Identification and prioritization of entrepreneurial opportunities in Hamadan smart urban transportation using a mixed-methods approach and the fuzzy VIKOR method

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Abstract

Rapid urbanization has exposed cities such as Hamedan to persistent transportation challenges, including structural weaknesses in public transport fleets and severe traffic congestion. The smart city approach, through technology-driven solutions, offers the potential to transform these challenges into entrepreneurial investment opportunities. However, growing uncertainty in identifying priority opportunities increases the risk of inefficient allocation of financial and managerial resources. Therefore, systematic prioritization of these opportunities is essential for effective investment decisions. This study aims to identify and prioritize entrepreneurial opportunities in Hamedan's smart urban transportation using a mixed-method approach. In the qualitative phase, a systematic review of smart city documents and reports identified six final opportunities in the form of products or services. In the quantitative phase, 16 experts from academia, the municipality, the city council, and smart city practitioners evaluated the opportunities and weighted the criteria using pairwise comparisons. Criteria weights were calculated using the Fuzzy Analytic Hierarchy Process (FAHP), and the opportunities were ranked using the Fuzzy VIKOR method. The consistency ratio (0.02) confirmed the reliability of the judgments. The results show that the most important criteria are availability of technological infrastructure (0.165), market demand (0.158), and market growth potential (0.135). The final ranking prioritizes traffic management systems and Smartification of buses and taxis, while electric vehicle charging stations rank last. These findings indicate that opportunities aligned with existing infrastructure and market demand have higher investment priority.

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1.Introduction

Rapid urbanization and the concentration of population and activities in cities have confronted urban management with persistent challenges such as traffic congestion, pollution, energy waste, and increasing pressure on urban infrastructure. Over recent decades, the share of the urban population has increased significantly, and future projections indicate the continuation of this trend. Under such conditions, the central challenge is no longer merely the expansion of urban services but rather improving efficiency, sustainability, and quality of life within limited resources and a complex, dynamic environment (United Nations, 2012).

One widely adopted approach to addressing these challenges is the transition toward the smart city. A smart city utilizes information and communication technologies (ICT), data-driven governance, and service integration to improve the accuracy, speed, and efficiency of decision-making and public service delivery. In this framework, the smart city is not merely a technological project but a model of urban governance and development in which technology acts as an enabler for solving real urban problems (Albino et al., 2015).

Among the various dimensions of the smart city, smart transportation represents one of the most critical and problem-oriented domains. A substantial portion of citizens' daily experiences including travel time, cost, safety, pollution, and accessibility depends directly on the performance of transportation systems. Consequently, many smart city initiatives tend to focus on solutions such as traffic and mobility management, improvements in public transportation services, smart parking, and data-driven mobility services. These solutions often have greater potential for rapid transformation into marketable products or services and allow for phased implementation (Neirotti et al., 2014).

At the same time, the research literature indicates that smart cities can create a favorable environment for innovation and urban entrepreneurship. The development of digital infrastructure and increased access to data and emerging urban needs open space for the formation of startups and the provision of innovative urban services. However, a major challenge for entrepreneurs and investors in this field is the abundance of options and the high level of uncertainty regarding which areas are more problem-oriented, feasible, and less risky within the specific local context of a city (Dana et al., 2022).

Despite this potential, a significant portion of the smart city literature remains at a conceptual and macro level and pays less attention to identifying concrete opportunities that can be presented as products or services and systematically prioritized for investment decisions. In other words, a gap exists between the description of urban problems and the formulation of implementable and ranked opportunities. If this gap is not addressed, there is a higher likelihood of focusing on low-impact or high-cost projects, ultimately leading to inefficient resource allocation (Scornavacca et al., 2020).

At the local level, the city of Hamedan faces significant challenges in urban transportation. Field studies and previous analytical reports have identified the high volume of daily trips and the dominance of private vehicles as key factors placing pressure on the urban road network. It is estimated that approximately 1.5 million intra-urban trips occur daily, a considerable portion of which are made by private cars, often with single occupants. From the supply perspective, structural weaknesses in public transportation are also evident. The limited number of active buses relative to travel demand, together with the aging taxi fleet, has reduced the capacity of the city's mobility system to adequately serve citizens.

Taken together, these observations indicate that transportation issues in Hamedan are not merely descriptive but can be empirically observed and substantiated through travel demand patterns, modal distribution, and the capacity of the public transport fleet. Therefore, Hamedan represents a real-world context in which these urban challenges should be transformed into specific, implementable, and investable entrepreneurial opportunities (Abbasi, 2018).

The rationale for this study becomes more evident considering that:

1. Urban financial and managerial resources are limited, and selecting low-impact projects may lead to resource wastage.
2. Entrepreneurs and investors entering the field of smart transportation face high uncertainty and numerous potential options; therefore, a problem-oriented list of opportunities and a transparent prioritization mechanism are needed to reduce decision-making risk.

Accordingly, the central problem of this research is to determine which entrepreneurial opportunities-presented as tangible products or services in Hamedan's smart urban transportation sector should be prioritized and according to which criteria they should be ranked. To address this issue, the study follows a two-stage logic:

(1) identifying and formulating opportunities through a review of documented projects and initiatives, and

(2) prioritizing these opportunities based on expert judgments using multi-criteria decision-making under uncertainty. For this reason, a mixed-method approach and fuzzy multi-criteria decision-making methods are employed in the ranking stage.

So Main research question is "Which entrepreneurial opportunities in Hamedan's smart urban transportation sector have priority, and how are they ranked?" and Sub-questions are:

1. Based on the review of documents and documented projects from smart cities, which entrepreneurial opportunities in the field of smart transportation can be identified as products or services, and which options remain after refining and merging overlapping cases?
2. What criteria are appropriate for evaluating and comparing these opportunities, and what are the weights of these criteria based on expert judgments?
3. Considering the weighted criteria, what is the final ranking of opportunities using the Fuzzy VIKOR method, and which opportunities have higher priority for entrepreneurship and investment in Hamedan?

In summary, this study focuses on the city of Hamedan to address the gap between urban transportation challenges and the formulation of clear, prioritizable entrepreneurial opportunities. The identified opportunities are extracted and refined, and then ranked using expert judgments and the Fuzzy VIKOR method. The results aim to provide a practical basis for decision-making by entrepreneurs, investors, and urban managers. The remainder of the paper is organized as follows: first, the literature and research gaps are reviewed; next, the research methodology is explained; the findings are then presented; and finally, the results are discussed, followed by conclusions and recommendations.

2. Literature Review and Theoretical Foundations

To accurately frame the research problem and clarify the position of the present study, this section first explains the theoretical foundations related to entrepreneurial opportunities in smart cities. It then reviews both domestic and international studies. However, this review is not merely descriptive; instead, each study is analyzed based on its proximity to four theoretical lenses: technological opportunity creation, ICT-based value co-creation, open innovation, and digital entrepreneurship and city branding. Finally, the research gap and the specific contribution of this study are clearly identified.

To explain how business opportunities emerge within the technological context of smart cities, it is necessary to distinguish between two theoretical perspectives: one that considers opportunities as pre-existing phenomena waiting to be discovered, and another that views them as outcomes of entrepreneurial action and creation. Recent studies in technological entrepreneurship particularly in complex and dynamic environments such as smart transportation tend to emphasize opportunity creation theories. According to this perspective, opportunities are largely constructed through active interaction between entrepreneurs, technology, data, and emerging citizen needs, rather than merely waiting to be discovered (Jamali et al., 2018).

Within this context, technology alone does not generate value. Instead, value emerges through a network of interactions among different urban actors and information technologies. The concept of value co-creation explains how intelligent systems for example in traffic management or smart parking derive their value not solely from algorithms but from continuous data exchange and collaboration among citizens (as end users), urban management (as providers of infrastructure and data), and startups (as solution developers). This process transforms opportunities from static products into dynamic and evolving services (Dehkordi Mobini & Baghestani, 2017).

