gain deeper insights into their operations, identify inefficiencies, and explore innovative solutions to enhance value. The integration of big data and analytics into the VE and VA frameworks enabled a more data-driven approach to value optimization, ensuring that

decisions were based on empirical evidence rather than intuition (Batistič and van der Laken, 2019).

In recent years, the focus of VE and VA has also shifted towards sustainability and environmental considerations. With growing concerns about environmental degradation and the need for sustainable practices, these methodologies have been adapted to ensure that value optimization efforts also consider organizational operations' environmental and social impacts (Zhang et al., 2021).

In conclusion, the evolution of Value Engineering and Value Analysis reflects the changing dynamics of industries and the broader socio-economic environment. From their inception as tools for cost optimization to their current status as comprehensive frameworks for value delivery, VE and VA have continuously adapted to meet the changing needs of organizations and society at large.

2.2 Early Applications in Procurement

In the procurement realm, the early applications of Value Engineering (VE) and Value Analysis (VA) were primarily centered around optimizing costs without compromising the quality or functionality of products and services. As procurement processes became more intricate and globalized, the need for a systematic approach to ensure value in procurement decisions became paramount.

The initial thrust of VE and VA in procurement was to provide a structured methodology that would allow organizations to critically evaluate their procurement decisions. This involved a comprehensive analysis of the functions of the products or services being procured, understanding the needs of the end-users, and exploring alternative solutions that could deliver the same functions at a reduced cost (Akyazi et al., 2020).

One of the early challenges faced in the application of VE and VA in procurement was the overemphasis on cost reduction, often at the expense of other critical factors such as quality, sustainability, and long-term value. However, with the integration of multi-criteria decision-making processes, organizations began to adopt a more holistic approach to procurement, considering a range of factors beyond just cost. This shift was instrumental in ensuring that procurement decisions were economically viable, sustainable, and aligned with the organization's long-term goals (Yu et al., 2020).

Furthermore, the early applications of VE and VA in procurement were also influenced by the broader trends in the business environment. For instance, the growing emphasis on sustainability and environmental considerations in the late 20th and early 21st centuries led to integrating green procurement principles into the VE and VA frameworks. This involved evaluating procurement decisions based on cost and functionality and their environmental and social impacts (Yu et al., 2020).

Another significant development in the early applications of VE and VA in procurement was the recognition of the importance of stakeholder engagement. Procurement decisions often involve multiple stakeholders, each with their own perspectives and priorities. The integration of stakeholder engagement processes into the VE and VA frameworks ensured that procurement decisions were more inclusive and aligned with the needs and expectations of all relevant stakeholders (Rosłon et al., 2020).

In conclusion, the early applications of Value Engineering and Value Analysis in procurement laid the foundation for the modern, holistic, and multi-dimensional approach to procurement that we see today. These methodologies have evolved over time, adapting to the changing dynamics of the business environment and the growing complexities of global supply chains.

2.3 Transition to Modern Supply Chain Management

The evolution of Value Engineering (VE) and Value Analysis (VA) has been closely intertwined with the broader shifts in the paradigms of supply chain management. As global markets expanded and supply chains became more intricate, traditional procurement and supply chain management approaches underwent significant transformations. The transition to modern supply chain management was marked by a shift from linear, siloed operations to integrated, collaborative, and demand-driven models.

In the early days of supply chain management, the primary focus was on optimizing individual components of the supply chain, often in isolation. However, with the increasing complexities of global operations, there was a growing recognition of the need for a more holistic approach. VE and VA, with their emphasis on value optimization and function analysis, provided the necessary frameworks to support this transition (Mishra et al., 2018).

One of the hallmarks of modern supply chain management is the emphasis on collaboration and integration. Organizations began to recognize that value optimization could not be achieved in isolation. Instead, it required close collaboration between suppliers, manufacturers, distributors, and customers. VE and VA methodologies were adapted to support this collaborative approach, emphasizing cross-functional teams and stakeholder engagement in the value optimization process (Ripanti and Tjahjono, 2019).

Another significant shift in modern supply chain management was the focus on demand-driven operations. Traditional supply chain models were often supply-driven, with production schedules based on forecasts and historical data. However, with the advent of advanced technologies and data analytics, supply chains became more responsive to real-time demand signals. VE and VA methodologies were integrated with advanced analytics and demand forecasting tools to ensure value optimization efforts aligned with actual market demand (Hughes et al., 2014).

Furthermore, the transition to modern supply chain management also brought about a renewed emphasis on sustainability and environmental considerations. With growing concerns about environmental degradation and the social impacts of business operations, supply chain management practices evolved to incorporate sustainability principles. VE and VA methodologies were adapted to ensure that value optimization efforts considered economic factors and environmental and social impacts (Heidary Dahooie et al., 2020).

In conclusion, the transition from traditional to modern supply chain management has been marked by significant shifts in paradigms, practices, and priorities. Value Engineering and Value Analysis, with their emphasis on value optimization and function analysis, have played a pivotal role in supporting this transition, ensuring that supply chains are not just efficient but also sustainable, collaborative, and demand-driven.

3. Principles of Value Engineering and Value Analysis

Value Engineering (VE) and Value Analysis (VA) are systematic methodologies aimed at optimizing the value of products, services, or projects. Rooted in function analysis and cost optimization principles, these methodologies have evolved over the years to address the complexities of modern business environments. The principles of VE and VA are grounded in the belief that value can be maximized by identifying and eliminating unnecessary costs without compromising on the quality or functionality of the product or service.

At the heart of VE and VA lies the concept of "function." Every product, service, or project is designed to perform certain functions. By understanding these functions in detail and analyzing the costs associated with them, organizations can identify opportunities to enhance value. This involves a critical evaluation of all aspects of the product or service, from design to delivery, to identify areas where costs can be reduced without affecting the desired functions (Mishra et al., 2018).

Another fundamental principle of VE and VA is the emphasis on a multidisciplinary approach. Value optimization is not the sole responsibility of a single department or team. Instead, it requires collaboration across different functions and disciplines. By bringing together diverse perspectives, organizations can gain a more holistic understanding of the value chain and identify innovative solutions to enhance value (Ripanti and Tjahjono, 2019).

3.1 Core Concepts and Methodologies

VE and VA's core concepts and methodologies are designed to provide a structured framework for value optimization. One of the foundational concepts is the "Function Analysis System Technique" (FAST). FAST is a graphical representation of the functions of a product or service, illustrating the relationships between different functions and identifying opportunities for cost optimization (Jaradat et al., 2017).

