

INNOVATION SCIENCE AND TECHNOLOGY



Scopus || Electronic journal specializing in Scopus

ISSUE 2



Acceptance of papers **February, 2026**



Acceptance of papers

Published monthly



Topics

economics, technology, social sciences

ISSN 3060-5229



Digital Object Identifier



Visit the website t.me/scopus_IST2100

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THE SCIENTIFIC-POPULAR ELECTRONIC
JOURNAL **"INNOVATION SCIENCE AND
TECHNOLOGY"** HAS BEEN REGISTERED
UNDER THE NUMBER **C-5669633** BY THE
AGENCY FOR INFORMATION AND MASS
COMMUNICATIONS (AOKA) OF THE
REPUBLIC OF UZBEKISTAN, EFFECTIVE
FROM OCTOBER 9, 2024.

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INNOVATIVE BUSINESS MODELS AND INTEGRATION MECHANISMS IN PASSENGER TRANSPORTATION ORGANIZATION

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Abstract: This paper analyzes innovative business models for managing passenger transportation systems in the context of digital transformation. The study examines the “four-link innovation spiral” model proposed by M. A. Yurevich as a conceptual framework for innovation development, emphasizing the importance of institutional integration among society, business, and the state. Additionally, within the framework of the “Mobility as a Service” (MaaS) concept, the study explores the integration of various transport modes into a single digital platform and the improvement of multimodal transport service efficiency. The transformation of traditional transport services is demonstrated through the example of the sharing economy, driven by the development of Internet technologies and GPS systems, as well as the activities of digital aggregators such as Uber, Lyft, and Yandex Taxi. The research findings indicate that digital platforms not only enhance service quality but also create a new competitive environment in the transport market and ensure the efficient use of resources.

Key words: digital transformation, passenger transportation systems, innovative business models, four-link innovation spiral model, institutional integration, Mobility as a Service (MaaS), multimodal transport, digital platforms, sharing economy, GPS technologies, Internet technologies, digital aggregators, Yandex Taxi, transport service transformation, competitive environment, efficient resource use, service quality.

INTRODUCTION

In today's rapidly evolving digital transformation environment, innovative business models for managing passenger transportation systems are emerging not merely as technological updates but as strategic determinants ensuring service efficiency and the openness of the transport ecosystem. The conceptual foundations of these processes have been examined in the research of M. A. Yurevich, where the institutional integration of society, business, and the state is interpreted within the framework of the “four-link innovation spiral” concept. This approach demonstrates that citizens' digital needs in the passenger transport services market are becoming the primary drivers of innovation and are forming the basis for new institutional initiatives.

The practical transformation of innovative business models is closely associated with the concept of “Mobility as a Service” (MaaS). Within the MaaS framework, various modes of transport (such as taxis, carsharing, and public transport) are integrated into a single digital platform, enabling users to plan multimodal journeys on a “one-stop-shop” basis.

According to the scientific findings of M. G. Girich and A. Saulenikh, the widespread adoption of Internet technologies and GPS navigation has contributed to the rapid development of the “sharing economy” and the gradual replacement of traditional dispatching services by digital aggregators. Multi-sided platforms such as Uber, Lyft, and Yandex Taxi represent prominent examples of this transformation, optimizing resource allocation through algorithmic solutions. As B. Edelman and D. Geradin note, such platforms act as innovative regulatory mechanisms that enhance market efficiency and fundamentally transform traditional forms of competition.

LITERATURE REVIEW

The development of taxi services and mobile aggregator platforms in modern transportation systems has been widely addressed in academic research. In particular, B. Alonso et al. (2018) modeled users' perceptions

of taxi service quality. The authors found that key service quality indicators—such as waiting time, driver behavior, safety, and pricing—have a direct impact on customer satisfaction.

The regulation of digital platforms was examined by B. Edelman and D. Geradin (2016), who argued that traditional regulatory mechanisms are insufficient for companies such as Uber and Airbnb. They emphasized the need to establish effective oversight systems without constraining innovation.

The concept of “Mobility as a Service” (MaaS) as a new transportation paradigm was introduced by S. Hietanen (2014), who proposed integrating transport services through a unified digital platform. This approach not only enhances user convenience but also improves the overall efficiency of the transport system. Similarly, S. Sochor et al. (2018) analyzed the MaaS ecosystem using a systematic (topological) approach, identifying its key stakeholders and their interrelationships.