The success of such opportunities also depends on the adoption of an open innovation approach. Within the smart transportation ecosystem, no single business can independently provide all the required data, infrastructure, and regulatory approvals. The acquisition of knowledge and resources from external institutions, collaboration with competitors, and the utilization of research capacities and municipal partnerships significantly increase the likelihood of success and scalability of opportunities. This model is particularly important for capital-intensive and multi-stakeholder initiatives such as electric vehicle charging stations or integrated transportation systems (Nafisi & Mohammadkazemi, 2024).

Finally, the impact of these technological opportunities on the image and identity of cities should not be overlooked. Research on digital entrepreneurship in creative urban industries shows that innovative solutions such as smart transportation systems can go beyond addressing traffic problems and become part of a city's brand identity. When a city employs advanced technologies and local startups to solve its challenges, it not only improves quality of life but also creates an attractive identity capable of attracting investment, tourists, and skilled professionals. This connection between digital entrepreneurship and city branding also facilitates public acceptance of new opportunities (Eqbal Moghaddam & Zabihi, 2022).

Overall, the theoretical framework of this study integrates the theories of technological opportunity creation, value co-creation, open innovation, and the linkage between digital entrepreneurship and city branding in order to explain the rationale and mechanisms for prioritizing smart transportation opportunities within the local context of Hamedan.

Table 1-A. Research Background (Domestic Studies)

Reference	Objective/Scope of the Study, Method and Data/Sample, Key Findings, Implication/Gap relative to the Present Study
Elahkarami et al. (2023)	Objective/Scope of the Study: Proposing a smart city model with emphasis on the capacity of startups (case study: District 20 of Tehran); Method and Data/Sample:Mixed method; qualitative phase: 11 experts; quantitative phase: 350 municipal managers; analysis using SPSS and SmartPLS; Key Findings: Startups have a positive and significant effect on the realization of a smart city; extraction of 9 overarching themes and 21 constituent themes; Implication/Gap relative to the Present Study: Remains at the level of a general relationship and does not identify concrete smart transportation opportunities. The present study extracts and prioritizes these opportunities
Nourizadeh and Keshtpour (2019)	Objective/Scope of the Study: The impact of smart city strategy on urban and organizational entrepreneurship (case study: Municipality of District 20, Tehran); Method and Data/Sample: Case study of the actions and decisions of the District 2 municipality in Smartification and in creating a platform for startups; Key Findings: Smart Tehran as a strategy has the capacity to create opportunities for startups and to stimulate a knowledge-based economy; Implication/Gap relative to the Present Study: The analysis is qualitative and macro-level and lacks a value co-creation framework for converting capacity into specific services. The present study fills this gap by operationally defining opportunities
Babaei Hazehjan et al. (2016)	Objective/Scope of the Study: Identification of economic factors influencing urban entrepreneurship (case: Tehran); Method and Data/Sample: Qualitative; semi-structured interviews with 12 participants (municipal officials, experts, entrepreneurs); purposive and snowball sampling; thematic analysis; Key Findings: Extraction of factors in the form of 5 main themes (tools, financial mechanisms, smart urban economy, urban jobs, commercialization of ideas/markets); Implication/Gap relative to the Present Study: Focuses on macro-economic drivers and does not address specific technological opportunities or innovation requirements. The present study focuses on operational opportunities within the local ecosystem

Domestic research generally either explains the relationship between smart cities and startups/entrepreneurship or identifies the factors influencing urban entrepreneurship. However, three practical components required for investment decision-making in a city's smart transportation sector (e.g., Hamedan) are often missing: (a) extraction of smart transportation product/service opportunities, (b) defining evaluation criteria tailored to the local context, and systematic prioritization of opportunities (for example, using multi-criteria decision-making approaches under uncertainty).

Table 1-B. Research Background (International Studies)

Reference	Objective/Scope of the Study, Method and Data/Sample, Key Findings, Implication/Gap relative to the Present Study
Dana et al. (2022)	Objective/Scope of the Study: The role of urban entrepreneurship in the sustainability of businesses in smart cities considering digital technologies; Method and Data/Sample: Applied study; descriptive–survey (quantitative); 315 technology firms located in Tehran; SEM analysis using PLS; Key Findings: Urban entrepreneurship contributes to business sustainability and digital technologies play a reinforcing role; Implication/Gap relative to the Present Study: Confirms the relationship between urban entrepreneurship and digital technology at a macro level but does not address concrete smart transportation opportunities or the mechanism of value co-creation
Skorunavaka et al. (2020)	Objective/Scope of the Study: Examination of the entrepreneurial landscape in the smart city literature; Method and Data/Sample: Bibliometric analysis + social network analysis covering 20 years of literature; Key Findings: Highlights entrepreneurial dimensions in the literature and proposes future research directions; Implication/Gap relative to the Present Study: Maps the bibliometric landscape of the literature and emphasizes the lack of context-based studies but does not extract or prioritize opportunities in a specific city
Kezai et al. (2020)	Objective/Scope of the Study: Smart economy and startups in medium-sized Visegrad cities; Method and Data/Sample: Data analysis based on the Crunchbase database and European Commission definitions; comparative study of medium-sized cities; Key Findings: No cities were found with above-average levels in both startup presence and smartness; Implication/Gap relative to the Present Study: Remains at the ecosystem and inter-city comparison level and highlights the startup gap but does not provide a localized and prioritized roadmap for addressing it

Barba-Sánchez et al. (2019)	Objective/Scope of the Study: Whether the smart city label/program increases the entrepreneurship rate (Spain); Method and Data/Sample: Empirical study examining 44 Spanish cities with smart city programs and entrepreneurship data; Key Findings: Positive relationship between smart city programs and entrepreneurship rates; Implication/Gap relative to the Present Study: Demonstrates the effect of smart city programs on entrepreneurship at the city level but does not identify through which specific opportunity domains this effect materializes
Kraus et al. (2015)	Objective/Scope of the Study: Factors influencing innovation and entrepreneurial opportunities in smart cities (Germany); Method and Data/Sample: Qualitative approach; interviews with entrepreneurs active in the smart city domain; Key Findings: Identification of conditions and factors influencing innovation from the entrepreneurs' perspective; Implication/Gap relative to the Present Study: Identifies influential innovation factors but does not weight them or transform them into a decision-support system for prioritizing opportunities

International studies show that the smart city can strengthen the entrepreneurial ecosystem, increase the rate of entrepreneurship, and contribute to business sustainability through digital technologies. However, a substantial portion of this research has remained at a macro or relational level and has seldom moved toward identifying specific opportunities (products/services) within a particular urban domain such as smart transportation and then systematically prioritizing them for investment decision-making under uncertainty.

Based on the literature review, it can be argued that although the relationship between the smart city and urban entrepreneurship, as well as the role of digital technologies in opportunity creation, has been confirmed in the literature, the related studies can be summarized into several main streams according to their thematic focus in order to avoid fragmentation.

The first stream mainly focuses on conceptual foundations, technological infrastructure, and macro-level smart city policies, and is largely concerned with what a smart city is and what dimensions it includes. The limitation of this stream is that it usually does not address the level of specific opportunities that can be offered as products/services, nor does it engage in prioritization for investment decisions.

The second stream focuses on the link between the smart city and urban entrepreneurship/startups and shows that digital infrastructure, data, and innovation can increase the capacity for the creation of new businesses. However, in many of these studies, the outputs remain general and, instead of providing a list of precise and investable opportunities, they mainly explain relationships and consequences.

The third stream emphasizes the importance of the local context of cities and case studies, showing that the feasibility and success of solutions depend on the institutional, infrastructural, and demand-side characteristics of each city. The challenge of this stream is that even when attention is given to the local context, a systematic framework is often not provided for transforming urban issues into opportunities and then ranking them in practical terms.

Therefore, the main gap in the literature is the absence of an applied bridge among three levels: (1) macro foundations and policies, (2) entrepreneurial and innovation capacity, and (3) local urban contingencies; that is, the identification of specific opportunities (products/services) in the smart transportation domain of a city and then their prioritization using a decision-support method under uncertainty.

By focusing on the city of Hamedan and adopting a systematic approach, the present study establishes this applied bridge: first, opportunities are extracted and refined as products/services from documents and documented experiences, and then they are prioritized based on expert judgment and a multi-criteria decision-making method (Fuzzy VIKOR).

