

Revealing Hidden Consumer Characteristics Through Sophisticated Grouping Techniques

Mahamat Saleh

Department of Information Technology and AI Systems, University of N'Djamena, Chad

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ABSTRACT

The rapid expansion of digital markets and data-driven decision-making environments has transformed consumer analysis into a complex analytical challenge. Organizations increasingly collect large volumes of consumer-related information from purchasing activities, online interactions, financial transactions, and social networks. However, traditional consumer analysis approaches frequently focus on observable characteristics and predefined categories, limiting their ability to identify hidden behavioral attributes and emerging consumer patterns. This research investigates sophisticated grouping techniques as an intelligent framework for revealing concealed consumer characteristics through advanced data partitioning, clustering, and analytical decision-making approaches.

The study presents a conceptual examination of how modern grouping methodologies can uncover latent consumer structures by analyzing similarities, behavioral relationships, and multidimensional data characteristics. The proposed framework integrates principles from data mining, machine learning, group decision-making models, and consumer segmentation research. Data mining techniques provide the foundation for extracting meaningful patterns from complex datasets, while clustering-based approaches enable the discovery of consumer groups that may not be visible through conventional classification methods. Jatav et al. (2025) demonstrated that advanced clustering techniques can effectively uncover latent behavioral patterns in customer segmentation, highlighting the importance of identifying hidden structures within consumer data.

The research explores the theoretical foundations of sophisticated grouping by examining similarity measurement, feature representation, multi-criteria evaluation, and adaptive segmentation mechanisms. Decision-making approaches such as TOPSIS-based group analysis contribute to understanding how multiple consumer attributes can be evaluated simultaneously. Similarly, big data analytics principles support efficient processing of large-scale consumer information.

The findings indicate that sophisticated grouping techniques provide significant advantages in identifying hidden consumer characteristics by transforming unstructured behavioral information into meaningful analytical groups. These approaches enable organizations to develop personalized marketing strategies, improve customer relationship management, and enhance predictive decision-making. However, challenges related to data quality, model interpretability, computational complexity, and ethical management of consumer information remain important considerations.

This research contributes a structured perspective on intelligent consumer analysis by demonstrating how advanced grouping techniques can bridge the gap between observable consumer attributes and concealed behavioral characteristics. The study emphasizes that effective consumer understanding requires analytical frameworks capable of discovering dynamic relationships rather than relying solely on traditional demographic segmentation.

Keywords: Consumer characteristics, sophisticated grouping, customer segmentation, data mining, clustering analysis, big data analytics, behavioral patterns, decision-making models, machine learning.

1. INTRODUCTION

1.1 Background and Research Context

The increasing availability of digital consumer data has created significant opportunities for organizations to understand customer behavior at a deeper level. Modern businesses generate extensive information through online

transactions, social media interactions, purchasing histories, financial activities, and digital engagement patterns. Although this information provides valuable insights, extracting meaningful knowledge from large and complex datasets remains a major analytical challenge.

Traditional consumer analysis methods have historically relied on demographic variables, geographic information, purchasing

frequency, and basic transactional indicators. These approaches have been effective for general market classification; however, they often fail to reveal hidden consumer characteristics that exist beneath visible patterns. Consumers with similar demographic profiles may demonstrate significantly different purchasing behaviors, while individuals with different backgrounds may share similar preferences and decision-making tendencies.

The concept of hidden consumer characteristics refers to behavioral attributes, preferences, motivations, and purchasing tendencies that are not directly observable through conventional analytical methods. These characteristics are embedded within complex relationships among multiple data dimensions. Discovering such hidden structures requires advanced analytical approaches capable of identifying similarities, generating meaningful groups, and interpreting behavioral relationships.

Sophisticated grouping techniques provide an effective solution to this challenge by enabling data-driven discovery of consumer segments. Unlike traditional segmentation methods based on predefined assumptions, intelligent grouping approaches analyze inherent patterns within datasets and automatically identify meaningful consumer clusters. These techniques allow organizations to understand consumers based on actual behavioral similarities rather than only visible attributes.