The legal aspects of the sharing economy within the European Union were comprehensively studied by V. Hatzopoulos (2018). The study highlights the complexity of regulating digital platform activities and underscores the necessity of a unified legal framework.

Information technologies and geoinformation systems play a crucial role in the transport sector. Y. Mironova (2020) examined the application of geoinformation systems in educational processes and demonstrated their practical relevance. Bushuev et al. (2015) analyzed the GLONASS system and its application in the “Yandex. Traffic” service, emphasizing the importance of such technologies in real-time traffic management.

Labor relations in the platform economy also represent a significant research area. A. Rosenblat and L. Stark (2016) investigated algorithmic management and information asymmetry using Uber drivers as a case study, demonstrating how platforms implement control mechanisms over workers.

The study by Shevgunov et al. (2022) on quality assessment systems in taxi services is also noteworthy. The authors developed a model for evaluating driver performance based on rating systems and substantiated its effectiveness in improving service quality.

Additionally, the influence of international standards on national taxi aggregator markets was analyzed by Girich and Saule (2020), who emphasized that global requirements play a significant role in shaping local regulatory frameworks.

RESEARCH METHODOLOGY

The sustainability of platform-based business models depends on their internal quality control mechanisms, particularly the phenomenon of “algorithmic labor.” According to A. Rosenblat and L. Stark, digital platforms directly influence driver behavior through information asymmetry and rating systems. In quality management, modeling users’ subjective perceptions (user perception modeling) serves as a key factor in shaping loyalty indicators such as Net Promoter Score (NPS) and Customer Satisfaction Index (CSI).

The mathematical foundation for ensuring service quality in taxi aggregator operations is based on the driver rating calculation algorithm. According to the research of T. Ya. Shevgunov and co-authors, the “Weighted Moving Average” method used in rating calculations enhances the system’s sensitivity to changes in service quality. In its general form, the rating calculation formula can be expressed as follows:

$$R = \sum(r_i \times w_i) / W$$

Where:

- R — current driver rating;
- r_i — score assigned by the passenger for the i -th order;
- w_i — weight coefficient of the i -th order (more recent orders have higher weights);
- W — width of the averaging window (number of recent orders).

This mathematical and logistical framework enables aggregators to maintain stable service standards with minimal human intervention. Table 1 presents a comparative analysis of major aggregators based on these indicators (Table 1).

Table 1. Comparative Analysis of Rating Calculation Indicators for Major Taxi Aggregators (as of 2022)

Aggregator Company	Smoothing Method	Window Width (W)	Minimum Threshold (TH)	Adaptation Period (NA)
Yandex Taxi	Weighted Moving Average	150	4.4	50
Uber	Simple Moving Average	500	4.6	100
Gett	Simple Moving Average	150	4.6	50
Citymobil	Simple Moving Average	200	4.6	30

As can be observed from the table data, the Yandex Taxi platform stands out due to its use of the “weighted moving average” method. This approach ensures that the most recent driver orders exert a greater influence on the overall rating, thereby enabling the system to respond rapidly to dynamic changes. The 150-order window and a minimum threshold of 4.4 indicate that the platform maintains strict quality control while simultaneously creating a flexible environment for market participants.

The transition from traditional dispatching models to digital platforms integrated into a multimodal transport environment constitutes a fundamental basis for enhancing economic efficiency and meeting societal demand for safe and accessible mobility.

The institutional architecture of the Yandex Taxi platform is characterized by its ability to create a flexible economic environment for small and medium-sized enterprises, particularly individual entrepreneurs and self-employed individuals. In this context, the platform functions not merely as an intermediary but as a “ready-made business infrastructure,” providing micro-entrepreneurs with technological tools, analytical resources, and stable access to consumers. As noted by V. Hatzopoulos, within the framework of the sharing economy, such models serve as effective institutional mechanisms for increasing transparency in service processes and reducing the scale of the informal economy.

The evolution of modern platform solutions is extending beyond traditional taxi services toward the concept of a multifunctional “super-app.” According to M. Hasselwander and J. F. Bigotte, the MaaS ecosystem integrates transport, logistics, and third-party services through a unified digital interface (API), thereby creating a seamless user experience. This, in turn, facilitates the diversification of logistics processes and the expansion of monetization opportunities.