Based on the literature review, the gaps can be coherently and clearly structured around four thematic axes, which are presented in Table 2. This structuring is precisely grounded in the dominant focal areas of previous studies and shows the specific point at which the present study contributes a scientific and practical contribution relative to the existing literature.

Table 2-A. Gap in the Literature

No.	Dominant Focus in Previous Studies	Gap in the Literature	Issue/Implication	Response of the Present Study
1	Conceptual/policy studies and smart city infrastructure	Lack of focus on specific investable opportunities (products/services), particularly in smart transportation	Absence of practical outputs for selecting priority opportunities	Identification of specific smart transportation opportunities and preparation of them as evaluation options
2	General-level urban entrepreneurship studies	Dominance of general analyses and lack of a direct link to investment decision-making	Uncertainty for the entrepreneur/investor regarding which opportunity is more important	Transformation of qualitative results into structured data and implementation of decision-support ranking
3	Limited case studies/non-Hamedan contexts	Lack of context-based studies aligned with the local characteristics of cities, especially Hamedan	Increased decision-making risk due to incompatibility with the local context	Focus on Hamedan and use of relevant experts for assessment in a real-world context
4	Description of urban challenges without a framework for conversion into opportunities	Gap between problem description (traffic, parking, weak public transportation, etc.) and conversion into structured business opportunities	Absence of a clear path from problem to an actionable opportunity	Extraction of opportunities from documented cases, refinement/merging of overlaps, and presentation of an actionable opportunity portfolio

Table 2-B. Comparison of the Present Study with the Thematic Focuses of Previous Research

Category/Focus in the Literature	Typical Output in Previous Studies	Extraction of Product/Service Opportunities	Prioritization/Ranking of Opportunities	Context-Based Urban Study (Hamedan)	Decision-Support Tool under Uncertainty
Conceptual/Strategic Smart City	Definitions/Dimensions/Policies/Infrastructure	✗	✗	Limited	✗
Smart City and Urban Entrepreneurship	Explanation of relationships and outcomes	Limited	✗	Limited	✗
Ecosystem/Local Context Studies	Emphasis on local capacity/institutions	✗	✗	Limited	✗
Smart Transportation Case Studies	Presentation of solutions/experiences	✓ (contains cases)	✗	✗	✗
Present Study	Opportunity portfolio + decision-support ranking	✓	✓	✓	✓ (Fuzzy VIKOR)

Overall, the existing literature confirms the role of the smart city and digital technology in strengthening urban entrepreneurship; however, at the applied level of investment decision-making that is, the extraction of specific product/service opportunities in a city's smart transportation sector and their systematic prioritization under uncertainty a clear gap remains. By focusing on Hamedan, the present study addresses this gap through a two-step process of opportunity identification/refinement and expert-based ranking using Fuzzy VIKOR, and provides practical outputs for entrepreneurs, investors, and urban management.

3. Materials and Methods

This study consists of two parts: (1) an exploratory section for discovering and identifying potential entrepreneurial opportunities related to the smart city, with a focus on urban transportation. And (2) a descriptive section for ranking and prioritizing the identified opportunities. Accordingly, the research design is of an exploratory–descriptive mixed type; the study is not hypothesis-driven and is guided by the research question(s).

Stage One: Identification and Extraction of Potential Opportunities (Exploratory/Qualitative)

In the first stage, a qualitative approach and the documentary/library research method were employed. The documentary corpus of the exploratory stage is not limited to the sources listed in the article's references; rather, it comprises a purposive set of theoretical sources and smart transportation case-based sources that were used as the qualitative-stage data for opportunity extraction.

The sources for the qualitative stage were defined and collected in two main categories: (a) theoretical/research sources related to the smart city and urban entrepreneurship, aimed at explaining the theoretical linkage and the literature gap; and (b) thematic/case-based smart transportation sources that directly refer to practical solutions and services, aimed at extracting instances of opportunities that can be transformed into products/services.

The collection of documentary data was carried out systematically: first, keywords related to smart transportation and service-oriented opportunities were identified, such as intelligent transportation systems, traffic management, smart parking, public transportation open data, trip integration, connected vehicles/telematics, and electric vehicle charging; then, printed and digital sources, including books, journals, scientific articles, theses, and project reports/documentation, were reviewed and the relevant sources were selected.

Table 3. Thematic/Case Sources on Smart Transportation

Domain/Use Case	Documented Source	Convertible Output to Product/Service Opportunity
Traffic Management & Intelligent Transportation Systems	Land Transport Authority (LTA) (2025)	Traffic monitoring/management, intelligent control, decision-support dashboard
Smart Parking	San Francisco Municipal Transportation Agency (SFMTA) (n.d.) + Biyik et al. (2021)	Parking search/reservation, real-time capacity information, demand management
Public Transport Open Data	Transport for London (TfL) (n.d.)	Real-time information/estimated arrival services, data-driven routing
Trip Integration	UITP (2019)	Planning + reservation + payment platform, intermodal trip integration
Connected Vehicle/Telematics	U.S. Department of Transportation (USDOT) (2017)	Telematics/safety services, data-driven transport network
Electric Vehicle Charging	C40 Cities (2023)	Charging network + reservation/payment + urban business models

Furthermore, previous research and documented project examples/experiences related to smart cities (particularly in the transportation sector) were reviewed in order to identify the smart city framework, practical applications of smart transportation, and ultimately potential entrepreneurial opportunities.

Stage Two: Quantification and Prioritization of Opportunities (Descriptive/Multi-Criteria Decision-Making)

In the second stage, a questionnaire was used to quantify the qualitative findings and conduct the ranking process. The questionnaire is one of the common tools for data collection in research and enables the measurement of variables and the extraction of structured data. At this stage, the final opportunities extracted from the qualitative stage were considered as decision alternatives, and the evaluation criteria were treated as the basis for comparison in order to enable decision-support ranking.

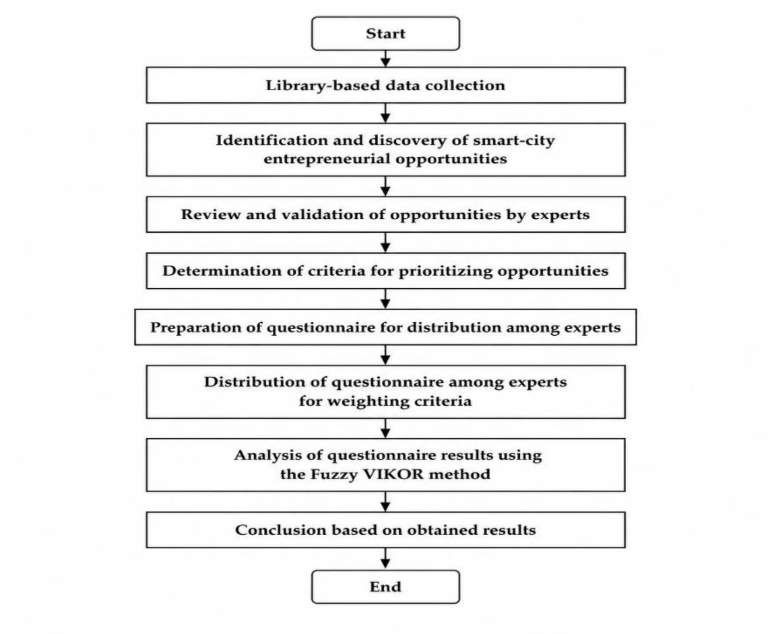

Figure 1. The Research Process Model

In the present study, two expert-based questionnaires were used: (1) a questionnaire for evaluating the performance of each opportunity with respect to the criteria, and (2) a pairwise comparison questionnaire for the criteria in order to determine their weights.

3.1.Statistical Population

The statistical population of this study consisted of experts from the faculty members of Bu-Ali Sina University and Hamedan University of Technology, members of the Hamedan City Council, employees of Hamedan Municipality, entrepreneurs and engineers in the field of artificial intelligence, as well as researchers working on urban Smartification. The selected individuals from these institutions and organizations were active in the areas of urban planning, urban management, information technology and computer science, electrical engineering, and artificial intelligence.

