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A Study on the Diffusion and Adoption Determinants of Modular Mobile Commercial Units in Urban Distribution and Retail Systems

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Abstract

Purpose: This study examines factors influencing the adoption of Modular Mobile Commercial Units (MMCUs) as an innovative urban commercial model. By identifying key adoption determinants, it provides insights into market acceptance, business feasibility, and strategic implications for urban planning, policy, and distribution. **Research design, data, and methodology**: Using Rogers' Diffusion of Innovations Theory, this study analyzes the impact of Relative Advantage, Compatibility, Complexity, Observability, and Trialability on MMCUs adoption. A quantitative survey was conducted among industry professionals and potential adopters, collecting data over one month (January 5, 2025 – February 5, 2025), yielding 413 responses, with 400 validated. Factor Analysis identified key constructs, and Multiple Regression Analysis assessed their impact on adoption intent. **Results:** Findings indicate Relative Advantage and Compatibility positively influence adoption, while Complexity presents a barrier. Observability and Trialability foster trust, increasing adoption likelihood. Prior experience with similar units is associated with lower adoption intent, suggesting skepticism among experienced users. Age and industry classification significantly impact adoption behavior. **Conclusions**: The study highlights that perceived benefits and ease of integration drive MMCUs adoption, while complexity and prior experience hinder it. Enhancing observability and trialability can mitigate concerns and promote adoption. These findings offer insights for businesses, policymakers, and urban retail logistics.

Keywords: Adoption, Diffusion, Modular Mobile Commercial Units, Urban Distribution, Retail Logistics

JEL Classification Code: D22, L81, M13, O33, R30

1. Introduction

1.1. Study Background

Rapid urbanization, e-commerce growth, and rising last-mile delivery needs have increased demand for flexible, cost-effective urban commercial spaces. Traditional stores require high initial investments and lack adaptability, while Mobile Commercial Units (MCUs) offer a lower-cost, flexible alternative (Rosenbaum et al., 2021; Warnaby & Medway, 2022).

MCUs, such as food trucks, container stores, and modular mobile commercial facilities, function as adaptive distribution nodes, enabling lower initial investment costs, greater spatial flexibility, and quicker market entry opportunities. These attributes make them particularly appealing to startups and small businesses aiming to minimize overhead while maximizing reach. For instance, food trucks offer mobility and lower setup costs compared

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to traditional restaurants, while container stores utilize repurposed shipping containers to create versatile retail spaces. Modular mobile commercial facilities take this

a step further by offering customizable, prefabricated units that can be easily relocated and adapted to various business needs.

Despite their advantages, the widespread adoption and diffusion of MCUs face several challenges. Food trucks often encounter regulatory hurdles, such as stringent health and safety standards, and may struggle with limited operational space and seasonal demand fluctuations. Container stores can face issues related to insulation, climate control, and zoning regulations, which may limit their usability in certain environments. Modular mobile commercial Units (MMCUs), while offering improved features, may still confront barriers related to consumer acceptance, perceived value, and integration into existing urban infrastructures.

Currently, there is a paucity of empirical research examining the factors influencing the diffusion and adoption of these innovative MCUs, particularly from the perspective of small business owners. Understanding these determinants is crucial for developing strategies to facilitate the integration of MCUs into urban commercial landscapes. Therefore, this study aims to analyze the key factors affecting the adoption and diffusion of MCUs among small business entrepreneurs. By conducting empirical analyses, including surveys and case studies, this research seeks to provide insights into the challenges and opportunities associated with MCUs, thereby contributing to the broader discourse on innovative commercial space solutions in contemporary urban settings and enhancing urban distribution efficiency and retail logistics flexibility.

1.2. Study Objectives

This study aims to empirically analyze the determinants influencing the diffusion and adoption of MMCUs in urban commercial environments. By identifying these factors, the research seeks to provide comprehensive insights into their market acceptance, potential barriers, and growth prospects, thereby enabling stakeholders to develop effective strategies for the successful implementation and integration of MMCUs within the dynamic landscape of urban commerce.

By evaluating the role and potential of MMCUs in contemporary commercial landscapes, this research offers strategic insights for entrepreneurs, small business owners, and urban planners, aiming to optimize the use of MMCUs in real estate and urban development to enable businesses to leverage them as cost-effective and flexible commercial solutions.

Additionally, this study examines the regulatory environment surrounding MMCUs and the challenges of integrating them within urban planning and commercial regulations. By identifying policy gaps and regulatory barriers, the research provides strategic recommendations to facilitate MMCU adoption. Ensuring alignment with urban development goals, zoning laws, and sustainability initiatives will be crucial for their long-term viability and market acceptance. Addressing these challenges through proactive policymaking, streamlined permitting processes, and stakeholder collaboration will create a more flexible and innovation-friendly urban landscape.

2. Theoretical Background

2.1. Innovative Products & MMCUs

Innovation has been extensively studied in various academic disciplines, leading to diverse definitions and interpretations. In the context of innovative products, innovation refers to the development and commercialization of new or significantly improved goods and services that offer superior value to users. Innovative products are characterized by their novelty, technological advancement, and market impact, distinguishing them from existing alternatives.

Several scholars have explored the concept of innovation, particularly in relation to product development. The definition of innovation can be found in the works of Rowe and Boise (1974), Dewar and Dutton (1986), Rogers (1983), Afuah & Utterback (1997), Fischer (2001), Garcia and Calantone (2002), McDermott and O'Connor (2002), and Pedersen and Dalum (2004).