The technological foundation of this ecosystem is formed by geoinformation infrastructure and big data processing algorithms. According to Y. Mironova, intelligent route planning based on spatial data represents a key determinant in improving transport system efficiency. Real-time data obtained via GSM networks, supported by GLONASS and GPS systems, enable the identification of traffic load levels and the formation of optimal routes using artificial intelligence algorithms. This approach ensures multimodal integration in addressing the “first and last mile” problem in urban transport systems.

The economic sustainability of platform-based management is ensured through dynamic pricing (surge pricing), which balances supply and demand. This mechanism incorporates external factors such as weather conditions, peak hours, and public events through stochastic modeling, allowing for automatic price adjustments. In simplified form, the mathematical model for determining the current fare can be expressed as follows:

$$P_{\text{current}} = P_{\text{base}} \times k_{\text{demand}} \times k_{\text{supply}} \times k_{\text{weather}}$$

Where:

- P_{current} — final current fare for the trip;
- P_{base} — base (fixed) fare;
- k_{demand} — coefficient reflecting demand intensity in a given area;
- k_{supply} — coefficient representing the number of active vehicles;
- k_{weather} — coefficient accounting for adverse weather conditions.

This mathematical framework not only determines pricing but also ensures service continuity by incentivizing additional drivers to enter the system. According to T. Ya. Shevgunov, such algorithms operate in conjunction with digital filters that define driver status (N — new, A — active, B — blocked, C — correction period). Furthermore, performance indicators such as BTR (order completion rate) and CAD (customer complaint index) serve as additional metrics for assessing the stability of the innovative business model.

Within the framework of the “innovation spiral” concept proposed by M. A. Yurevich, user feedback (ratings and reviews) forms a self-regulating closed-loop mechanism within the system. This mechanism reduces information asymmetry, optimizes transaction costs, and creates conditions for safe, environmentally sustainable, and economically efficient mobility.

The rapid development of the platform economy is transforming not only technological processes but also the institutional foundations of labor relations. As noted by N. L. Lyutov, platform-based employment models redefine the boundaries between traditional labor relations and independent entrepreneurship, giving rise to a new digital form of the “independent contractor” institution. In this context, digital platforms evolve beyond simple intermediaries into intelligent systems for management and activity monitoring of large networks of individual entrepreneurs and self-employed workers.

ANALYSIS AND RESULTS

Ensuring consistent service quality through not only subjective feedback but also telematic data and multi-criteria rating systems constitutes an essential component of innovative business models. According to the

research of T. Ya. Shevgunov et al., driver ratings can be interpreted as stochastic processes and represented in the form of a state graph.

This mechanism dynamically adjusts driver status based on quality indicators, thereby minimizing the subjective influence of the human factor. Table 2 presents the structure of the multi-criteria system used in modern aggregators for evaluating driver performance (Table 2).

Table 2. Multi-Criteria System for Evaluating Driver Performance and Impact Mechanisms

Criterion Group	Key Indicators	Economic and Managerial Impact
Subjective Evaluation	Passenger reviews and star ratings	Priority in order allocation
Telematic Sensors	Speed, harsh braking, trajectory	Safety coefficient and insurance rate
Operational Metrics	Order acceptance rate	Restriction of system access rights
Quality Coefficient	Vehicle cleanliness, communication standards	Upgrade to higher fare categories (Comfort, Business)

Big Data analysis enables platform operators to anticipate high-demand areas and allocate resources more efficiently. According to the findings of M. V. Bushuev and S. I. Krasitskaya, real-time data obtained through geoinformation systems play a decisive role in traffic flow management. At the same time, the technical reliability of software systems and the minimization of operational errors directly influence economic efficiency.

According to the mathematical model proposed by I. V. Kuchumov, the relationship between the probability of detecting software errors (P) and system stability can be expressed as follows:

$$P = 1 - e^{-\lambda t}$$

Where:

- λ — intensity of errors occurring within the system;
- t — continuous operating time of the system.

This mathematical framework contributes to reducing transaction costs by enhancing the technological stability of the platform. The “four-link innovation spiral” concept proposed by M. A. Yurevich further confirms that the interaction among the state, business, and civil society in the transport ecosystem is evolving to a new level.

