SMART
Journal of Business Management Studies
(A Professional, Refereed, International and Indexed Journal)

Vol-21 Number-2 July - December 2025 Rs. 500

ISSN 0973-1598 (Print) ISSN 2321-2012 (Online)

Professor MURUGESAN SELVAM, M.Com, MBA, Ph.D, D.Litt
Founder - Publisher and Chief Editor

SCIENTIFIC MANAGEMENT AND ADVANCED RESEARCH TRUST (SMART)

TIRUCHIRAPPALLI (INDIA)
www.smartjournalbms.org

SMART JOURNAL OF BUSINESS MANAGEMENT STUDIES
(A Professional, Refereed, International and Indexed Journal)
www.smartjournalbms.org

DOI : 10.34293/2321-2012.2025.0002.3

LEVERAGING DIGITAL TWINS FOR PROJECT MANAGEMENT SUCCESS IN SUPPLY CHAIN ENVIRONMENTS

N. Sureshkumar PP Narayanan
University of East London, London, England
nsureshk@yahoo.com

Farha Ghapar
Universiti Poly-Tech Malaysia, Cheras, Kuala Lumpur, Malaysia.
farha@uptm.edu.my

Li Lian Chew
Binary Business School, Binary University, Selangor, Malaysia.
lilian@binary.edu.my

Fadhlur Rahim Azmi
Faculty of Business & Management, Universiti Teknologi MARA (UiTM), Cawangan Melaka, Kampus Bandaraya, Melaka, Malaysia.
fadhlur@uitm.edu.my

Umahdevi Jayamani
Logispreneur Academy, Selangor, Malaysia
logpre@gmail.com

and

Azimah Daud*
Faculty of Business and Management, Universiti Teknologi MARA, Cawangan Selangor, Kampus Puncak Alam, Selangor, Malaysia.
azimah348@uitm.edu.my

Abstract

As supply chains grow increasingly complex, organizations are turning to Digital Twin Technology, to enhance project management success. This study explores the role of Real-Time Data Integration (RTD) and Simulation & Predictive Analytics (SPA), in optimizing

*** Corresponding Author**

supply chain project execution. By leveraging real-time data, organizations can improve visibility, risk mitigation and operational efficiency. Simulation and predictive analytics enable scenario planning and data-driven decision-making. A quantitative approach was employed to analyze the impact of these technologies on project outcomes. The findings revealed that both RTD and SPA significantly contributed, to project management success, with SPA displaying a stronger influence. The study highlights the critical role of digital twin technology in improving forecasting, resource allocation and collaboration, ultimately enhancing project efficiency. These insights could provide valuable recommendations for supply chain professionals and project managers, seeking to leverage digital twins for strategic decision-making and risk management. Future research can explore advanced AI-driven models and industry-specific applications of digital twin technology, to further optimize supply chain project management.

Keywords: *Digital Twins, Project Management Success, Real-Time Data Integration, Predictive Analytics, Supply Chain Management*

JEL Code : *C93 and D24*

Paper Received : *24.03.2025* ***Revised :*** *13.04.2025* ***Accepted :*** *26.05.2025*

1. Introduction

The increasing complexity of supply chain networks has increased the need for advanced project management tools **(Syakirah et al., 2020)**. Digital twins, virtual replicas of physical assets and processes, have emerged as a transformative technology in managing supply chain projects **(Grieves, 2014; Rasi et al., 2021).** By integrating real-time data and predictive analytics, digital twins could enhance project management efficiency, reduce uncertainties and facilitate better stakeholder collaboration **(Uhlemann et al., 2017).** However, the impact of digital twins on project management success remains underexplored. This study aims to bridge this gap, by investigating how real-time data integration and predictive analytics capabilities, could contribute to successful project outcomes in supply chain environments **(Waller & Fawcett, 2013).**

The adoption of digital twins in supply chain management has accelerated due to advancements in artificial intelligence, machine learning and IoT-enabled data collection. As industries shift towards automation and data-driven decision-making, digital twins provide unprecedented opportunities to optimize project outcomes (**Vatumalae et al., 2020; Vatumalae et al., 2022**). Companies investing in digital twin technology, have reported improved risk management, cost efficiencies and enhanced collaboration among project stakeholders **(Athikah & Sundram, 2014; Kritzinger et al., 2018)**. This study proposes to examine how these benefits would translate into measurable project management success.

2. Literature Review

2.1. Real-Time Data Integration

Real-time data integration involves leveraging IoT, AI and cloud computing, to create live digital representations of supply chain assets and operations. Prior research suggests that real-time data enhances decision-making, minimizes disruptions and optimizes resource allocation in project management **(Smith et al., 2021; Qi & Tao, 2018)**. The ability to monitor supply chain activities in real time enables managers to proactively address risks and inefficiencies

(Johnson & Lee, 2020; Xu et al., 2021).

