

ACHIEVING CUSTOMER SATISFACTION DRIVE-THRU SERVICES THROUGH DIGITAL TWINS IN AMERICA

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ABSTRACT

In today's dynamic business environment, comprehending consumer behavior stands as a pivotal factor for achieving success. However, traditional methods of gathering consumer insights often prove to be time-consuming, expensive, and limited in depth. Digital Twins technology emerges as a promising solution, offering virtual representations of consumers and real-time insights into their behaviors and preferences. This study, which has yielded promising results, investigates the implementation of Digital Twins in enhancing efficiency, performance, and user experience within drive-thru services, focusing on consumer perspectives. Additionally, it evaluates the technology's impact on operational management and customer interactions while addressing data security and privacy concerns. Employing a quantitative approach, the study surveys 2000 drive-thru consumers in the United States through purposive sampling. Data collected covers consumer satisfaction, perceptions of Digital Twins' effectiveness, and drive-thru service preferences, analyzed using Structural Equation Modeling (SEM-PLS). Findings indicate the significant impacts of Digital Twins on drive-thru services, including purchase accuracy, interactivity, process efficiency, and overall customer satisfaction. Reliability and validity tests affirm the robustness of the research model. This research contributes to understanding Digital Twins technology's potential benefits and challenges in drive-thru services. It underscores the importance of strategic approaches to maximize its advantages across industries. Furthermore, it offers a comprehensive framework for securely and effectively implementing Digital Twins, considering broader aspects beyond technical considerations.

Keywords: Consumer Behavior, Digital Twins, Drive-Thru Services, Efficiency, Consumer Experience, Operational Management, Data Security

ABSTRAK

Dalam lingkungan bisnis yang dinamis saat ini, memahami perilaku konsumen merupakan faktor kunci untuk mencapai kesuksesan. Namun, metode tradisional untuk mengumpulkan wawasan konsumen sering kali memakan waktu, mahal, dan terbatas dalam kedalamannya. Teknologi Digital Twins muncul sebagai solusi yang menjanjikan, menawarkan representasi virtual dari konsumen dan wawasan real-time tentang perilaku dan preferensi mereka. Penelitian ini menyelidiki penerapan Digital Twins dalam meningkatkan efisiensi, kinerja, dan pengalaman pengguna dalam layanan drive-thru, dengan fokus pada perspektif konsumen. Selain itu, penelitian ini mengevaluasi dampak teknologi terhadap manajemen operasional dan interaksi pelanggan, sambil mengatasi kekhawatiran terkait keamanan dan privasi data. Menggunakan pendekatan kuantitatif, penelitian ini mensurvei 2000 konsumen drive-thru di Amerika Serikat melalui purposive sampling. Data yang dikumpulkan mencakup kepuasan konsumen, persepsi terhadap efektivitas Digital Twins, dan preferensi layanan drive-thru, yang dianalisis menggunakan Structural Equation Modeling (SEM-PLS). Temuan menunjukkan dampak signifikan dari Digital Twins pada berbagai aspek layanan drive-thru, termasuk akurasi pembelian, interaktivitas, efisiensi proses, dan kepuasan pelanggan secara keseluruhan. Uji reliabilitas dan validitas menegaskan kokohnya model penelitian. Penelitian ini berkontribusi pada pemahaman tentang potensi manfaat dan tantangan teknologi Digital Twins dalam layanan drive-thru dan menekankan pentingnya pendekatan strategis untuk memaksimalkan keuntungannya di berbagai industri. Selain itu, penelitian ini menawarkan kerangka kerja komprehensif untuk mengimplementasikan Digital Twins secara aman dan efektif, dengan mempertimbangkan aspek yang lebih luas di luar pertimbangan teknis.

Kata Kunci: Perilaku Konsumen, Digital Twins, Layanan Drive-Thru, Efisiensi, Pengalaman Konsumen, Manajemen Operasional, Keamanan Data

ARTICLE INFO

Article History:

Received: February 09, 2024

Revised: April 04, 2024

Published Online: June 10, 2024

How to cite:

Lanawaang, Y. M., Suryawijaya, T. W. E., Mahmud, & Zhou, B. (2024). Achieving Customer Satisfaction Drive-Thru Services through Digital Twins in America. *International Journal of Digital Entrepreneurship and Business (IDEB)*, 5(1), 1–15. <https://doi.org/10.52238/ideb.v5i1.148>



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Conflict of interest statement: The author(s) reported no conflict of interest.

INTRODUCTION

Business dynamics continue to change and coincide with technological developments as time passes. To achieve success, consumer insight through customer responsiveness is needed. Existing businesses tend to rely on traditional methods of gathering consumer insights. Telephone survey techniques, face-to-face interviews, and focus groups have long been the gold standard. Although these methods provide valuable insights, they have limitations such as taking a long time, being quite expensive, and lacking depth and breadth in understanding the modern consumer. Digital Twins is confronting us with a virtual replica created by combining real-time data with sophisticated algorithms (VanDerHorn & Mahadevan, 2021). Relevant to consumer insight, Digital Twins has become a virtual representation of consumers, reflecting their behavior, preferences, and purchasing patterns. This technology is not just a new tool for marketers; it will redefine the entire consumer research landscape. In contrast to traditional research methods that involve months-long waiting periods, Digital Twins can provide insights almost instantly, enabling businesses to respond to market changes at unprecedented speed. Not only in the business realm, so far Digital Twins has been implemented in disaster mitigation in the transportation sector (see Figure 1). Comprehensive data analysis is an advantage of Digital Twins, which can integrate multiple data points, from geolocation to online browsing habits, providing a multi-dimensional view of consumers (Lizar et al., 2023). For businesses with global operations, Digital Twins is a game changer created to represent consumers from different regions, ensuring insights that are culturally relevant and geographically specific (Hu et al., 2021).