The implementation of innovative business models in passenger transportation has transformed transport services from a purely technical process into a complex socio-economic ecosystem. The integration of subscription mechanisms, dynamic pricing, and intelligent rating systems ensures economic efficiency, enhances market transparency, democratizes quality control, and lays the foundation for future “Smart City” infrastructure.

A comparative analysis of international experiences in implementing the MaaS (Mobility as a Service) concept holds significant methodological value for understanding the evolutionary development of innovative business models. The practical implementation of MaaS can be categorized into several levels depending on the technological and economic depth of service provision. This internationally recognized hierarchy, proposed by S. Sochor, enables the assessment of digital maturity in transport systems and the degree of integration among operators.

MaaS Integration Hierarchy (based on Sochor et al., 2018):

- Level 0: No integration (separate services)
- Level 1 (Information Integration): Passengers are provided with the ability to plan routes and obtain information on available transport modes
- Level 2 (Booking and Payment Integration): Tickets for multiple transport modes can be purchased via a single digital wallet
- Level 3 (Service Package Integration): Introduction of subscription-based and bundled service packages
- Level 4 (Policy and Social Goals Integration): Full alignment of transport systems with urban environmental and sustainable development strategies

According to the research of S. Sochor et al. (2018), the level of MaaS integration is determined by the depth of cooperation among transport operators. The utility function of this integration for the user can be expressed as follows:

$$U_{\text{MaaS}} = \sum(Q_i \times w_i) - T_{\text{trans}} - T_{\text{wait}}$$

Where:

- U_{MaaS} — overall utility of the integrated service for the user;
- Q_i — service quality of the i -th transport mode;
- w_i — priority weight of the i -th transport mode for the user;
- T_{trans} — transaction costs (time and monetary costs) incurred via the unified platform;
- T_{wait} — waiting time during multimodal transfers.

The integration of transport operators with different ownership structures into a unified digital environment within the MaaS framework marks a qualitatively new stage in urban mobility management. Table 3 presents a systematized comparison of the practical implementation of this concept across leading global megacities (Table 3).

Table 3. Comparative Description of MaaS Implementation in International Megacities

City	Platform & Operator	Integration Level	Available Transport Types	Payment Models	Innovative Features
Helsinki	Whim (MaaS Global — private)	Level 3: Full integration (planning, booking, package payment)	Public transport, taxi, bicycle sharing, carsharing	Subscription packages (Urban 30, Weekend, Unlimited) and pay-as-you-go	First commercially launched MaaS platform; strategy focused on reducing private car use
Vienna	WienMobil (Wiener Linien — public)	Level 2: Booking and payment integration (gradually expanding)	Public transport (metro, tram), carsharing, bicycle and scooter sharing, taxi	Integrated payment via app; linked to annual subscription system	Open modular platform managed by a public operator; integrated with national road graph (GIP)
Hannover	Mobilitätsshop (ÜSTRA/GVH — public)	Level 2: Information and e-ticketing integration	Public transport (bus, train), taxi, carsharing	Post-pay system based on a unified monthly account	Focus on corporate clients; includes a 10% discount mechanism for taxi services
Turku	Föli / Tuup (public-private partnership)	Open API and data integration	Buses, water transport, shared bicycles	Contactless payment; integration with Whim app	ID-based ticketing system; open data environment for external developers

The results of the comparative analysis confirm that the sustainability of the MaaS model depends not only on technological infrastructure but also directly on the effectiveness of institutional cooperation among transport market actors.

In particular, the experience of Helsinki demonstrates that subscription packages (such as Urban 30 and Unlimited) serve as primary economic incentives for increasing the frequency of public transport usage. In Vienna and Hannover, the leading role of municipal operators ensures the social orientation of the transport system and facilitates centralized control over tariff policy.

Indicators such as NPS (Net Promoter Score) and CSI (Customer Satisfaction Index) occupy a central role in the quantitative assessment of platform efficiency. According to the findings of T. Ya. Shevgunov and co-authors, the implementation of intelligent rating systems is essential for minimizing negative customer experiences. In particular, the “Simple Moving Average” algorithm used to stabilize driver service quality is based on calculating the average value of recent trips. This mathematical model can be expressed as follows:

$$R = (1 / L) \times \sum r_i$$

Where:

- R — current driver rating;
- r_i — individual score assigned by the passenger for the i -th trip;
- L — number of recent trips considered (typically $L = 150$).