Table 4. Frequency Distribution by Gender

Gender	Frequency	Percentage
Male	13	81.25%
Female	3	18.75%

Table 5. Frequency Distribution by Age

Age	Frequency	Percentage
30–40	7	43.75%
41–50	6	37.5%
Unspecified (not reported by the expert)	3	18.75%

Table 6. Frequency Distribution by Educational Degree

Education	Frequency	Percentage
Bachelor’s	3	18.75%
Master’s	4	25%
PhD	9	56.25%

Table 7. Frequency Distribution by Field of Study

Field of Study	Frequency	Percentage
Urban Planning	4	25%
Artificial Intelligence	6	37.5%
Other Fields	6	37.5%

The term artificial intelligence in this study does not necessarily refer to a distinct academic major; rather, it denotes experts whose primary field of study (such as computer engineering, information technology, or electrical engineering) is related to AI, and who have conducted research or professional activities in artificial intelligence/machine learning and their applications in urban Smartification and transportation.

To ensure the credibility of the data collection instruments, the validity and reliability of the expert-based data were examined. The validity of the instrument was assessed through face and content validity, meaning that the evaluation forms (including the pairwise comparison section for the criteria and the scoring section for the alternatives relative to the criteria) were reviewed and refined by a group of experts and specialists. Feedback regarding clarity of items, alignment with the research objectives, and removal of potential ambiguities was incorporated.

Regarding reliability, given that the data are judgment-based and pertain to multi-criteria decision-making (and the questionnaire is not a psychometric scale), the use of classical reliability indicators such as Cronbach’s alpha is not necessarily appropriate. Therefore, the dependability of the results was ensured through two approaches:

1. *Consistency check of judgments in criteria weighting:*

   For the pairwise comparison of the criteria, the consistency ratio was calculated and reported as the reliability control indicator. The consistency ratio obtained in this study was 0.02 (based on the pairwise comparison matrix), indicating acceptable judgment consistency and the dependability of the derived weights.

2. *Reducing individual judgment error and increasing dependability in evaluating alternatives:*

   In the evaluation of alternatives with respect to the criteria, a standard and uniform linguistic–fuzzy scale was employed to enhance reliability. Subsequently, the judgments of the 16 experts were aggregated into a final collective estimate using an appropriate aggregation method. This aggregation reduced the influence of individual biases and increased the convergence of results in group decision-making. Accordingly, the final analysis and ranking were conducted using the Fuzzy VIKOR method.

3.2.Data Analysis

To analyze the data and rank the identified entrepreneurial opportunities, the Fuzzy VIKOR method was employed as a multi-criteria decision-making approach. In addition, the Fuzzy Analytic Hierarchy Process (FAHP) was used to determine the weights of the criteria. Considering the article length limitations and to avoid turning the methodology section into an instructional discussion, the full expansion of mathematical formulas is not presented in the text; instead, the focus is placed on the operational steps and the process of generating the outputs. The detailed relations and calculations can be followed in the standard methodological references (Buckley, 1985; Opricovic & Tzeng, 2004).

Determining Criteria Weights Using FAHP (Buckley Method):

In this study, the weights of the criteria were calculated using fuzzy pairwise comparisons based on Buckley's geometric mean method. Experts compared the criteria in pairs, and their preferences were converted into fuzzy values using triangular fuzzy numbers. Subsequently:

• Construction of the fuzzy pairwise comparison matrix of the criteria based on the pairwise comparison questionnaire;

• Calculation of fuzzy weights of the criteria using the geometric mean method;

• Defuzzification and normalization of the weights for use in the ranking process;

• Consistency check of judgments: the consistency ratio was calculated and obtained as 0.02, indicating acceptable consistency in the experts' judgments.

To verify the consistency of judgments in the pairwise comparison matrix, after aggregating the experts' opinions and defuzzifying the final matrix (to convert it into a crisp matrix), the AHP consistency indices were calculated according to Saaty's standard procedure. First, the largest eigenvalue of the matrix (λ_max) was obtained, and then the inconsistency index was calculated using the following relation:

$$CI = \frac{\lambda_{\max} - n}{n - 1}$$

It was then calculated; subsequently, the consistency ratio (CR) was obtained as the ratio of the consistency index (CI) to the random index (RI) (based on Saaty's table and according to the number of criteria, n).

$$CR = \frac{CI}{RI}$$

The obtained value was CR = 0.02, which is lower than the commonly accepted threshold of 0.10. This indicates that the experts' pairwise comparisons demonstrate an acceptable level of consistency and that the derived weights are reliable.

After the opportunities were finalized in the qualitative stage, they were ranked using the Fuzzy VIKOR method. To evaluate the performance of each opportunity with respect to each criterion, a linguistic–fuzzy scale was employed. After aggregating the experts' judgments, the results were converted into a fuzzy decision matrix. The operational steps of the Fuzzy VIKOR method in this study are as follows:

1. Construction of the fuzzy decision matrix (opportunities in rows and criteria in columns).
2. Determination of the ideal and anti-ideal values for each criterion according to the criterion type (benefit or cost).
3. Normalization of the decision matrix to ensure comparability among criteria.
4. Calculation of the group utility index (S) and the individual regret index ® considering the weights of the criteria.
5. Calculation of the final index (Q) and extraction of the final ranking (a smaller value of Q indicates a higher priority).
6. Examination of acceptable advantage and decision stability conditions to determine the best alternative or alternatives.

In this study, since there was no explicit preference regarding the precedence of group utility or the minimization of maximum regret, $v = 0.5$ was considered as the balanced condition. The calculation of indices and the selection conditions in VIKOR follow the standard framework of this method (Opricovic & Tzeng, 2004).

Operational Definition of Entrepreneurial Opportunity and Its Boundary with Urban Policy/Projects

In this study, an entrepreneurial opportunity is operationally defined as a service or product option in the field of smart transportation that: (1) addresses a clearly defined urban problem, (2) can be provided by the private sector or knowledge-based companies, (3) creates value for citizens or urban management, and (4) has the potential for a viable business model.

The boundary of this research is that policy-making (such as determining tariffs, restrictions, regulations, and permits) is not considered an entrepreneurial opportunity. Instead, entrepreneurial opportunities are oriented toward the operational and technological domain (systems, platforms, sensors, dashboards, and data-driven services) that can be implemented within the framework of urban policies.

Based on this approach, six final opportunities were identified and evaluated in the quantitative stage using the Fuzzy VIKOR method. These opportunities are introduced in the findings section with the codes A1 to A6.

4. Findings

This section first presents the results of weighting the identified entrepreneurship criteria using Buckley's geometric mean method. Then, based on the obtained weights, the criteria are prioritized, followed by the ranking of the identified entrepreneurial opportunities through the application of the Fuzzy VIKOR method.

4.1. Identified Criteria for Ranking Entrepreneurial Opportunities

According to the research method, a set of criteria for ranking and prioritizing entrepreneurial opportunities was identified through the study and examination of documentary and library sources. These criteria were weighted by experts using the Analytic Hierarchy Process questionnaire and the pairwise comparison method. This weighting process ensures that entrepreneurial opportunities receiving better scores on more important criteria have a greater overall chance of obtaining a higher rank. Some of the criteria are positive in nature, meaning

that a higher score increases the overall score of the entrepreneurial opportunity, whereas others are negative in nature, meaning that a lower score is more desirable.