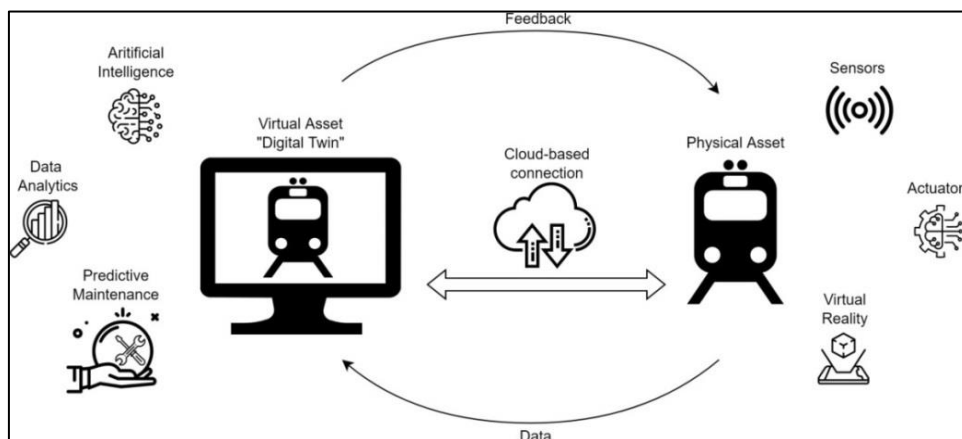


Figure 1: Implementation of Digital Twins in Disaster Mitigation

Source: (Patandianan & Assidiq, 2022)

Traditional telephone surveys may capture feedback rate by rate from 50,000 consumers during a month. Digital Twins can simulate feedback from 30,000 virtual consumers in one day. Focus group sessions, which may cost as much as \$6,000 per session, can be replaced by virtual product testing with Digital Twins, resulting in potential savings of up to 80%. The ability of Digital Twins to simulate various market scenarios can reduce the product testing phase from several months to just a few days. With the ability to integrate real-time data, Digital Twins can predict consumer behavior with an accuracy rate of up to 90%, experiencing a significant jump from the 60-70% accuracy rate in traditional methods (Attaran & Celik, 2023). Digital Twins and their significant impact in various sectors, including banking, business, and financial services, have exemplified their implementation. Nevertheless, challenges and opportunities remain to be explored. Digital Twins in the banking, business, and financial services sectors have shown immense potential value in understanding customer behavior, enhancing security, and providing profound insights into business risks (Heluany & Gkioulos, 2023). However, despite the success of Digital Twins technology in this sector, several aspects require further attention. In this context, implementing Digital Twins technology in the drive-thru service

sector, such as drive-thru services, is an intriguing research topic. Drive-thru represents an innovative service format capable of offering convenience and comfort to customers during transactions.

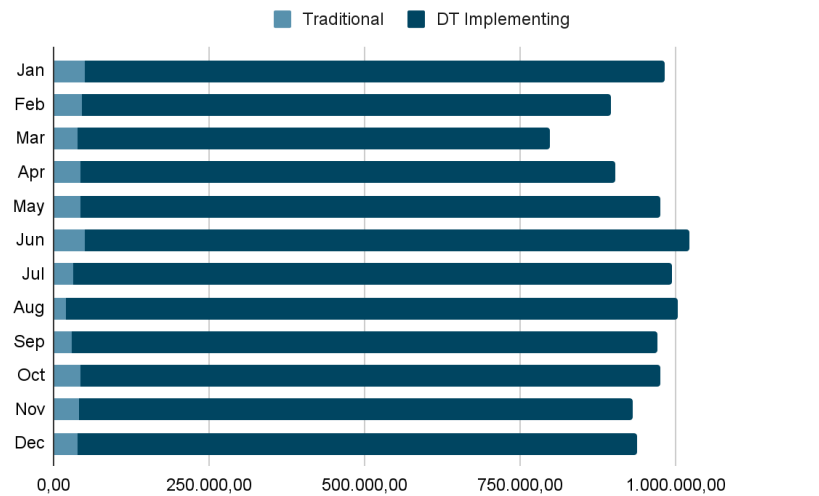


Figure 2: Performance comparison in traditional survey and DT implementation
 Source:(Jones et al., 2020)

Digital Twins are very useful in helping various sectors. Research by Human et al. (2023) has revealed how Digital Twins can work in the consumer goods sector based on a reference architecture. The results enable systematic decisions that reflect complex systems. Other research results show that implementing integrated procurement, production, and distribution (PPD) has provided significant benefits. Specifically, the study observed a 65% utilization of pasteurization and aging containers and an impressive 97% utilization of freezers. In addition, by implementing the DT model, the currently implemented model has resulted in a reduction in storage space capacity of 6%, which further simplifies operations and increases efficiency (Maheshwari et al., 2023). Wu et al. (2023) research also shows that Digital Twins have proven effective in managing staff safety, operational information, product quality assurance, and maintaining stakeholder loyalty, showing a real improvement in the Service Platform for Cold Chain Logistics. Han et al. (2023) The study shows that digital twinning methods enable real-time and continuous control of related operational tasks and further encourage the development of digitalization, automation, and intelligence in hospital operations.