This model mitigates the impact of occasional low ratings and ensures that only participants meeting high service standards remain active within the system.

The economic effectiveness of the platform model is particularly evident in the increased income of micro-entrepreneurs and self-employed individuals. The allocation of orders based on geographic proximity significantly reduces the share of “dead mileage,” thereby improving working time efficiency by approximately 30–40%. As noted by N. L. Lyutov, such models contribute to lowering barriers to market entry and enhancing the institutional stability of the labor market.

Methods such as A/B testing and software quality audits play a crucial role in verifying the economic validity of innovations. According to I. V. Kuchumov, testing algorithms initially within limited areas (for example, a specific district of Tashkent city) and subsequently scaling them across the entire network based on achieved results (such as reduced ETA and increased income) ensures system stability (Table 4).

Table 4. Comparative Analysis of Passenger Transportation Models by Efficiency Metrics

Indicator	Traditional Model	Innovative (Platform) Model	Efficiency Source
Order processing time	5–15 minutes	10–30 seconds	Automated dispatching
Vehicle arrival time	15–30 minutes	3–5 minutes	Geolocation and optimal routing
Share of empty mileage	40–60%	10–15%	Order density and routing algorithms
Service quality control	Selective / episodic	Continuous (rating system)	Passenger feedback
Price setting	Static / fixed	Dynamic (surge pricing)	Supply–demand balance

The analysis of the table data demonstrates that the superiority of innovative models is primarily explained by the maximization of resource utilization intensity. In this context, geoinformation systems (GIS), as highlighted by Yu. N. Mironova, serve as a strategic source of information for developing digital models aimed at managing urban traffic flows through spatial data processing.

The implementation of innovative business models and integration mechanisms in the transport sector not only enhances the economic efficiency of service providers but also establishes the institutional foundation for creating a safe, reliable, and efficient urban mobility ecosystem.

At the current stage, the evolutionary development of passenger transportation systems indicates that innovative business models based on digital platforms have become key determinants transforming the structural and functional foundations of traditional transport logistics. The high economic efficiency observed in the Yandex Go ecosystem is attributed not only to technological advancement but also to the synergistic interaction between intelligent management algorithms, dynamic pricing mechanisms, and digital user feedback systems.

From the perspective of the four-stage innovation spiral (Quadruple Helix) concept substantiated by M. A. Yurevich, digital platforms in the transport sector function as an enabling environment that ensures institutional integration among the state, science, business, and civil society.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, international experience demonstrates that the introduction of innovative business models in passenger transportation systems requires the integration of technological solutions, institutional coordination, and economic incentive mechanisms. The systematic study of these trends provides a theoretical foundation for developing scientific and practical recommendations aimed at the digitalization of transport services and the formation of a unified multimodal platform in the context of Uzbekistan. These approaches will be further examined in subsequent research stages using the example of the Yandex Go ecosystem, which holds a leading position in the regional market.

The fundamental advantage of digital aggregator models is reflected in the speed of service delivery and the transparency of logistics processes. As noted by M. V. Bushuev and S. I. Krasitskaya, the intelligent integration of GLONASS and GPS navigation systems has enabled a significant reduction in the estimated time of arrival (ETA — Estimated Time of Arrival) to just a few minutes. Furthermore, real-time visualization of fare prices, driver information, and route trajectories during the ordering process serves as a key institutional factor in building consumer trust.

As emphasized by Yu. N. Mironova, the deep integration of geoinformation systems (GIS) into transport service structures facilitates the optimization of traffic flows and the reduction of urban time losses through real-time spatial data processing. This, in turn, forms the foundational infrastructure supporting the long-term sustainability of the MaaS (Mobility as a Service) concept.

The socio-economic sustainability of innovative business models is also supported by their positive impact on the labor market and small-scale entrepreneurship. According to N. L. Lyutov, platform-based employment reduces barriers to market entry for independent contractors and creates a complex institutional environment that includes elements such as insurance mechanisms, quality control systems, and leasing opportunities.

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Proofreader: Zokir ALIBEKOV

Layout and Designer: Oloviddin Sobir ugli

2026. № 2

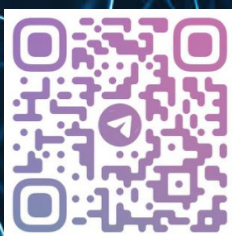
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