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Systematic Review of Marketing Attribution Techniques for Omnichannel Customer Acquisition Models

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Abstract

In the evolving landscape of digital commerce, the ability to accurately attribute marketing outcomes to specific touchpoints within the customer journey is critical for optimizing omnichannel acquisition strategies. This systematic review examines the current state of marketing attribution techniques applied in omnichannel customer acquisition models, with the goal of identifying prevailing methodologies, comparative effectiveness, and emerging trends. A comprehensive search of peer-reviewed journals, industry reports, and conference proceedings published between 2013 and 2024 was conducted using databases such as Scopus, Web of Science, and Google Scholar. The review categorizes attribution techniques into rule-based models (e.g., first-touch, last-touch, linear), algorithmic models (e.g., logistic regression, Markov chains), and advanced machine learning approaches (e.g., Shapley value models, deep learning). Findings indicate a significant shift from traditional rule-based methods to data-driven and probabilistic techniques that account for inter-channel synergies and temporal dependencies. Algorithmic models like Markov chains demonstrate superior performance in capturing the non-linear and dynamic nature of customer

journeys, while machine learning approaches offer greater predictive accuracy and scalability in complex omnichannel environments. However, challenges such as data integration across disparate channels, attribution bias, model interpretability, and real-time application remain prominent. The review further highlights the importance of contextual factors such as industry type, customer segmentation, and campaign objectives in selecting appropriate attribution models. It also identifies a growing interest in hybrid frameworks that blend business rules with machine learning for enhanced transparency and decision-making support. The study concludes that while advanced attribution models hold substantial promise, successful implementation hinges on data quality, cross-functional collaboration, and technological maturity. Future research should focus on real-time adaptive attribution, causal inference techniques, and standardized evaluation metrics to further advance the field. This review provides a critical foundation for marketers, analysts, and researchers seeking to enhance omnichannel acquisition performance through informed attribution strategies.

Keywords: Systematic Review, Marketing Attribution, Techniques, Omnichannel, Customer Acquisition, Models

1. Introduction

In the current digital economy, the proliferation of channels through which consumers interact with brands has given rise to omnichannel marketing a strategy that integrates multiple touchpoints, including physical stores, websites, mobile apps, email, social media, and customer service platforms, to deliver a seamless customer experience. This evolution has fundamentally changed how businesses engage with potential customers, creating increasingly complex and non-linear customer journeys (Ojika *et al.*, 2023; Onukwulu *et al.*, 2023). As organizations allocate substantial portions of their marketing budgets across

these diverse platforms, the need to accurately measure the effectiveness of each channel in acquiring customers has become imperative. This process, known as marketing attribution, seeks to determine the contribution of individual touchpoints in driving conversions and customer acquisitions (Adekunle *et al.*, 2023; Ilori *et al.*, 2023).

Accurate attribution is vital for optimizing marketing strategies, budget allocation, and return on investment (ROI). In the context of omnichannel acquisition, where a customer may engage with a brand through several offline and online channels before making a purchase (Iwe *et al.*, 2023; Agho *et al.*, 2023), the attribution process becomes significantly more complicated. Traditional models that assign credit solely to the first or last touchpoint in the journey often fail to capture the nuanced interplay among different marketing efforts. As a result, businesses may misallocate resources, under-invest in effective channels, or overlook the synergistic effects of multi-channel campaigns. Hence, a systematic understanding of current attribution techniques and their applicability to omnichannel models is essential for data-driven decision-making in marketing (Nwaimo *et al.*, 2023; Onukwulu *et al.*, 2023).

The purpose of this review is twofold: First, to assess and categorize the various marketing attribution techniques used in practice and academia, ranging from rule-based to algorithmic and machine learning models; and second, to evaluate their applicability and performance specifically within omnichannel customer acquisition environments. This review aims to shed light on which techniques offer the greatest accuracy, transparency, and scalability in mapping multi-touchpoint journeys.

To guide this analysis, three key research questions are posed: (1) What types of attribution techniques are currently used in marketing analytics? (2) How do these techniques perform in omnichannel customer acquisition models? (3) What are the main limitations of existing methods, and what emerging trends are shaping the future of attribution modeling?

By addressing these questions, this review seeks to contribute a comprehensive and critical perspective on marketing attribution in the omnichannel era, providing insights for researchers, practitioners, and decision-makers striving to optimize customer acquisition strategies (Chukwuma-Eke *et al.*, 2023; Adekunle *et al.*, 2023).