Figure 3: Concept of using Digital Twins in various sectors
 Source:(Stavropoulos & Mourtzis, 2022)

This research aims to investigate the effective implementation of Digital Twins technology in enhancing the efficiency, performance, and user experience of drive-thru services from a consumer perspective.

Additionally, the study intends to assess the impact of Digital Twins on operational management, customer interactions, and other relevant aspects of the drive-thru environment. Challenges related to data security and privacy, coordinating responses to change, and adapting to different scenarios will also be explored. Therefore, this research will contribute to understanding the concept of Digital Twins in the context of drive-thru services and detail potential problems and solutions in its implementation. By integrating insights from the successful use of Digital Twins in related sectors and focusing on drive-thru implementation, this research aims to provide a comprehensive view of the potential benefits and challenges for achieving optimal customer satisfaction.

LITERATURE REVIEW

Customers naturally have increasingly higher expectations for service experiences. This drives organizations to seek new ways to enhance customer satisfaction and improve operational efficiency. One promising innovation is the implementation of Digital Twins technology in drive-thru services. Digital Twins are virtual replicas of physical objects in the real world, enabling real-time monitoring and analysis to enhance service efficiency and quality (Kang & Mo, 2024). This literature review will explore the concept of Digital Twins and their impact on drive-thru services. Digital Twins is an innovation that revolutionizes understanding and managing physical objects in the real world (Jeddoub et al., 2023). This concept involves creating accurate virtual replicas of physical objects, which are then linked to real-time data and analyzed using advanced algorithms. In the context of drive-thru services, Digital Twins can be utilized to replicate the processes of ordering, payment, and food delivery, thus enabling better monitoring and analysis of operational performance and customer experience (Pittaras et al., 2023).

Implementing Digital Twins in drive-thru services offers numerous benefits, primarily enhancing the accuracy of purchases. Through this technology, businesses can collect and analyze data on customer preferences and purchasing habits, enabling them to present more tailored menus and reduce order errors (Hunhevicz et al., 2022). Additionally, Digital Twins enables real-time inventory tracking, ensuring the availability of desired products for customers. Moreover, interactivity is crucial in improving customer experience in drive-thru services. By utilizing Digital Twins, businesses can enhance customer interactivity through more intuitive and responsive interfaces. For example, customers can use mobile apps to pre-order food. Digital Twins can integrate this data into the drive-thru process to ensure that their orders are ready upon arrival (Ehemann et al., 2023).

Customer experience is integral to the success of drive-thru services. With Digital Twins, businesses can enhance customer experience by providing more personalized and responsive services (Human et al., 2023). For instance, Digital Twins can remember customer preferences and purchasing habits, offer more relevant recommendations, and reduce wait times. Moreover, Digital Twins facilitates process efficiency, improving operational performance and customer satisfaction in drive-thru services. By using Digital Twins, businesses can identify and address bottlenecks in the service process, thus enhancing throughput and reducing wait times. For example, Digital Twins can predict customer traffic patterns and schedule food deliveries to avoid congestion. Service performance is a critical measure of operational effectiveness in drive-thru services. With Digital Twins, businesses can monitor service performance in real-time and identify areas for improvement. For instance, Digital Twins can notify staff when wait times exceed a certain threshold, enabling them to take action to expedite the process. Security is paramount in drive-thru services, especially concerning payment and food delivery. With Digital Twins, businesses can enhance security by monitoring real-time transactions and detecting suspicious activities. Service quality is a determinant factor in enhancing customer satisfaction in drive-thru services. With the Digital Twins, businesses can ensure service quality by monitoring and analyzing interactions between staff and customers. Digital Twins can record conversations between staff and customers to evaluate customer satisfaction levels and identify areas for improvement (De Azambuja et al., 2024). Customer satisfaction is the ultimate measure of success in drive-thru services. With Digital Twins, businesses can improve customer satisfaction by providing faster, more responsive,

and more personalized services (Durão et al., 2024). For example, Digital Twins can send notifications to customers when their orders are ready for pickup, thereby reducing wait times and enhancing overall customer satisfaction.

Based on this literature review, it can be concluded that implementing Digital Twins in drive-thru services has significant potential to improve operational efficiency and customer satisfaction. Through this technology, businesses can enhance the accuracy of purchases, interactivity, customer experience, process efficiency, service performance, security, service quality, and customer satisfaction. However, achieving its full potential requires collaboration among academics, practitioners, and technology developers to address challenges related to system integration, data security, and implementation costs. With adequate cooperation, the implementation of Digital Twins in drive-thru services has the potential to transform the industry landscape and enhance the overall customer experience. Based on this literature review, Figure 4 illustrates the context of the relationships between variables, as described below:

- a. **X₁ (Accuracy of Buying):** Directly influences C₁ (Service Performance), C₂ (Security), C₃ (Service Quality), and indirectly influences Y₁ (Consumer Satisfaction) through its impact on the variable M₁ (Consumer Experience).
- b. **X₂ (Interactivity):** Directly influences M₁ (Consumer Experience), C₁ (Service Performance), C₂ (Security), and C₃ (Service Quality), and indirectly influences Y₁ (Consumer Satisfaction) through its impact on M₁ (Consumer Experience).
- c. **M₁ (Consumer Experience):** Directly influences Y₁ (Consumer Satisfaction) and indirectly influences Y₁ (Consumer Satisfaction) through its impact on C₁ (Service Performance), C₂ (Security), and C₃ (Service Quality).
- d. **M₂ (Process Efficiency):** Directly influences C₁ (Service Performance), C₂ (Security), and C₃ (Service Quality), and indirectly influences Y₁ (Consumer Satisfaction) through its impact on M₁ (Consumer Experience).
- e. **C₁(Service Performance), C₂(Security), and C₃(Service Quality):** Directly influence Y₁ (Consumer Satisfaction).

