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Identification of factors affecting opportunity recognition with an entrepreneurial bricolage approach in industrial waste management in Ardakan county

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Abstract This study aims to identify and validate the key components influencing opportunity recognition through an entrepreneurial bricolage approach in the industrial waste management sector of Ardakan county. This study adopts a qualitative, applied research design conducted in two stages. First, directed content analysis of the literature was combined with semi-structured interviews with 8 purposively selected waste management and entrepreneurship experts (using snowball sampling) to identify initial components. Second, these components were validated and screened through a two-round Fuzzy Delphi Method (FDM) with the same expert panel. The study identified and validated 15 main components. Among these, "environmental," "organizational and resource," and "entrepreneurial individual" components achieved the highest level of expert consensus. Conversely, "logistical and operational" and "ecological and sustainability" components received the lowest relative consensus from the experts. The findings suggest that bricolage-based waste management is a multidimensional process depending on the interaction of environmental constraints, resource availability, institutional support, and the entrepreneur's resourcefulness. The proposed conceptual framework provides valuable insights for policymakers and entrepreneurs to exploit opportunities and create value from industrial waste under resource constraints.

Keywords: Opportunity Recognition, Entrepreneurial Bricolage, Industrial Waste Management, Bricolage Opportunity Recognition Model, Fuzzy Delphi Technique.

1 Introduction

The beginning of human activities for the development of industry and technology has led to negative impacts at global, regional, national, and even local scales. The environment, as one of the main components of sustainable development, has been severely damaged by industrial development over recent decades, and these adverse effects, which contradict the principles of sustainable development, are at odds with the concept of a common future. One of the problems of unsustainable industrial development is the generation and disposal of various

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types of industrial waste. Although the establishment of industrial parks plays a significant role in regional and urban economic and industrial development, how to minimize the negative impacts arising from waste management is one of the main challenges. In this regard, it should be noted that nowadays the nature of a large portion of non-hazardous or low-hazard waste has turned into hazardous waste, such that their adverse and destructive effects have led to the emergence of unknown neurological and genetic diseases and cancers in humans and caused the extinction of wildlife species [1]. The term "industrial waste" applies to all waste generated from industrial and mining activities, as well as refinery waste from gas, oil, petrochemical, and power plant industries and the like, such as shavings, overflows, and industrial sludge [2].

On the other hand, to overcome the constraints of industrial waste management, entrepreneurs use bricolage within the framework of opportunity recognition. Evidence shows that new ventures engaged in bricolage are better able to manage resource constraints and achieve superior performance. Accordingly, most existing studies in the field of entrepreneurship view bricolage as an approach to overcoming the problem of resource limitations in new ventures. However, the effects of bricolage go beyond removing resource constraints. Some researchers have pointed to the impact of bricolage on knowledge creation and opportunity recognition. Through generating new knowledge, bricolage may enable organizations to identify more opportunities; therefore, the process of opportunity recognition is considered another important process in entrepreneurship [3]. Entrepreneurial bricolage is known as a firm's ability to organize combinations of available resources in order to respond quickly to complexities and challenges in the contemporary business environment. Entrepreneurial bricolage allows firms to differentiate their offerings by creating innovations while relying on existing resources, thus making it a suitable lens for extending research in service innovation [4].

In this regard, although all provinces in Iran are more or less involved with this issue, Yazd Province and among its counties, Ardakan in particular is in a very unfavorable situation. Eighty percent of the industries in Yazd Province are located in the Yazd–Ardakan plain. This concentration of industrial establishments, along with other factors, has caused severe pollution in this plain. The breadth and diversity of industries in this area and their destructive impacts have prompted studies aimed at achieving integrated management in the field of industrial waste [5]. In addition, industrial wastes are highly diverse and exist in solid, semi-solid, and liquid forms. Therefore, effective control and proper management of industrial waste are of particular importance for public health and resource management [6].