2. Methodology

This systematic review follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure a structured and transparent research process. A comprehensive literature search was conducted across multiple academic and industry databases including Scopus, Web of Science, IEEE Xplore, ScienceDirect, and Google Scholar to identify relevant studies published between 2013 and 2024. Keywords and Boolean operators were used to refine the search strategy, including terms such as "marketing attribution," "customer acquisition," "omnichannel," "multi-touch attribution," "algorithmic models," and "machine learning in marketing." Studies were included if they met the following criteria: (1) peer-reviewed journal articles, conference proceedings, or

authoritative industry reports; (2) studies that focused on attribution modeling in marketing; (3) those that included application or evaluation in omnichannel or multi-channel customer acquisition contexts; and (4) written in English. Exclusion criteria encompassed non-peer-reviewed sources, articles without empirical or methodological content (e.g., opinion pieces, editorials), and works that focused exclusively on single-channel attribution without relevance to an omnichannel framework.

The selection process followed four PRISMA phases: Identification, screening, eligibility, and inclusion. During the identification phase, a total of 634 articles were retrieved. After removing duplicates, 472 articles remained. In the screening phase, titles and abstracts were reviewed for relevance, resulting in the exclusion of 287 papers. The remaining 185 full-text articles were assessed for eligibility based on the inclusion criteria, after which 98 studies were excluded for lack of methodological rigor or contextual relevance. Ultimately, 87 studies were included in the final review.

Data were extracted from the selected studies using a structured template that recorded publication details, attribution models used, analytical methods, data sources, performance metrics, and application context. The findings were synthesized qualitatively to categorize the attribution models and evaluate their comparative effectiveness, limitations, and suitability for omnichannel customer acquisition strategies.

2.1 Categorization of Attribution Techniques

Marketing attribution techniques can be broadly categorized into three primary groups: Rule-based models, algorithmic models, and machine learning models. Each category reflects a different level of sophistication and capability in measuring the contribution of marketing touchpoints in omnichannel customer acquisition pathways as shown in figure 1 (Chukwuma-Eke *et al.*, 2023; Ayodeji *et al.*, 2023). The progression from rule-based to machine learning models demonstrates an increasing ability to capture the complexity, interdependence, and non-linearity of customer interactions across multiple channels.

Rule-based models are the most traditional and widely used attribution techniques, primarily due to their simplicity and ease of interpretation. These models apply predefined rules to assign credit to marketing touchpoints based on their sequence in the customer journey (Oyeyipo *et al.*, 2023; Adepoju *et al.*, 2023). Common types include **first-touch attribution**, which assigns all credit to the initial interaction; **last-touch attribution**, which attributes the conversion solely to the final interaction; **linear attribution**, which distributes credit equally among all touchpoints; and **time-decay attribution**, which gives more weight to touchpoints closer to the time of conversion. While rule-based models are intuitive and easy to implement, they suffer from a number of limitations. Chief among these is their inability to capture the complex interactions between touchpoints or account for the varying influence of different channels. As a result, they may lead to biased conclusions and suboptimal marketing decisions, especially in environments where customer journeys are long and non-linear (Collins *et al.*, 2023; Adepoju *et al.*, 2023).

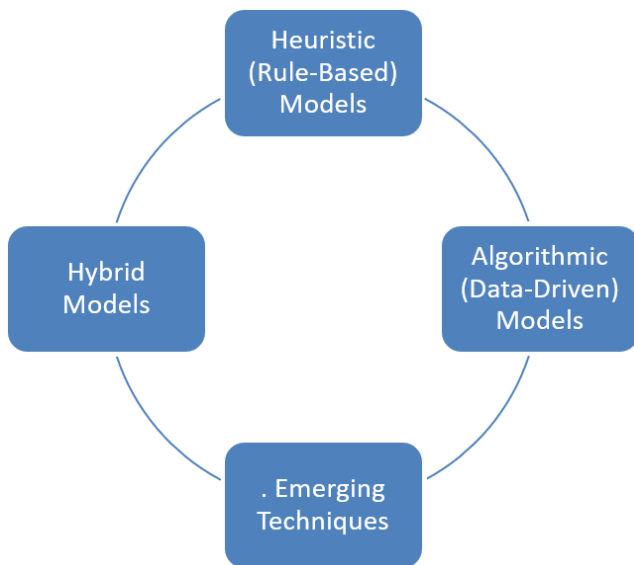


Fig 1: Classification of Attribution Techniques

Algorithmic models address many of the shortcomings of rule-based approaches by employing statistical techniques to infer the contribution of each touchpoint based on observed behavior. Notable examples include **Markov chain models**, **logistic regression**, and **survival analysis**. Markov chains model the customer journey as a series of probabilistic transitions between touchpoints, allowing for the calculation of the incremental contribution of each channel by analyzing the removal effects on conversion paths. Logistic regression can be used to estimate the probability of conversion based on exposure to various channels, incorporating control variables to account for contextual differences (Hamza *et al.*, 2023; Onukwulu *et al.*, 2023). Survival analysis, typically used in time-to-event data, helps in understanding the temporal effects of touchpoints on the timing of conversions. The primary strength of algorithmic models lies in their ability to **model non-linear paths**, handle interaction effects, and provide more accurate representations of channel performance. However, they often require large datasets and statistical expertise, and their interpretability may be limited for business users without technical backgrounds.