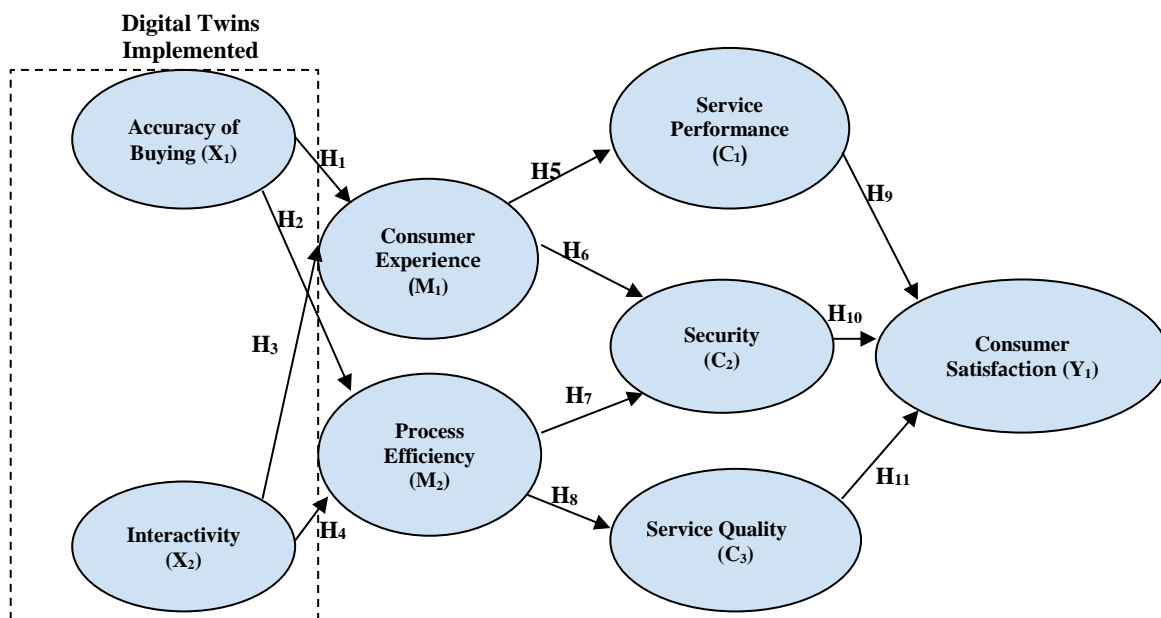


Figure 4: Research Conceptual Framework
Source: Author's Elaboration, 2023

METHODS

This research adopts a quantitative approach to investigate consumer satisfaction using Digital Twins technology for drive-thru (Esteban-Bravo & Vidal-Sanz, 2021). The research population consists of experienced consumers using the service drive through the United States. This was chosen because the drive-thru system was reasonably implemented in the fast-food sector and other buying and selling sectors where a drive-thru system is possible. A sample of 2000 respondents will be selected using purposive sampling (Gregori, 2023). The sample criteria were individuals who had used the drive-thru service at least once. The study was conducted from July to November 2023, a sufficient period to collect representative data and examine potential changes over time. The main instrument of this research is an online survey using an interval scale of 1-10 (Saris, 2021). This survey is designed to cover essential aspects related to consumer satisfaction, perception of the effectiveness of Digital Twins, and preference for drive-thru service (See Table 1).

Table 1: Variable Distribution

Variable	Indicator	
X ₁ (Accuracy of Buying)	X1.1	Accuracy of Product Information
	X1.2	Precision in Order Processing
	X1.3	Correctness of Transaction Amount
	X1.4	Accuracy in Delivery Time
X ₂ (Interactivity)	X2.1	Responsiveness of Customer Support
	X2.2	Ease of Navigation in the Interface
	X2.3	Availability of Real-time Assistance
M ₁ (Consumer Experience)	M1.3	Satisfaction with User Interface
	M1.2	Enjoyment in Navigating the Platform
	M1.3	Overall Pleasure in the Shopping Experience
M ₂ (Process Efficiency)	M2.1	Timeliness in Order Processing
	M2.2	Efficiency in Payment Procedures
	M2.3	Speed of Conflict Resolution
C ₁ (Service Performance)	C1.1	Timeliness in Service Delivery
	C1.2	Accuracy in Order Fulfillment
	C1.3	Effectiveness in Handling Customer Inquiries
C ₂ (Security)	C2.1	Data Privacy Assurance
	C2.2	Secure Payment Transactions
	C2.3	Protection Against Unauthorized Access
C ₃ (Service Quality)	C3.1	Quality of Product Offerings
	C3.2	Reliability of Service Availability
	C3.3	Consistency in Service Standards
Y ₁ (Consumer Satisfaction)	Y1.1	Overall Satisfaction with the Service
	Y1.2	Willingness to Recommend to Others
	Y1.3	Likelihood of Repeat Purchase

Source: Author's Elaboration, 2023

The questionnaires were distributed through the Triaba survey service (Triaba, 2022) because it can help get respondents who match the research target. The ethical aspects of research will be maintained by the applicable research code of ethics, including data security and respondent privacy. Participation in this research is voluntary, and data will be processed anonymously to maintain the confidentiality of respondents' identities (Poth, 2021). Data analysis will be carried out using the SEM-PLS method with the support of SmartPLS 4.0 software; this method will be used to evaluate the relationship between research variables, allowing a deeper understanding of the impact of Digital Twins technology on consumer satisfaction in the context of drive-thru services.