Despite sufficient information on opportunity recognition in the field of environmental management, the impact of bricolage on opportunity recognition has unfortunately rarely been examined in the existing literature; in particular, no comprehensive study has yet been conducted on the use of bricolage for opportunity recognition in industrial waste management in Iran. Moreover, given the prevailing resource scarcity in the country due to the imposition of unjust sanctions, the increasing air and water pollution in Ardakan county and its surrounding areas in recent years, the significant rise in the number of people suffering from specific diseases such as cancer in recent years, and the need to prevent certain industrial activities from reaching a dead end as a result of technological dominance and autocratic decision-making, the necessity of conducting this research is felt more than ever. This study seeks to explore how the awareness, knowledge, and capabilities of managers in using available resources material, financial, and human and in recognizing hidden opportunities can contribute to the field of industrial waste management. The lack of such structured knowledge constitutes the foundation of this research. Therefore, in order to understand the

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concept and application of the dimensions of bricolage in the process of opportunity recognition in industrial waste management, the main objective of the study is to identify the components influencing opportunity recognition with an entrepreneurial bricolage approach in industrial waste management.

2 Theoretical foundations

2.1 Opportunity recognition

Every scientific field needs to delineate its boundaries from other disciplines. In the domain of entrepreneurship, this distinction has also been emphasized. Many researchers believe that what differentiates entrepreneurship research from other studies in various scientific fields such as management is the focus on and emphasis upon investigating opportunities discovered by entrepreneurs. This includes all activities and actions related to perceiving and understanding opportunities and establishing an organization to exploit these opportunities. Therefore, opportunity recognition and exploitation have been regarded as the core subject and essence of entrepreneurship as a scientific field. In fact, without examining the mechanisms and factors influencing the emergence and growth of entrepreneurial opportunities, it is impossible to gain an accurate understanding of entrepreneurship as a whole [7]. Without opportunity, entrepreneurship is meaningless; thus, the concept of opportunity must be at the center and focus of entrepreneurship research. Researchers define entrepreneurial opportunities as conditions under which new goods, new services, raw materials, and new markets and organizing methods can be introduced through new combinations of means, ends, or means ends relationships. Entrepreneurial opportunities are among those constructs for which there is no consensus regarding their definition. Some of the definitions proposed by different scholars are as follows: entrepreneurial opportunities are situations in which new goods, services, raw materials, markets, or organizing methods can be introduced through the development and creation of means ends relationships. These are situations where goods, services, raw materials, and new organizing methods can be initiated and sold at a price higher than their cost of production [8].

2.2 Entrepreneurial bricolage

The originator of the term “bricolage” is the structural anthropologist, that primarily defined this concept as part of his attempt to explain how a society borrows structural elements of other cultures especially elements of myths and recombines them to suit its own purposes. In complement to this “idea-based” form of bricolage, he also describes a more material form of bricolage and introduces it as the process of “making do with what is at hand.” This concept was introduced to distinguish between the actions of an engineer and those of a “bricoleur” or bricolage expert [9]. Since the introduction of this concept, bricolage has been used across a wide range of fields and for various phenomena, including in the biological sciences, to explain formation processes in teaching, legislation, psychology, institutionalization, and information technology. The concept of bricolage has been applied in the business literature to understand organizational phenomena such as sense making, innovation, and entrepreneurship. It has also been examined in areas such as commercial entrepreneurship, family businesses, high growth technology ventures, and social entrepreneurship [10]. Many scholars extend the concept of bricolage to organizations. Organizational symbolism

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describes bricolage as a process in which organizational members make sense of and order the world against a backdrop of material and social constraints. From a sense making perspective, bricolage enhances adaptive capacity in destabilizing situations. Researchers associate bricolage with flexibility, which enables an individual or organization to overcome a critical situation while maintaining identity coherence and the capacity for action. Entrepreneurs who are eager to grow their ventures and devise new solutions are more likely to engage in bricolage. Moreover, bricolage is considered a type of effectual reasoning employed by entrepreneurs to mitigate the risks that firms experience during their critical early years [11].

2.3 The Effect of bricolage on opportunity recognition in entrepreneurship

In the entrepreneurship literature, the importance of bricolage has been conceptualized in relation to the ability to overcome resource constraints and, consequently, to create markets and foster the growth of startups [12]. Most existing studies in the field of entrepreneurship view bricolage as an approach to overcoming problems associated with resource limitations in new venture creation. However, the effects of bricolage extend beyond merely alleviating resource constraints. Some scholars have pointed to the impact of bricolage on knowledge creation and opportunity recognition. By generating new knowledge, bricolage may enable organizations to recognize more opportunities; therefore, the process of opportunity recognition is considered another important process in entrepreneurship [13]. Nonetheless, the effect of bricolage on opportunity recognition has rarely been examined in the existing literature. Opportunity recognition is a multifaceted concept that has only recently received attention in academic research. Entrepreneurs are individuals who, due to their specific characteristics, possess the ability to recognize opportunities, and it may be argued that the most important entrepreneurial activity is opportunity recognition. In fact, entrepreneurship is the recognition and exploitation of opportunities that have not yet been exploited [14].