Machine learning models represent the most advanced class of attribution techniques, leveraging data-driven approaches to uncover patterns in customer behavior and predict the effectiveness of marketing touchpoints. Techniques such as **Shapley value-based models**, **random forest**, and **neural networks** have been applied to attribution problems with increasing frequency (Adekunle *et al.*, 2023; Agho *et al.*, 2023). Shapley values, derived from cooperative game theory, assign credit to each touchpoint based on its marginal contribution to conversion across all possible combinations of touchpoints. Random forest models, an ensemble learning method, can handle high-dimensional

data and interactions, producing variable importance scores that inform attribution decisions. Neural networks, particularly deep learning models, can automatically learn complex hierarchical representations of customer journeys, enabling the identification of nonlinear dependencies and hidden patterns across multiple channels. These machine learning approaches offer substantial advantages in **prediction accuracy** and **personalization**, making them particularly suitable for real-time and large-scale omnichannel environments.

Despite their strengths, machine learning models also present challenges. Their complexity can hinder interpretability, raising concerns about transparency and explainability in marketing decision-making (Bristol-Alagbariya *et al.*, 2023; Hamza *et al.*, 2023). Additionally, their dependence on high-quality, well-labeled data, and computational resources may limit accessibility for smaller firms or those with less mature data infrastructures.

The choice of attribution technique must balance trade-offs between simplicity, interpretability, and accuracy. Rule-based models offer clarity but lack nuance; algorithmic models provide statistical rigor with moderate complexity; and machine learning models excel in predictive performance and scalability but demand greater data and technical sophistication (Charles *et al.*, 2023; Okolie *et al.*, 2023). Understanding the characteristics of each category is essential for selecting the appropriate model that aligns with the strategic goals and operational capabilities of an organization engaged in omnichannel customer acquisition.

2.2 Comparative Evaluation

The effectiveness of marketing attribution techniques in omnichannel customer acquisition models can be critically assessed through several dimensions, notably performance metrics, contextual fit, and data requirements (Egbuhuzor *et al.*, 2023; Akintobi *et al.*, 2023). A comparative evaluation of rule-based, algorithmic, and machine learning models along these axes helps determine their suitability across varying business environments and technological capabilities.

A key set of performance metrics includes **accuracy**, **interpretability**, and **scalability**. Accuracy refers to the model's ability to correctly estimate the contribution of each marketing channel to conversions (Onyeke *et al.*, 2023; Fiemotongha *et al.*, 2023). In this regard, machine learning models, particularly those using Shapley values or deep neural networks, tend to outperform rule-based and algorithmic models due to their capacity to capture complex, nonlinear relationships in customer behavior. Algorithmic models such as Markov chains and logistic regression offer moderate accuracy but depend on the correctness of statistical assumptions. Rule-based models perform weakest in accuracy because they fail to account for interdependencies between touchpoints or adjust for the sequence or timing of interactions.

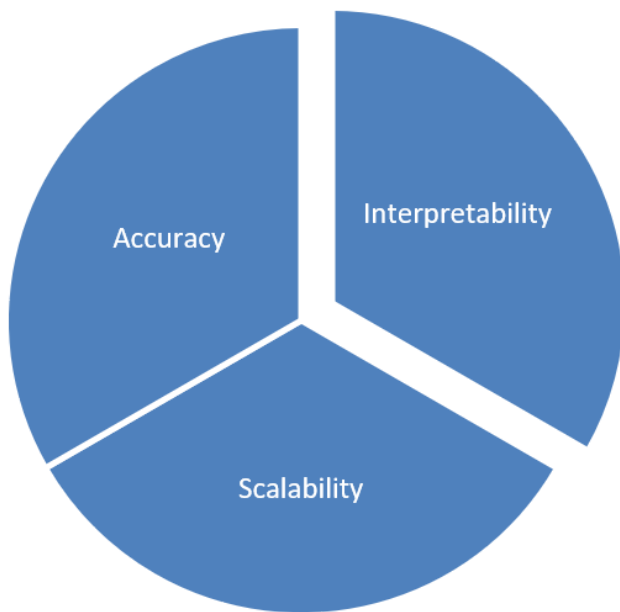


Fig 2: Key set of performance metrics

However, **interpretability** is often inversely related to model complexity. Rule-based models are the most interpretable easy for marketers and stakeholders to understand and communicate (Onukwulu *et al.*, 2023; ADIKWU *et al.*, 2023). Algorithmic models provide statistical explanations, though they may require analytical literacy. Machine learning models, while accurate, often behave as “black boxes,” making it challenging to extract actionable insights without additional techniques such as LIME (Local Interpretable Model-agnostic Explanations) or SHAP (SHapley Additive exPlanations). Hence, there is a trade-off between accuracy and transparency that organizations must navigate depending on their goals.