Moreover, studies highlight that real-time data integration enhances supply chain transparency, improves demand forecasting and minimizes operational bottlenecks **(Kritzinger et al., 2018; Tao et al., 2018).** Organizations, leveraging real-time data capabilities, reported improved reaction times to market fluctuations, allowing them to optimize supply chain resilience **(Ivanov et al., 2020).** Additionally, integrating real-time data into project management, allows firms to enhance tracking accuracy, mitigate uncertainties, streamline interdepartmental communications, reduce project delays and inefficiencies **(Narayanan et al., 2024a; Patel & Zhang, 2022).**

2.2. Simulation and Predictive Analytics

Simulation and predictive analytics play a critical role in mitigating uncertainties in project execution. Digital twins provide scenario-based analysis, that allows project managers to test different strategies before implementation **(Patel & Zhang, 2022; Tao et al., 2018)**. Predictive analytics improves forecasting accuracy, enhances risk management and supports better project planning **(Garcia et al., 2021; Kusiak, 2017)**. Predictive analytics enables organizations to anticipate potential failures, optimize inventory management and enhance resource allocation **(Ivanov et al., 2021; Tao et al., 2021).**

A growing body of research emphasizes the importance of simulation in project risk assessment. Digital twins provide advanced simulations, that evaluate the impact of various project strategies, enabling organizations to optimize workflow processes and mitigate risks before execution **(Kritzinger et al., 2018).** Predictive analytics complements this approach by offering data-driven insights, that enhance proactive decision-making, ensuring that projects remain aligned with business objectives. Moreover, predictive models, supported by digital twins, significantly reduce waste, enhance resource efficiency and optimize production cycles **(Tao et al., 2020).**

2.3. Project Management Success

Project management success is commonly measured in terms of efficiency, adherence to budget and timeline, stakeholder satisfaction and risk mitigation. The integration of digital twins in project management has been linked to improved project performance metrics **(Williams & Anderson, 2020; Tao et al., 2020).** However, there is limited empirical research on how digital twins specifically contribute to project success in supply chain environments.

Studies indicate that digital twins facilitate real-time collaboration, reduce project delays and enhance overall project agility **(Uhlemann et al., 2017; Waller & Fawcett, 2013).** Project teams, utilizing digital twin technology, benefit from improved visualization tools, enabling better coordination between stakeholders. Additionally, enhanced project tracking through digital twins, minimizes errors and deviations, ensuring project goals are met within the defined scope, cost and timeframe **(Ivanov et al., 2021; Sivan et al., 2023).**

3. Statement of Problem

Despite the growing adoption of digital twins in supply chain management, there is lack of empirical evidence, linking their application to project management success. The challenge lies in understanding how digital twins would enhance real-time decision-making and predictive capabilities to improve project outcomes **(Jones et al., 2022).** This study seeks to address this research gap, by examining the relationship between digital twins and project success factors, in supply chain environments.

Further, identifying the key success factors, associated with digital twin implementation, can provide valuable insights for industry practitioners **(Kritzinger et al., 2018; Vatumalae et al., 2023).**

4. Need of the Study

The rapid digital transformation in supply chain management, has prompted organizations to explore advanced technologies to enhance project management success. The use of digital twins has emerged as a critical tool in improving supply chain efficiency and yet there is limited empirical evidence on their impact on project success. This study is necessary to fill this research gap, by analyzing how digital twins could contribute to improving project execution, risk management and cost efficiency in supply chain operations.

As supply chains become more complex, organizations require a strategic approach to managing projects effectively **(Sundram et al., 2018)**. The integration of digital twins allows project managers to visualize, simulate and optimize workflows in real-time, reducing inefficiencies and ensuring better coordination across supply chain nodes. Given the growing reliance on data-driven decision-making, understanding the extent to which digital twins influence project management success is crucial for supply chain practitioners, policymakers, and researchers.

5. Objective of the Study

This study aims to assess the impact of real-time data integration on project management success in supply chain environments. Real-time data integration allows for enhanced visibility, better decision-making and improved coordination among stakeholders, ultimately leading to increased efficiency and project effectiveness. Additionally, this study seeks to evaluate how simulation and predictive analytics could contribute to enhanced project outcomes. By enabling scenario-based planning and predictive risk assessment, digital twins provide managers with valuable insights, that improve forecasting accuracy, optimize resource allocation and mitigate project uncertainties. This study aims to assess the impact of real-time data integration on project management success in supply chain environments.