2.4 Industrial waste

Various organizations and individuals have provided multiple definitions of waste. In a general definition, solid waste, garbage, or refuse refers to all discarded solid or semi solid materials that have no retention value at the point of generation but may be usable elsewhere [15]. In another definition, solid waste refers to waste or combinations of wastes that have the potential to cause destruction or harm to human health, hygiene, or the biosphere [16]. In yet another definition, any solid, liquid, semisolid, or gaseous material resulting from agricultural, mining, commercial, and industrial operations or from social activities is called solid waste [17]. According to the Waste Management Law in Iran, waste (residual materials) refers to solid, liquid, and gaseous substances (other than wastewater) that are directly or indirectly generated by human activities and are considered unwanted by the producer [18].

2.5 Research background

Rahmati [13] conducted a study entitled “The Effect of Entrepreneurial Bricolage on Export Intensity through the Identification of International Opportunities, Considering the Moderating Role of Ambidextrous Learning (Case Study: Small and Medium Sized Exporting

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Firms in Tehran Province).” The statistical population consisted of 734 small and medium sized exporting firms in the province. The results of hypothesis testing showed that entrepreneurial bricolage has a positive and significant relationship with international opportunity recognition; exploratory learning positively moderates the relationship between entrepreneurial bricolage and the identification of international opportunities; international opportunity recognition has a positive and significant relationship with export intensity; and exploitative learning positively moderates the relationship between the identification of international opportunities and export intensity. Ghaleh Kari [6] carried out a study titled “Exploring the Challenges of Green Entrepreneurship with a Crisis Approach: Disposal of Household Waste and Discarded Waste in Urban Areas of Masks, Gloves, and Tissues.” In this research, using purposive and snowball sampling methods, interviews were conducted with 18 experts in the field, including managers and specialists from the municipality, the crisis management headquarters, and the recycling company of Kermanshah. Overall, based on the final findings obtained from open coding and the resulting concepts and categories, the data were grouped into 10 general categories. The six categories obtained in the challenges section included: educational and cultural barriers; economic and social barriers; managerial barriers; supportive and governmental support barriers; legal barriers; and monitoring and evaluation barriers. The four categories in the solutions section included: education, culture building and awareness-raising; socio-economic institutionalization; managerial effectiveness, supportive and legal services; and monitoring effectiveness. Poteluri [11], in a study entitled “The Role of Bricolage in Women’s Green Entrepreneurship: An Exploratory Study,” states that this research, based on integrating green entrepreneurship, women’s entrepreneurship, and ecofeminism, aims to propose, validate, and conceptualize women’s green entrepreneurship. This study employs a multiple qualitative case study approach and is conducted in the contexts of India and Australia, representing a developing and a developed country, respectively. While the research compares the contexts of the two countries and thereby expands the output of green women’s entrepreneurship research, it offers several theoretical and policy implications for both developed and developing nations. Shokrollahi [17], in a study titled “German Artificial Intelligence Technologies in the Waste Management Industry Applicable in Iran,” notes that the aim of the present research is to examine innovative waste management technologies in Germany and the potential for their transfer and utilization in Iran. The research data cover different periods, with a particular focus on the past seven years. In this study, data were collected through expert interviews with elites, opinion leaders, managers, and specialists in the present and past. The sample size was determined using the criterion of theoretical saturation. Various technologies were examined, and based on the analyses conducted throughout the report, blockchain technology and machine learning were identified and introduced as the best solutions. Musona et al. [10] conducted a study titled “Bricolage in Environmental Entrepreneurship: How Environmental Innovators at the Base of the Pyramid ‘Make Do with Whatever They Have’.” This study considers environmental bricolage as a creative method of innovation for socio-environmental entrepreneurs. Networks, marketing, waste materials, and skills and knowledge are identified as mechanisms used by social and environmental entrepreneurs to address resource challenges when creating low-cost, high-value solutions at the base of the pyramid.