RESULT AND DISCUSSION

Table 2 presents the demographic profiles of the respondents, who are the focal point of this research. The data is categorized into several clusters, including gender, age group, type of service used, and frequency of Digital Twins service usage. The respondents comprised 1,137 males, representing 56.85% of the total, and 863 females, accounting for 43.15%. Most respondents were within the 22–35 age group (977 individuals or 48.85%), followed by the 35–42 age group (812 individuals or 40.60%). Respondents under 22 and over 42 contributed 4.90% and 5.65%, respectively. The services utilized by respondents spanned various categories, with “Fast Food” services being the most prevalent (704 individuals or 35.20%), followed by “Prayer Rooms” (227 individuals or 11.35%) and “Retail Products” (210 individuals or 10.50%). This table provides a comprehensive data foundation for analyzing user preferences and behaviors in implementing Digital Twins across different drive-thru services.

Table 2: Respondent Profile

Cluster	Type	Amount	Present
Gender	Male	1137	56.85%
	Female	863	43.15%
Age Group	<22 Years	98	4.90%
	22 - 35 Years	977	48.85%
	35 - 42 Years	812	40.60%
	>42 Years	113	5.65%
Service Type	Fast Food	704	35.20%
	Retail Products	210	10.50%
	Funeral Home	107	5.35%
	Voting	102	5.10%
	Emergency	215	10.75%
	Prayer Room	227	11.35%
	Wedding	116	5.80%
	Law Firm	203	10.15%
	Bar/Club	111	5.55%
Politician	5	0.25%	
frequency of use of Digital Twins services	1 - 2	127	6.35%
	3 - 5	1303	65.15%
	>5	570	28.50%

This study evaluates the internal model’s reliability by applying the convergent validity test. Convergent validity is assessed using the Average Variance Extracted (AVE) value, with a minimum threshold of 0.5. Additionally, the model’s reliability is verified by examining the Composite Reliability value, which should surpass 0.7 to confirm the model’s robustness (Hair, 2014).

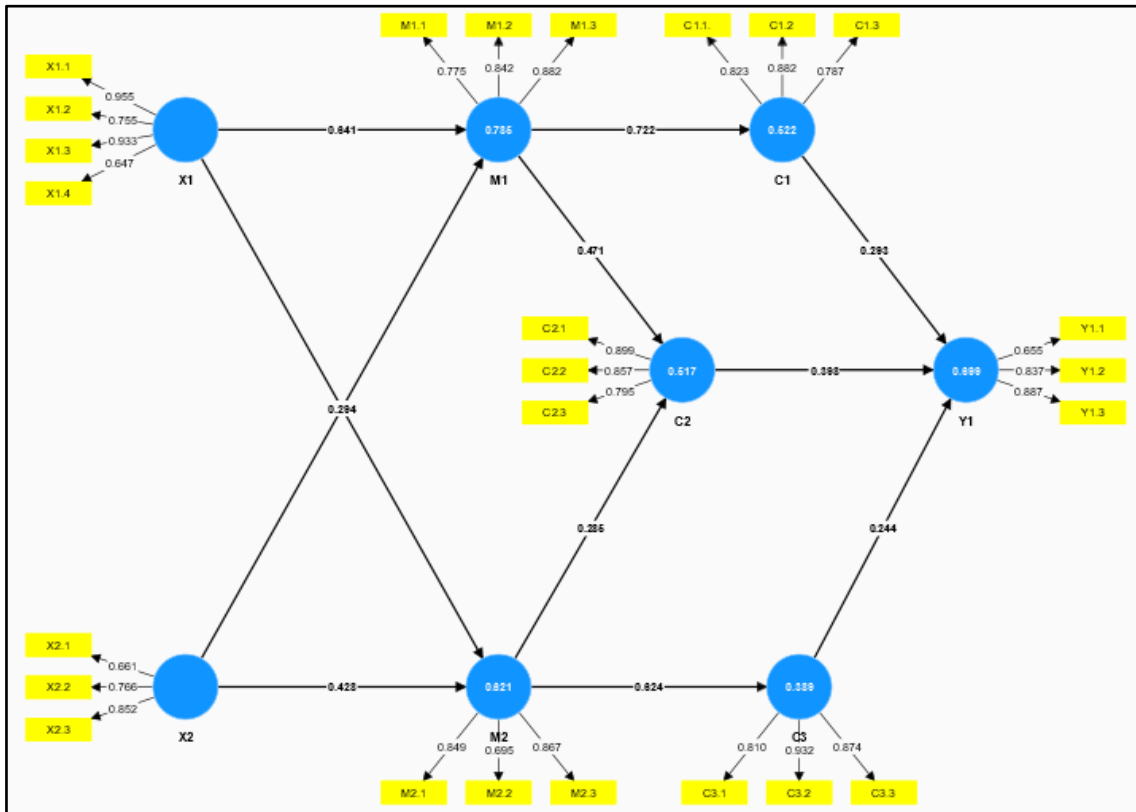


Figure 5: Path Analysis Results (Author’s Elaboration, 2023)

Table 3 shows the Average Variance Extracted (AVE) values for all variables, consistently reaching figures above 0.5. These results indicate that the data collected in the context of this research can be considered valid. Furthermore, the Composite Reliability results show that the value for each variable exceeds the 0.7 limit. Therefore, it can be concluded that this research shows a significant level of reliability and validity of the data (Magno et al., 2022).