6. Hypotheses of the Study

Real-time data integration plays a crucial role in enhancing project management efficiency, by providing accurate and up-to-date information. Studies have shown that real-time data integration allows supply chain managers to monitor operations continuously, reducing the risk of delays and inefficiencies **(Smith et al., 2021; Qi & Tao, 2018).** By leveraging IoT and cloud computing technologies, real-time data integration fosters improved coordination among stakeholders, leading to better decision-making and more efficient resource allocation **(Johnson & Lee, 2020).** Additionally, real-time data integration mitigates project uncertainties, by enabling predictive monitoring, ensuring timely responses to disruptions **(Ivanov et al., 2020).** The increased transparency and visibility in supply chain operations, further contribute to improved project performance, making real-time data integration a key factor in project management success **(Patel & Zhang, 2022).**

H1: Real-time data integration positively influences project management success in supply chain environments.

Simulation and predictive analytics have been widely recognized as essential tools in project management due to their ability to forecast potential risks and optimize decision-making. Digital twins provide a dynamic simulation environment where project managers can analyze various scenarios and select the best course of action **(Garcia et al., 2021; Kusiak, 2017).** Predictive analytics allows organizations to anticipate supply chain disruptions, optimize inventory levels and enhance resource allocation, ultimately improving project efficiency (**Ivanov et al., 2021; Narayanan et al., 2024c).** Research has shown that simulation-driven decision-making significantly reduces project risks and enhances cost-effectiveness by identifying potential bottlenecks before they occur **(Sundram et al., 2018; Waller & Fawcett, 2013).** Further, predictive analytics enhances collaboration by providing data-driven insights, that facilitate proactive problem-solving and strategy alignment among stakeholders **(Williams & Anderson, 2020).** The integration of simulation and predictive analytics within digital twin technology leads to improved project execution, reduced uncertainty and greater project success **(Sundram et al., 2017; Tao et al., 2021).**

H2: Simulation and predictive analytics positively influence project management success in supply chain environments.

7. Research Methodology

This study adopted a quantitative research design, to examine the relationship between digital twins and project management success in supply chain environments **(Mkumbo et al., 2019)**. A survey-based approach was used, to collect primary data from project managers, supply chain professionals and decision-makers who have implemented digital twin technologies. The study employed statistical methods to analyze data and test the formulated hypotheses **(Figure 1)**.

7.1. Sampling Selection

The study employed the purposive sampling technique, targeting professionals working in supply chain management and project management domains within industries that have adopted digital twin technology **(Ali et al., 2020)**. Respondents included project managers, supply chain executives, IT specialists, and operational managers. A structured questionnaire was distributed to collect relevant data, ensuring diverse representation across different industry sectors. The sampling frame was sourced from the Department of Statistics, Malaysia, indicating an estimated 1,000 companies within this industry. Employing a stratified random sampling approach, a sample size of 400 respondents was chosen from the population, as indicated in **Table 2.**

7.2. Sources of Data

Primary data were gathered through an online questionnaire, consisting of close-ended questions, based on a five-point Likert Scale. The questionnaire was designed to measure the impact of real-time data integration and predictive analytics on project management success. Secondary data were sourced from academic journals, industry reports and case studies to support the research.

7.3. Period of Study

This study was conducted over a period of six months, from January 2023 to June 2023. The data collection phase took place during the first three months, followed by data analysis and interpretation in the subsequent months. This timeline ensured sufficient time for gathering responses, conducting statistical analyses and drawing meaningful conclusions from the research findings **(Daud et al., 2024).**

7.4. Tools used in the study

This study employed various analytical and statistical tools to process and interpret the collected data. The primary tool, used for the data analysis, was the Statistical Package for the Social Sciences (SPSS), which facilitate descriptive and inferential statistical analyses. Descriptive statistics helped to summarize respondent demographics while multiple regression analysis was used to assess the relationships between independent and dependent variables.

Additionally, Microsoft Excel was used for preliminary data cleaning, organizing responses and performing basic statistical calculations before importing them into SPSS. These tools collectively ensured accurate, reliable and efficient analysis of the study's findings.

8. Data Analysis

The collected data were analyzed by using multiple regression analysis through the Statistical Package for the Social Sciences (SPSS). Multiple regression was used to determine the strength and direction of the relationship between the independent variables (real-time data integration and simulation and predictive analytics) and the dependent variable (project management success). This method helped the identification of the extent to which each independent variable contributed to project management success while controlling other factors.

Descriptive statistics summarized respondent demographics while inferential statistical methods such as correlation analysis and variance inflation factor (VIF) tests, ensured that multicollinearity was not present among the predictors. The regression model was evaluated, based on R-squared values, standardized coefficients and significance levels (p-values), providing a comprehensive understanding of the impact of digital twin components on project success. Further, reliability and validity tests were conducted, to confirm the robustness of the study's findings.