Table 8. Identified Criteria for Ranking Opportunities and Their Respective Sources

Source	Description	Identified Criterion
Mokhtari & Khodamoradi (2014) Saridakis et al. (2018) Ziyae & Sadeghi (2022)	This criterion refers to the degree of necessity for each entrepreneurial opportunity in the city and indicates the importance and urgency of establishing such a business. In fact, it is the city's issues, problems, and challengesas well as citizens' preferences that create the need for such businesses. Therefore, market need serves as a measure of how much the city and its residents require the value created by the entrepreneurial opportunity. Kotler, known as the father of marketing, considers market need as the starting point of marketing and business creation.	Market Need
Mokhtari & Khodamoradi (2014) Saridakis et al. (2018) Ziyae & Sadeghi (2022)	The market size index refers to the number of potential customers who are willing to pay a specific amount for a product or service. Market size also reflects the potential revenue available in the market. A larger market size can significantly increase entrepreneurs' motivation to launch a new business.	Market Size
Mokhtari & Khodamoradi (2014) Nambisan et al. (2019) Ziyae & Sadeghi (2022)	The market growth potential criterion refers to the capacity for expansion and development of an entrepreneurial opportunity and consequently, the businesses operating within it. This criterion is influenced by technological trends, and businesses grounded in such trends have greater potential for growth and development. Therefore, market growth potential is a key factor in assessing the likelihood of business success.	Market Growth Potential
Mokhtari & Khodamoradi (2014) Jamal & Attarnia (2017)	The ease of entry into the market and industry relates to the level of competition. The more competitors and active players in a field, the more difficult market and industry entry become. This situation is often described as a "red ocean," where competition is intense and each player captures only a small share of the market. In contrast, in a "blue ocean" market, business development is easier, competition is lower, and market entry becomes more accessible.	Ease of Entry into Market and Industry
Mokhtari & Khodamoradi (2014) Tur-Porcar et al. (2018)	This criterion, unlike the previous positive ones, is negative in nature. The higher the initial capital required to launch a business, the more difficult it	Required Initial Investment

Ziyae & Sadeghi (2022)	becomes to start it and vice versa. Although a high initial capital requirement can act as a barrier that reduces the likelihood of new competitors entering the market, it simultaneously makes participation more challenging and turbulent for entrepreneurs.	
Mokhtari & Khodamoradi (2014) Nambisan et al. (2019) Ziyae & Sadeghi (2022)	Access to the necessary facilities and technological infrastructure for launching and developing a new business is a fundamental prerequisite. This criterion refers to infrastructures such as the internet, smartphones, virtual-reality devices, and similar technologies. Adequate and appropriate infrastructure facilitates the growth of modern businesses.	Availability of Technological Infrastructure
Saridakis et al. (2018) Tur-Porcar et al. (2018) Ghanbari & Rezaei (2021)	Obtaining business licenses and meeting regulatory requirements significantly affects entrepreneurs' ability to enter a given industry. Similar to the initial investment requirement, this criterion is negative in nature: the more difficult and complicated the legal procedures are, the more they hinder entrepreneurial entry, assigning a negative weight in the prioritization of opportunities.	Legal Barriers and Licensing Requirements
Ghanbari & Rezaei (2021) Dana et al. (2022)	This criterion assesses how well the identified entrepreneurial opportunity aligns with the characteristics, needs, and issues of the city of Hamedan.	Opportunity–City Fit

4.2.Results of Buckley's Geometric Mean Method

This section presents the weighting of the eight research criteria. Two criteria namely, Required Initial Investment (C5) and Legal Barriers and Licensing Requirements (C7) are negative in nature, while the remaining criteria are positive. This implies that for the six positive criteria, a higher score on a scale of 1 to 5 indicates more favorable conditions for starting a business. Conversely, for the two negative criteria, a higher score represents more unfavorable conditions for entrepreneurship.

1. Market Need (Positive) (C1)
2. Market Size (Positive) (C2)
3. Market Growth Potential (Positive) (C3)
4. Ease of Entry into Industry and Market (Positive) (C4)
5. Required Initial Investment (Negative) (C5)
6. Availability of Technological Infrastructure (Positive) (C6)
7. Legal Barriers and Licensing Requirements (Negative) (C7)
8. Opportunity–City Fit (Positive) (C8)

Subsequently, the pairwise comparison matrix of the criteria was constructed and provided to 16 experts. The responses were aggregated using the geometric mean method, and the resulting final pairwise comparison matrix is reported in Table 9.

Table 9. Pairwise comparison of criteria (Consistency Ratio: 0.02)

	C1	C2	C3	C4	C5	C6	C7	C8

C1	(1,1,1)	(1.409,1.693,2.003)	(0.683,0.85,1.071)	(2.087,2.899,3.707)	(0.815,1.064,1.496)	(0.794,1.072,1.379)	(0.841,1.077,1.352)	(1.36,1.584,1.835)
C2	(0.499,0.591,0.71)	(1,1,1)	(0.449,0.543,0.68)	(0.598,0.795,1.056)	(0.82,1.013,1.227)	(0.614,0.795,1.018)	(0.718,0.959,1.25)	(1.168,1.548,2.021)
C3	(0.934,1.177,1.465)	(1.471,1.84,2.226)	(1,1,1)	(0.924,1.264,1.624)	(0.713,0.872,1.081)	(0.674,0.846,1.107)	(0.932,1.247,1.591)	(0.666,0.937,1.221)
C4	(0.27,0.345,0.479)	(0.947,1.257,1.673)	(0.616,0.791,1.083)	(1,1,1)	(0.562,0.705,0.917)	(0.222,0.267,0.342)	(0.419,0.508,0.626)	(0.617,0.826,1.11)
C5	(0.668,0.94,1.227)	(0.815,0.987,1.22)	(0.925,1.147,1.402)	(1.091,1.418,1.781)	(1,1,1)	(0.558,0.716,0.896)	(0.871,1.064,1.284)	(0.842,1.109,1.455)
C6	(0.725,0.932,1.259)	(0.982,1.257,1.627)	(0.903,1.182,1.484)	(2.927,3.749,4.51)	(1.116,1.397,1.791)	(1,1,1)	(0.947,1.215,1.515)	(1.055,1.319,1.604)
C7	(0.74,0.928,1.189)	(0.8,1.043,1.393)	(0.629,0.802,1.074)	(1.597,1.967,2.387)	(0.779,0.94,1.149)	(0.66,0.823,1.056)	(1,1,1)	(0.84,1.003,1.234)

Calculation of Fuzzy and Normalized Weights

In this step, the geometric mean of the fuzzy numbers in each row of the table is first calculated. Subsequently, each obtained geometric mean is divided by the sum of all geometric means to derive the fuzzy weights.

$$\tilde{r}_i = \left(\prod_{j=1}^{n} \tilde{P}_{ij}\right)^{1/n} \qquad i = 1,2,3,\ldots,n \qquad\qquad w_i = r_i \otimes (r_1 \oplus r_2 \oplus \ldots \oplus r_m)^{-1}$$

Subsequently, each fuzzy weight is defuzzified using Equation $\frac{l+2m+u}{4}$. To normalize the defuzzified weights, each weight is divided by the sum of all defuzzified weights. As an illustration, for criterion C1 in Table 10, the calculations are performed as follows: first, the geometric mean of the entries in the corresponding row of the table is computed, as shown below.

Geometric Mean of the Row= $[(1,1,1) \times (1.409,1.693,2.003) \times (0.683,0.85,1.071) \times \ldots \times (0.841,1.077,1.352) \times (1.36,1.584,1.835)]^{\frac{1}{8}} = (1.075,1.299,1.589)$

Similarly, these calculations were carried out for the remaining rows, and the results for all rows are reported in the second column of Table 10. Subsequently, the sum of all the calculated geometric means was obtained: (6.638,8.203,10.11) Subsequently, the fuzzy weight of each criterion is given by the ratio of the geometric mean of that criterion's row to the sum of all geometric means. For illustration, the fuzzy weight of criterion C1 is computed as follows:

Fuzzy WeightC1= $\frac{(1.075,1.299,1.589)}{(6.638,8.203,10.11)} = (0.104,0.158,0.239)$

The same procedure was carried out for all criteria, and the resulting fuzzy weights are reported in the third column of Table 10. To defuzzify each fuzzy weight, the following procedure was employed:

$$\text{Fuzzy WeightC1} = (0.104,0.158,0.239) => \text{Defuzzified weightC1} = \frac{0.104 + 2 \times 0.158 + 0.239}{4} = 0.165$$

The same procedure was applied to all criteria, and the results are reported in the fourth column of Table 10. Subsequently, each defuzzified weight was normalized using the following calculation:

$$\text{Defuzzified weightC1} = 0.165 ==> Norma\ WeightC1 = \frac{0.165}{\begin{array}{c}0.165 + 0.11 + 0.141 + 0.082 \\ +0.131 + 0.173 + 0.131 + 0.113\end{array}} = 0.158$$