Scalability, or the ability to process increasing volumes of data and channels, favors machine learning models. These models, particularly those designed for real-time analytics, can scale effectively with growing datasets and expanding channel touchpoints (Fredson *et al.*, 2023; Ozobu *et al.*, 2023). Algorithmic models are moderately scalable but may encounter limitations when incorporating large-scale interactions or high-dimensional data. Rule-based models are limited in scalability and become inefficient in highly complex omnichannel environments, as manually assigning and managing rules becomes cumbersome.

Contextual fit is another essential consideration, especially regarding industry specificity and channel configuration. For example, in retail and e-commerce sectors where customer journeys are fast and heavily influenced by digital promotions, algorithmic and machine learning models are particularly valuable for tracking quick conversions and measuring cross-device behavior. In contrast, industries with longer sales cycles such as B2B services or healthcare may benefit from survival analysis or logistic regression models

that can account for extended time horizons (George *et al.*, 2023; Dosumu *et al.*, 2023). Similarly, organizations heavily dependent on **offline channels** such as brick-and-mortar stores face difficulties in deploying machine learning models unless robust tracking systems (e.g., CRM integration, in-store sensors) are in place. On the other hand, **online and mobile channels**, with their inherently traceable nature, align well with data-intensive models.

The configuration of marketing channels also influences model selection. In settings with a few dominant digital touchpoints, rule-based or simpler algorithmic models may suffice (Nyangoma *et al.*, 2023; Ogunwole *et al.*, 2023). However, for brands operating across **diverse platforms including web, mobile, physical stores, social media, and customer support**, only advanced machine learning methods can adequately model the complex inter-channel effects and evolving customer behavior patterns.

Data requirements and integration challenges further differentiate these models. Machine learning models demand **large volumes of high-quality, structured, and labeled data**, as well as continuous data pipelines for training and updating models. Integrating data across silos such as CRM, e-commerce, POS systems, and digital advertising platforms poses a substantial challenge, especially for organizations with fragmented IT infrastructure (Okolo *et al.*, 2023; Ogunnowo *et al.*, 2023). Algorithmic models are less data-intensive but still require a baseline level of clean, sequential customer journey data. Rule-based models can operate on minimal data but offer low accuracy and insight in return.

The comparative evaluation of attribution models reveals no one-size-fits-all solution. High-performing models in terms of accuracy and scalability, such as machine learning approaches, are best suited for data-rich, digitally mature organizations (Ogunwole *et al.*, 2023; Ojadi *et al.*, 2023). In contrast, rule-based or algorithmic models may offer sufficient insight for firms with limited data capabilities or simpler channel structures. A hybrid approach, combining rule-based interpretability with algorithmic or machine learning accuracy, may offer a practical middle ground, especially during transitional phases of digital transformation.

2.3 Key Challenges and Limitations

The implementation and operationalization of marketing attribution techniques in omnichannel customer acquisition models face numerous challenges and limitations as shown in figure 3 (Ojadi *et al.*, 2023; Bristol-Alagbariya *et al.*, 2023). As businesses strive to capture the contribution of each touchpoint across complex and dynamic customer journeys, they must contend with barriers related to data integration, model reliability, execution speed, and evaluation standardization. These obstacles not only hinder the effectiveness of attribution models but also impact strategic decision-making and resource allocation.