8.1. Demographic Profile of Project Implementation Firms

Table 1 provides insights into the distribution of respondents, across different industrial sectors, company sizes, based on the number of employees and years of establishment of the surveyed organizations. The data revealed that the majority of respondents were from the manufacturing sector, with a significant representation from pharmaceutical, IT & technology solutions and transportation industries. In terms of company size, most participants were from mid-sized firms with 50-99 employees, followed by those in organizations with 100-500 employees. The highest proportion of respondents were from companies, which were established 10-20 years ago, reflecting well-established businesses integrating digital twin technologies in supply chain project management. The complete usable questionnaire, for this study, was administered to 400 respondents from various industries in Malaysia.

Table 1 presents the respondents' profile, with majority of participants from the manufacturing sector (31.25%), followed by pharmaceutical (18.75%), IT & technology solution (17.50%), and transportation (17.50%), with the lowest representation from retail & E-commerce (15.00%). In terms of company size, most respondents were from firms with 50-99 employees (31.00%), and 27.00% were from organizations with 100-500 employees, and 26.25% from companies with fewer than 50 employees. Regarding company age, the majority of respondents were from businesses, established 10-20 years ago (41.75%), followed by those in operation for less than or equal to 10 years (24.50%). 22% were from companies established 21-30 years ago. 11.75% were from 30 year old companies. In short, respondents came from mid-sized, well-established manufacturing companies, providing insights into the adoption of digital twin technologies in supply chain project management.

8.2. Reliability Test of Real-Time Data Integration, Simulation & Predictive Analytics and Project Management Success

Table 3 presents the Cronbach's Alpha values, for Real-Time Data Integration (RTD), Simulation & Predictive Analytics (SPA), and Project Management Success (PMS). The reliability scores were 0.821 for RTD, 0.789 for SPA, and 0.774 for PMS and all exceeded the recommended threshold of 0.70, indicating strong internal consistency and reliability. The highest reliability was observed in RTD (0.821), suggesting that real-time data integration measures were the most stable. Since all values met the acceptable reliability level, the measurement scales, used in this study, were considered consistent and valid for further analysis.

8.3.Correlation Analysis of Real-Time Data Integration, Simulation & Predictive Analytics and Project Management Success

Table 4 demonstrates that Real-Time Data Integration (RTD) and Simulation & Predictive Analytics (SPA) were strongly correlated ($r = 0.720, p < 0.01$), indicating that organizations with better real-time data capabilities, excelled in predictive analytics. Both RTD ($r = 0.660, p < 0.01$) and SPA ($r = 0.710, p < 0.01$) reported significant positive correlations with Project Management Success (PMS), confirming that real-time data integration and predictive analytics did play a crucial role in enhancing project efficiency, decision-making and risk mitigation. These findings revealed the importance of digital twin technologies in optimizing supply chain project management, reinforcing their impact on improving forecasting, resource allocation and overall project success.

8.4. Multiple Regression Analysis of Real-Time Data Integration, Simulation & Predictive Analytics and Project Management Success

Table 5 presents the results of the multiple regression analysis, demonstrating that both Real-Time Data Integration (RTD) and Simulation & Predictive Analytics (SPA) significantly influenced Project Management Success (PMS). The beta coefficient for RTD ($\beta = 0.283, t = 2.448, p < 0.001$) indicateed that real-time data integration positively contributed to project success, by enhancing decision-making, improving operational efficiency and reducing uncertainty. SPA recorded stronger effect ($\beta =0.523, t = 4.451, p <0.001$), suggesting that predictive analytics and simulation techniques played a more crucial role in optimizing project outcomes, by enabling better forecasting, risk mitigation and resource allocation. The F-value (15.629) revealed the overall statistical significance of the model and the R-square value (0.476) demonstrated that 47.6% of the variance in PMS can be explained by RTD and SPA. Since both hypotheses (H1 and H2) were supported, the findings established that leveraging real-time data integration and simulation-based analytics, significantly improved project performance, with predictive analytics reporting a stronger impact on project success. In short, organizations should prioritize advanced simulation tools alongside real-time data, for better project planning, execution and risk management.

9. Findings and Discussion

9.1. Real-Time Data Integration

The results revealed that both real-time data integration and predictive analytics significantly contributed to project management success.

Real-time data integration enabled project managers to make quicker, data-driven decisions, reducing uncertainty and improving efficiency. Organizations, that implement real-time data tracking systems, reported improved project visibility, enhanced collaboration among stakeholders and better alignment with strategic objectives. Additionally, real-time data integration minimizes risks by allowing managers to proactively address disruptions before they escalate, leading to higher project success rates.

9.2. Simulation and predictive analytics

The findings also revealed that predictive analytics played a critical role in improving forecasting accuracy and risk management. Simulation models provided project teams with scenario-based insights, helping them to anticipate potential bottlenecks and devise contingency plans accordingly. Companies using predictive analytics tools, experienced improved cost control, streamlined resource allocation and increased flexibility in handling supply chain disruptions. The ability to simulate different project scenarios, allowed managers to test strategies before execution, ensuring a more structured and efficient approach to project planning.