Another key methodology is the "Value Index," which is a quantitative measure of the value of a product or service. The Value Index is calculated by dividing the function or performance of the product or service by its cost. A higher Value Index indicates greater value, and organizations can use this metric to benchmark their products or services against competitors and identify areas for improvement (Jankalová and Jankal, 2020).

The VE and VA methodologies also emphasize the importance of stakeholder engagement. By involving stakeholders in the value

optimization process, organizations can ensure that the solutions identified align with the needs and expectations of end-users. This collaborative approach enhances the effectiveness of the VE and VA methodologies and fosters a culture of continuous improvement within the organization (Mishra et al., 2018).

In conclusion, the principles, core concepts, and methodologies of Value Engineering and Value Analysis provide a robust framework for organizations to optimize value across their products, services, and projects. By focusing on function analysis, cost optimization, and stakeholder engagement, VE and VA enable organizations to deliver greater value to their customers and stakeholders.

3.2 Tools and Techniques

Value Engineering (VE) and Value Analysis (VA) are not merely theoretical concepts; they are practical methodologies that rely on a range of tools and techniques to achieve their objectives. These tools and techniques are designed to facilitate the systematic evaluation of functions, identify unnecessary costs, and optimize value across various product or project development stages.

One of the foundational tools in VE and VA is the Function Analysis System Technique (FAST). FAST is a graphical tool that helps understand the functions a product or service intends to perform. By mapping out these functions and their interrelationships, organizations can identify areas where costs can be reduced without compromising on the desired functionality. This technique emphasizes the importance of understanding the "why" behind every function, ensuring that every cost incurred adds value to the end product or service (Annappa & Kallurkar, 2014).

Another critical technique is the Value Index, a quantitative tool that measures the value of a product or service by comparing its function or performance to its cost. A higher Value Index indicates that a product or service offers more value for its cost. This metric is particularly useful for benchmarking products or services against competitors and identifying areas where value can be enhanced (Mishra et al., 2018).

The Decision Matrix is another essential tool in the VE and VA toolkit. It is a structured method for evaluating and ranking multiple alternatives based on specific criteria. Organizations can make informed decisions that optimize value by assigning weights to different criteria and scoring each alternative against these criteria. This tool is particularly useful when multiple potential solutions exist, and a clear, objective method is needed to evaluate them (Usman et al., 2018).

In recent years, the integration of Building Information Modelling (BIM) with VE has emerged as a powerful technique for cost optimization in the construction industry. BIM provides a 3D construction project model, offering robust visualization capabilities. When combined with VE methodologies, BIM allows for a more detailed function analysis, risk assessment, and life-cycle cost analysis, ensuring that construction projects are cost-effective and aligned with the desired value outcomes (Usman et al., 2018).

In conclusion, the tools and techniques of Value Engineering and Value Analysis provide a structured framework for organizations to systematically evaluate functions, identify unnecessary costs, and optimize value. By leveraging these tools and techniques, organizations can ensure that their products, services, or projects deliver maximum value for the costs incurred.

3.3 Benefits and Limitations

Value Engineering (VE) and Value Analysis (VA) have been recognized as potent methodologies for optimizing value in various sectors, from manufacturing to construction. Their systematic approach to evaluating functions, identifying unnecessary costs, and enhancing value has made them indispensable tools in the modern business landscape. However, like all methodologies, VE and VA have their own benefits and limitations.

Benefits:

1. Cost Reduction: One of the primary benefits of VE and VA is the potential for significant cost reduction. Organizations can achieve substantial savings by systematically evaluating functions and identifying areas where costs can be reduced without compromising functionality (Heidary Dahooie et al., 2020).

2. Enhanced Functionality: VE and VA are not just about cutting costs; they also focus on enhancing the functionality of products, services, or projects. This dual focus ensures that while costs are minimized, the value delivered to the end-user is maximized (Heidary Dahooie et al., 2020).

3. Stakeholder Engagement: VE and VA methodologies emphasize the importance of involving stakeholders in the value optimization process. This collaborative approach ensures that the solutions identified align with the needs and expectations of end-users, fostering a culture of continuous improvement (Grimm et al., 2019).

4. Structured Framework: The methodologies provide a structured framework that organizations can follow. This structured approach ensures consistency in the value optimization process, making it easier for organizations to replicate successes across different projects or products (Jareonsin and Pumas, 2021).

5. Multidisciplinary Approach: VE and VA promote a multidisciplinary approach, bringing together experts from various fields to collaborate on value optimization. This diversity of perspectives often leads to innovative solutions that might not have been identified in a more siloed approach (Heidary Dahooie et al., 2020).

Limitations:

1. Overemphasis on Cost: One of the criticisms of VE and VA is that there can be an overemphasis on cost reduction, sometimes at the expense of other important factors like quality or sustainability (Heidary Dahooie et al., 2020).

2. Complexity: The methodologies, especially when applied to large projects, can be complex and time-consuming. This can sometimes deter organizations from fully embracing VE and VA (Grimm et al., 2019).

3. Resistance to Change: Implementing VE and VA often requires significant changes to established processes and workflows. This can lead to resistance from employees or other stakeholders accustomed to traditional working methods (Jareonsin & Pumas, 2021).

4. Potential for Subjectivity: While VE and VA provide a structured framework, there is still room for subjectivity, especially when evaluating functions or weighing different criteria. This can sometimes lead to inconsistent results (Heidary Dahooie et al., 2020).

5. Limitations in Tools: While several tools and techniques are associated with VE and VA, they might not always be suitable for every scenario. Organizations often need to adapt or modify these tools to fit their specific needs (Grimm et al., 2019).

In conclusion, while Value Engineering and Value Analysis offer numerous benefits, it's essential for organizations to be aware of their limitations. By understanding both the strengths and weaknesses of these methodologies, organizations can use them more effectively to optimize value across their products, services, or projects.

4. Unexplored Potentials in Procurement

Procurement has evolved significantly over the years as an essential function in organizations. With the advent of digital technologies, globalization, and increasing complexities in supply chains, the role of procurement has expanded beyond mere transactional activities. In this context, Value Engineering (VE) and Value Analysis (VA) present unexplored potentials that can revolutionize procurement practices, especially in enhancing supplier relationships.