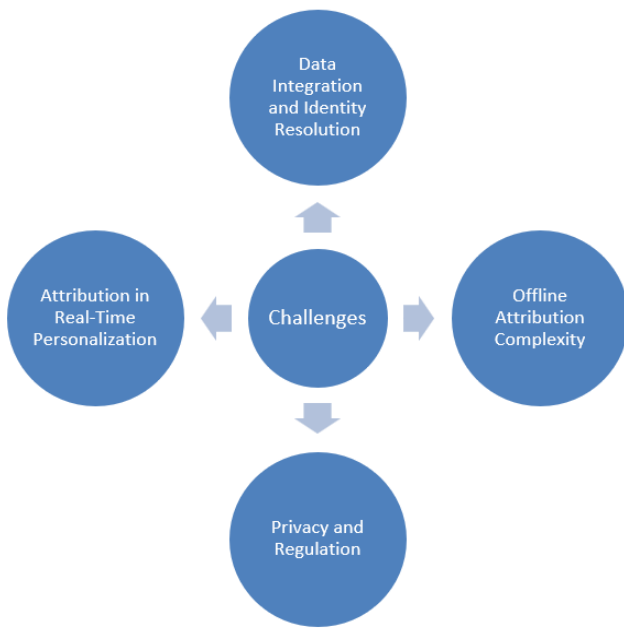


Fig 3: Omnichannel-Specific Challenges

One of the most pervasive challenges is the existence of **data silos and integration issues**. In omnichannel environments, customer data is often fragmented across multiple platforms, such as customer relationship management (CRM) systems, e-commerce platforms, in-store POS systems, web analytics tools, and social media advertising networks (Bristol-Alagbariya *et al.*, 2023; Ozobu *et al.*, 2023). These data sources frequently operate independently, using incompatible formats and identifiers, making it difficult to construct a unified, end-to-end view of the customer journey. Without effective data integration strategies such as data warehousing, customer data platforms (CDPs), and identity resolution tools the accuracy and completeness of attribution models are severely compromised. Moreover, privacy regulations (e.g., GDPR, CCPA) further restrict access to personally identifiable information (PII), complicating cross-channel data linkage.

A second critical challenge involves **attribution bias and underlying model assumptions**. Rule-based models inherently simplify the customer journey by relying on rigid heuristics, such as assigning full credit to the first or last touchpoint. This creates systematic bias that over- or underestimates the contribution of specific channels. Even algorithmic and machine learning models, while more flexible, rest on assumptions that may not hold in all contexts. For example, Markov chains assume a memoryless process, ignoring long-term dependencies, while logistic regression assumes linear relationships between input variables (Bristol-Alagbariya *et al.*, 2023; Nyangoma *et al.*, 2023). Misinterpretation of model outputs due to unrecognized biases or invalid assumptions can lead to flawed conclusions and ineffective marketing strategies. Additionally, many models fail to consider external influences such as seasonality, competitor actions, or macroeconomic conditions, which may distort attribution outcomes.

Real-time execution and adaptability also present significant barriers, particularly in high-velocity, data-rich environments. As customer interactions increasingly occur in real time across digital and physical touchpoints, the need for instantaneous attribution becomes critical (Onukwulu *et*

al., 2023; Nyangoma *et al.*, 2023). Traditional models, especially those based on batch processing or manual data aggregation, are ill-equipped to support real-time insights. Machine learning models can, in theory, support real-time prediction and updating, but doing so requires advanced infrastructure, including real-time data pipelines, automated retraining mechanisms, and edge computing capabilities. Additionally, adapting attribution models to reflect sudden changes such as a viral marketing campaign or a supply chain disruption demands both computational agility and organizational responsiveness, which are often lacking.

A final and overarching limitation is the **lack of standardized evaluation frameworks** for attribution models. Unlike disciplines such as statistics or machine learning, which rely on well-defined metrics (e.g., accuracy, precision, AUC), marketing attribution lacks universally accepted benchmarks for model performance. Organizations often define success idiosyncratically using ROI uplift, CPA reductions, or customer lifetime value leading to inconsistencies in model validation and comparison (OJADI *et al.*, 2023; Abimbade *et al.*, 2023). This fragmentation makes it difficult to assess whether one model performs better than another across contexts or industries. Furthermore, without standard metrics, it becomes challenging to evaluate trade-offs between competing objectives such as interpretability and predictive accuracy (Ogunwole *et al.*, 2022).

While marketing attribution models hold considerable promise for optimizing omnichannel customer acquisition strategies, they are constrained by fundamental challenges (Ihekoronye *et al.*, 2023; Aina *et al.*, 2023). Data silos impede the construction of holistic customer views; attribution bias and unrealistic assumptions undermine model credibility; real-time execution strains organizational infrastructure; and the absence of standardized evaluation criteria obscures model benchmarking. Addressing these challenges requires not only technical solutions such as data unification platforms, explainable AI, and adaptive modeling but also strategic shifts toward cross-functional collaboration, investment in infrastructure, and development of industry-wide standards for attribution model assessment (Akintobi *et al.*, 2023; Okolo *et al.*, 2023). Only by systematically overcoming these limitations can organizations fully leverage attribution analytics to drive smarter, customer-centric marketing.