Schumpeter (1982) viewed innovation as the economic impact of technological change, emphasizing the use of new combinations of existing productive forces to create novel products and drive market transformation. Twiss (1989) defined innovation as a process that integrates science, technology, economics, and management, extending from idea generation to commercialization. This perspective underscores the iterative nature of product development. Molchanov (Siauliai, 2013) described innovation as the result of scientific work aimed at enhancing social activities and driving the production of goods and services. This view highlights the societal benefits of innovative products beyond economic gains.

From a consumer-oriented perspective, perceived newness plays a critical role in defining product innovation.

Zaltman et al. (1973) define innovation as "any idea, practice, or physical product perceived as new by the appropriate unit of adoption." Rogers (1985) similarly states that innovation is "an idea, practice, or object that is perceived as new by an individual or other unit of adoption."

These definitions emphasize consumer perception rather than the intrinsic novelty of a product, underscoring the importance of market acceptance and diffusion in the innovation process.

In this study, we define Modular Mobile Commercial Units (MMCUs) as innovative products that address the limitations of traditional mobile commercial facilities. MMCUs offer superior thermal insulation, enhanced space utilization, potential for regulatory flexibility, sustainability, and the integration of smart technologies compared to existing options like food trucks and container shops. Consequently, MMCUs are poised to overcome the challenges of current mobile commercial facilities and create new market opportunities. This research aims to analyse the factors influencing the adoption and diffusion of such innovative products in the market.

2.2. Rogers' Innovation Product Diffusion Theory

In his seminal work Diffusion of Innovations, Everett Rogers (1995) identifies five key factors that influence the rate at which new products are adopted and diffused within a market.

Relative advantage refers to the degree to which an innovation is perceived as superior to existing alternatives. The greater the perceived benefits, such as improved functionality, cost savings, or enhanced user experience, the more rapidly the innovation is likely to be adopted.

First, compatibility assesses how well the innovation aligns with potential adopters' existing values, past experiences, and current needs. Innovations that are consistent with the user's lifestyle and beliefs are more readily embraced.

Second, complexity refers to the perceived difficulty of understanding and using the innovation. Innovations that are straightforward and user-friendly tend to experience higher adoption rates, whereas those perceived as complex may face resistance.

Third, observability describes the extent to which the results of an innovation are visible to others, significantly impacting its adoption. When the benefits of an innovation are easily observable, it can lead to increased interest and subsequent adoption by others.

Fourth, trialability pertains to the ability of potential adopters to experiment with the innovation on a limited basis before making a full commitment. Opportunities to test or trial an innovation can reduce uncertainty and facilitate adoption.

Fifth, subsequent studies, such as those by Holak and Lehmann (1990), have highlighted that among these factors, relative advantage and compatibility are particularly influential in determining an innovation's adoption success.

Understanding these factors provides valuable insights for businesses and policymakers aiming to promote the adoption of new products and technologies.

Building upon Rogers' five factors, this study aims to analyze the adoption and diffusion of Modular Mobile Commercial Units (MMCUs) in the market.

The adoption of an innovation can be modelled as a function of five key factors: relative advantage (RA), compatibility (C), complexity (CX), observability (O), and trialability (T). The general function representing the adoption likelihood (A) can be formulated as follows.

$$A = f((\mathrm{RA}, \mathrm{C}, \mathrm{CX}, \mathrm{O}, \mathrm{T})$$

Expanding this into a mathematical model.

$$A = \beta_0 + \beta_1 RA + \beta_2 C - \beta_3 CX + \beta_4 O + \beta_5 T + \epsilon$$

Where:

- A = Adoption likelihood of the innovation
- RA = Relative Advantage (perceived superiority over existing alternatives)
- C = Compatibility (alignment with values, experiences, and needs)
- CX = Complexity (difficulty in understanding and using the innovation, negatively affecting adoption)
- O = Observability (visibility of the innovation's results)
- T = Trialability (opportunity to experiment with the innovation before full commitment)
- β_0 = Intercept
- $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ = Coefficients representing the influence of each factor
- ϵ = Error term representing unobserved influences

This function provides a structured way to assess the likelihood of innovation adoption, helping businesses and policymakers develop targeted strategies for promoting new products and technologies.

2.3. Prior Experience and Innovation Adoption

This study examines the influence of prior experience with similar products on the adoption of innovative products, building upon existing research. Prior knowledge derived from experience is categorized into exploratory experience, usage experience, and actual ownership experience, often collectively referred to as familiarity. Subjective knowledge, defined as confidence in one's level of knowledge, has been shown to be associated with past experiences (Alba & Hutchinson, 1987).

Furthermore, Moreau et al. (2001) investigated the relationship between knowledge and the ability to comprehend new products, considering product category knowledge and the level of innovation. Their findings suggest that consumer understanding, perceived utility, and preference for new products vary according to the degree of innovation and prior knowledge levels.

Building upon these prior studies, this research empirically tests the hypothesis that past experiences with similar products influence the selection of innovative products.

2.4. Personal Traits and Innovation Adoption

Consumer adoption of innovative products is influenced by various individual personality traits and consumer-specific characteristics, as supported by previous research. Stock et al. (2016) highlights the role of personality traits in determining consumer innovation success, emphasizing that openness to experience and risk-taking tendencies significantly impact the likelihood of adopting novel products.

Furthermore, Helm and Conrad (2015) investigate the effects of both customer-specific and market-related variables on consumer preference for highly innovative products. Their findings suggest that individual differences in consumer innovativeness and willingness to experiment with new technologies play a crucial role in shaping product selection behaviour.

Additionally, Chang et al. (2017) explores the interplay between consumer traits, social influences, and product uncertainty in the adoption of nano-foods. Their research underscores that perceived risk, social norms, and prior knowledge affect a consumer's willingness to try innovative products.

Building upon these studies, the present research aims to empirically test the hypothesis that individual personality traits and consumer-specific characteristics influence the selection of innovative products. By examining factors such as openness to innovation, risk-taking propensity, and prior knowledge, this study seeks to validate the theoretical framework established in previous literature.