Table 10. Fuzzy and Defuzzified (Crisp) Weights of the Evaluation Criteria

Criterion Name	$\left(\left(\prod_{j=1}^{n} \tilde{P}_{ij}\right)^{1/n}\right)$ Geometric Mean	$(\widetilde{W})$ Fuzzy Weight	Defuzzifed Weight	Normal Weight
C1	(1.075,1.299,1.589)	(0.104,0.158,0.239)	0.165	0.158
C2	(0.698,0.862,1.061)	(0.069,0.105,0.16)	0.110	0.105
C3	(0.885,1.113,1.369)	(0.088,0.136,0.206)	0.141	0.135
C4	(0.517,0.637,0.812)	(0.051,0.078,0.122)	0.082	0.079
C5	(0.83,1.031,1.258)	(0.082,0.126,0.189)	0.131	0.125
C6	(1.097,1.359,1.667)	(0.109,0.166,0.251)	0.173	0.165
C7	(0.844,1.022,1.26)	(0.083,0.125,0.19)	0.131	0.125
C8	(0.716,0.88,1.094)	(0.071,0.107,0.165)	0.113	0.108
$\sum\left(\prod_{j=1}^{n} \tilde{P}_{ij}\right)^{1/n}$	(6.638,8.203,10.11)			

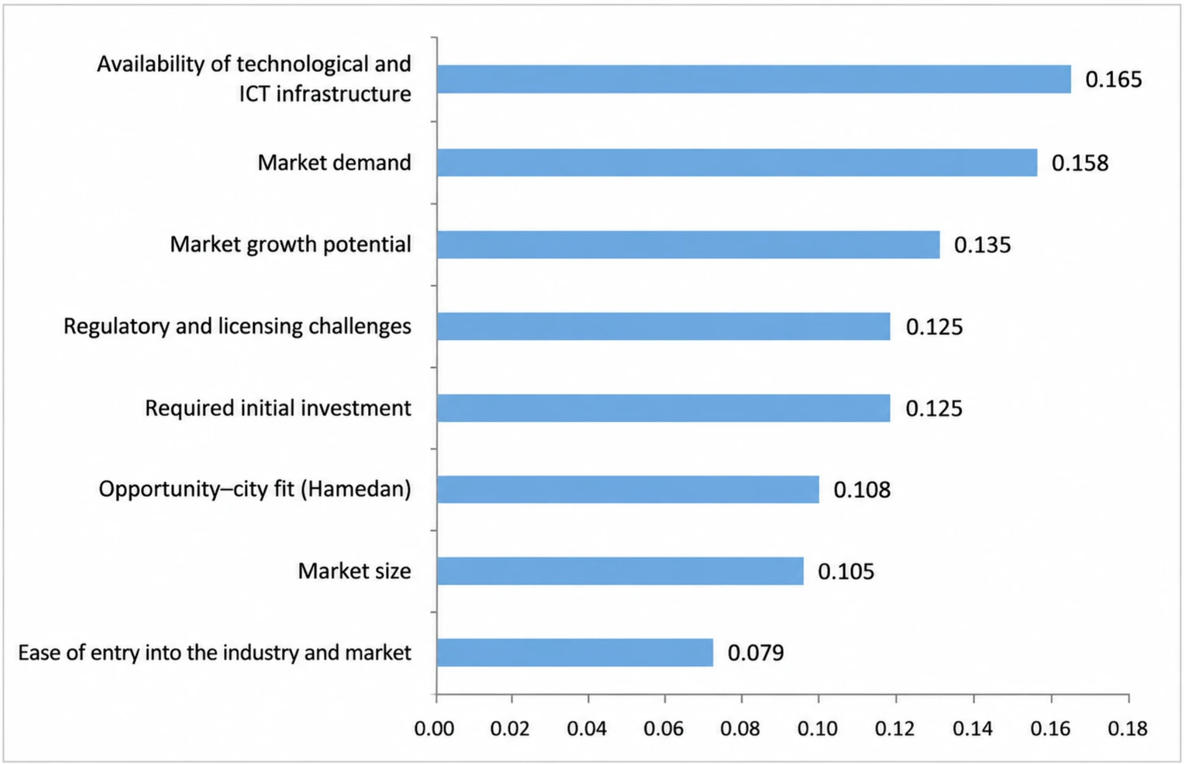

Figure 2. Calculated Weights of the Criteria

Based on the results presented in Table 10 and Figure 2, the criterion of availability of technological and ICT infrastructures (weight = 0.165) emerged as the most influential factor in ranking the identified entrepreneurial opportunities in the smart-city domain. This was followed by the criteria of market need and market growth potential, with respective weights of 0.158 and 0.135, ranking second and third. Subsequently, the criteria of regulatory barriers and licensing requirements and initial capital required both with a weight of (0.125)were positioned next. The criterion of alignment of the opportunity with the city of Hamedan (0.108) and market size (0.105) occupied the following ranks. Finally, ease of market and industry entry (0.079) was identified as the least influential criterion in prioritizing the entrepreneurial opportunities.

Accordingly, the overall ranking of criteria by importance is as follows:

1. Availability of technological and ICT infrastructures (0.165)
2. Market need (0.158)
3. Market growth potential (0.135)
4. Regulatory barriers and licensing requirements; initial capital required (0.125)
5. Alignment of the opportunity with the city of Hamedan (0.108)
6. Market size (0.105)
7. Ease of market and industry entry (0.079)

4.3.Results of the Fuzzy VIKOR Method and Opportunity Ranking

To rank the entrepreneurial opportunities in the smart urban transportation sector of Hamedan, potential opportunities were initially identified in the exploratory/qualitative phase through a systematic review of theoretical and exemplary smart transportation sources. These opportunities were then refined, coded, and merged to eliminate redundancies, resulting in six final opportunities that could be offered in the form of a product or service:

1. Searching for and reserving parking spaces (A1)
2. Traffic management at the entrances of parking lots, toll gates, etc. (A2)
3. Deployment of bicycles and electric micro-mobility vehicles (A3)
4. Establishing charging stations for electric vehicles (A4)
5. Smartification of intra-city buses and taxis (A5)
6. Smartification of private vehicles (A6)

4.4.Step 1: Construction of the Decision Matrix

The performance of each opportunity relative to each criterion was assessed using a five-level linguistic scale ranging from “very low” to “very high.” These linguistic judgments were subsequently mapped onto triangular fuzzy numbers. To aggregate the evaluations of the 16 experts, the arithmetic mean was applied separately to the lower, middle, and upper bounds of the fuzzy numbers. The resulting fuzzy decision matrix is presented in Table 11. The fuzzy VIKOR decision matrix in Table 11 contains the eight research criteria as columns and the six entrepreneurial opportunity alternatives as rows, forming the foundation for subsequent steps of the fuzzy VIKOR procedure.

Table 11. Fuzzy VIKOR Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8
A1	(6.375,8.375,10.375)	(6.125,8.125,10.125)	(5.375,7.375,9.375)	(4.75,6.75,8.75)	(3.625,5.25,7.25)	(2.5,4.5,6.5)	(3.625,5.625,7.625)	(4.5,6.5,8.5)
A2	(5.5,7.5,9.5)	(5.125,7.125,9.125)	(4.75,6.75,8.75)	(3.875,5.875,7.875)	(4,5.75,7.75)	(3.375,5.125,7.125)	(2.5,4.125,6.125)	(4.25,6.125,8.125)
A3	(5.25,7.125,9.125)	(5.375,7.375,9.375)	(5.375,7.375,9.375)	(5.125,7.125,9.125)	(4.625,6.375,8.375)	(3,4.625,6.625)	(3.875,5.875,7.875)	(4.5,6.5,8.5)
A4	(3.875,5.375,7.375)	(5.125,6.875,8.875)	(4.25,5.75,7.75)	(3.375,5,7)	(5.375,7.25,9.25)	(2.125,3.375,5.375)	(3.875,5.75,7.75)	(4,5.75,7.75)
A5	(6,8,10)	(5.375,7.375,9.375)	(5.25,7.25,9.25)	(3.875,5.875,7.875)	(4.375,6.25,8.25)	(3.75,5.25,7.25)	(3.625,5.375,7.375)	(3.5,5.125,7.125)
A6	(5.125,7.125,9.125)	(5,7,9)	(4.5,6.5,8.5)	(3.625,5.5,7.5)	(4,5.625,7.625)	(2.75,4.375,6.375)	(3.125,4.875,6.875)	(3.375,5.125,7.125)

he values presented in Table 11 represent the aggregated judgments of 16 experts regarding the performance of each opportunity with respect to the evaluation criteria. These evaluations were obtained using a linguistic–fuzzy scale, which was subsequently converted into triangular fuzzy numbers.