With regard to studies that have examined issues through the lens of bricolage, the populations under investigation have also been selected from among individuals or groups whose work is most closely connected with waste (garbage). What appears to have been neglected, and is of particular importance, is the recognition of entrepreneurial opportunities at the reuse stage. The creative and novel combination of existing resources (scrap and

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residues) through the use of skilled human resources (bricoleurs) can lead to resource recovery and, in some cases, innovation. The present study seeks to formulate its research innovation and scientific contribution based on the theoretical gap identified in recent studies on sustainable entrepreneurship mentioned in the background, as well as the practical gap arising from reviews and practice-based accounts of problems in the environmental domain. Based on the conducted research, it can be stated that numerous studies have examined ways to protect the environment against pollutants in various contexts, mostly focusing on recycling, landfilling, and incineration, and occasionally on reduction at the source. In practice, the focus in the field of waste management has been directed towards "waste" itself. What seems to have been overlooked in studies in this field is the importance of the reuse stage. This study intends to address the management of human (bricoleurs) and material resources (scrap and residues) in the field of industrial waste (reuse stage) from the perspective of entrepreneurial bricolage. Given its capabilities such as creatively combining whatever is at hand to solve a problem or create a new product under resource constraints and refusing to be limited by those constraints bricolage can contribute to this field in the current conditions of the country. Since entrepreneurial bricolage emerges in a context free from rigid administrative and organizational constraints, it is necessary for this process to begin with managers, who determine the frameworks and regulations. Because there is no structured body of knowledge on entrepreneurial bricolage that can effectively assist managers and industrial owners in opportunity recognition in the field of industrial waste management (reuse stage), the present study is novel in terms of its topic and innovative with respect to the relationships and components of its proposed model. Accordingly, the main objective of this research is to identify the components of opportunity recognition through entrepreneurial bricolage in the field of industrial waste management.

Compared with prior studies, this research extends the literature in three ways. First, while previous bricolage studies have mainly examined entrepreneurial opportunity recognition in general business or export contexts, this study applies the bricolage lens specifically to industrial waste management. Second, unlike earlier waste-management research that has predominantly focused on recycling, landfill, incineration, or source reduction, this study centers on the reuse stage as a source of opportunity. Third, the study proposes and validates a multi-component model that integrates individual, organizational, environmental, market, institutional, and technological factors affecting opportunity recognition. Therefore, the contribution of this research lies not only in introducing a new context, but also in specifying how entrepreneurial bricolage can be operationalized for opportunity recognition in industrial waste reuse.

The novelty of this study lies in examining opportunity recognition through the lens of entrepreneurial bricolage in the reuse stage of industrial waste management, a context characterized by severe resource constraints, institutional pressure, and environmental urgency. Unlike prior studies that have addressed bricolage or opportunity recognition in general entrepreneurial settings, this research proposes an integrated framework combining individual, organizational, environmental, institutional, market, technological, logistics, and risk-related dimensions in the specific context of Ardakan county.

3 Methods

This study is applied in terms of its objective. On the other hand, in terms of data collection, it is a field study that uses a survey method to collect data and therefore falls under the general

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category of non-experimental methods. In order to achieve the research objectives and answer the research questions, the present study has been conducted in two separate but interrelated steps.

This applied study employed a two-stage exploratory design to identify and validate the components influencing opportunity recognition through an entrepreneurial bricolage approach in industrial waste management in Ardakan county. In terms of data collection, the study was field-based and non-experimental. The first stage involved a directed qualitative content analysis of the relevant literature, previous studies, and semi-structured interviews with experts. The second stage used the fuzzy Delphi technique to integrate and validate the identified components and to achieve consensus among experts. The participants were specialists, academics, and industrial experts in industrial waste management and entrepreneurship in Yazd Province and Ardakan county. Experts were selected through purposive sampling and the snowball technique. Eligibility was based on relevant managerial, technical, academic, research, or professional experience and sustained involvement in industrial waste-management activities. At least eight experts participated in the semi-structured individual interviews, and theoretical saturation was used as the stopping criterion for the qualitative stage. The fuzzy Delphi panel consisted of the same expert population and included eight experts.

Participants were selected purposively and through snowball sampling based on their relevant expertise and direct involvement in industrial waste management, entrepreneurship, or related academic and operational activities. In line with the qualitative exploratory nature of the study, interviews continued until theoretical saturation was achieved, that is, until no new concepts or categories emerged from the data. Accordingly, eight experts were interviewed. This sample size was deemed adequate because saturation had been reached and the same panel provided informed judgments in the fuzzy Delphi phase.