2.5. Review of Previous Studies

The transformation of commercial spaces has given rise to highly flexible and adaptable retail models, including food trucks, pop-up shops, and modular retail units. These MMCUs present significant advantages over conventional brick-and-mortar stores, particularly in terms of space optimization, operational versatility, and adaptability to shifting consumer preferences. As these formats continue to gain traction in urban settings, scholars have examined their structural design, functional efficiency, and regulatory implications. However, existing studies have primarily focused on economic viability, business strategies, and consumer engagement, with comparatively less attention given to the architectural and spatial factors that shape their utilization. To address this gap, this study examines the literature on mobile commercial spaces, identifying key insights into their characteristics and the factors influencing their effective implementation within urban contexts.

2.5.1. Concept and Types of Mobile Commercial Units

MMCUs refer to movable commercial spaces designed to maximize consumer accessibility and enhance operator flexibility. These units have evolved into various forms, including food trucks, pop-up stores, and modular retail spaces, each offering distinct advantages over traditional brick-and-mortar establishments, such as greater spatial flexibility, lower initial investment costs, and quicker market entry opportunities (Moon et al., 2006).

Recent studies highlight the growing role of modular construction in enhancing the efficiency and scalability of MCUs. Coskun et al. (2024) emphasize that modular construction methods reduce construction time, enhance quality control, and improve sustainability, particularly in high-density urban areas where MCUs serve as a critical component of flexible urban commerce.

Food trucks have gained popularity due to their mobility and affordability, making them an attractive option for small business owners and entrepreneurs. Compared to traditional restaurants, food trucks operate with lower initial investment costs and greater operational flexibility (Lee & Kim, 2022).

Recently, modular retail spaces have emerged as a new form of mobile commercial units. These spaces utilize prefabricated technology, allowing for easy assembly and disassembly, thus enabling their deployment in diverse locations (Lee, 2013). Among these, MMCUs represent an advanced model that addresses the limitations of traditional mobile commercial units. MMCUs feature improved thermal insulation, eco-friendly materials, and potential smart technology integration, offering better market adaptability and consumer convenience compared to conventional food trucks or pop-up stores (Moon et al., 2006).

2.5.2. Architecture and Space Utilization of MCUs

MMCUs stand out from traditional fixed commercial spaces due to their mobility, spatial flexibility, and ease of assembly and disassembly. These architectural features are essential for enhancing consumer accessibility and enabling operational adaptability across various environments. In recent years, the adoption of modular construction technology has further optimized MMCU design and functionality, improving spatial versatility, streamlining setup and dismantling processes, and boosting overall operational efficiency (Rajanayagam et al., 2024).

One of the primary advantages of MCUs is their ability to adapt to different spatial and commercial demands. Unlike conventional brick-and-mortar establishments, mobile commercial units can be relocated as needed, allowing businesses to respond dynamically to shifts in consumer demand and market trends (Godbole et al., 2021).

Food trucks and pop-up stores, for instance, leverage their mobility to operate in a wide range of locations, including urban centers, suburban areas, and temporary event spaces. Their ability to relocate based on seasonal demand or special events provides them with a competitive advantage over fixed-location businesses. Studies have shown that the mobility of MCUs enhances commercial fluidity and enables more efficient utilization of underutilized urban spaces. The integration of modular construction techniques has significantly improved the design and efficiency of MCUs, making them easier to install, dismantle, and repurpose. Modular Mobile Commercial Units (MMCUs), in particular, employ advanced prefabrication methods that simplify their manufacturing and construction processes (Rajanayagam et al., 2024).

MMCUs are constructed using steel frames and lightweight panels, enabling modular scalability, which reduces construction time, minimizes waste, and lowers costs while promoting sustainability.

Additionally, advancements like smart environmental controls, energy-efficient materials, and renewable energy integration enhance their adaptability and durability, making them a versatile, future-ready solution for diverse commercial applications (Godbole et al., 2021; Generalova et al., 2016).

MMCUs play a vital role in enhancing urban land efficiency by repurposing underutilized spaces such as vacant lots and temporary event venues, while also supporting dynamic commercial activities. Their ability to serve as flexible retail spaces for seasonal markets, festivals, and exhibitions allows for rapid deployment and removal, making them a practical alternative to permanent commercial establishments. Furthermore, MMCUs align with modern urban planning strategies by fostering a more adaptable and resilient commercial landscape that seamlessly integrates both mobile and permanent retail infrastructures, ultimately contributing to a more sustainable and efficient urban environment (Godbole et al., 2021).

2.5.3. Case Studies of Mobile Commercial Units

MMCUs have become an alternative commercial model that effectively utilizes underutilized urban spaces while enhancing consumer accessibility (Jung et al., 2022). In recent years, MCUs have expanded beyond traditional commercial roles, incorporating brand marketing and consumer experience strategies (Mai et al., 2021). This section explores key case studies of MMCUs and their applicability to neighbourhood commercial facilities.

Capsule commercial spaces, a notable example of mobile commercial architecture, employ modular structures designed for short-term operations, making them particularly well-suited for seasonal events and promotional campaigns (Jung et al., 2022). In Tokyo, for example, a “Modular Pop-up Café” operates in various locations for limited periods before relocating, demonstrating greater operational flexibility and increased brand visibility compared to traditional commercial spaces (Jung et al., 2022).

Pop-up stores function as short-term commercial units strategically deployed for brand promotions and product launches. Research indicates that pop-up stores significantly enhance brand awareness and customer engagement by incorporating interactive marketing strategies. In cities such as New York and London, leading fashion brands have leveraged pop-up stores to rapidly assess market reactions while minimizing operational costs compared to permanent retail spaces (Mai et al., 2021).