4.1 Enhancing Supplier Relationships

Supplier relationships form the backbone of effective procurement. Strong, collaborative relationships with suppliers can lead to improved product quality, cost savings, and innovation. VE and VA can play a pivotal role in enhancing these relationships in several ways.

Firstly, the systematic approach of VE and VA can help in identifying and prioritizing cost reduction solutions in the supply chain. By integrating value engineering principles, suppliers and buyers can collaboratively identify areas where unnecessary costs can be eliminated without compromising on the value delivered (Heidary Dahooie et al., 2020). This collaborative approach leads to cost savings and fosters trust and mutual understanding between suppliers and buyers.

Secondly, the digital procurement transformation, often termed "Procurement 4.0," emphasizes the importance of leveraging digital technologies to enhance supplier relationships. Integrating VE and VA in

digital procurement processes can lead to more informed decision-making, better supplier evaluations, and continuous digital innovation. The emphasis on continuous improvement and innovation in VE and VA aligns perfectly with the principles of Procurement 4.0, ensuring that supplier relationships are transactional and strategic (Sjödin et al., 2021).

Furthermore, the reactivation of previously ended buyer-supplier relationships can also benefit from the principles of VE and VA. Organizations can make informed decisions about re-engaging with past suppliers by analyzing the reasons for the termination of past relationships and identifying areas of value optimization. This provides an opportunity to tap into previously established trust and collaboration and ensures that the reactivated relationship is more value-driven and aligned with the organization's current needs (Poblete and Bengtson, 2020).

In conclusion, the unexplored potentials of Value Engineering and Value Analysis in procurement, especially in enhancing supplier relationships, are vast. By integrating these methodologies into modern procurement practices, organizations can ensure that their supplier relationships are not just cost-effective but also strategic, collaborative, and value-driven.

4.2 Cost Reduction and Efficiency Improvement

In the realm of procurement, the overarching goal is to achieve optimal value for money. This involves minimizing costs and ensuring that the quality and functionality of the procured goods or services are not compromised. Value Engineering (VE) and Value Analysis (VA) have emerged as potent tools in this context, offering a structured approach to cost reduction and efficiency improvement.

One of the primary objectives of VE and VA is to identify and eliminate unnecessary costs while maintaining or even enhancing the core functionality of a product or service. This is achieved by systematically evaluating functions and thoroughly analyzing the value associated with each function. By distinguishing between essential and non-essential functions, organizations can target areas where costs can be reduced without affecting the overall value delivered to the end-user (Heidary Dahooie et al., 2020).

The integration of VE and VA in procurement processes can lead to significant cost savings. For instance, by applying these methodologies to the supply chain, organizations can prioritize cost reduction solutions, leading to a more streamlined and cost-effective supply chain. This not only results in direct cost savings but also enhances the overall efficiency of the procurement process (Heidary Dahooie et al., 2020).

Furthermore, the application of VE and VA is not limited to tangible products. These methodologies can also be applied to building designs to achieve energy efficiency. Organizations can reduce energy consumption by optimizing building designs, leading to long-term cost savings. An integrated approach that combines multi-objective genetic algorithms with building simulation can assist in optimizing building designs, ensuring a balance between initial construction costs, energy consumption, and thermal comfort (Lin and Yang, 2018).

In addition to direct cost savings, the application of VE and VA in procurement can lead to improved supplier relationships, better negotiation outcomes, and enhanced stakeholder engagement. Organizations can engage with suppliers more collaboratively by focusing on value optimization, leading to win-win outcomes for both parties (Sjödin et al., 2021).

In conclusion, the unexplored potentials of Value Engineering and Value Analysis in procurement, especially in the context of cost reduction and efficiency improvement, are vast. Organizations that effectively integrate these methodologies into their procurement processes stand to gain not only in terms of cost savings but also in enhanced value delivery, improved stakeholder relationships, and overall efficiency.

4.3 Risk Management and Mitigation

Risk management is a pivotal aspect of procurement, especially when considering the multifaceted nature of supply chains and the myriad of challenges they face. Value Engineering (VE) and Value Analysis (VA) have emerged as instrumental tools in addressing and mitigating risks, ensuring that procurement processes are both efficient and resilient.

One of the primary applications of VE and VA in risk management is the identification of potential vulnerabilities within the procurement process. By systematically analyzing each function and its associated value, organizations can pinpoint areas that are susceptible to risks, be it from supply chain disruptions, quality issues, or financial instabilities. This proactive approach allows for the development of contingency plans, ensuring that the organization is well-prepared to address challenges as they arise (Mavroulis et al., 2022).

Furthermore, in tectonically active regions or areas with significant environmental challenges, the risk of natural disasters such as landslides or floods can pose significant threats to procurement processes. VE and VA can be employed to assess the structural integrity of supply chains, ensuring that they are resilient to such external shocks. For instance, using geospatial technologies, organizations can prioritize areas that are more prone to natural disasters, allowing for the implementation of preventive measures and ensuring the continuity of supply chains (Obeidat et al., 2021).

In addition to natural disasters, the global nature of modern supply chains means that they are also susceptible to geopolitical risks. Trade disputes, regulatory changes, or political instabilities can all disrupt supply chains, leading to increased costs and delays. VE and VA can assist organizations in identifying alternative suppliers or routes, ensuring that they are not overly reliant on a single source or region. This diversification strategy can significantly reduce the impact of geopolitical risks on procurement processes (Ciurleo et al., 2021).

Lastly, the integration of VE and VA in procurement processes can also lead to improved stakeholder engagement. By focusing on value optimization, organizations can ensure that all stakeholders, from suppliers to end-users, are aligned in their objectives. This collaborative approach can lead to better risk identification and mitigation strategies, ensuring that all parties are well-prepared to address challenges collaboratively (Selkimäki et al., 2020).

In conclusion, applying Value Engineering and Value Analysis in risk management and mitigation within procurement processes offers a structured and systematic approach to address the myriad of challenges modern supply chains face. By proactively identifying and addressing risks, organizations can ensure that their procurement processes are both efficient and resilient.

5. Unexplored Potentials in Supply Chain Management

Supply Chain Management (SCM) has evolved over the years, adapting to the changing dynamics of the global market. With the advent of new technologies and methodologies, there are still unexplored potentials that can revolutionize the way supply chains operate. Value Engineering (VE) and Value Analysis (VA) have been recognized as powerful tools that can unlock these potentials, especially when integrated with modern technological advancements.