In the qualitative stage, the interview recordings were transcribed and repeatedly reviewed. Relevant statements concerning opportunity recognition through entrepreneurial bricolage and the reuse of existing industrial-waste resources were extracted, while irrelevant material was excluded. The data were then analyzed through open and axial coding. The resulting codes were integrated with the components identified from the literature review to develop the preliminary framework. For the validation stage, a closed-ended questionnaire was developed based on the findings of the qualitative content analysis. The experts evaluated the importance of each identified component using a Likert-type scale. The triangular fuzzy mean and the corresponding defuzzified value were calculated for each component. In the first Delphi round, the degree of disagreement between each expert's assessment and the panel mean was determined. In the second round, the experts received a revised questionnaire containing their previous responses and the deviation from the panel mean. The results of the two rounds were then compared. Because the inter-round disagreement fell below the very-low threshold of 0.20, the Delphi process was terminated after the second round and consensus was considered to have been achieved. The operational stages of the research are schematically shown in Figure 1.

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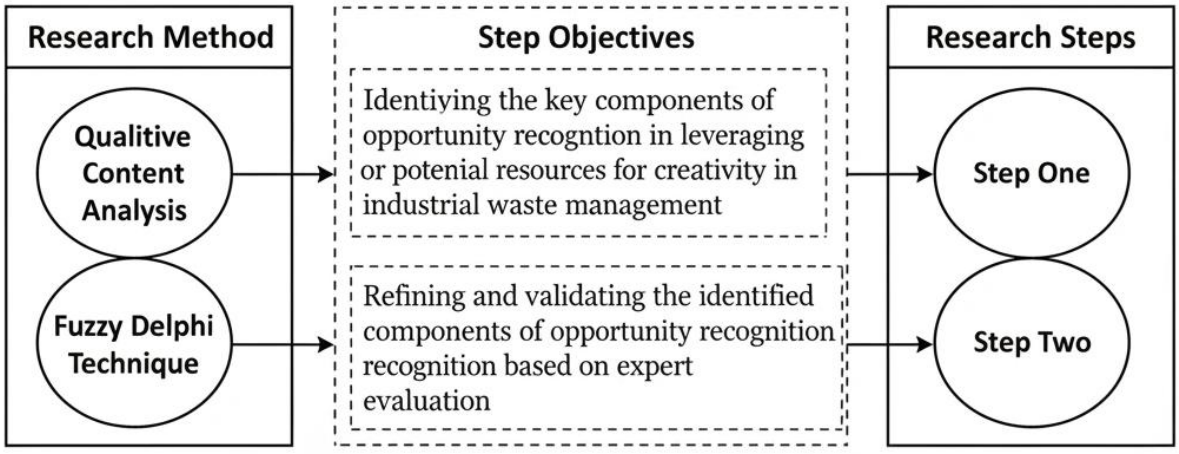

Fig.1 Research methodology structure

According to Figure 1, in the first step of the research, the components of opportunity recognition in the revitalization of existing resources through entrepreneurial bricolage in the field of industrial waste management are identified by reviewing the literature and previous studies using the qualitative content analysis technique. Subsequently, in the second step, given the need to develop, integrate, and validate the components of opportunity recognition, and considering the potential bias in the researcher's opinions, the fuzzy Delphi technique is used to achieve group consensus among experts, in order to ensure the accuracy, precision, applicability, and comprehensiveness of the identified stages and to eliminate possible biases. The initial step of the research is applied in terms of its purpose, and its statistical population consists of specialists, scholars, and academic and industrial experts in Yazd province and Ardakan county, who, through their work experience and continuous involvement in managerial, expert, scientific, and research activities in the field of industrial waste management, are regarded as experts. Using purposive sampling and following the snowball method, semi-structured individual interviews are conducted with at least eight of them until theoretical saturation is reached.

3.1 Research validity and reliability

On the one hand, issues of validity and reliability are two important factors that every qualitative researcher must take into account when designing the study, analyzing the results, and judging the quality of the research. To test validity and reliability, the concept of trustworthiness is used as a substitute for validity and reliability in qualitative studies. This concept encompasses a set of criteria, including credibility or acceptability (as a substitute for the quantitative concept of internal validity), transferability (as a substitute for the quantitative concept of external validity), dependability or consistency (as a substitute for the quantitative concept of reliability), and confirmability or neutrality (as a substitute for the quantitative concept of objectivity) for conceptualizing quality in qualitative research.