An increasing number of MCUs are integrating interactive digital technologies to improve consumer engagement. For instance, a “Digital Experience Pop-up Store” in Seoul utilized Augmented Reality (AR) and QR code-based interactive content, leading to a substantial increase in brand interaction and marketing effectiveness (Mai & Kim, 2022).

Food trucks represent a major category of mobile commercial units, enhancing consumer accessibility while optimizing underutilized urban spaces (Kim & Jung, 2018). Recent studies have examined how spatial layout and exterior design influence consumer acceptance, highlighting the role of architectural elements in shaping consumer experiences (Son & Cho, 2024). Research on food truck user segmentation suggests that consumers perceive food trucks not merely as food vendors but as multifunctional spaces that integrate cultural and experiential elements (Kim & Jung, 2018).

The introduction of designated food truck zones has been shown to enhance consumer satisfaction, as clustering multiple food trucks in one area creates a more engaging atmosphere compared to isolated operations. Additionally, the exterior design of food trucks significantly impacts consumer perceptions, with thematic and regionally inspired designs receiving higher acceptance rates (Son & Cho, 2024). These findings are consistent with Rogers’ Diffusion of Innovations Theory, particularly the principles of observability and compatibility, which emphasize that innovations are more likely to be adopted when their benefits are easily recognizable and align with existing consumer preferences. In the context of mobile commercial units (MCUs), aesthetically appealing and familiar designs are key to consumer acceptance and engagement. Therefore, incorporating strategic design considerations into their planning and development is essential for ensuring functional efficiency, market viability, and effectiveness in urban environments.

2.5.4. Research Differentiation

Previous studies have primarily focused on traditional mobile commercial formats, such as food trucks and container-based retail units, analyzing their economic feasibility, operational strategies, and consumer engagement. However, these studies have not sufficiently addressed the emergence of Modular Mobile Commercial Units (MMCUs) as a new market entrant.

This study expands the scope beyond conventional mobile commercial units by examining MMCUs as an independent commercial model. While previous research has primarily analyzed fixed or semi-mobile structures, this study explores the distinct characteristics of MMCUs, including their spatial flexibility, modular adaptability, and potential for smart technology integration. By doing so, it provides a broader understanding of how MMCUs differentiate themselves from existing mobile commercial spaces and their potential role in shaping urban retail environments.

Additionally, while prior studies have focused primarily on the architectural design and structural engineering aspects of MMCUs, research on their diffusion and adoption as an innovative market product remains insufficient. This study addresses this gap by analyzing the determinants influencing the acceptance and market penetration of MMCUs, integrating perspectives from business innovation, urban planning, and policy implementation. By doing so, it broadens the discussion beyond technical aspects to include the socioeconomic and regulatory factors shaping MMCU adoption.

Finally, unlike previous research that primarily assessed the technical feasibility and economic viability of mobile commercial spaces, this study adopts a policy-oriented approach to facilitate the widespread adoption and integration of MMCUs into urban commercial ecosystems. By identifying key barriers and enablers of MMCU adoption, this research offers strategic insights for policymakers, urban planners, and business stakeholders.

3. Data and Research Methods

3.1. Data

The data utilized in this study was collected through an online survey designed to gather insights from self-employed individuals who are either planning to establish or currently operating a business utilizing MMCUs. The data collection process was conducted over a one-month period, from January 5, 2025, to February 5, 2025, during which a total of 413 responses were obtained. To ensure the reliability and consistency of the collected data, a thorough validation process was carried out, leading to the selection of 400 valid responses for final analysis. These validated responses serve as the foundation for examining the adoption and utilization patterns of MMCUs among entrepreneurs and small business owners, thereby contributing to a deeper understanding of their economic and operational impact within the commercial sector.

3.2. Analysis model

In this study, we aim to examine the factors influencing the intention to operate MMCUs. The research framework is structured as follows Figure 1. This model aims to assess how the independent variables influence the dependent variable, while accounting for the potential effects of the control variables.

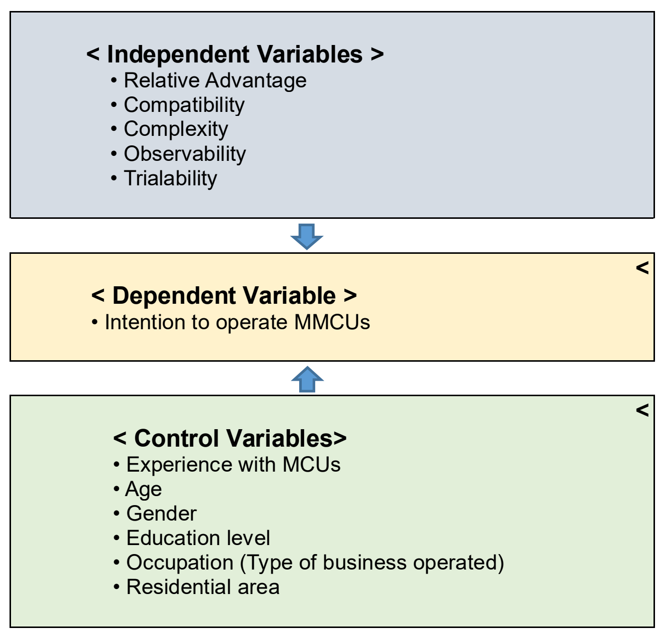

Illustration by the author

Figure 1: Analysis model of the study

3.2.1. Independent Variables

The independent variables in this study are organized into five categories, encompassing a total of twelve specific variables, as detailed in Table 1 below.