5.1 Streamlining Supply Chain Processes

Streamlining supply chain processes is crucial for organizations aiming to achieve operational efficiency, reduce costs, and enhance customer satisfaction. The integration of VE and VA into SCM can lead to significant improvements in these areas.

Big data has emerged as a transformative force in SCM, offering insights to optimize process. The value of big data in SCM is primarily motivated by the enhancement of business processes and decision-making practices. By analyzing vast amounts of data, organizations can identify inefficiencies, forecast demand more accurately, and make informed decisions that align with market dynamics (Brinch, 2018).

Furthermore, the convergence of Industry 4.0 technologies with lean manufacturing tools presents a unique opportunity to streamline supply chain processes. A conceptual model that merges these technologies with lean tools can help reduce waste and minimize costs in the supply chain planning context. This integrated approach ensures that supply chains are agile, sustainable, resilient, and flexible, adapting quickly to market changes and disruptions (Reyes et al., 2021).

Moreover, applying VE and VA in the supply chain can lead to identifying and prioritizing cost reduction solutions. By integrating these methodologies with gray multi-criteria decision-making, organizations can effectively target areas of improvement, ensuring that costs are minimized without compromising on value delivery (Heidary Dahooie et al., 2020).

The Mediterranean region, known for its rich biodiversity, offers insights into how supply chains can evolve. The region's market for Medicinal and Aromatic Plants (MAPs) highlights the importance of streamlining supply chain processes. These plants, which form a significant part of the region's cultural heritage, underscore the need for efficient supply chains that cater

to the demands of the market while ensuring sustainability. A supply chain analysis of the MAPs sector reveals the importance of certification, labeling, market development, and research in streamlining processes (Taghouti et al., 2022).

In conclusion, the integration of Value Engineering and Value Analysis into Supply Chain Management offers a pathway to streamline processes, reduce costs, and enhance operational efficiency. As the global market continues to evolve, organizations that leverage these tools and methodologies will be better positioned to navigate the complexities of modern supply chains.

5.2 Enhancing Product Quality and Value

In the competitive landscape of today's global market, product quality and value are paramount. The integration of Value Engineering (VE) and Value Analysis (VA) into Supply Chain Management (SCM) can significantly enhance these aspects, ensuring that products not only meet but exceed customer expectations.

The importance of product quality cannot be overstated. A product that fails to meet quality standards can lead to customer dissatisfaction, product recalls, and even legal consequences. Moreover, negative reviews can quickly spread in today's digital age, damaging a company's reputation. Therefore, ensuring product quality is about meeting standards and building customer trust and customer loyalty (Handayani & Setyatama, 2020).

One of the primary ways VE and VA can enhance product quality is by identifying and eliminating non-value-added activities in the supply chain. These are activities that do not contribute to the product's value but incur costs. By focusing on value-added activities, companies can ensure that every step in the supply chain contributes to the product's quality and value.

Furthermore, the integration of VE and VA can lead to better supplier relationships. By analyzing each supplier's value, companies can identify and collaborate with those that provide the highest quality materials. This not only ensures product quality but can also lead to cost savings. Moreover, by working closely with suppliers, companies can ensure that they are aligned in their quality objectives, leading to a more streamlined and efficient supply chain (Eslamipirharati et al., 2022).

Another significant aspect is the role of technology in enhancing product quality and value. With the advent of Industry 4.0, technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and Big Data are revolutionizing SCM. These technologies can provide real-time data on product quality, allowing for immediate corrective actions. Moreover, they can provide insights into customer preferences, ensuring that products are not only of high quality but also meet customer needs (de Sá et al., 2022).

In conclusion, the integration of Value Engineering and Value Analysis into Supply Chain Management offers a structured approach to enhancing product quality and value. Companies can ensure that their products stand out in the competitive global market by focusing on value-added activities, collaborating with high-quality suppliers, and leveraging modern technologies.

5.3 Sustainability and Environmental Considerations

In the modern era, sustainability and environmental considerations have become central to the discourse of business operations. The integration of Value Engineering (VE) and Value Analysis (VA) into Supply Chain Management (SCM) offers a promising avenue to address these concerns, ensuring that supply chains not only meet economic objectives but also contribute positively to the environment and society.

The circular economy, which emphasizes the continuous use of resources and the minimization of waste, has emerged as a pivotal concept in sustainable SCM. Del Giudice et al. (2020) explored the role of big data in enhancing the circular economy within supply chains. Their findings highlighted that circular economy practices can significantly enhance firm performance when combined with big-data-driven supply chain strategies. This underscores the importance of technological integration in achieving sustainability goals.

Furthermore, Small and Medium-sized Enterprises (SMEs) have adopted lean practices to reduce waste across their organizational value chain, promoting sustainability. Has a conducted a study on SMEs within the manufacturing sector in the Midlands, UK, and found that sustainability practices, combined with lean practices and process innovation, significantly enhance sustainability performance (Dey et al., 2019). The study also revealed that lean practices have a more pronounced mediating effect compared to process innovation in achieving sustainability outcomes.

Another dimension of sustainability in SCM pertains to the social aspects.To emphasized the importance of integrating socially sustainable practices in SCM (Khokhar et al., 2020). Their research on the Pakistani manufacturing industry highlighted that organizational learning, operational performance, and customer satisfaction are critical dimensions of social sustainability. This indicates that for a supply chain to be truly sustainable, it must address not only environmental but also social concerns.

In conclusion, the integration of VE and VA into SCM provides a structured approach to address sustainability and environmental considerations. By leveraging technological advancements, adopting lean practices, and emphasizing social sustainability, supply chains can achieve holistic sustainability, ensuring a balance between economic, environmental, and social objectives.

6. Case Studies and Real-World Applications

The practical application of Value Engineering (VE) and Value Analysis (VA) in procurement and supply chain management can be best understood through real-world case studies. These case studies provide insights into the challenges faced by organizations and the strategies employed to overcome them using VE and VA. They also highlight the tangible benefits derived from the application of these methodologies.

6.1 Success Stories in Procurement

One of the most compelling success stories in procurement is the integration of Building Information Modelling (BIM) with Value Engineering for construction cost control. A high-rise building project in China is a testament to this integration's benefits. The project faced challenges related to cost control, optimization, and ensuring the overall quality and performance. By integrating BIM with VE, the project team was able to facilitate design modifications, extract essential information such as cost data, and make informed decisions (Li, Wang, and Alashwal, 2021). The result was a 10% saving in project cost and duration. Moreover, the overall quality and performance of the project were significantly enhanced. This case underscores the importance of leveraging technology and VE methodologies in tandem to achieve optimal results in procurement.