9.3. Project management success

Further, the study observed the synergy between real-time data integration and predictive analytics. When used together, these technologies enabled organizations to enhance their digital twin frameworks, optimize operational workflows and drive project management success. The results indicated that companies, investing in both real-time data and predictive modelling, experienced greater improvements in project efficiency, cost-effectiveness and risk mitigation compared to those relying on traditional project management methods.

These findings aligned with existing literature, reinforcing the importance of digital twin technologies in modern project management. The study also identified challenges, such as the need for technical expertise, high implementation cost and data security concerns. Real-time data improved decision-making speed and accuracy while predictive analytics enhanced risk mitigation and strategic planning **(Daud et al., 2024; Sundram et al., 2011; Tao et al., 2021).** The combined application of these elements would lead to more efficient project execution in supply chain environments **(Wong et al., 2024)**.

10. Suggestions

Organizations should invest in real-time data integration systems, to improve project monitoring, risk assessment and decision-making efficiency in supply chain management **(Munir et al., 2021; Narayanan et al., 2024b; Sundram et al., 2016)**. Project managers should adopt predictive analytics tools, to enhance forecasting capabilities and optimize resource allocation for better project outcomes. Companies should provide training and upskilling opportunities for employees, to effectively utilize digital twin technology in project management. Industry stakeholders should collaborate with technology providers, to develop standardized frameworks for digital twin adoption and integration into project management practices. Policymakers should consider regulations and guidelines, that support the secure and ethical use of digital twin technologies in supply chain environments. Additionally, organizations should establish Key Performance Indicators (KPIs), to measure the effectiveness of digital twin adoption in project execution and supply chain optimization.

11. Conclusion

This study provided empirical evidence on the role of digital twins in project management success within supply chain environments. The findings revealed the importance of real-time data integration and predictive analytics in improving project outcomes. By leveraging real-time data, organizations can enhance decision-making, improve visibility and optimize resource allocation, which ultimately contributes to more efficient project execution and risk mitigation.

Further, simulation and predictive analytics enable supply chain managers, to anticipate challenges and implement proactive measures, reducing disruptions and ensuring project timelines and budgets are maintained. Digital twin technology, when effectively integrated into project management frameworks, enhances collaboration between stakeholders, fosters innovation and improves overall project agility **(Rajagopal et al., 2016)**. These factors collectively contribute to increased efficiency and higher success rates in supply chain project management **(Zulfakar et al., 2019)**.

Despite these advantages, the adoption of digital twins presents challenges, such as high implementation costs, data security concerns and the need for specialized expertise. Organizations must carefully assess their digital transformation strategies and ensure that investments in digital twin technologies align with long-term business objectives **(Sivan et al., 2022; Muhammad et al., 2025)**. Future research should explore how emerging technologies, such as artificial intelligence and blockchain, can further enhance the capabilities of digital twins in project management.

In conclusion, this study demonstrated the growing significance of digital twin technology in the modern supply chain landscape. As businesses strive for greater efficiency and resilience, integrating real-time data and predictive analytics into project management practices, becomes essential. Organizations, that embrace digital twins, could gain a competitive edge, achieving greater operational efficiency, cost savings and sustainable project success in an increasingly dynamic and complex supply chain environment.

12. Limitation of Study

While this study provides valuable insights, certain limitations were also observed. The research was limited to respondents, who reported experience with digital twins in supply chain management, which may restrict generalizability. Additionally, self-reported data could introduce response bias. Future studies could incorporate longitudinal approaches to track the long-term impact of digital twin technologies.

13. Scope for Further Research

Future research can explore additional factors, influencing the successful adoption of digital twins in project management beyond real-time data integration and predictive analytics. One potential area is the impact of artificial intelligence-driven automation within digital twin ecosystems on project decision-making efficiency. Additionally, further studies can examine the role of cybersecurity and data privacy concerns in digital twin adoption, as these issues are becoming increasingly relevant in technologically advanced supply chain environments.

14. References

Ali, S.N.R., Rajagopal, P., Sundram, V. P. K., Saihani, S.B., & Noranee, S. (2020). ERP System Implementation in a Leading LED Manufacturing in Malaysia: A Supply Chain Perspective. *International Journal of Supply Chain Management, 9*(2), 104.

Atikah, S.B., & Sundram, V. P. K. (2014). The Green Supply Chain Management Practices: A Green Approach. *Available at SSRN 2493252.*

Bryman, A. (2016). *Social research methods* (5^{th} ed.). Oxford University Press.