Table 1: Categories and Variables of Independent Variables

Independent Variables	Sub Independent Variables
Relative Advantage (RA)	• Superior functionality and performance • Cost-effectiveness • Flexibility in installation and operation
Compatibility (C)	• Alignment with business objectives • Meeting target customer needs • Fits cultural and regulatory contexts
Complexity (CX)	• Ease of installation and maintenance • Intuitive and user-friendly operation
Observability (O)	• Observing real-world use • Access to performance data
Trialability (T)	• VR/AR simulation use • Importance of feature comparison reports

The author created the table

Each of these variables plays a crucial role in assessing the adoption and diffusion of Modular Mobile Commercial Units (MMCUs). Relative advantage refers to the degree to which an innovation is perceived as superior to existing alternatives. Compatibility measures the extent to which the innovation aligns with the potential adopters' values, past experiences, and specific needs. Complexity represents the perceived difficulty in understanding and using the innovation, where lower complexity is associated with higher adoption rates. Trialability captures the extent to which an innovation can be tested before full adoption, while observability reflects the degree to which the benefits of the innovation are visible to others, potentially influencing adoption decisions.

A thorough evaluation of these variables will provide insights into the factors that facilitate or hinder the successful implementation of MMCUs in commercial operations.

3.2.2. Dependent Variable

The dependent variable in this study is the intention to operate Modular Mobile Commercial Units (MMCUs), which represents the likelihood or willingness of individuals or businesses to adopt and integrate MMCUs into their operational strategies. The analysis of this variable aims to identify key determinants influencing the adoption and diffusion of MMCUs as an innovative commercial solution.

3.2.3. Control Variables

The control variables in this study include experience with MCUs, age, gender, education level, occupation, and residential area, each of which may influence the adoption and diffusion of MMCUs.

Experience with MCUs refers to prior experience in managing or operating similar mobile commercial units, which may impact the respondent's familiarity and willingness to adopt MMCUs. Age is measured in years to account for potential generational differences in adoption tendencies. Gender is coded as male or female to examine whether there is any gender-based variations in adoption behaviours. Education level is classified into two categories (high school diploma or lower and bachelor's degree or higher) to assess how educational background influences adoption decisions. Occupation, defined as the specific industry or sector in which the respondent's business operates, serves as a control for sectoral differences in innovation adoption. Lastly, residential area is categorized into metropolitan and non-metropolitan regions to consider potential geographical disparities in the adoption and diffusion of MMCUs.

By controlling for these variables, this study aims to isolate the effects of the independent variables and ensure a more precise analysis of the factors influencing the adoption of MMCUs.

3.3. Analysis Methods

In this study, both the dependent and explanatory variables were measured using a 7-point Likert scale. Given the need to identify underlying latent constructs from observed variables, Factor Analysis was employed as a data reduction technique to extract meaningful dimensions from the dataset. Factor Analysis allows for the identification of key constructs by grouping correlated items into distinct factors, which helps improve the interpretability of the dataset (Lakens & Caldwell, 2021; McNeish & Wolf, 2023; Shrestha, 2021; Yıldırım & Güler, 2022).

Factor Analysis assumes that the observed variables $X_1, X_2, \dots, X_p$ can be expressed as linear combinations of a smaller number of latent factors $F_1, F_2, \dots, F_m$ and an error term ϵ_i. The model is given by:

$$X_i = \lambda_{i1}F_1 + \lambda_{i2}F_2 + \cdots + \lambda_{im}F_m + \epsilon_i$$

Where:

- X_i represents the observed variables (Likert scale items).
- $F_1, F_2, \dots, F_m$ are the unobserved latent factors.
- λ_{ij} represents the factor loadings, indicating the strength of the relationship between each observed variable and the underlying factors.
- ϵ_i represents the unique variance (measurement error) not explained by the factors.

The extracted factors were then used as independent variables in a Multiple Regression Model to examine their influence on the dependent variable.

Following Factor Analysis, Multiple Regression Analysis was conducted to examine the relationship between the extracted factors (independent variables) and the dependent variable. Multiple Regression is an appropriate statistical method when analyzing the impact of multiple predictors on a continuous dependent variable, as it quantifies the contribution of each independent variable while controlling for others (Breuer & DeHaan, 2024; Goldsmith-Pinkham et al., 2024; Ma et al., 2021; McNeish & Wolf, 2023; Wooldridge, 2021).

The Multiple Regression Model estimates the linear relationship between the dependent variable Y and a set of explanatory variables $X_1, X_2, \dots, X_n$, which in this study correspond to the factors derived from Factor Analysis. The model is specified as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \epsilon$$

Where:

- Y represents the dependent variable (e.g., intention to adopt MMCUs or business feasibility perception).
- $X_1, X_2, \dots, X_n$ are the independent variables (factors identified through Factor Analysis).
- β_0 is the intercept, while $\beta_1, \beta_2, \cdots, \beta_n$ are the regression coefficients.
- ϵ represents the error term.

By integrating Factor Analysis and Multiple Regression, this study employs a comprehensive analytical framework to identify the key determinants influencing the adoption and feasibility of Modular Mobile Commercial Units (MMCUs). While Factor Analysis extracts meaningful constructs from observed variables, Multiple Regression quantifies their impact, offering a robust foundation for data-driven policy recommendations and strategic business approaches that facilitate the effective integration and long-term dynamic urban markets and evolving commercial environments.

3.4. Research Hypothesis

The hypothesis of this study is as follows.

H1: The higher the perceived Effect of Five Factors from the Diffusion of Innovations Theory (Relative Advantage, Compatibility, Complexity, Observability, and Trialability) the greater the likelihood of adopting MMCUs.

H2: Individuals or businesses with prior experience operating Mobile Commercial Units (MCUs) are less likely to adopt MMCUs.

