

Analysis and Modeling of Factors Affecting the Acceptance of Delivery Robots among Transportation Network Users in Iran

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ABSTRACT

Delivery robots have emerged as one of the most promising innovations in urban transportation logistics, offering an efficient and sustainable solution to last-mile delivery challenges. This study aims to analyze and model the factors influencing Iranian consumers' behavioral intention to adopt autonomous delivery robots (ADRs). To achieve this, a comprehensive conceptual framework was developed by integrating the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT2), complemented by additional constructs including financial risk, perceived risk, and user knowledge. Data were collected through an online survey distributed across multiple social media platforms, yielding 325 valid responses. The proposed model was empirically tested using Partial Least Squares Structural Equation Modeling (PLS-SEM). The results revealed that performance expectancy ($\beta = 0.636$), perceived usefulness ($\beta = 0.531$), and perceived ease of use ($\beta = 0.486$) exert the strongest positive influences on users' intention to adopt ADRs. Conversely, financial risk ($\beta = -0.496$) and perceived risk ($\beta = -0.245$) significantly and negatively affect user acceptance, while knowledge ($\beta = 0.300$) positively contributes to perceived usefulness. The findings suggest that enhancing technological reliability, usability, and affordability can strengthen public confidence and accelerate ADR adoption. Accordingly, developers and policymakers should focus on improving user experience, promoting trust through safety assurances, and providing transparent pricing models. This study offers valuable insights for designing effective implementation strategies and fostering sustainable integration of delivery robots into Iran's urban transportation systems.

Keywords

Delivery robots; Financial risk; Performance expectancy; Perceived usefulness; Perceived ease of use.

1. Introduction

The surge in online shopping has led to a remarkable increase in fossil-fueled delivery traffic, resulting in congestion, air pollution, and safety risks [1]. Consequently, autonomous delivery robots (ADRs) are being adopted as eco-friendly alternatives utilizing AI and smart navigation [2–5]. Studies in countries such as Germany, the UK, and South Korea show that ease of use and safety perception are key determinants of public trust [6–9]. The COVID-19 pandemic further boosted the demand for contactless deliveries, accelerating acceptance of ADRs globally.

In Iran, the rapid expansion of e-commerce—especially after the pandemic—has created major challenges for last-mile delivery systems. To ensure the successful deployment of ADRs, it is crucial to understand consumer behavioral intentions and the contextual factors affecting adoption.

The present research fills this gap by extending the TAM and UTAUT2 frameworks with financial risk and perceived risk, two constructs often overlooked in previous studies. This hybrid approach enables a comprehensive understanding of how technological, psychological, and socio-economic factors influence consumer acceptance. Accordingly, the proposed conceptual framework integrating these constructs is presented in Figure 1.

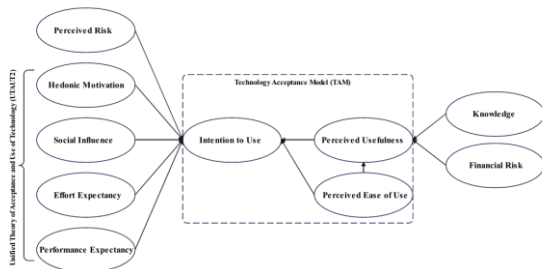


Figure 1. Proposed Research Model

2. Methodology

A conceptual model was developed by combining TAM and UTAUT2 to explain behavioral intention toward delivery robots. The model comprises ten latent variables and thirty-two observed indicators measured on a seven-point Likert scale, covering Perceived Usefulness, Perceived Ease of Use, Performance Expectancy, Effort Expectancy, Social Influence, Hedonic Motivation, Perceived Risk, Financial Risk, Knowledge, and Behavioral Intention.

An online questionnaire was distributed via social networks (Instagram, Telegram, WhatsApp, and email) between September and December 2023. Respondents without prior online-shopping experience were excluded. After screening for reliability and consistency, 325 valid responses (response rate: 92.8%) were retained.

The measurement model was validated using Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE), all exceeding threshold values (α , CR > 0.70; AVE > 0.50). Discriminant validity was verified through the Fornell–Larcker criterion and Heterotrait–Monotrait ratio (HTMT < 0.90).

The structural model was tested using the bootstrapping technique with 5000 resamples to estimate path coefficients (β), t-values, and p-values. Additionally, control variables (age, gender, education, income, and familiarity with ADRs) were analyzed to evaluate demographic influences.

3. Results and Discussion

All ten hypotheses were statistically supported ($p < 0.05$). The detailed path coefficients, standard deviations, t-values, and p-values for each hypothesized relationship are presented in Table 1. Among the positive determinants, performance expectancy showed the strongest impact on behavioral intention ($\beta = 0.636$, $p < 0.001$), followed by perceived usefulness ($\beta = 0.531$) and perceived ease of use ($\beta = 0.486$). Effort expectancy, social influence, and hedonic motivation also had significant positive effects, highlighting the role of user convenience, peer influence, and enjoyment in ADR acceptance. Conversely, perceived risk ($\beta = -0.245$) and financial risk ($\beta = -0.496$) negatively affected user intention, underscoring that uncertainty about cost and safety remains a key barrier. Furthermore, knowledge ($\beta = 0.300$) had a significant positive influence on perceived usefulness.

Control variable analysis indicated that age, gender, income, residence, and familiarity with ADRs significantly affect adoption intention, whereas education level did not. The model explained 78% of the variance in behavioral intention ($R^2 = 0.78$) and 72% in perceived usefulness ($R^2 = 0.72$), confirming the model's robustness. These findings align with prior international studies [1–9], validating the hybrid TAM–UTAUT2 model in the Iranian context.

From a managerial viewpoint, consumers are more likely to adopt ADRs when they perceive them as

useful, easy to use, and reliable. Efforts to reduce perceived and financial risks—through transparent pricing, insurance guarantees, and public demonstrations—can significantly improve trust. Governmental and industry initiatives that promote user education and awareness campaigns will also increase perceived usefulness and overall acceptance.

4. Conclusion

This research contributes to the growing body of knowledge on consumer acceptance of autonomous delivery technologies by presenting an integrated TAM-UTAUT2 model tailored to Iran's urban logistics context. The empirical findings confirm that enhancing usability, perceived usefulness, and operational performance while mitigating financial and perceived risks are essential to encouraging adoption. Public education programs and pilot implementations can further strengthen trust and familiarity.

For practitioners, developing user-friendly platforms, ensuring safety compliance, and maintaining cost transparency are critical to promoting ADR integration. Policymakers should design supportive regulations, provide subsidies for green logistics, and facilitate test zones for autonomous delivery operations.

Future studies should employ longitudinal data to track behavioral change over time, incorporate cross-cultural comparisons, and examine additional factors such as environmental awareness and ethical trust. Overall, the study offers theoretical and managerial insights for advancing smart and sustainable last-mile delivery systems in developing economies.

5. References

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