Table 3: Reliability & Convergent Validity Test Results

Variable	Composite Reliability	AVE	R-Square
X ₁ (Accuracy of Buying)	0.898	0.639	0.522
X ₂ (Interactivity)	0.806	0.583	0.517
M ₁ (Consumer Experience)	0.873	0.696	0.785
M ₂ (Process Efficiency)	0.848	0.652	0.621
C ₁ (Service Performance)	0.870	0.692	0.522
C ₂ (Security)	0.887	0.725	0.517
C ₃ (Service Quality)	0.906	0.762	0.389
Y ₁ (Consumer Satisfaction)	0.840	0.639	0.699

The structural model was also evaluated using the R-Square test, as shown in Table 3. The results indicate that the R-Square value is close to 1, although it has not yet reached the median value of the criteria range for variable C₃, which spans from 0 to 1. Therefore, it can be concluded that the variation in the dependent variable in this study can be explained by the model with an appropriate level of adequacy (Westfall & Arias, 2020).

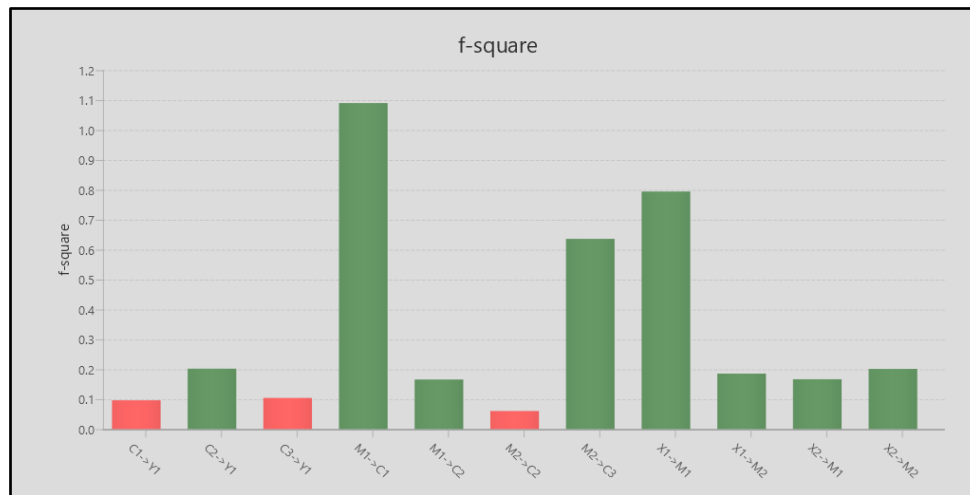


Figure 6: F-Square Test Results (Author’s Elaboration, 2023)

The structural model was also evaluated using the f-square test. As illustrated in Figure 4, the test results reveal that three out of the eleven relationships tested have f-square values below 0.1. Despite this, it can be concluded that the relationships between the variables have a significant influence.

Table 4: Total Effects Results

Hypotheses		Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistic	P Values
H ₁	X ₁ → M ₁	0.641	0.654	0.081	7.888	0.000
H ₂	X ₁ → M ₂	0.411	0.383	0.143	2.879	0.004
H ₃	X ₂ → M ₁	0.294	0.289	0.094	3.116	0.002
H ₄	X ₂ → M ₂	0.428	0.456	0.118	3.635	0.000
H ₅	M ₁ → C ₁	0.722	0.714	0.107	6.722	0.000
H ₆	M ₁ → C ₂	0.471	0.473	0.215	2.191	0.028
H ₇	M ₂ → C ₂	0.285	0.285	0.207	1.376	0.169
H ₈	M ₂ → C ₃	0.624	0.638	0.097	6.417	0.000
H ₉	C ₁ → Y ₁	0.293	0.265	0.141	2.072	0.038
H ₁₀	C ₂ → Y ₁	0.398	0.392	0.116	3.437	0.001
H ₁₁	C ₃ → Y ₁	0.244	0.275	0.112	2.182	0.029

The results of the bootstrapping analysis in Table 4 reveal several key findings regarding the total effect of the independent variable on the dependent variable and the total effects between the control and mediator variables. Firstly, C₁ (Service Performance) has a significant influence on Y₁ (Consumer Satisfaction), with a total effect of 0.293, indicated by a T statistic of 2.072 and a p-value of 0.038. Secondly, C₂ (Security) demonstrates a more substantial influence on Y₁ (Consumer Satisfaction), with a total effect of 0.398, a T statistic of 3.437, and a p-value of 0.001, confirming its high significance. Additionally, C₃ (service quality) significantly contributes with a total effect of 0.244 and a T statistic of 2.182 (p-value 0.029).

At the mediator level, M₁ (Consumer Experience) significantly influences C₁ (service performance), C₂ (security), and Y₁ (Consumer Satisfaction). At the same time, M₂ (Process Efficiency) is significant only for C₂ (security) and C₃ (service quality), with no significant influence on Y₁ (Consumer Satisfaction). Furthermore, the independent variables X₁ (Accuracy of Buying) and X₂ (Interactivity) exhibit a significant total effect on all related variables, reinforcing their contribution to the model. The

bootstrapping results support the research model's structure and suggest that the relationships between these variables have substantial statistical significance (Abdi, 2021).