H3: Certain demographic characteristics, such as age, gender, education level, occupation (type of business operated), and residential area, partially influence the intention to adopt MMCUs.

Therefore, the model of this study is as follows.

$$Y^* = \beta_0 + \beta_1 \times RA + \beta_2 \times C + \beta_3 \times CX + \beta_4 \times O + \beta_5 \times T + \beta_6 \times E + \beta_7 \times D_1 + \beta_8 \times D_2 + \varepsilon$$

Where:

- Y^*: Unobserved latent variable indicating the propensity to operate MMCUs
- β_0: Intercept term
- $\beta_1, \beta_2, \cdots, \beta_8$: Coefficients corresponding to each independent variable
- RA: Relative Advantage
- C: Compatibility
- CX: Complexity
- O: Observability
- T: Trialability
- E: Experience with MCUs
- D_1: Respondent Characteristic 1 (e.g., Age)
- D_2: Respondent Characteristic 2 (e.g., Gender)
- ε: Error term, typically assumed to follow a standard logistic distribution

The observed ordinal outcome Y is determined by the latent variable Y^* crossing certain thresholds.

4. Results and Discussion

4.1. Basic Analysis

The descriptive statistics, based on a valid sample of 400 respondents, indicate that cost-effectiveness (M = 4.77, SD = 1.301), flexibility in installation and operation (M = 5.20, SD = 1.314), and access to performance data (M = 5.41, SD = 1.233) are highly rated factors influencing MMCU adoption. Additionally, decision-support tools such as real-world demonstrations (M = 5.38, SD = 1.254) and feature comparison reports (M = 5.30, SD = 1.267) are considered crucial. The average respondent age is 38.21 years (SD = 11.184), ranging from 19 to 72. These findings are summarized in Table 2.

Table 2: Descriptive Statistics

Variable	Minimum	Maximum	Mean	Standard Deviation
Superior functionality	1	7	4.38	1.379
Cost-effectiveness	1	7	4.77	1.301
Flexibility in installation	1	7	5.2	1.314

Variable	Minimum	Maximum	Mean	Standard Deviation
Alignment with business	1	7	4.12	1.482
Meeting target customers	1	7	4.37	1.454
Fits cultural and regulatory	1	7	4.36	1.413
Ease of installation and use	1	7	4.64	1.369
Intuitive and user-friendly	1	7	4.75	1.299
VR/AR simulation use	1	7	4.98	1.515
Importance of feature	1	7	5.3	1.267
Observing real-world data	1	7	5.38	1.254
Access to performance data	1	7	5.41	1.233
Age	19	72	38.21	11.184

The author created the table

Table 3 presents the demographic characteristics of the 400 valid respondents. The sample consists of 52.8% males and 47.3% females. In terms of education, 76.5% have a university degree or higher, while 23.5% have a high school diploma or lower. Regarding occupation, the respondents are distributed across retail (23.5%), food service (25.3%), service industry (28.0%), and manufacturing (23.3%). A majority (63.3%) reside in metropolitan areas, while 36.8% are from non-metropolitan regions. Additionally, 22.5% have prior experience operating mobile commercial units, whereas 77.5% do not.

Table 3: Demographic Summary

Category	Frequency (N)	Valid Percentage (%)
Gender: Male	211	52.8
Gender: Female	189	47.3
Education: High School or Below	94	23.5
Education: College or Above	306	76.5
Industry: Retail	94	23.5
Industry: Food Service	101	25.3
Industry: Service	112	28.0
Industry: Manufacturing	93	23.3
Residence: Metropolitan Area	253	63.3
Residence: Non-Metropolitan Area	147	36.8
Experience with Similar Mobile Commercial Units: Yes	90	22.5
Experience with Similar Mobile Commercial Units: No	310	77.5

The author created the table

4.2. Factor Analysis Results

As demonstrated in Table 4, these findings validate the appropriateness of factor analysis for this study. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy produced a value of 0.892, which falls within the excellent range, indicating that the dataset possesses a high degree of suitability for factor analysis and ensuring the reliability of extracted factors in capturing underlying patterns within the data.

Furthermore, Bartlett's Test of Sphericity was statistically significant ($p < 0.001$), thereby rejecting the null hypothesis that the correlation matrix is an identity matrix.

This finding confirms that the variables demonstrate sufficient intercorrelations, meeting the prerequisite conditions for structure detection through factor analysis.

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Table 4: KMO and Bartlett's Test

KMO and Bartlett's Test		Value
Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy		0.892
Bartlett's Test of Sphericity	Approx. Chi-Square	2383.261
	Degree of freedom	66
	Sig. (p-value)	0.000

The author created the table

Collectively, these diagnostic indicators affirm that the dataset satisfies the fundamental assumptions for conducting exploratory factor analysis, ensuring the validity and robustness of the factor extraction process.

The table 5 presents the results of factor analysis for the adoption of Modular Mobile Commercial Units (MMCUs), reducing the initially identified five-factor structure into a more refined four-factor model. The four factors are summarized as follows.

Factor 1 (Relative Advantage: RA) now includes three elements from the original RA factor (superior functionality

and performance, cost-effectiveness, flexibility in installation and operation) along with one element from Compatibility (alignment with business objectives), consolidating aspects related to performance, cost-effectiveness, flexibility, and strategic alignment.

Factor 2 (Compatibility & Complexity: C, CX) integrates two elements from Compatibility (C) (meeting target customer needs, fits cultural and regulatory contexts) and two elements from Complexity (CX) (ease of installation and maintenance, intuitive and user-friendly operation). This factor reflects how well MMCUs align with market demands, regulatory conditions, and ease of implementation for businesses.

Factor 3 (Observability - O) remains unchanged from the previous structure, emphasizing the importance of real-world visibility and access to performance data as critical influences on adoption.