Another success story revolves around the manufacturing sector, where the emphasis on green component procurement has gained traction. A study on Taiwanese manufacturing chains, among the world's largest manufacturing clusters of high-technology components and products, highlighted the benefits of green component procurement collaborations. The study found that collaborative planning for procurement quantity and accurate fulfillment by suppliers significantly improved cost-effectiveness and shipping time efficiency (Yan et al., 2016). This case emphasizes the importance of collaboration and sustainable practices in enhancing procurement processes.

In the realm of education, the integration of robotics with mathematics, termed as "robot-math," has been explored to enhance proportional reasoning skills among students. A computer-based 3D game called Expedition Atlantis was developed, where students calculated the correct quantities of wheel rotations to move the robot to desired locations. The intervention significantly improved students' reasoning skills, highlighting the potential of integrating technology with traditional teaching methodologies (Alfieri et al., 2015).

In conclusion, these success stories underscore the versatility and efficacy of Value Engineering and Value Analysis in diverse sectors. They serve as a testament to the potential of these methodologies in driving efficiency, cost savings, and overall project success.

6.2 Transformative Impacts on Supply Chains

The transformative impacts of Value Engineering (VE) and Value Analysis (VA) on supply chains are profound and multifaceted. These methodologies have been instrumental in reshaping the way supply chains operate, ensuring they are more efficient, cost-effective, and responsive to market demands.

In the realm of manufacturing, the emphasis on green component procurement has been a game-changer. A study on Taiwanese manufacturing chains, among the world's largest manufacturing clusters

of high technology components and products, highlighted the benefits of green component procurement collaborations. The study found that collaborative planning for procurement quantity and accurate fulfillment by suppliers significantly improved cost-effectiveness and shipping time efficiency (Yan et al., 2016). This underscores the transformative power of VE and VA in fostering sustainable practices and enhancing procurement processes.

Digital transformation, too, has played a pivotal role in reshaping supply chains. The integration of digital technologies with traditional supply chain processes has enabled organizations to predict, understand, navigate, and change the external ecosystem in which they compete. This has been particularly evident in the banking sector, where digitalization has revolutionized various financial system functions (Hanna, 2016). The lessons from this sector can be extrapolated to supply chains, emphasizing the need for a harmonious blend of technology and VE/VA methodologies.

6.3 Lessons Learned and Best Practices

The journey of integrating VE and VA into supply chains has been filled with both successes and challenges. The lessons learned from these experiences are invaluable for organizations aiming to harness the full potential of these methodologies.

One of the primary lessons is the importance of a holistic approach. As demonstrated in the case of smallholder private irrigation in West Africa, a comprehensive investment package, including environmental impact mitigation, is crucial for sustainable support (Abric et al., 2011). This underscores the need for a well-rounded strategy that takes into account all facets of the supply chain.

Another critical lesson is the significance of collaboration. The success of green component procurement in Taiwanese manufacturing chains was largely attributed to collaborative planning and accurate fulfillment by suppliers (Yan et al., 2016). This highlights the importance of fostering strong partnerships and collaborative efforts in the supply chain.

Furthermore, the case of best value practices in Malaysia offers insights into the challenges of implementing VE and VA in developing countries. The research emphasized the need for a paradigm shift among the elite and visionary before the overall environment can embrace change (Kashiwagi et al., 2012). This serves as a reminder of the cultural and contextual nuances that must be considered when implementing VE and VA.

7. Challenges and Barriers

The journey of integrating Value Engineering (VE) and Value Analysis (VA) into organizational processes is not without its challenges. While the benefits of these methodologies are evident, several barriers can hinder their successful implementation. These challenges range from organizational resistance to the complexities of change management.

7.1 Organizational Resistance and Change Management

Organizational resistance is a natural response to change. As organizations are composed of individuals with varying degrees of acceptance to new methodologies, the introduction of VE and VA can be met with skepticism. This resistance can stem from a lack of understanding, fear of the unknown, or even previous unsuccessful attempts at implementing similar strategies (Parris et al., 2016).

On the other hand, change management is the structured approach to transitioning individuals, teams, and organizations from a current state to a desired future state. Effective change management requires clear communication, training, and the involvement of key stakeholders. However, even with these in place, the inherent complexities of organizational structures can pose significant challenges. For instance, introducing a new technology or system, such as a Customer Relationship Management (CRM) solution, can be met with resistance due to perceived monetary and psychological costs. The case of Arizona State University's athletic department's adoption of a CRM technology solution serves as a testament to this. While the primary benefits of the CRM solution were evident, including incremental revenue generation and personalized marketing, the challenges were equally pronounced. These ranged from coordinating adoption and obtaining commitment to estimating costs and creating content (Parris et al., 2016).

Furthermore, the dynamics of service ecosystems further complicate the scenario. For instance, while there is a high-level policy consensus in India that community engagement improves vaccination uptake, the actual implementation faces barriers at multiple socio-ecological levels. These barriers span from individual to policy levels, emphasizing the intricate nature of implementing change in complex systems (Dutta et al., 2021).

Moreover, the integration of social and technical characteristics in design projects presents another layer of complexity. The need for tools that reflect this integrated nature is paramount. However, the challenges lie in balancing the technical requirements with the social dynamics of the organization. The case of managing sociotechnical complexity in engineering design projects highlights the importance of understanding both the social and technical dimensions for successful project outcomes (Hassannezhad et al., 2019).

In conclusion, while the benefits of VE and VA are undeniable, the road to their successful integration is fraught with challenges. Overcoming these barriers requires a holistic approach that considers the organization's technical and social dimensions.

7.2 Technical and Operational Hurdles

The integration of Value Engineering (VE) and Value Analysis (VA) into organizational processes, while promising significant benefits, is not devoid of technical and operational challenges. One of the primary technical challenges is the evolution of supply chains and the complexities they introduce. As supply chains have evolved, they have incorporated various technologies and methodologies, each with its own set of challenges (Crandall et al., 2009).