Digital Twins, as a technological innovation, can significantly enhance the efficiency of drive-thru services, as demonstrated by the case data presented. The restaurant case underscores the necessity for improvements in the drive-thru experience, particularly emphasizing service speed and technology implementation (T. W. E. Suryawijaya et al., 2023). Consumer surveys reveal that long wait times and lack of service friendliness are major challenges faced by customers. In this context, Digital Twins can provide valuable insights into traffic flow, order patterns, and staff performance at drive-thru locations. By analyzing this data, restaurant owners can identify areas for efficiency improvements, thereby reducing wait times and enhancing customer interactions. Notably, the integration of technology in restaurants, including automation and artificial intelligence, received positive feedback from the majority of respondents (Tao et al., 2018). Consequently, the future of Digital Twin computing involves advanced analysis and modeling techniques to meet emerging needs (Le & Fan, 2024). Integrating Digital Twins into drive-thru operations aligns with consumer expectations (Vrabič et al., 2018). For example, implementing AI voice assistants for faster ordering, personalized menus, and smartphone payments can effectively increase efficiency and customer satisfaction (Luna, 2023).

The retail business sector demonstrates that the drive-thru concept can extend beyond fast food. For retailers, drive-thru services can offer a quick and convenient shopping experience without requiring customers to leave their vehicles (Zhong & Moon, 2020). Specifically, in the context of retail stores and non-food item sales, drive-thru services can provide an efficient solution for goods pickup and delivery (Suryawijaya & Aqmala, 2023). By implementing Digital Twins, business owners can optimize the design of pickup areas and enhance overall operational coordination (Tao et al., 2019). Analyzing data on customer preferences and shopping patterns becomes an invaluable tool for creating more personalized and efficient drive-thru experiences (Whitenack & Mahabir, 2022). This approach is particularly significant in addressing the 'last mile' challenge in goods delivery, where Digital Twins-based drive-thru services are emerging as a promising alternative.

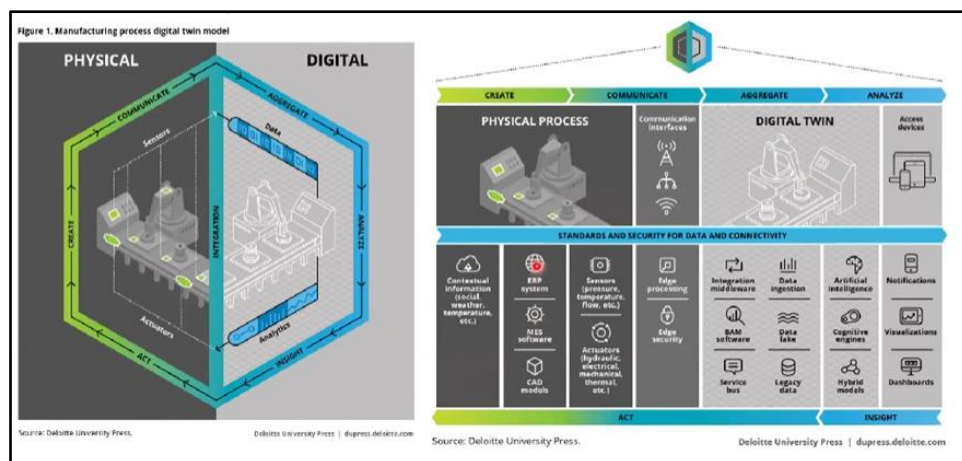


Figure 7: The process of translating physical and digital aspects of Drive Thru services
 Source:(Tao et al., 2018)

The effectiveness of Digital Twins in drive-thru services represents a progressive step toward enhancing customer experience, reducing wait times, and providing adaptable solutions to consumer trends. By leveraging data, business owners can make informed decisions to optimize drive-thru operations, thereby advancing this innovation within the retail sector. However, it is important to acknowledge that

despite the efficiency gains from Digital Twins, some customers may still experience delays in queuing times (Lahrichi et al., 2020). This research indicates that Digital Twins are a technological innovation capable of significantly enhancing the efficiency of drive-thru services, ultimately increasing customer satisfaction.

Digital Twins are set to revolutionize industry operations by transitioning from physical asset management to increasingly automated, data-driven remote working modes. However, this potential revolution also carries significant risks if not managed properly. The threat of cyber-attacks, supply chain fraud, errors, missed maintenance, and other issues can compromise system integrity and erode trust in the data generated and utilized (Alcaraz & Lopez, 2022). Moreover, Digital Twins that operate on inaccurate data cannot be considered true Digital Twins. These systems comprise various components, including diverse hardware and software, physical environments, and actors that collaborate and exchange data to gain a comprehensive understanding of system operations and improve decision-making.

In this context, it is crucial to prioritize security and trust as fundamental components, where risks and responsibilities are shared, and actions taken by one party can affect others (Hammar & Stadler, 2023). Therefore, ensuring the security of Digital Twins is akin to a team sport, with applications in both technical and commercial realms.