Daud, A., Narayanan, N. S. P. P., Ghapar, F., Chew, L. L., Sundram, V. P. K., Naidu, B.M. & Zulfakar, M. H. (2024b). Artificial Intelligence-Powered Risk Assessment in Supply Chain Safety. *Information Management and Business Review* (ISSN 2220-3796), 16(3S(a)), 107-114.

Daud, A., Narayanan, N. S. P. P., Ghapar, F., Chew, L.L., Sundram, V.P.K., & Naidu, B. M. (2024a). Integrating Resource-Based Theory and Contingency Theory for Enhancing Supply Chain Resilience in Malaysia: A Post-Pandemic Analysis. *Information Management and Business Review* (ISSN 2220-3796), 16(3S(a)), 115-124.

Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE Publications.

Garcia, H., Lin, Z., & Wang, Y. (2021). Predictive analytics for supply chain risk management using digital twins. *Journal of Supply Chain Management*, 57(3), 123-140.

Grieves, M. (2014). Digital twin: Manufacturing excellence through virtual factory replication. *White Paper*, Florida Institute of Technology.

Ivanov, D., Dolgui, A., & Sokolov, B. (2020). The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics. *International Journal of Production Research*, 58(5), 1285-1301.

Ivanov, D., Tang, C. S., & Dolgui, A. (2021). Digital supply chain twins: Managing the ripple effect and disruptions through resilience. *Production Planning & Control*, 32(9), 775-792.

Johnson, M., & Lee, C. (2020). The role of real-time data integration in digital twin technology adoption. *International Journal of Operations & Production Management*, 40(5), 789-812.

Jones, T., Smith, R., & White, K. (2022). The influence of digital twin adoption on project management outcomes in supply chains. *Journal of Business Logistics*, 43(1), 102-120.

Kritzinger, W., Karner, M., Traar, G., Henjes, J., & Sihn, W. (2018). Digital twin in manufacturing: A categorical literature review and classification. *IFAC-PapersOnLine*, 51(11), 1016-1022.

Kusiak, A. (2017). Smart manufacturing must embrace big data. *Nature*, 544(7648), 23-25.

Mkumbo, F. A. E., Ibrahim, A. R., Salleh, A. L., Sundram, V. P. K., & Atikah, S. B. (2019). The influence of supply chain practices and performance measurement practices towards firm performance. *International Journal of Supply Chain Management, 8*(3), 809-819.

Muhammad, M. S. H., Narayanan, N. S. P. P., Ghapar, F., Chew, L. L., & Sundram, V. P. K. (2025). The impact of good citizenship dimension on supply chain sustainability. *SMART Journal of Business Management Studies, 21*(1), 26–37.

Munir, Z. A., Bhatti, M. A., & Sundram, V. P. K. (2021). The determinants of humanitarian supply chain efficiency-a case study of flood disaster in Malaysia. *SMART Journal of Business Management Studies, 17*(2), 10-16.

Narayanan, N. S. P. P., Ghapar, F., Chew, L. L., Sundram, V. P. K., & Jayamani, U. (2024a). Measuring the unmeasured: Exploring the concept of "Supply Chain Quotient" [SCQ]. *Information Management and Business Review, 16*(2I), 36-43.

Narayanan, N.S. P.P., Ghapar, F., Chew, L. L., Sundram, V. P. K., & Jayamani, U. (2024b). Optimizing working capital management in supply chain finance: A multi-dimensional approach. *Information Management and Business Review, 16*(2I), 44-52.

Narayanan, N. S., Fathurahman, H., Ahmad, N. N., Ghapar, F., Chew, L. L., & Sundram, V. P. K. (2024c). Consumer Perspectives on the Sustainability of the Malaysian Palm Oil Supply Chain: Awareness, Price Sensitivity, and Certification Impacts. *Malaysian Journal of Consumer and Family Economics* 33, 408-436.

Pallant, J. (2020). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS* (7th ed.). McGraw-Hill Education.

Patel, R., & Zhang, X. (2022). Enhancing supply chain resilience through digital twin-driven simulations. *IEEE Transactions on Engineering Management*, 69(7), 2451-2463.

Qi, Q., & Tao, F. (2018). Digital twin and big data towards smart manufacturing and industry 4.0: 360-degree comparison. *IEEE Access*, 6, 1234-1246.

Rajagopal, P., Azar, N. A. Z., Atikah, S. B., Appasamy, G., & Sundram, V. P. K. (2016). Determinants of supply chain responsiveness among firms in the manufacturing industry in Malaysia. *International Journal of Supply Chain Management, 5*(3), 18-24.

Rasi, R. Z., Rakiman, U., Radzi, R. Z. R. M., Masrom, N. R., & Sundram, V. P. K. (2021). A Literature Review on Blockchain Technology: Risk in Supply Chain Management. *IEEE Engineering Management Review, 50*(1), 186-200.