Factor 4 (Trialability - T) retains its original structure while incorporating VR/AR simulation use and the importance of feature comparison reports, highlighting how interactive evaluation tools and comparative analyses enhance potential adopters' confidence in MMCUs.

This revised model improves the clarity and applicability of the factors, offering a streamlined yet comprehensive framework for understanding the key determinants influencing MMCUs adoption.

Table 5: Factor Analysis Table

No	Factor	Factor 1: Relative Advantage (RA, C)	Factor 2: Compatibility & Complexity (C, CX)	Factor 3: Observability (O)	Factor 4: Trialability (T)
1	Superior functionality and performance (RA)	0.858	0.083	0.223	0.022
2	Cost-effectiveness (RA)	0.837	0.149	0.253	0.071
3	Flexibility in installation and operation (RA)	0.762	0.107	-0.092	0.282
4	Alignment with business objectives(C)	0.745	0.070	0.369	0.070
5	Meeting target customer needs (C)	0.068	0.829	0.118	0.152
6	Fits cultural and regulatory contexts(C)	0.057	0.823	0.089	0.219
7	Ease of installation and maintenance (CX)	0.085	0.808	0.099	0.209
8	Intuitive and user-friendly operation (CX)	0.289	0.710	0.304	-0.048
9	Observing real-world use (O)	0.208	0.254	0.807	0.133
10	Access to performance data (O)	0.258	0.146	0.792	0.220
11	VR/AR simulation use(T)	0.144	0.342	0.301	0.764
12	Importance of feature comparison reports (T)	0.492	0.313	0.193	0.540

Extraction Method: Principal Component Analysis, Rotation Method: Varimax with Kaiser Normalization
The author created the table

4.3. Multiple Regression Analysis Results

Table 6 presents the ANOVA results, providing statistical evidence for the significance of the regression model. The regression sum of squares (SS) is 841.334, with 13 degrees of freedom, indicating the proportion of variance explained by the model. The residual sum of squares is 1098.344, with 386 degrees of freedom, representing the unexplained variance in the dependent variable. The total sum of squares is 1939.677, capturing the overall variability in the dataset.

These results suggest that the model accounts for a substantial portion of the variance in the dependent variable, supporting its statistical validity.

The F-statistic of 22.744, with a significance value of $p < 0.001$, suggests that the overall regression model is highly significant. This indicates that the independent variables collectively contribute to explaining a substantial proportion of the variance in the dependent variable, supporting the model's validity.

Table 6: ANOVA Table

Model	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance (p-value)
Regression	841.334	13	64.718	22.744	0.0
Residual	1098.344	386	2.845		
Total	1939.677	399			

The author created the table

The results of the multiple regression analysis are shown in Table 7.

Table 7: Multiple Regression Table

Independent Variables	Std. Beta	p-value	VIF
(Constant)		0.000	
Age	0.087	0.038	1.292
Gender	-0.075	0.054	1.097
Education	0.042	0.271	1.044
Industry: Food Service	0.020	0.665	1.610
Industry: Service	-0.042	0.376	1.652
Industry: manufacturing	-0.105	0.024	1.590
Residence	-0.040	0.294	1.051
Experience with Similar MCUs	-0.093	0.018	1.137
Relative Advantage (RA)	0.496	0.000	1.153
Compatibility &Complexity (C, CX)	0.132	0.001	1.082
Observability (O)	0.101	0.007	1.028
Trialability (T)	0.117	0.002	1.021

Adjusted $R^2 = 0.62$
The author created the table

The results of the multiple regression analysis, including standardized beta coefficients (Std. Beta), significance levels (p-values), and variance inflation factors (VIFs), are presented in the table. The multicollinearity assessment, based on Variance Inflation Factors (VIFs) ranging from

1.021 to 1.652, confirms that multicollinearity is not a significant concern, ensuring the stability and reliability of the estimated coefficients. The model assesses the impact of various independent variables on the dependent variable, with a particular focus on factors influencing the adoption of Modular Mobile Commercial Units (MMCUs).

4.3.1. Control Variables: Respondent Characteristics

The results indicate that age has a statistically significant positive effect ($\beta = 0.087$, $p = 0.038$), suggesting that older respondents are slightly more likely to adopt MMCUs. In contrast, gender shows a marginally insignificant negative relationship ($\beta = -0.075$, $p = 0.054$), implying that while gender differences may influence adoption, the effect is not strong. Education level ($\beta = 0.042$, $p = 0.271$) and residence ($\beta = -0.040$, $p = 0.294$) are not statistically significant, indicating that neither educational background nor geographic location plays a crucial role in the likelihood of MMCUs adoption.

Regarding industry sectors, no significant effect is observed for respondents in the food service industry ($\beta = 0.020$, $p = 0.665$) or the service industry ($\beta = -0.042$, $p = 0.376$). However, respondents in the manufacturing industry exhibit a statistically significant negative effect ($\beta = -0.105$, $p = 0.024$), suggesting that individuals in manufacturing are less likely to adopt MMCUs compared to other industries.

4.3.2. Experience with Similar MMCUs

Experience with similar MMCUs exhibits a statistically significant negative effect ($\beta = -0.093$, $p = 0.018$), indicating that individuals who have previously worked with or been exposed to similar modular mobile commercial units are less likely to adopt new MMCUs. This suggests that prior exposure may lead to preconceived notions or scepticisms regarding the effectiveness or necessity of adopting a new MMCU system. Additionally, previous experiences may have shaped preferences, making respondents more resistant to change or innovation in the field. This resistance could stem from concerns about operational challenges, perceived redundancy, or dissatisfaction with past experiences, ultimately reducing the likelihood of adoption.