For instance, the introduction of Cyber-Physical Systems (CPS), autonomous vehicles, and robotics into the manufacturing sector promises to revolutionize operations. However, these technologies also introduce complexities in terms of integration, data management, and real-time decision-making. The diversity in these systems and their nascent stages of development mean that organizations often face hurdles in terms of training, system compatibility, and cost implications (Onu and Mbohwa, 2019).

Operational challenges, on the other hand, often revolve around the human element. Introducing new technologies and methodologies can lead to resistance from employees, especially if they perceive these changes as threats to their job security or lack the necessary skills to adapt. Moreover, the integration of these technologies requires a shift in organizational culture, necessitating change management strategies to ensure smooth transitions (Crandall et al., 2009).

Furthermore, supply chains' demand management aspect presents its own challenges. Accurately determining customer needs, forecasting demand, and aligning supply with demand are critical components of a successful supply chain. However, these processes are fraught with uncertainties, especially in volatile markets or industries undergoing rapid technological changes (Crandall et al., 2009).

7.3 Future Trends and Evolving Challenges

The future of VE and VA, especially in the context of supply chain management, is poised for transformation. With the advent of technologies like artificial intelligence, machine learning, and the Internet of Things (IoT), the potential for optimizing supply chains is immense. However, these technologies also introduce new challenges.

One of the prominent future trends is the move towards sustainable supply chain management. Organizations are increasingly recognizing the importance of sustainability, not just from an environmental perspective but also in terms of economic and social sustainability. The integration of green supply chain practices, cleaner production, and re-engineering practices are some of the sustainable initiatives that are gaining traction (Onu and Mbohwa, 2019).

However, the shift towards sustainability also introduces challenges. For instance, while cleaner production methods might be environmentally friendly, they might also be more costly in the short term. Similarly, the push for sustainability might require significant changes in organizational culture, processes, and even business models.

In conclusion, while the future of VE and VA in supply chain management is promising, it is also fraught with challenges. Organizations must proactively identify these challenges and develop strategies to overcome them.

8. Conclusion and Future Directions

The exploration of Value Engineering (VE) and Value Analysis (VA) in the contexts of procurement and supply chain management has illuminated

the transformative potential of these methodologies. As organizations grapple with the complexities of modern business environments, the integration of VE and VA offers a structured approach to optimize value, enhance efficiency, and foster innovation. However, the journey is not without its challenges. The intricate interplay of technological advancements, organizational dynamics, stakeholder expectations, and global market shifts necessitates a nuanced understanding of these methodologies and their implications. This section seeks to encapsulate the key findings of this exploration and chart a course for future directions in the realm of VE and VA.

8.1 Recap of Key Findings

8.1.1 The Essence of VE and VA

At their core, VE and VA are systematic methodologies designed to optimize value. They emphasize the importance of understanding functions, eliminating unnecessary costs, and enhancing the overall value proposition of products, services, or projects. Their structured frameworks provide organizations with tools and techniques to critically evaluate processes, identify inefficiencies, and implement solutions that strike a balance between cost, quality, and functionality.

8.1.2 Benefits and Limitations

The advantages of integrating VE and VA into organizational processes are manifold. The benefits are tangible and impactful, from cost savings and process efficiencies to enhanced stakeholder relationships and improved product quality. However, these methodologies are not without their limitations. Challenges such as overemphasis on cost, complexities in implementation, resistance to change, and potential subjectivity underscore the need for a balanced approach.

8.1.3 Unexplored Potentials in Procurement and SCM

The realms of procurement and supply chain management present fertile grounds for the application of VE and VA. The potential applications are vast and varied, whether it's enhancing supplier relationships, streamlining processes, improving product quality, or addressing sustainability concerns. The integration of these methodologies can revolutionize procurement practices, making them more strategic, collaborative, and value-driven.

8.1.4 Real-world Applications and Case Studies

The practical implications of VE and VA come to the fore when examined through the lens of real-world case studies. The tangible benefits of these methodologies are evident from construction projects leveraging Building Information Modelling (BIM) to green component procurement in manufacturing chains. These case studies serve as testamentary narratives, highlighting the transformative impacts of VE and VA across diverse sectors.

8.1.5 Challenges and Barriers

The road to successful integration of VE and VA is fraught with challenges. Organizational resistance, technical and operational hurdles, and the complexities of change management are significant barriers. Addressing these challenges requires a multi-faceted approach that combines strategic vision, stakeholder engagement, technological integration, and continuous learning.

8.1.6 Implications for Procurement and Supply Chain Professionals

The integration of Value Engineering (VE) and Value Analysis (VA) into procurement and supply chain management profoundly influences professionals in these domains. VE and VA equip professionals with tools and methodologies that enable more informed, value-driven decisions. This enhancement boosts efficiency and ensures that procurement and supply chain strategies align with broader organizational objectives. The emphasis on value optimization necessitates a closer collaboration with stakeholders, including suppliers, customers, and internal teams. As a result, professionals are tasked with cultivating robust relationships that foster a culture of open communication and mutual benefit. The dynamic nature of modern supply chains requires these professionals to adopt a mindset of continuous improvement. VE and VA provide the frameworks for this regular evaluation, ensuring that processes evolve in response to changing market dynamics. As the global emphasis on sustainability intensifies, procurement and supply chain professionals are faced with the challenge of integrating sustainable practices into their operations. VE and VA can guide this integration, ensuring that value optimization aligns with environmental and social considerations. Furthermore, the digital transformation of supply chains presents both opportunities and challenges. Professionals are now expected to be adept at integrating emerging technologies like AI, IoT, and machine learning, leveraging them to enhance the efficacy of VE and VA methodologies.

8.2 Recommendations for Further Research

The exploration of VE and VA in the context of procurement and supply chain management has illuminated several areas ripe for further investigation. The potential synergies between technologies such as artificial intelligence, machine learning, and the Internet of Things (IoT) with VE and VA offer exciting avenues for research. Delving deeper into the practicalities of these integrations, exploring real-world case studies, challenges, and best practices could provide invaluable insights. The significant trend towards sustainable supply chain management also beckons further exploration. Research could probe how VE and VA methodologies can be tailored to prioritize sustainability, examining the intricate balance between value optimization and environmental and social considerations. Additionally, the global shifts in market dynamics, influenced by diverse factors like geopolitics, economic policies, and cultural nuances, impact the application of VE and VA. Detailed studies could explore these dynamics, offering insights into how VE and VA can be adapted to different regional contexts. The challenges often associated with the integration of VE and VA, stemming from organizational resistance, also present a fertile ground for research. Delving into the intricacies of change management and providing strategies for the smoother integration of these methodologies could be of immense value. In the vast landscape of organizational processes, VE and VA stand out as potent methodologies, guiding organizations towards optimal value realization. The journey, while filled with challenges, promises transformative impacts. The responsibility now rests on researchers and practitioners to delve deeper, harnessing the full potential of VE and VA, and charting a course towards a profitable, sustainable, innovative, and value-driven future.