2.4 Emerging Trends and Hybrid Approaches

The field of marketing attribution is rapidly evolving, driven by advancements in technology, increased data availability, and a growing understanding of customer behavior across multiple touchpoints. Emerging trends and hybrid approaches are reshaping how organizations measure the effectiveness of marketing channels in omnichannel customer acquisition models (Ogunwole *et al.*, 2023; Okolo *et al.*, 2023). These trends reflect the growing complexity of customer journeys and the need for more sophisticated, flexible, and interpretable attribution models that can accommodate real-time changes and causal relationships. Four key areas of focus in this evolution are the combination of rule-based and machine learning (ML) techniques, the development of real-time and adaptive attribution systems, the use of causal inference for attribution, and the incorporation of explainable AI (XAI) in attribution modeling.

One of the most promising trends is **combining rule-based and machine learning (ML) techniques** (OJIKA *et al.*, 2023). Rule-based models, despite their limitations in capturing complex customer journeys, offer simplicity, interpretability, and fast computation. Machine learning models, on the other hand, excel in capturing nonlinear relationships and offering predictive insights. The hybrid approach leverages the strengths of both: Rule-based models provide a baseline for attribution and allow for quick initial analysis, while machine learning models refine the results by learning from data patterns and adjusting for interactions between touchpoints (Ogunwale *et al.*, 2022; Okolo *et al.*, 2022). This approach balances accuracy with interpretability, making it particularly appealing for organizations that need both fast insights and detailed performance tracking (Adekunle *et al.*, 2021; Chukwuma-Eke *et al.*, 2021).

Another emerging trend is the development of **real-time and adaptive attribution systems**. The dynamic nature of customer interactions especially in digital environments requires attribution models that can operate in real time, adapting to ongoing shifts in customer behavior, market conditions, and marketing strategies (Adekunle *et al.*, 2021; Chukwuma-Eke *et al.*, 2021). Traditional attribution models, which often rely on historical data and batch processing, are ill-suited for this purpose. Real-time attribution systems, powered by machine learning and big data technologies, can continuously process data streams from multiple touchpoints, enabling marketers to make immediate adjustments to their campaigns (Oyedokun, 2019; Elujide *et al.*, 2021). These systems allow for dynamic recalibration of attribution weights based on new data, such as changes in customer engagement or the introduction of a new marketing channel. As customer journeys become more fragmented, real-time attribution systems are essential for providing actionable insights that reflect the current state of customer behavior (Ezekiel and Akinyemi, 2022; Ogunnowo *et al.*, 2022). The ability to make attribution decisions in real time also helps brands optimize their marketing spend and refine targeting strategies on-the-fly, resulting in more efficient customer acquisition (Akinyemi and Ezekiel, 2022; Aremu *et al.*, 2022).

The use of **causal inference for attribution** is also gaining traction as an emerging trend in marketing analytics. Unlike traditional attribution models, which focus on correlation (i.e., the relationship between marketing touchpoints and conversion events), causal inference seeks to identify the direct cause-and-effect relationships between touchpoints and customer actions (Elujide *et al.*, 2021; Agho *et al.*, 2021). Techniques such as **difference-in-differences** and **propensity score matching** are being adapted for marketing attribution to estimate the incremental impact of each touchpoint on customer conversion, while controlling for external factors that might confound the relationship. Causal inference can help businesses understand not just which channels contribute to customer acquisition, but also the magnitude and direction of that contribution (Attah *et al.*, 2022; Akinyemi *et al.*, 2022). This approach provides deeper insights into the effectiveness of different marketing strategies and helps avoid the attribution biases that can arise from correlational methods. Furthermore, causal models allow businesses to simulate “what-if” scenarios, helping them predict the impact of changes to their marketing mix before implementing them (Fredson *et al.*,

2022; Attah *et al.*, 2022).

Finally, the integration of **explainable AI (XAI) in attribution modeling** represents another critical shift. As machine learning models grow in complexity, one of the significant challenges is the lack of interpretability, especially in decision-making processes (Kolade *et al.*, 2021; Egbuhuzor *et al.*, 2021). Explainable AI aims to make complex models more transparent by providing human-readable explanations for the decisions made by AI algorithms. In the context of attribution, XAI methods like SHAP (Shapley Additive exPlanations) and LIME (Local Interpretable Model-agnostic Explanations) are being employed to shed light on how individual touchpoints contribute to the overall attribution score (Adewoyin, 2022; Ozobu *et al.*, 2022). These tools provide insights into the importance of different features or channels, helping marketers understand the reasoning behind the model's predictions. As a result, organizations can make more informed decisions and ensure that their attribution models align with their business objectives (Ajayi and Osunsanmi, 2018; James *et al.*, 2019). Additionally, XAI fosters trust in AI-driven insights, addressing concerns about “black box” models and enabling businesses to confidently act on the results.