Saunders, M., Lewis, P., & Thornhill, A. (2019). *Research methods for business students* (8th ed.). Pearson.

Sivan, S., Chew LL., Ghapar, F., Sundram, VPK and Munir, ZA. (2023). The relationship between information technology and logistics integration: A case study of Malaysia's logistics and distribution industry, *SMART Journal of Business Management Studies* 19 (2), 1-11.

Sivan, S., Ghadiri, S. M., Rajagopal, P., Atikah, S. B., & Sundram, V. P. K. (2022). Adoption and Benefit of Industrial Revolution 4.0 in Logistics Industry: A Conceptual Paper. *Journal of Entrepreneurship, Business and Economics, 10*(2S1), 79-94.

Smith, J., Brown, T., & Williams, R. (2021). Leveraging real-time data analytics for improved supply chain visibility. *International Journal of Production Economics*, 234, 107-123.

Sundram, V. P. K., Atikah, S. B., Akmal, A. O., & Munir, Z. A. (2017). Green supply chain management practices in Malaysia manufacturing industry. *International Journal of Supply Chain Management, 6*(2), 89-95.

Sundram, V.P.K., Atikah, S.B., Natarajan, V.D., Hariri, S., Rajagopal, R., & Krishnasamy, T. (2016). *Technology & Industrial Management*. MLSCA, Selangor.

Sundram, V. P. K., Chhetri, P., & Atikah, S. B. (2020). The consequences of information technology, information sharing and supply chain integration, towards supply chain performance and firm performance. *Journal of International Logistics and Trade, 18*(1), 15-31.

Sundram, V. P. K., Rajagopal, P., Atikah, S. B., & Subramaniam, G. (2018). The role of supply chain integration on green practices and performance in a supply chain context. A conceptual approach to future research. *International Journal of Supply Chain Management, 7*(1), 95-104.

Sundram, V. P. K., Rajagopal, P., Nur Atiqah, Z. A., Atikah, S. B., Appasamy, G., & Zarina, A. M. (2018). Supply chain responsiveness in an Asian global electronic manufacturing firm: ABX energy (M). *International Journal of Supply chain management, 7*(2), 23-31.

Sundram, V. P. K., Razak Ibrahim, A., & Chandran Govindaraju, V. G. R. (2011). Supply chain management practices in the electronics industry in Malaysia: Consequences for supply chain performance. *Benchmarking: An International Journal, 18*(6), 834-855.

Syakirah, N., Rajagopal, P., Sundram, V. P. K., Zuraidah, R. R., Ratna, M. N. & Zamry, G. (2020). Achieving Supply Chain Excellence through Effective Supplier Management: A Case Study of a Marine Organisation. *International Journal of Supply Chain Management, 9*(4), 11-23.

Tao, F., Cheng, J., Qi, Q., Zhang, M., Zhang, H., & Sui, F. (2018). Digital twin-driven product design, manufacturing and service with big data. *The International Journal of Advanced Manufacturing Technology*, 94(9-12), 3563-3576.

Tao, F., Zhang, H., Liu, A., & Cheng, J. (2020). Digital twin and deep learning-enabled smart manufacturing: A review. *Applied Sciences*, 10(3), 1854.

Tao, F., Zhang, L., & Liu, Y. (2021). Smart manufacturing based on digital twin technologies. *Advances in Manufacturing*, 9(2), 1-17.

Tao, F., Zhang, M., Liu, Y., & Nee, A. Y. C. (2019). Digital twin in industry: State-of-the-art. *IEEE Transactions on Industrial Informatics*, 15(4), 2405-2415.

Uhlemann, T. H., Lehmann, C., & Steinhilper, R. (2017). The digital twin: Realizing the cyber-physical production system for industry 4.0. *Procedia CIRP*, 61, 335-340.

Vatumalae, V., Rajagopal, P., & Sundram, V. P. K. (2020). Warehouse Operations Measurement in Hypermarket Retailers: A Review of Literature. *International Journal of Supply Chain Management, 9*(5), 1276.

Vatumalae, V., Rajagopal, P., Sundram, V. P. K., & Hua, Z. (2022). A study of retail hypermarket warehouse inventory management in Malaysia. *SMART Journal of Business Management Studies, 18*(1), 71-79.

Vatumalae, V., Rajagopal,P., Sundram, VPK., Zarina, A.M., and Ghapar., F. (2023). Linking Factors Leading to Retail Hypermarket Warehouse Operations Performance in Malaysia, *SMART Journal of Business Management Studies* 19 (1), 1-**9.**

Waller, M. A., & Fawcett, S. E. (2013). Data science, predictive analytics, and big data: A revolution that will transform supply chain design and management. *Journal of Business Logistics*, 34(2), 77-84.