Recent research on customer segmentation emphasizes the importance of latent pattern discovery. Jatav et al. (2025) highlighted that advanced clustering approaches can uncover hidden behavioral structures within customer datasets, demonstrating that sophisticated grouping methods provide deeper insights compared with conventional segmentation strategies. Their research establishes the importance of analyzing underlying consumer dynamics for improved decision-making.

1.2 Problem Statement

Despite significant developments in data analytics and machine learning, accurately identifying hidden consumer characteristics remains challenging. The primary difficulty arises from the complexity and diversity of consumer behavior. Purchasing decisions are influenced by numerous interconnected factors, including personal preferences, economic conditions, social influence, product relationships, and changing market trends.

Conventional segmentation techniques often simplify consumer behavior by assigning individuals to fixed categories. While such approaches provide basic understanding, they may overlook subtle behavioral differences and emerging consumer patterns. As markets

become increasingly personalized, organizations require analytical systems capable of discovering complex and dynamic consumer structures.

Another challenge involves the representation of consumer information. Large-scale datasets often contain heterogeneous data types, including numerical transactions, categorical preferences, behavioral sequences, and social interactions. Effective grouping techniques must integrate these diverse information sources while maintaining analytical reliability.

Data mining research provides important foundations for addressing these challenges. Data mining and machine learning approaches focus on extracting valuable knowledge from large datasets by identifying patterns, relationships, and predictive structures (Bi and Xu, 2020). Similarly, big data analysis methodologies emphasize efficient processing and interpretation of massive information environments (Wu and Zhou, 2020).

1.3 Research Relevance

Understanding hidden consumer characteristics has become strategically important for organizations operating in competitive environments. Businesses increasingly require accurate consumer insights to improve personalization, optimize product recommendations, and develop targeted marketing strategies.

Sophisticated grouping techniques enhance consumer analysis by shifting the focus from simple classification toward deeper behavioral understanding. By identifying hidden similarities among consumers, organizations can develop more accurate customer profiles and anticipate future purchasing behavior.

For example, two consumers may appear unrelated based on demographic characteristics but demonstrate similar purchasing patterns through product preferences, transaction timing, and online engagement behavior. Intelligent grouping methods can detect these relationships and create meaningful consumer segments.

The relevance of this research extends beyond marketing applications. Grouping and classification techniques are also important in financial analysis, social network analysis, and decision-support systems. Russell (2015) emphasized the importance of data analysis approaches for understanding relationships within social networks, demonstrating how structured analysis can reveal hidden patterns among interconnected entities.

1.4 Research Objectives

This research aims to examine how sophisticated grouping techniques can reveal hidden consumer characteristics through intelligent data analysis. The specific objectives are:

1. To analyze the theoretical foundations of advanced

consumer grouping and segmentation approaches.

2. To examine how clustering, data mining, and decision-making techniques identify concealed consumer patterns.

3. To develop a conceptual framework for discovering hidden consumer characteristics.

4. To evaluate the practical implications and limitations of sophisticated grouping methods in consumer analytics.

1.5 Scope and Significance

This research focuses on conceptual analysis of sophisticated grouping techniques applied to consumer behavior discovery. The study examines relationships between data mining, machine learning, clustering, group decision-making, and consumer segmentation.

The significance of this research lies in demonstrating how advanced analytical approaches can improve understanding of consumers beyond traditional categories. By revealing hidden characteristics, organizations can achieve more precise customer targeting, improved resource allocation, and enhanced strategic planning.

The study considers consumer behavior as a dynamic and multidimensional phenomenon requiring adaptive analytical approaches. Sophisticated grouping techniques provide the foundation for transforming complex consumer data into meaningful insights while supporting evidence-based decision-making.

2. LITERATURE REVIEW

2.1 Evolution of Consumer Data Analysis and Grouping Techniques

Consumer data analysis has evolved significantly from basic statistical segmentation toward intelligent computational approaches. Early methods primarily focused on descriptive analysis, where consumers were grouped according to easily measurable characteristics. However, the increasing complexity of consumer interactions has created demand for more advanced grouping mechanisms.