The future of marketing attribution is marked by the integration of hybrid approaches and the adoption of cutting-edge techniques that enhance model accuracy, adaptability, and interpretability (Bristol-Alagbariya *et al.*, 2022; Akintobi *et al.*, 2022). The combination of rule-based and machine learning methods offers a balanced approach that provides both simplicity and complexity, while real-time and adaptive attribution systems ensure that businesses can respond to customer behavior in a timely and dynamic manner (Abimbade *et al.*, 2017; Olanipekun, 2020). The use of causal inference elevates the understanding of attribution beyond correlation, and the application of explainable AI ensures that complex models are accessible and trustworthy. As these trends continue to evolve, marketing attribution will become more accurate, insightful, and actionable, helping businesses optimize their omnichannel customer acquisition strategies and drive more effective marketing outcomes (Bristol-Alagbariya *et al.*, 2022; Nwaimo *et al.*, 2022).

2.5 Implications for Practice and Research

The rapidly evolving landscape of marketing attribution presents both significant opportunities and challenges for practitioners and researchers alike. As businesses strive to optimize customer acquisition strategies across multiple channels, the implications of attribution models extend beyond technical advancements to influence broader strategic decisions (Akinyemi and Ojetunde, 2020; Adelana and Akinyemi, 2021). This essay explores the strategic implications for marketers, the technical considerations for data scientists, and the future research directions in the field, including the development of standardized benchmarks, cross-industry validation, and the ethical considerations surrounding customer data usage.

For marketers, the adoption of sophisticated marketing attribution techniques has profound strategic implications (Isibor *et al.*, 2022; Fredson *et al.*, 2022). First, accurate attribution is critical for optimizing marketing spend and improving the efficiency of customer acquisition campaigns. By understanding the relative contribution of each channel,

from paid search and social media to email and in-store interactions, marketers can allocate resources more effectively, ensuring that the most productive channels are adequately funded (Akinyemi, 2013; Famaye *et al.*, 2020). In an omnichannel environment, where customers frequently interact across multiple touchpoints before converting, attribution models enable marketers to identify which interactions have the greatest influence on conversion decisions, providing actionable insights for campaign optimization.

Moreover, the integration of real-time and adaptive attribution models allows marketers to dynamically adjust their strategies as customer behaviors shift, offering a competitive advantage (Hamza *et al.*, 2022; Chukwuma-Eke *et al.*, 2022). Similarly, hybrid models that combine rule-based and machine learning techniques provide marketers with a balance between speed and accuracy, allowing them to execute campaigns while continuously improving their attribution insights (Adeniran *et al.*, 2016; Akinyemi and Ebimomi, 2020). As a result, businesses can drive more personalized and targeted customer acquisition strategies, improving customer lifetime value and brand loyalty.

Finally, attribution also plays a role in customer experience management. By identifying the key touchpoints that influence customer decision-making, marketers can craft seamless and consistent experiences across all channels (Aremu and Laolu, 2014; Akinyemi and Ojetunde, 2019). This holistic view of the customer journey helps brands engage with consumers in meaningful ways, increasing the likelihood of conversion and customer retention. Marketers must, therefore, not only rely on attribution models for campaign optimization but also to enhance the overall customer experience.

For data scientists, the development and implementation of marketing attribution models require careful consideration of both technical and organizational challenges (Charles *et al.*, 2022; Okolie *et al.*, 2022). The first major consideration is data quality and integration. Omnichannel attribution relies on data from a wide variety of sources, including online and offline channels, which may have varying degrees of granularity and accuracy (Adewoyin, 2021; Dienagha *et al.*, 2021). Data scientists must work with marketing teams to ensure that data from different platforms are integrated and harmonized to create a unified, accurate picture of the customer journey. This often involves addressing issues such as data silos, duplicate entries, and missing information, which can undermine the reliability of attribution models.

Additionally, when building attribution models, data scientists must navigate the challenges posed by complex customer behaviors (Adepoju *et al.*, 2022; Collins *et al.*, 2022). In many cases, customer journeys are non-linear and influenced by external factors such as promotions, seasonality, and competitor actions. As a result, the models used to attribute conversions must be sophisticated enough to account for these variables (Oluokun, 2021; Ogunnowo *et al.*, 2021). For example, machine learning models such as random forests, neural networks, or Markov chains offer the flexibility to model these complex relationships, but they require significant computational power and specialized expertise in model training and tuning.