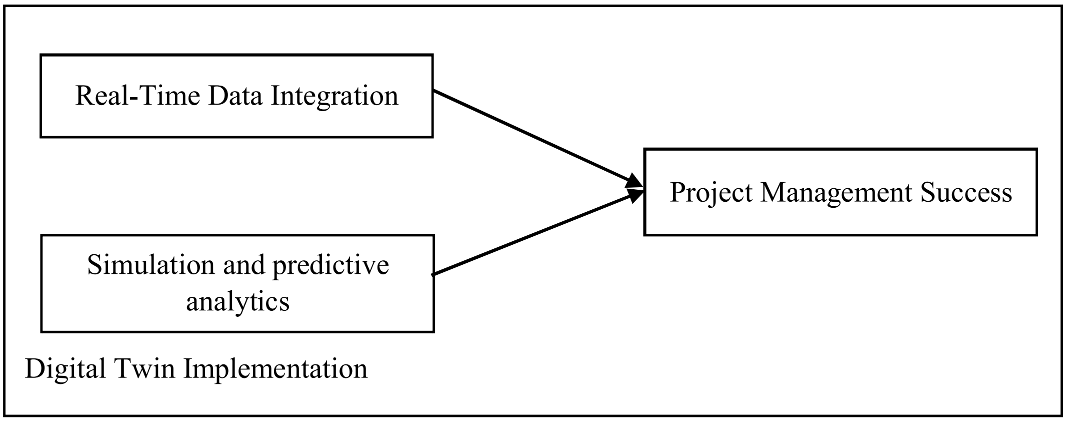
Williams, C., & Anderson, D. (2020). Measuring project success using digital twin integration. *Project Management Journal*, 51(4), 332-345.

Wong Chee, H., Sundram, V. P. K., Bakar, S. M. S. A., & Narayanan, N. S. P. P. (2024). Charting a thriving path for the Malaysian palm oil supply chain: A SWOT-QSPM-powered strategic roadmap. *Journal of Distribution Science, 22*(10), 31–41.

Xu, X., He, L., & Lin, X. (2021). The role of AI and real-time analytics in digital twin applications. *Computers in Industry*, 125, 103-118.

Zulfakar, M., Chan, C., Jie, F., & Sundram, V.P.K.(2019). Halal accreditation and certification in a non-muslim country setting: Insights from Australia halal meat supply chain. *International Journal of Supply Chain Management, 8*(1), 10-17.

Figure-1: Conceptual Framework of Leveraging Digital Twins for Project Management Success in Supply Chain Environments



Source: Framed by Authors

Table-1: Profile of Respondents Working in Supply Chain Management and Project Management Domains within Industries that have Adopted Digital Twin Technology

	Categories	Frequency	Percentage (%)
Industrial Sector	Manufacturing	125	31.25%
	Retail & E-Commerce	60	15.00%
	Pharmaceutical	75	18.75%
	IT & Technology Solution	70	17.50%
	Transportation	70	17.50%
Number of employees	Less than 50	105	26.25%
	50- 99	124	31.00%
	100 - 500	108	27.00%
	More than 500	63	15.75%
Years of establishment	Less than or equal to 10	98	24.50%
	10 - 20	167	41.75%
	21 - 30	88	22.00%
	More than 30	47	11.75%

Source: Primary data computed using SPSS

Table-2: Strata for the Population, Sample Frame, and Survey Responses

Strata	Population	Sample	Responses (response rate)
Less than 50	500	220	179 (35.8%)
50- 99	400	110	85 (17.0%)
100 - 500	300	80	60 (12.0%)
More than 500	300	90	76 (15.2%)
	1500	**500**	**80%**

Source: Generated by Authors

Table-3: Reliability Test of Real-Time Data Integration, Simulation & Predictive Analytics and Project Management Success

Variables	Cronbach Alpha
Real-Time Data Integration [RTD]	0.821
Simulation and predictive analytics [SPA]	0.789
Project Management Success [PMS]	0.774

Source: Primary data computed using SPSS

Table-4: Correlation between Real-Time Data Integration, Simulation & Predictive Analytics and Project Management Success

Variable	RTD	SPA	PMS
RTD	1.000		
SPA	0.720**	1.000	
PMS	0.660**	0.710**	1.000

*** significant at 0.01 level (2-tailed)*

Source: Primary data computed using SPSS

Table-5: Multiple Regression Analysis of Real-Time Data Integration and Simulation & Predictive Analytics towards Project Management Success

Independent Variable	Project Management Success			Hypothesis	Result
	Beta (β)	t-value	Sig.		
Real-Time Data Integration	0.283	2.448	0.000	H1	Accepted
Simulation and predictive analytics	0.523	4.451	0.000	H2	Accepted
F-value	15.629				
R-square	0.476				

****Significant at the 0.001 level*

Source : Primary data computed using SPSS