Data mining and machine learning provide essential theoretical foundations for this evolution. Bi and Xu (2020) explained that data mining techniques enable the extraction of valuable patterns from large datasets by identifying relationships that may not be apparent through traditional analytical methods. These principles are directly applicable to consumer analysis, where hidden characteristics often exist within complex

behavioral structures.

Sophisticated grouping techniques represent a shift toward discovering naturally occurring consumer patterns. Instead of assigning consumers according to predefined categories, these methods analyze similarities among multiple attributes and generate data-driven groups.

2.2 Advanced Clustering and Latent Consumer Pattern Discovery

Clustering has become one of the most important analytical techniques for discovering hidden structures within consumer datasets. Unlike traditional classification methods that require predefined labels, clustering algorithms identify groups based on similarities among data objects. This capability makes clustering particularly suitable for discovering implicit consumer characteristics because consumer behaviors are often complex, dynamic, and not directly categorized.

Jatav et al. (2025) emphasized the importance of advanced clustering methods in identifying latent behavioral patterns within customer segmentation. Their study demonstrates that clustering techniques can reveal relationships among consumers that are difficult to identify using conventional analytical approaches. The significance of this perspective lies in understanding that consumer groups are not always defined by visible characteristics but may emerge from deeper behavioral similarities.

The effectiveness of clustering depends on several factors, including feature selection, similarity measurement, and algorithmic design. Consumer datasets may include purchasing frequency, product preferences, transaction values, engagement patterns, and temporal behaviors. Appropriate representation of these factors allows grouping techniques to identify meaningful consumer structures.

However, clustering approaches also present challenges. The selection of an appropriate number of groups, interpretation of generated clusters, and handling of changing consumer behavior remain important research concerns. Sophisticated grouping systems must therefore incorporate adaptive mechanisms to maintain accuracy over time.

2.3 Data Mining Foundations for Consumer Characteristic Analysis

Data mining provides the theoretical basis for extracting meaningful information from large-scale consumer datasets. It involves processes such as data preprocessing, pattern discovery, classification, clustering, and knowledge extraction. The objective is not merely organizing data but transforming raw information into actionable knowledge.

Chen Yan (2011) discussed data mining technology and applications, emphasizing the importance of computational methods for discovering hidden relationships within complex

datasets. These principles are highly relevant to consumer analytics because purchasing behaviors are influenced by multiple interconnected factors.

A consumer's purchasing decision may depend on previous transactions, product associations, economic conditions, and social influences. Data mining techniques allow organizations to analyze these relationships systematically. Through intelligent grouping, consumer information can be transformed into behavioral profiles representing underlying characteristics.

Big data analysis further strengthens these capabilities by enabling organizations to process large and diverse datasets. Wu Minghui and Zhou Su (2020) highlighted the importance of big data analysis methods for extracting useful information from massive information environments. In consumer analytics, this capability allows organizations to examine millions of interactions and identify patterns that would be impossible to detect manually.

2.4 Multi-Criteria Decision-Making and Consumer Group Evaluation

Consumer characteristics are rarely determined by a single factor. Purchasing behavior usually involves multiple attributes, including price sensitivity, product preference, loyalty, engagement level, and purchasing frequency. Therefore, evaluating consumer groups requires analytical methods capable of considering multiple criteria simultaneously.

Group decision-making models provide important theoretical contributions in this area. Hwang and Lin (2012) examined group decision-making under multiple criteria and highlighted the importance of combining different perspectives when evaluating complex decisions. This principle can be applied to consumer analysis, where multiple behavioral dimensions must be considered together.

TOPSIS-based approaches represent one example of multi-criteria evaluation methods. Shih et al. (2001) explored group decision-making for TOPSIS, demonstrating how multiple criteria can be integrated to support structured evaluation. Similarly, Shih et al. (2004) proposed a multi-attribute group decision support system for problem-solving, emphasizing the role of systematic evaluation frameworks.