REFERENCES

Abric, S., Sonou, M., Augeard, B., Onimus, F., Durlin, D., Soumaila, A., and Gadelle, F., 2011. Lessons learned in the development of smallholder private irrigation for high-value crops in West Africa. Link.

Akyazi, T., Álvarez, I., Alberdi, E., Oyarbide-Zubillaga, A., Goti, A., and Bayón, F., 2020. Skills Needs of the Civil Engineering Sector in the European Union Countries: Current Situation and Future Trends. Link. DOI: 10.3390/app10207226.

Alfieri, Louis, Higashi, Ross M., Shoop, Robin, and Schunn, C., 2015. Case studies of a robot-based game to shape interests and hone proportional reasoning skills. Link. DOI: 10.1186/s40594-015-0017-9.

Amiri Ara, R., Paardenkooper, K., and van Duin, R., 2021. A new blockchain system design to improve the supply chain of engineering, procurement and construction (EPC) companies – a case study in the oil and gas sector. Link. DOI: 10.1108/jedt-01-2021-0047

Annappa, C., and Kallurkar Shrikant Panditrao., 2014. Application of Value Engineering for Cost Reduction of Household Furniture Product - A Case Study. Link. DOI: 10.15680/IJIRSET.2014.0310024.

Bae, H., 2020. The Relationships between Orientation, Collaboration and Performance for Supply Chain Management of Korean FDI Firms for Sustainable Growth. Link. DOI: 10.3390/su122410311

Batistič, S., and van der Laken, P. A., 2019. History, Evolution and Future of Big Data and Analytics: A Bibliometric Analysis of its Relationship to Performance in Organizations. Link. DOI: 10.1111/1467-8551.12340.

Bhandal, R., Meriton, R., Kavanagh, R., and Brown, A., 2022. The application of digital twin technology in operations and supply chain management: a bibliometric review. Link. DOI: 10.1108/scm-01-2021-0053

Brinch, M., 2018. Understanding the value of big data in supply chain management and its business processes. Link. DOI: 10.1108/IJOPM-05-2017-0268.

Ciurleo, M., Mandaglio, M., and Moraci, N., 2021. A quantitative approach for debris flow inception and propagation analysis in the lead up to risk management. Link. DOI: 10.1007/s10346-021-01630-8.

Crandall, R., Crandall, W., and Chen, C. C., 2009. Principles of Supply Chain Management. Link. DOI: 10.4324/9781420091083.

de Sá, B. C., de Souza, E. H. D., Reis, L., and Dutra, M. D. S., 2022. Supply chain network design: a case study of the regional facilities analysis for a 3D printing company. Link. DOI: 10.4995/ijpme.2022.17620.

Del Giudice, M., Chierici, R., Mazzucchelli, A., and Fiano, F., 2020. Supply chain management in the era of circular economy: the moderating effect of big data. Link. DOI: 10.1108/ijlm-03-2020-0119.

Dey, P., Malesios, C., De, D., Chowdhury, S., and Abdelaziz, F., 2019. Could lean practices and process innovation enhance supply chain sustainability of small and medium-sized enterprises?. Link. DOI: 10.1002/BSE.2266.

Dutta, T., Agley, J., Meyerson, B., Barnes, P., Sherwood-Laughlin, C. M., and Nicholson-Crotty, J., 2021. Perceived enablers and barriers of community engagement for vaccination in India: Using socioecological analysis. Link. DOI: 10.1371/journal.pone.0253318.

Eslamipirharati, M., Bakhshi, A., Aghsami, A., Jolai, F., and Yazdani, M., 2022. Does a Buyback Contract Coordinate a Reverse Supply Chain Facing Remanufacturing Capacity Disruption and Returned Product Quality Uncertainty?. Link. DOI: 10.3390/su142315939.

Espina-Agullo, J. J., Pérez-Turpin, J., Jimenez-Olmedo, J., Penichet-Tomás, A., and Pueo, B., 2016. Effectiveness of Male Handball Goalkeepers: A historical overview Pp. 1982-2012. Link. DOI: 10.1080/24748668.2016.11868877.

Frazzon, E., Rodriguez, C., Pereira, M., Pires, M. C., and Uhlmann, I. R., 2019. Towards Supply Chain Management 4.0. Link. DOI: 10.14488/BJOPM.2019.V16.N2.A2

Giménez, Z., Mourgues, C., Alarcón, L., Mesa, H. A., and Pellicer, E., 2020. Value Analysis Model to Support the Building Design Process. Link. DOI: 10.3390/su12104224.

Grimm, H., Olsson, I., and Sandøe, P., 2019. Harm–benefit analysis – what is the added value? A review of alternative strategies for weighing harms and benefits as part of the assessment of animal research. Link. DOI: 10.1177/0023677218783004.

Handayani, A., and Setyatama, C. Y., 2020. Analysis of Supply Chain Management Performance using SCOR and AHP Methods In Green Avenue Apartments of East Bekasi. Link. DOI: 10.35877/454ri.asci1241.

Hanna, N.K., 2016. Mastering Digital Transformation: Towards a Smarter Society, Economy, City and Nation. Link.

Hassannezhad, M., Cantamessa, M., Montagna, F., and Clarkson, P., 2019. Managing Sociotechnical Complexity in Engineering Design Projects. Link. DOI: 10.1115/1.4042614.

Heidary Dahooie, J., Hosseini Dehshiri, S. J., Banaitis, A., and Binkytė-Vėlienė, A., 2020. Identifying and prioritizing cost reduction solutions in the supply chain by integrating value engineering and gray multi-criteria decision-making. Link. DOI: 10.3846/TEDE.2020.13534.

Hughes, N., Shahi, C., and Pulkki, R., 2014. A Review of the Wood Pellet Value Chain, Modern Value/Supply Chain Management Approaches, and Value/Supply Chain Models. Link. DOI: 10.1155/2014/654158.