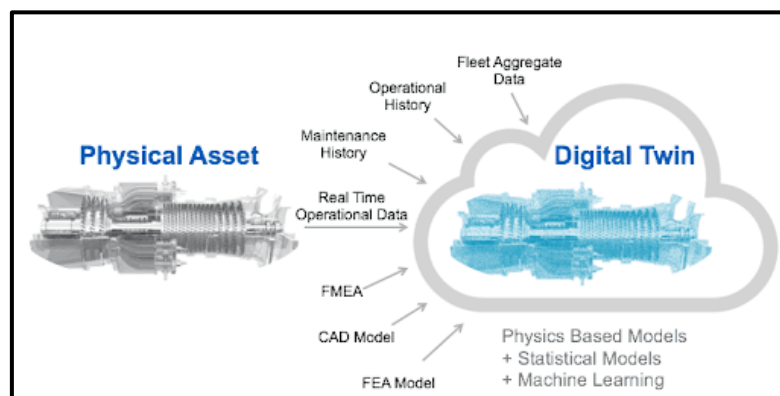


Figure 9: Digital Twins concept in supporting security systems
Source: (Timperi et al., 2023)

The Digital Twins Consortium is presently engaged in developing and documenting a security and trust approach tailored to the unique features of Digital Twins systems and their operations. This research presents a novel and comprehensive framework for evaluating, adopting, and operating Digital Twins technologies and products, particularly focusing on security considerations. Notably, this approach encompasses threat management in cyberspace, regulatory compliance, personal safety protection, and investment management (Timperi et al., 2023). By addressing shared risks and responsibilities, this research provides a holistic perspective on Digital Twins security, likening it to a team sport. Its main contribution lies in offering a framework that encompasses the full spectrum of security challenges, including less exposed aspects such as investment management and regulatory compliance (Kurvinen et al., 2022; T. Suryawijaya & Aqmal, 2023). Thus, it goes beyond technical aspects to encompass broader considerations, serving as a comprehensive guide for end users and system integrators seeking to implement Digital Twins safely and effectively.

Consumer involvement is pivotal in determining the success of implementing Digital Twins technology, as their experiences and perceptions influence its adoption and acceptance. By examining the consumer perspective, we can gauge how Digital Twins technology is perceived, accepted, and responded to, particularly in the context of drive-thru services (Heluany & Gkioulos, 2023). Research findings suggest significant consumer acceptance of Digital Twins technology in enhancing the drive-thru transaction experience, albeit with reservations regarding security (Hammar & Stadler, 2023). The integration of Digital Twins technology into service enhancement represents a strategic approach to improving efficiency and service quality within the drive-thru industry. It enables business owners to gain insights into order patterns, traffic flow, and employee performance, allowing them to identify areas for efficiency enhancement and offer tailored solutions to elevate service quality (Attaran & Celik, 2023; Westfall & Arias, 2020). Moreover, Digital Twins technology facilitates the adoption of innovations such as personalized menus and smartphone payments, enhancing consumer convenience and satisfaction (T. W. E. Suryawijaya & Wardhani, 2023).

Despite its potential benefits, Digital Twins technology encounters various challenges that must be addressed for successful implementation (Alcaraz & Lopez, 2022). Additionally, considerations regarding its future direction, particularly concerning security aspects, are essential. With a comprehensive understanding of these challenges and future directions, strategic steps can be identified to maximize the benefits of Digital Twins technology in improving efficiency and service quality across industries, including the drive-thru sector.

The research is subject to several limitations that warrant consideration. Firstly, a geographical constraint is evident as the study exclusively focuses on drive-thru customers in America, potentially restricting the generalizability of findings to a global or non-American population. Cultural disparities, divergent consumer preferences, and varying business infrastructures in other regions may yield disparate results. Secondly, the method of data collection via online surveys through the Triaba service could introduce selection bias, as individuals less adept with technology or lacking internet access may be underrepresented in the sample. Thirdly, the study only includes respondents who have utilized drive-thru services at least once, potentially overlooking the diversity in user experiences that could influence perceptions and attitudes towards Digital Twins technology. Fourthly, while the research encompasses various types of drive-thru services such as fast-food, retail stores, and polling stations, other service types remain unexplored, limiting the generalizability of findings to alternate service categories. Moreover, the research was conducted within a confined timeframe from July to November 2023, potentially affecting the understanding of long-term dynamics in Digital Twins technology adoption within drive-thru services. Lastly, challenges were encountered in sourcing relevant literature due to the emerging nature of Digital Twins technology in the drive-thru service context, possibly constraining the depth of the literature review.

CONCLUSION

In conclusion, this study underscores the potential advantages of integrating Digital Twins technology into drive-thru services to enhance operational efficiency and elevate the customer experience. Analysis of consumer surveys underscores the importance of addressing challenges such as prolonged wait times and service quality issues in drive-thru establishments. Through the deployment of Digital Twins, restaurant owners can gain valuable insights into customer behavior, traffic patterns, and staff performance, enabling them to streamline operations and enhance service delivery. The findings indicate that embracing innovations like AI voice assistants, personalized menus, and mobile payment solutions can help alleviate common challenges encountered by drive-thru patrons, ultimately resulting

in heightened satisfaction and loyalty. Therefore, the successful integration of Digital Twins carries significant implications for the drive-thru industry, fostering a more seamless and tailored customer experience while driving business growth and competitiveness.

ACKNOWLEDGEMENTS

We express our sincere gratitude to Universitas Dian Nuswantoro for their generous support of this research endeavor. Additionally, we extend our appreciation to Triaba and UCLA for their collaboration in facilitating the implementation of this study. Special thanks are also due to the committee of DIYC 2024 for providing a valuable scientific platform for the exchange of research findings.

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