4.3.3. Innovation Factors in MMCU Adoption

The regression analysis results indicate that Relative Advantage (RA) has the most substantial influence on the adoption of MMCUs ($\beta = 0.496$, $p = 0.000$), demonstrating that the perceived benefits of MMCUs, such as enhanced functionality, cost-effectiveness, and operational flexibility, significantly drive adoption decisions.

Additionally, Compatibility & Complexity (C, CX) exhibits a statistically significant impact ($\beta = 0.132$, $p = 0.001$), suggesting that alignment with business objectives, regulatory fit, and ease of implementation contribute to the adoption process.

Furthermore, Observability (O) ($\beta = 0.101$, $p = 0.007$) and Trialability (T) ($\beta = 0.117$, $p = 0.002$) also play important roles, indicating that businesses are more likely to adopt MMCUs when they can observe real-world applications and assess performance through trial-based evaluations.

These findings highlight the critical role of Relative Advantage (RA), Compatibility (C), Complexity (CX), Observability (O), and Trialability (T) in MMCU adoption, aligning with innovation diffusion theories, and suggest that enhancing perceived advantages, streamlining integration, and expanding experiential evaluation opportunities through real-world demonstrations and digital simulations can accelerate adoption, fostering greater business engagement and market penetration.

5. Conclusions

5.1. Study Results

The results of the multiple regression analysis provide empirical support for H1, confirming that the perceived effect of innovation attributes significantly influences the likelihood of adopting MMCUs. Specifically, Relative Advantage ($\beta = 0.496$, $p = 0.000$), Compatibility ($\beta = 0.132$, $p = 0.001$), and Observability & Trialability ($\beta = 0.117$, $p = 0.002$) exhibit positive and significant effects on adoption intention. In contrast, Complexity ($\beta = 0.101$, $p = 0.007$) has a significant negative effect, indicating that higher perceived complexity hinders adoption.

Regarding H2, the findings do not support the hypothesis. The variable Experience with Similar MMCUs ($\beta = -0.093$, $p = 0.018$) shows a significant negative effect on adoption likelihood, suggesting that individuals or businesses with prior experience operating similar modular commercial units are less likely to adopt MMCUs, potentially due to prior cognitive biases or skepticism.

For H3, the impact of demographic characteristics on MMCU adoption is partially supported. Age ($\beta = 0.087$, $p = 0.038$) has a statistically significant positive effect, implying that older individuals are more inclined to adopt MMCUs. However, gender ($\beta = -0.075$, $p = 0.054$), education level ($\beta = 0.042$, $p = 0.271$), and residence ($\beta = -0.040$, $p = 0.294$) are not statistically significant predictors of adoption. Additionally, the results reveal industry-specific differences, as the manufacturing sector ($\beta = -0.105$, $p = 0.024$) demonstrates a significant negative effect, suggesting lower adoption rates in this sector, whereas food service and service industries show no significant impact.

These findings underscore the significant influence of innovation attributes in facilitating MMCUs adoption while contradicting the notion that prior experience universally promotes adoption. Additionally, demographic variables demonstrate heterogeneous effects, with age and industry classification emerging as key determinants.

The results indicate that Relative Advantage (+), Compatibility (+), Observability & Trialability (+), and Age (+) positively influence MMCUs adoption, suggesting that perceived benefits, alignment with business needs, technological accessibility, and the ability to test MMCUs through interactive demonstrations enhance adoption likelihood. In contrast, Complexity (-), Experience with Similar MMCUs (-), and the Manufacturing Industry (-) negatively affect adoption, implying that operational challenges, learning curve difficulties, cost concerns, prior exposure leading to skepticism, and industry-specific regulatory constraints hinder adoption.

5.2. Implications

The empirical results of this study generate significant policy implications for enhancing the adoption, scalability, and institutional integration of Modular Mobile Commercial Units (MMCUs) within the broader commercial, urban distribution, and retail logistics landscape, thereby fostering a more adaptive and sustainable business environment.

First, given the strong positive influence of Relative Advantage (RA) and Compatibility (C) on adoption likelihood, policymakers should focus on incentivizing businesses to recognize the operational and strategic benefits of MMCUs. This can be achieved through financial subsidies, tax incentives, or public awareness campaigns that emphasize cost efficiency, adaptability, and market alignment.

Second, the negative impact of Complexity (CX) suggests that reducing operational and regulatory barriers is critical. Simplifying installation procedures, streamlining administrative approvals, and providing technical support can mitigate concerns about the complexity of adopting MMCUs, making them more accessible to potential users.

Third, Observability and Trialability (O&T) positively influence adoption, indicating that demonstration programs, pilot projects, and experiential marketing initiatives could be effective strategies. Creating test zones or shared-use MMCU hubs where businesses can experience MMCUs before full-scale implementation may enhance confidence in their feasibility and effectiveness.

Fourth, the study challenges the assumption that prior experience with similar mobile units universally promotes adoption. This suggests that education and training programs should be tailored not only for new adopters but also for experienced users, addressing misconceptions or skepticism that may hinder broader implementation.

Finally, demographic factors such as age and industry type play a crucial role in MMCUs adoption decisions, highlighting the need for sector-specific policy interventions. Industries with lower adoption rates, such as manufacturing, may benefit from targeted support mechanisms, including specialized financing options and tailored regulatory frameworks to ease integration.

Developing these comprehensive and adaptive policies can help governments, regulatory bodies, and industry stakeholders create a more conducive and sustainable adoption environment, encouraging businesses to embrace MMCUs with greater confidence and strategic foresight. Such efforts will ultimately foster technological innovation, drive economic growth, support small enterprises, strengthen localized distribution networks, improve market accessibility, and enhance urban commercial flexibility in rapidly evolving business landscapes.

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