In consumer analytics, such approaches can enhance grouping techniques by allowing organizations to evaluate consumer segments based on multiple performance indicators. For example, a consumer group may be assessed according to profitability, loyalty, engagement, and long-term value rather than a single purchasing factor.

2.5 Social Network and Relationship-Based Consumer Analysis

Modern consumer behavior is increasingly influenced by relationships, interactions, and digital networks. Consumers are not isolated entities; their preferences may be affected by social connections, online communities, and shared experiences.

Russell (2015) examined data mining and analysis of social networks, demonstrating the importance of relationship-based analysis for identifying hidden structures within interconnected data. These concepts provide valuable insights for consumer analytics because social relationships can reveal additional dimensions of consumer characteristics.

Relationship-based grouping techniques can identify communities of consumers with similar interests or behaviors. For example, customers who frequently interact with similar products, brands, or online discussions may represent a hidden consumer segment even if their demographic profiles differ.

This perspective expands traditional segmentation by incorporating relational information. Instead of analyzing consumers individually, organizations can examine patterns among groups and networks, enabling deeper understanding of collective behavior.

2.6 Big Data Analytics and Scalable Consumer Grouping

The increasing volume of consumer information has made scalability a critical concern in analytical systems. Traditional methods may struggle when processing large datasets containing millions of consumer interactions. Big data analytics provides frameworks for managing these challenges through efficient storage, processing, and analytical techniques.

Xu Wei and Liang Xun (2013) discussed financial data mining from a big data perspective, emphasizing the importance of extracting meaningful information from large-scale datasets. Although focused on financial applications, the principles are applicable to consumer analytics because both domains require analysis of complex and high-volume information.

Scalable grouping techniques enable organizations to process extensive consumer data while maintaining analytical efficiency. These approaches support real-time analysis, continuous consumer profiling, and dynamic segmentation.

However, scalability introduces additional challenges. Increasing dataset size may create difficulties related to computational resources, model complexity, and data quality management. Therefore, sophisticated grouping systems must balance analytical depth with practical implementation requirements.

2.7 Research Gap and Theoretical Positioning

The reviewed literature demonstrates significant advancements in data mining, clustering, decision-making, and big data analysis. However, existing studies often examine these techniques separately rather than integrating them into a unified framework for revealing hidden consumer characteristics.

Customer segmentation research emphasizes behavioral pattern discovery, while data mining studies focus on information extraction. Decision-making models address multi-criteria evaluation, and social network analysis examines relational structures. A comprehensive approach requires combining these perspectives.

This research positions sophisticated grouping techniques as an integrated analytical framework that combines clustering, data mining, multi-criteria evaluation, and relationship analysis. The objective is to move beyond traditional consumer classification toward intelligent discovery of concealed characteristics.

The proposed perspective recognizes that consumer behavior is multidimensional and continuously evolving. Therefore, effective analytical systems must identify hidden relationships, adapt to changing patterns, and provide interpretable insights.

3. METHODOLOGY

3.1 Research Framework

This research adopts a conceptual methodology to analyze sophisticated grouping techniques for revealing hidden consumer characteristics. The framework integrates principles from data mining, clustering analysis, and multi-criteria decision-making.

The proposed framework consists of four primary stages:

1. Consumer data preparation and representation.
2. Intelligent grouping and similarity analysis.
3. Multi-dimensional characteristic evaluation.
4. Interpretation and refinement of discovered consumer groups.

3.2 Data Representation and Feature Selection

The first stage involves transforming raw consumer information into structured analytical features. These features may include purchasing history, transaction patterns, product preferences, engagement behavior, and interaction relationships.

Effective feature representation is essential because hidden characteristics can only be identified when

relevant behavioral information is captured. Data mining principles support this transformation by converting raw information into meaningful analytical structures (Chen, 2011).

3.3 Intelligent Grouping Process

The grouping stage applies clustering and similarity-based techniques to identify consumer groups. Consumers are organized according to behavioral similarities rather than fixed categories.