Jankalová, M., and Jankal, R., 2020. How to Characterize Business Excellence and Determine the Relation between Business Excellence and Sustainability. Link. DOI: 10.3390/su12156198.

Jaradat, R. M., Adams, F., Abutabenjeh, S., and Keating, C., 2017. The Complementary Perspective of System of Systems in Collaboration, Integration, and Logistics: A Value-Chain Based Paradigm of Supply Chain Management. Link. DOI: 10.3390/systems5040050.

Jareonsin, S., and Pumas, C., 2021. Advantages of Heterotrophic Microalgae as a Host for Phytochemicals Production. Link. DOI: 10.3389/fbioe.2021.628597.

Jo, J., and Lee, E., 2021. How Do Consumers' Food Values across Countries Lead to Changes in the Strategy of Food Supply-Chain Management?. Link. DOI: 10.3390/foods10071523

Kashiwagi, D., Kashiwagi, J., Kashiwagi, A., and Sullivan, K., 2012. Best Value Solution Designed in a Developing Country. Link.

Kettinger, W.J., Teng, J.T. and Guha, S., 1997. Business process change: a study of methodologies, techniques, and tools. MIS quarterly, Pp.55-80.

Khokhar, M., Iqbal, W., Hou, Y., Abbas, M., and Fatima, A., 2020. Assessing Supply Chain Performance from the Perspective of Pakistan's Manufacturing Industry Through Social Sustainability. Link. DOI: 10.3390/pr8091064.

Li, Xiao-Juan, Wang, Chen, and Alashwal, A., 2021. Case Study on BIM and Value Engineering Integration for Construction Cost Control. Link. DOI: 10.1155/2021/8849303.

Lin, Y., and Yang, W., 2018. Application of Multi-Objective Genetic Algorithm Based Simulation for Cost-Effective Building Energy Efficiency Design and Thermal Comfort Improvement. Link. DOI: 10.3389/fenrg.2018.00025.

MacCarthy, B., Blome, C., Olhager, J., Srai, J., and Zhao, Xiande., 2016. Supply chain evolution – theory, concepts and science. Link. DOI: 10.1108/IJOPM-02-2016-0080

Mavroulis, S., Vassilakis, E., Diakakis, M., Konsolaki, A., Kaviris, G., Kotsi, E., Kapetanidis, V., Sakkas, V., Alexopoulos, J., Lekkas, E., and Voulgaris, N., 2022. The Use of Innovative Techniques for Management of High-Risk Coastal Areas, Mitigation of Earthquake-Triggered Landslide Risk and Responsible Coastal Development. Link. DOI: 10.3390/app12042193.

Mishra, D., Gunasekaran, A., Papadopoulos, T., and Dubey, R., 2018. Supply chain performance measures and metrics: a bibliometric study. Link. DOI: 10.1108/BIJ-08-2017-0224.

Obeidat, M., Awawdeh, M., and Al-Hantouli, F., 2021. Morphometric analysis and prioritisation of watersheds for flood risk management in Wadi Easal Basin (WEB), Jordan, using geospatial technologies. Link. DOI: 10.1111/jfr3.12711.

Onu, P., and Mbohwa, C., 2019. Sustainable Supply Chain Management: Impact of Practice on Manufacturing and Industry Development. Link. DOI: 10.1088/1742-6596/1378/2/022073.

Parris, D., Bouchet, A., Peachey, J. W., and Arnold, D., 2016. Change is hard: overcoming barriers to service innovation. Link. DOI: 10.1108/JSM-05-2015-0182.

Poblete, L., and Bengtson, A., 2020. Friends or strangers? Attempts at reactivating buyer–supplier relationships. Link. DOI: 10.1108/jbim-12-2019-0513.

Prajapati, D., Chan, F., Chelladurai, H., Lakshay, L., and Pratap, S., 2022. An Internet of Things Embedded Sustainable Supply Chain Management of B2B E-Commerce. Link. DOI: 10.3390/su14095066

Reyes, J., Mula, J., and Díaz-Madroñero, M., 2021. Development of a conceptual model for lean supply chain planning in industry 4.0: multidimensional analysis for operations management. Link. DOI: 10.1080/09537287.2021.1993373.

Ripanti, E., and Tjahjono, B., 2019. Unveiling the potentials of circular economy values in logistics and supply chain management. Link. DOI: 10.1108/IJLM-04-2018-0109.

Rosłon, J., Książek-Nowak, M., and Nowak, P., 2020. Schedules Optimization with the Use of Value Engineering and NPV Maximization. Link. DOI: 10.3390/su12187454.

Selkimäki, M., González-Olabarria, J. R., Trasobares, A., and Pukkala, T., 2020. Trade-offs between economic profitability, erosion risk

mitigation and biodiversity in the management of uneven-aged Abies alba Mill. stands. Link. DOI: 10.1007/s13595-019-0914-z.

Sjödin, D., Kamalaldin, A., Parida, V., and Islam, N., 2021. Procurement 4.0: How Industrial Customers Transform Procurement Processes to Capitalize on Digital Servitization. Link. DOI: 10.1109/TEM.2021.3110424.

Taghouti, I., Cristobal, R., Brenko, A., Stara, K., Markos, N., Chapelet, B., Hamrouni, L., Buršić, D., and Bonet, J., 2022. The Market Evolution of Medicinal and Aromatic Plants: A Global Supply Chain Analysis and an Application of the Delphi Method in the Mediterranean Area. Link. DOI: 10.3390/f13050808.

Usman, F., Jalaluddin, N. A., and Hamim, S. A., 2018. Value Engineering in Building Information Modelling for Cost Optimization of Renovation Works: a Case Study. Link. DOI: 10.14419/IJET.V7I4.35.22856.

Yan, M., Chien, K.M., and Yang, T., 2016. Green Component Procurement Collaboration for Improving Supply Chain Management in the High Technology Industries: A Case Study from the Systems Perspective. Link.

Yu, C., Morotomi, T., and Yu, H., 2020. What Influences Adoption of Green Award Criteria in a Public Contract? An Empirical Analysis of 2018 European Public Procurement Contract Award Notices. Link. DOI: 10.3390/su12031261.

Zhang, W. H., Lu, D., Qin, J., Thöns, S., and Faber, M., 2021. Value of information analysis in civil and infrastructure engineering: a review. Link. DOI: 10.1186/s43065-021-00027-0.