4.4.Step 2: Normalization of the Decision Matrix

To normalize the fuzzy decision matrix, different normalization formulas were applied for benefit (positive) criteria and cost (negative) criteria. The results of the normalization process are reported in Table 12.

For positive criteria $\tilde{f}_j^* = \max_i \tilde{f}_{ij} \qquad i = 1,2,\ldots,n$

For Negative criteria $\tilde{f}_j^* = \min_i \tilde{f}_{ij} \qquad i = 1,2,\ldots,n$

In this study, normalization was performed within the framework of triangular fuzzy numbers $(L، m، u)$. In the arithmetic of triangular fuzzy numbers, the subtraction of two triangular fuzzy numbers is defined as: $(L_1, m_1, u_1) - (L_2, m_2, u_2) = (L_1 - u_2,\ m_1 - m_2,\ u_1 - L_2)$

Accordingly, when the value of an alternative is very close to the ideal value (or becomes equal to it), the middle component of the difference may become zero. However, due to the interval-based nature of uncertainty in fuzzy numbers, the lower bound of the normalized value may become negative while the upper bound remains positive$(L - u,\ 0,\ u - L)$

Therefore, the presence of negative bounds in some entries of the normalized matrix arises from the standard definition of subtraction in triangular fuzzy numbers and reflects the representation of uncertainty around zero. It does not imply a negative distance in a deterministic interpretation.

Table 12. Normalized Fuzzy VIKOR Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8
A1	(-0.593,0,0.593)	(-0.561,0,0.561)	(-0.41,0.098,0.623)	(-0.509,0.053,0.614)	(-0.51,0.082,0.673)	(-0.524,0.167,0.929)	(-0.308,0.308,0.827)	(-0.711,0,0.711)
A2	(-0.463,0.13,0.722)	(-0.421,0.14,0.702)	(-0.328,0.18,0.705)	(-0.386,0.175,0.737)	(-0.449,0.163,0.755)	(-0.643,0.048,0.762)	(-0.481,0.077,0.596)	(-0.644,0.067,0.756)
A3	(-0.407,0.185,0.759)	(-0.456,0.105,0.667)	(-0.41,0.098,0.623)	(-0.561,0,0.561)	(-0.347,0.265,0.857)	(-0.548,0.143,0.833)	(-0.269,0.346,0.865)	(-0.711,0,0.711)
A4	(-0.148,0.444,0.963)	(-0.386,0.175,0.702)	(-0.197,0.311,0.77)	(-0.263,0.298,0.807)	(-0.224,0.408,1)	(-0.31,0.381,1)	(-0.269,0.327,0.846)	(-0.578,0.133,0.8)
A5	(-0.537,0.056,0.648)	(-0.456,0.105,0.667)	(-0.393,0.115,0.639)	(-0.386,0.175,0.737)	(-0.388,0.245,0.837)	(-0.667,0.024,0.69)	(-0.308,0.269,0.788)	(-0.467,0.244,0.889)
A6	(-0.407,0.185,0.778)	(-0.404,0.158,0.719)	(-0.295,0.213,0.738)	(-0.333,0.228,0.772)	(-0.449,0.143,0.735)	(-0.5,0.19,0.881)	(-0.385,0.192,0.712)	(-0.467,0.244,0.911)

4.5.Step 3: Calculation of Utility, Regret, and VIKOR Index Values for the Alternatives

In this step, the utility measure (S) and the regret measure are first calculated using the following two equations. These values are then used to determine the VIKOR index (**Q)** for the alternatives.

The calculated values of utility (S)**,** regret , and the VIKOR index **(Q)** are presented in Table 13**.**

Utility value (S)

$$\tilde{S}_i = \sum_{i=1}^{n} (\tilde{w}_j \otimes \tilde{d}_{ij})$$

Regret value

$$\tilde{R}_i = \max_i(\tilde{w}_j \otimes \tilde{d}_{ij})$$

VIKOR index value (Q)

$$\tilde{Q}_i = v\frac{(\tilde{S}_j \ominus \tilde{S}^*)}{S^{or} - S^{*l}} \oplus (1-v)\frac{(\tilde{R}_j \ominus \tilde{R}^*)}{R^{or} - R^{*l}}$$

Table 13. Calculated Values of Utility, Regret, and the VIKOR Index for the Alternatives

	S	R	Q	S(Crisp)	R(Crisp)	Q(Crisp)
A1	(-0.513,0.094,0.703)	(-0.038,0.038,0.154)	(-0.808,0.035,0.905)	0.0942	0.0480	0.0415
A2	(-0.484,0.118,0.717)	(-0.03,0.024,0.126)	(-0.778,0.009,0.842)	0.1176	0.0361	0.0206
A3	(-0.456,0.154,0.748)	(-0.034,0.043,0.138)	(-0.776,0.068,0.882)	0.1499	0.0477	0.0605
A4	(-0.286,0.323,0.876)	(-0.021,0.07,0.165)	(-0.683,0.194,0.996)	0.3091	0.0713	0.1752
A5	(-0.464,0.144,0.73)	(-0.03,0.034,0.114)	(-0.77,0.041,0.818)	0.1384	0.0378	0.0322
A6	(-0.41,0.192,0.784)	(-0.026,0.031,0.146)	(-0.741,0.053,0.914)	0.1895	0.0456	0.0696

4.6.Step 4: Ranking of the Alternatives

The final ranking of the alternatives is determined based on the VIKOR index (Q) values, which are presented in Table 14. A lower value of the VIKOR index indicates a higher priority for the respective alternative. Accordingly, the entrepreneurial opportunity related to "traffic management at parking lot entrances, toll booths, etc." achieved the first rank. Conversely, the entrepreneurial opportunity for "establishing charging stations for electric vehicles" was identified as the least prioritized opportunity within the smart city domain in Hamedan. Table 14 summarizes the ranking of the entrepreneurial opportunities and their corresponding VIKOR index values.

Table 14. Ranking of Smart City Entrepreneurial Opportunities in Hamedan

Code	Alternative	Q Value	Final Rank
A2	Traffic management at parking lot entrances, toll booths, etc.	0.0206	1
A5	Smartification of urban buses and taxis	0.0322	2
A1	Car parking space search and reservation	0.0415	3

A3	Provision of bicycles and electric micro-mobility vehicles	0.0605	4
A6	Smartification of private vehicles	0.0696	5
A4	Establishment of electric vehicle charging stations	0.1752	6

5. Discussion and Interpretation of Findings

The primary objective of this study was to transform transportation-related challenges in Hamedan into prioritized entrepreneurial opportunities and to bridge the gap between theoretical literature and investment decision-making. In this section, the findings are interpreted at two levels: first, the rationale underlying the importance of the evaluation criteria; and second, the analysis of the ranking of the identified opportunities.

5.1. Interpretation of Criteria Weights

The weighting results indicate that availability of technological infrastructure (0.165), market demand (0.158), and market growth potential (0.135) are the most significant criteria for prioritizing opportunities from the experts' perspective. This pattern suggests that in the context of a medium-sized city such as Hamedan, infrastructural readiness is perceived as a necessary precondition for the realization of any entrepreneurial opportunity.

This finding aligns with the theory of technology-driven opportunity creation, which emphasizes the enabling role of digital technologies in the emergence of entrepreneurial opportunities (Jamali et al., 2018). In other words, even when a genuine market need exists, without adequate technical foundations such as urban data availability, stable internet connectivity, and integrated digital systems the opportunity cannot materialize in practice.