The process includes:

- Data collection.
- Feature extraction.
- Similarity measurement.
- Group formation.
- Pattern interpretation.

Advanced clustering approaches provide the foundation for identifying latent consumer structures (Jatav et al., 2025).

3.4 Evaluation and Refinement

The final stage evaluates generated consumer groups using multiple criteria. Factors such as behavioral consistency, business relevance, and predictive value are considered.

Multi-criteria decision-making principles support this evaluation by allowing multiple consumer attributes to be analyzed simultaneously (Hwang and Lin, 2012).

4. RESULTS

The analysis of sophisticated grouping techniques demonstrates that intelligent consumer grouping provides an effective mechanism for revealing hidden consumer characteristics that are difficult to identify through traditional segmentation methods. The findings indicate that data-driven grouping approaches improve consumer understanding by identifying behavioral similarities, latent preferences, and multidimensional relationships among consumers.

The first major finding is that clustering-based approaches significantly enhance the discovery of concealed consumer patterns. Traditional segmentation methods generally depend on predefined attributes, whereas advanced grouping techniques analyze relationships among multiple behavioral factors. This enables organizations to identify consumer groups based on actual purchasing tendencies rather than assumptions. Jatav et al. (2025) demonstrated that advanced clustering can uncover latent behavioral patterns in customer segmentation, supporting the effectiveness of intelligent

grouping approaches for discovering hidden consumer structures.

The second finding highlights the importance of comprehensive data representation. Consumer characteristics are influenced by multiple variables, including purchasing frequency, product preferences, transaction history, and engagement behavior. Analytical models that consider only limited attributes may produce incomplete consumer profiles. Data mining approaches enable the extraction of meaningful patterns from complex datasets by integrating diverse information sources (Bi and Xu, 2020).

The third finding relates to the role of multi-criteria evaluation in improving consumer group interpretation. Since consumer behavior cannot be accurately represented by a single measurement, decision-making frameworks that consider multiple factors provide more reliable analysis. Group decision-making approaches demonstrate the importance of combining different criteria when evaluating complex situations (Hwang and Lin, 2012).

The analysis also reveals that relationship-based grouping provides additional insights into consumer characteristics. Social and behavioral connections among consumers can reveal hidden similarities that may not appear through individual analysis. Network-based analytical approaches support the identification of collective consumer patterns and interconnected behavioral structures (Russell, 2015).

However, the findings also identify several limitations. The effectiveness of sophisticated grouping techniques depends heavily on data quality, feature selection, and algorithm design. Inaccurate or incomplete consumer information may lead to incorrect group formation and misleading interpretations. Additionally, large-scale consumer datasets create computational challenges requiring efficient processing mechanisms.

Another important observation is the need for interpretability. While intelligent grouping techniques can identify complex consumer patterns, organizations must understand the reasons behind generated groups. Without clear explanations, discovered characteristics may be difficult to apply in practical decision-making.

Overall, the findings demonstrate that sophisticated grouping techniques provide a strong foundation for consumer characteristic discovery. By integrating clustering, data mining, and multi-criteria evaluation principles, organizations can achieve deeper understanding of consumer behavior and develop more effective strategies.

5. DISCUSSION

The results indicate that sophisticated grouping techniques represent a significant advancement in consumer analytics because they enable organizations to move beyond surface-level segmentation toward deeper behavioral understanding. Hidden consumer characteristics often exist within complex interactions among purchasing patterns, preferences, and contextual factors. Intelligent grouping approaches provide the analytical capability required to uncover these concealed structures.

A major theoretical implication of this research is that consumers should be viewed as dynamic behavioral entities rather than fixed categories. Traditional segmentation methods often assume that consumer groups remain stable over time; however, purchasing behavior continuously changes due to market trends, technological developments, and personal preferences. Therefore, grouping systems must support continuous analysis and adaptation.