Another key consideration is model interpretability. As machine learning models become more complex, understanding why a model has assigned a particular weight

to a touchpoint becomes increasingly difficult (Akintobi *et al.*, 2022; Collins *et al.*, 2022). Explainable AI (XAI) techniques, such as Shapley values and LIME, can help data scientists create more transparent models, but these methods require a deep understanding of both the algorithm and the data (OJIKI *et al.*, 2021; Oyeniyi *et al.*, 2021). Ensuring that attribution models are interpretable and actionable is crucial for business decision-making, as stakeholders need to trust the insights generated by these models.

The field of marketing attribution is still evolving, and several key research areas promise to further refine the practice and enhance its applicability. One of the most pressing needs is the development of **standardized benchmarks** for attribution model evaluation (Govender *et al.*, 2022; Okolo *et al.*, 2022). Currently, there is no universally accepted framework for comparing different attribution techniques. The lack of standardized performance metrics makes it difficult for marketers and data scientists to assess the effectiveness of various models in a consistent manner. Future research should focus on defining and validating these benchmarks, considering factors such as accuracy, scalability, and real-time adaptability (Chima *et al.*, 2021; Fredson *et al.*, 2021). Standardization would enable cross-industry comparisons and provide clearer guidance for practitioners seeking to implement attribution models.

Another important area of research is **cross-industry validation** of attribution models (Ezeafulukwe *et al.*, 2022; Chukwuma-Eke *et al.*, 2022). While many attribution studies focus on specific industries or use cases, there is a lack of generalizability across sectors. Marketing attribution strategies in retail may not translate directly to those in financial services or healthcare. Future studies should explore how attribution models perform across different industries, considering sector-specific challenges, customer behavior, and marketing strategies (Chima and Ahmadu, 2019; Okolie *et al.*, 2021). This research would help develop more flexible attribution models that can be adapted to various industries while maintaining their effectiveness.

Lastly, the growing reliance on customer data raises **ethical considerations** regarding privacy and data usage (Ajiga *et al.*, 2022; Bristol-Alagbariya *et al.*, 2022). Attribution models often require detailed insights into individual customer behavior, which may involve the collection and analysis of sensitive data. As regulations such as GDPR and CCPA evolve, researchers and practitioners must consider how to balance the need for accurate attribution with the protection of customer privacy (Okolie *et al.*, 2021; Isibor *et al.*, 2021). Ethical research in this area could explore best practices for data anonymization, transparency in data collection, and the use of consent-based models to ensure that attribution efforts are aligned with ethical standards and privacy laws.

Marketing attribution for omnichannel customer acquisition represents a dynamic intersection of strategic decision-making, technical innovation, and ethical responsibility (Fredson *et al.*, 2021). By addressing the challenges related to data integration, model complexity, and real-time adaptability, marketers can leverage attribution to optimize customer acquisition and enhance the customer experience. As the field continues to evolve, future research will be critical in developing standardized benchmarks, validating models across industries, and ensuring that attribution practices remain ethically sound in an increasingly data-

driven world (Chukwuma-Eke *et al.*, 2022; Bristol-Alagbariya *et al.*, 2022).

3. Conclusion

This systematic review of marketing attribution techniques for omnichannel customer acquisition has highlighted the evolving nature of attribution models and their critical role in optimizing marketing strategies across multiple channels. Key findings reveal that attribution techniques can be broadly categorized into rule-based models, algorithmic models, and machine learning models, each with its distinct advantages and limitations. Rule-based models, while simple and interpretable, often fail to capture the complexity of customer journeys. In contrast, machine learning models provide greater flexibility and predictive power but can suffer from reduced interpretability. The hybridization of these techniques is emerging as a promising approach to balance simplicity with predictive accuracy, providing marketers with more actionable insights in real-time.

The review also identified several challenges and limitations, such as data silos, attribution bias, and the lack of standardized evaluation frameworks, which hinder the development and effectiveness of attribution models. Furthermore, emerging trends like real-time attribution, the use of causal inference, and explainable AI are addressing these challenges, offering more adaptive, accurate, and transparent models.

Based on these findings, it is recommended that marketers adopt hybrid attribution approaches to benefit from both rule-based simplicity and machine learning sophistication. Additionally, the implementation of real-time adaptive attribution systems will allow for more agile and dynamic decision-making. Data scientists should prioritize the integration of diverse data sources and focus on improving model interpretability through the use of explainable AI techniques. For further research, the development of standardized evaluation frameworks, cross-industry validation of attribution models, and addressing the ethical considerations surrounding customer data usage are essential to advancing the field and ensuring sustainable, responsible practices in attribution modeling.

The future of marketing attribution lies in refining existing techniques, incorporating emerging trends, and addressing key challenges, allowing businesses to make more informed, effective decisions in customer acquisition strategies.

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