Following technological infrastructure, the high priority assigned to market demand and growth potential reflects the problem-oriented and forward-looking perspective of the experts. This hierarchy is consistent with the value co-creation approach, as opportunities that directly address tangible and immediate citizen needs foster stronger interaction networks among users, municipalities, and businesses, thereby generating more sustainable value (Dehkordi Mobini & Baghestani, 2017).

Conversely, the relatively lower weight assigned to criteria such as ease of entry into the industry (0.079) indicates that experts do not perceive entry barriers as absolute obstacles; rather, they consider them manageable through innovation in business models and collaboration with urban institutions.

5.2. Rationale Behind the Ranking of Opportunities

The final Fuzzy VIKOR ranking reveals that traffic management systems (A2) with a VIKOR index of 0.0206 and Smartification of urban buses and taxis (A5) with an index of 0.0322 ranked first and second, respectively. To explain this outcome, it is necessary to revisit their performance across the highly weighted criteria: both alternatives achieved strong evaluations in technological infrastructure, market demand, and growth potential.

This indicates that experts regard these opportunities as both feasible under current infrastructural conditions and responsive to urgent and widespread urban challenges. From a theoretical perspective, these opportunities offer greater potential for value co-creation than the other alternatives: citizens contribute data and demand, municipalities provide infrastructure and regulatory support, and startups supply technology and innovation ultimately creating value within an interactive ecosystem.

The car parking search and reservation system (A1), with a VIKOR index of 0.0415, ranked third. Although it addresses a genuine urban problem (parking shortages), its success depends on data integration across parking facilities and cooperation with private parking owners, which increases implementation complexity. The relatively small gap between this option and the top two suggests that, if institutional barriers are mitigated, it could be positioned within the second wave of investment initiatives.

The provision of bicycles and electric micro-mobility vehicles (A3) and Smartification of private vehicles (A6), with indices of 0.0605 and 0.0696 respectively, occupy middle positions in the ranking. While aligned with criteria such as growth potential and sustainability, these opportunities are more dependent on physical infrastructure (e.g., safe cycling paths), cultural acceptance, and behavioral changes in travel patterns. Consequently, they may yield lower short-term returns. This finding is consistent with the principles of open innovation, which emphasize the gradual maturation of ecosystems for the successful implementation of multi-stakeholder opportunities (Nafisi & Mohammadkazemi, 2024).

Finally, electric vehicle charging stations (A4), with a VIKOR index of 0.1752, ranked last. The primary reasons for this ranking include its weak performance in the initial investment requirement criterion (a cost-type criterion) and the currently limited demand for electric vehicles in Hamedan. However, this does not imply rejection of the opportunity; rather, it suggests that the necessary conditions for its emergence such as sufficient EV penetration, electrical grid readiness, and viable business models remain in a pre-emergence stage. Therefore, this opportunity should be pursued from a long-term, phased perspective. Its development requires an open-innovation approach in which knowledge and capital are progressively absorbed from external stakeholders (electricity companies and automobile manufacturers) to enable its realization.

5.3. Managerial Implications and Proposed Roadmap

From a theoretical standpoint, this study demonstrates that the final ranking of each opportunity reflects the degree of local ecosystem readiness for its emergence. The findings confirm that integrating opportunity creation theory, value co-creation, and open innovation provides an analytical framework for transitioning from merely describing urban problems to systematically prioritizing investment opportunities. This integration directly addresses the research gap identified in the literature.

From a practical perspective, the proposed roadmap suggests a phased investment strategy:

1. Immediate Phase: Pilot implementation of traffic management systems and Smartification of urban bus and taxi fleets through collaboration between the municipality and startups.
2. Development Phase: Expansion toward smart parking systems and electric micro-mobility services.
3. Long-Term Phase: Design of a business model for EV charging stations based on public–private partnership (PPP) contracts.

By reducing risk and fostering iterative learning cycles, this phased approach facilitates the gradual maturation of Hamedan's smart transportation ecosystem. Moreover, in alignment with digital entrepreneurship-based city branding models (Eqbal Moghaddam & Zabihi, 2022), it can strengthen the city's smart identity and competitive positioning.

5.4. Recommendations for Entrepreneurs

Based on the findings of this study, the following strategic recommendations are proposed for entrepreneurs and investors:

Prioritizing Market Entry: For initial market entry, entrepreneurs should focus on the highest-ranked opportunities, namely A2 (Traffic Management), A5 (Bus/Taxi Smartification), and A1 (Parking Management). They should build their competitive advantage by leveraging high-impact criteria; specifically, they must demonstrate that their solutions are feasible within the existing infrastructure (C6), address a genuine market need (C1), and possess significant scalability and growth potential (C3).

Risk Mitigation through Phased Implementation: To minimize entry risks, a phased or pilot implementation model is recommended. For instance, executing A2 in one or two high-traffic zones or implementing A5 within a limited fleet or specific transit line. This approach aligns with the evaluative logic of the research criteria, facilitating higher institutional acceptance and providing a foundation for future expansion.

Addressing Cost-Type Barriers: Regarding the two criteria with negative impact initial investment and legal barriers entrepreneurs should develop barrier-reduction strategies. Potential solutions include adopting Software as a Service (SaaS) models, forming public–private partnerships (PPP) with municipalities, or establishing B2B revenue models with corporate entities. Furthermore, designing for regulatory compliance from the outset is essential to navigate licensing complexities.

Long-Term Strategic Perspective for Emerging Opportunities: If pursuing lower-ranked opportunities such as A4 (EV Charging Stations) or A6 (Private Vehicle Smartification), a long-term strategic vision based on demand-growth scenarios is required. In the short term, entrepreneurs in these sectors should pivot their focus toward niche segments that are most compatible with the high-weight criteria of technological readiness (C6), market demand (C1), and growth potential (C3).

6. Conclusion

This study utilized a mixed-methods approach to identify and prioritize six product/service-oriented entrepreneurial opportunities within the smart transportation sector of Hamadan, Iran, using the Fuzzy VIKOR method. The criteria weighting results, derived from the insights of 16 academic and executive experts, identified technological infrastructure (0.165), market demand (0.158), and market growth potential (0.135) as the primary pillars of opportunity evaluation. This pattern underscores that in the context of a medium-sized city like Hamadan, infrastructural readiness serves as a *sine qua non* (necessary condition), while the presence of actual market demand acts as a sufficient condition for the success of smart transportation entrepreneurial ventures.

The primary ranking findings highlight traffic management systems (A2) (VIKOR index: 0.0206) and the smartification of buses and taxis (A5) (0.0322) as the opportunities exhibiting the highest alignment with key evaluative criteria. Due to their capacity for fostering value co-creation among citizens, the municipality, and startups, these opportunities demonstrate a higher degree of readiness compared to other alternatives—for transformation into successful and impactful businesses. Conversely, electric vehicle charging stations (A4) (0.1752) received a lower priority due to substantial initial capital requirements and limited current demand; however, this opportunity remains a vital component of the long-term strategic horizon.

From a policy perspective, this research suggests that Hamadan's urban management should pivot from fragmented resource distribution toward a phased, data-driven investment roadmap:

- Phase I: Pilot implementation of opportunities A2 and A5, supported by open access to urban data and the establishment of public–private partnership (PPP) frameworks.
- Phase II: Development of smart parking systems and electric micro-mobility infrastructure.
- Phase III: Long-term planning for EV charging stations, contingent upon demand growth and the adoption of open innovation models.

This trajectory not only enhances the probability of entrepreneurial success but also facilitates the gradual maturation of Hamadan's smart ecosystem through iterative learning cycles, ultimately strengthening the city's brand identity.

Scientifically, by integrating theories of technological opportunity creation, value co-creation, and open innovation with an empirical prioritization framework, this study demonstrates that the final ranking of opportunities reflects the specific maturity level of the local ecosystem. This analytical framework offers a scalable model for other medium-sized cities in Iran to prioritize smart entrepreneurial opportunities, effectively bridging the gap between theoretical foundations and executive decision-making.

Author Contributions

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