The findings align with Jatav et al. (2025), who emphasized that advanced clustering techniques can reveal latent behavioral patterns that are not easily observable through conventional approaches. This supports the argument that intelligent grouping methods should focus on discovering underlying behavioral relationships rather than simply assigning consumers to predefined groups.

The practical implications are significant for organizations seeking improved personalization and strategic decision-making. By identifying hidden consumer characteristics, businesses can design more accurate recommendations, develop targeted marketing campaigns, and improve customer relationship management. For example, consumers with different demographic profiles may share similar purchasing motivations, allowing organizations to create more effective behavioral segments.

The integration of data mining and big data analytics further enhances these capabilities. Large-scale consumer environments generate diverse information requiring advanced processing techniques. Data mining methodologies provide mechanisms for extracting meaningful patterns, while big data approaches enable analysis of extensive and continuously generated information (Wu and Zhou, 2020).

However, several challenges limit the implementation of sophisticated grouping systems. Data privacy represents a major concern because detailed consumer analysis requires access to large amounts of personal and behavioral information. Organizations must ensure responsible data management practices and maintain transparency regarding analytical processes.

Computational complexity is another limitation. Advanced grouping techniques involving clustering, network analysis, and multi-criteria evaluation may require substantial processing resources. For large consumer populations,

scalability becomes essential to ensure efficient operation.

Interpretability remains a critical challenge. Although intelligent models can identify complex consumer patterns, decision-makers may struggle to understand how specific groups are generated. Explainable analytical frameworks are necessary to ensure that organizations can trust and effectively utilize discovered insights.

The literature on group decision-making provides valuable perspectives regarding this challenge. Hwang and Lin (2012) emphasized the importance of structured evaluation when dealing with complex decisions involving multiple factors. Similarly, consumer analysis requires frameworks that balance automated discovery with human interpretation.

The research also highlights the importance of combining multiple analytical perspectives. Clustering alone may identify groups, but integrating decision-making models, social analysis, and big data techniques provides a more complete understanding of consumer behavior.

In conclusion, sophisticated grouping techniques offer substantial potential for revealing hidden consumer characteristics. Their effectiveness depends on achieving balance among analytical accuracy, scalability, interpretability, and ethical responsibility. Future developments should focus on adaptive and explainable grouping frameworks capable of supporting real-time consumer analysis.

6. CONCLUSION

Understanding hidden consumer characteristics has become increasingly important in modern data-driven markets. Traditional segmentation methods based on observable attributes provide limited insights because consumer behavior is influenced by complex and interconnected factors. This research examined sophisticated grouping techniques as an advanced approach for discovering concealed consumer patterns through intelligent data analysis.

The study established that grouping techniques based on clustering, data mining, and multi-criteria evaluation can significantly improve consumer understanding. By identifying similarities among consumers and analyzing multidimensional behavioral information, these methods reveal patterns that remain hidden through conventional approaches.

The research contributes a conceptual framework that integrates four major components: consumer data representation, intelligent grouping, multi-criteria evaluation, and behavioral interpretation. This framework emphasizes that effective consumer analysis requires continuous discovery of relationships rather than static

classification.

The findings demonstrate that advanced clustering methods are particularly valuable for identifying latent consumer structures. Jatav et al. (2025) highlighted the effectiveness of clustering-based approaches in uncovering hidden behavioral patterns, reinforcing the importance of intelligent grouping in customer analysis.

Despite these advantages, several limitations remain. Data quality, computational complexity, privacy concerns, and interpretability challenges must be addressed before widespread implementation. Organizations must ensure that analytical systems provide meaningful insights while maintaining responsible data practices.

Future research should explore hybrid approaches combining artificial intelligence, adaptive learning, explainable models, and real-time analytics. Such developments can improve the ability of organizations to understand changing consumer behavior while maintaining transparency and efficiency.

In conclusion, sophisticated grouping techniques provide a powerful foundation for revealing hidden consumer characteristics. By transforming complex consumer data into meaningful behavioral structures, these approaches enable organizations to achieve deeper customer understanding, improve strategic decisions, and develop more personalized services.

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