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3.2 Data analysis method

In order to analyze the qualitative content in the present study, content analysis was used. Content analysis is one of the main methods of documentary observation through which texts, documents, and in fact any type of written or recorded material whether related to the past or to the present can be evaluated and analyzed in a more systematic and precise manner, and more importantly, with higher degrees of reliability. In the second step, the development, integration, and confirmation of the components of opportunity recognition in the revitalization of existing resources through entrepreneurial bricolage in the field of industrial waste management are carried out by experts. This phase of the research is applied in terms of purpose and, in terms of paradigm, is a mixed qualitative–quantitative study with an exploratory approach, conducted with the aim of developing, integrating, and confirming the components of opportunity recognition in the revitalization of existing resources through entrepreneurial bricolage in the field of industrial waste management. Given the potential for bias in the researcher's opinions, in order to ensure the accuracy, precision, applicability, and comprehensiveness of the identified steps and to eliminate possible biases, the fuzzy Delphi technique is used to achieve group consensus among experts. The statistical population of this part is the same as that of the first step and includes specialists and experts in the field of industrial waste management and entrepreneurship. Using purposive sampling and the snowball method, at least eight of them participate in several rounds of the fuzzy Delphi technique until final agreement is reached in this stage of the research.

4 Results

The identification of the components of opportunity recognition in the revitalization of existing resources through entrepreneurial bricolage in the field of industrial waste management, based on the review of the literature and previous studies as well as audio files and recorded statements during the interviews, was carried out using directed content analysis in two stages: open coding and axial coding. Accordingly, each interview was first listened to several times; then, the parts related to the components influencing opportunity recognition with an entrepreneurial bricolage approach in the field of industrial waste management were compiled into a single text and irrelevant content was removed. Subsequently, the primary and secondary codes extracted from the interviews are presented in Table 1.

Table 1 Primary codes and main (secondary) components identified from the literature review and expert interviews

Main components	Initial codes
Environmental components	Tightening of government regulations on industrial waste disposal; obligation to recycle or pay fines for pollution; drafting regulations for providing alternative solutions; environmental laws and regulations; demand for secondary materials (such as metals, recycled plastics); energy generated from industrial waste; market demand for recycled products; industries' willingness to improve their image through green waste management; social pressure regarding industrial waste management; corporate social responsibility in revisiting waste management; technical, economic and environmental requirements
Entrepreneurial individual components	Safe disposal methods; awareness of recycling processes; waste-to-energy technologies; technical knowledge and experience in the waste domain; ability to combine limited resources (such as second-hand equipment, informal networks) to create low-cost solutions; creativity and bricolage capability; access to key stakeholders such as waste-producing industries, regulatory bodies and buyers of recycled materials; entrepreneurial networking

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Organizational and resource components	Using unused industrial waste as valuable raw material; access to idle resources; partnerships with factories for waste management; ability to cooperate with large industries; designing revenue models; selling recycled materials; receiving fees for waste management; energy production; flexible revenue model
Technological and innovation components	Using simple but effective methods (such as pyrolysis, industrial composting); adapting existing technologies for new applications; low-cost waste processing technologies; waste tracking or use of resource-sharing platforms; optimization of waste collection; using software for waste management; digitalization and smart industrial waste management in factories; production of construction materials from industrial waste; extraction of valuable materials (such as rare metals from electronic waste); development of new products from waste
Institutional and ecosystem components	Financial facilities for industrial waste management; fast-track permits for industrial waste; acceleration programs for environmental start-ups; support from governmental bodies; support from NGOs for waste management and use of existing recycled resources; use of university research to develop advanced recycling technologies; collaboration with scientific and research centers; existence of a public belief in the need to reduce waste; support for sustainable businesses; culture of green entrepreneurship
Bricolage-driving components	Smart use of limited resources; need for low-cost solutions; use of refurbished, environmentally compliant machinery; financial constraints in industrial waste management; adaptability to price fluctuations of secondary raw materials; market uncertainty regarding industrial waste; building stable relationships with suppliers (industries) and customers (secondary markets); complexity of the industrial-waste supply chain
Socio-cultural components	Public participation in segregation of industrial waste; willingness to purchase recycled products (such as green building materials); societal mindset towards recycling; companies' willingness to reduce waste at source; companies' reluctance to pay disposal costs; culture of waste reduction in industries; use of traditional waste management methods; combining traditional waste management methods with modern technologies; local traditions and indigenous knowledge regarding waste management
Logistical and operational components	Access to low-cost transport networks for moving industrial waste; improvement of transport and waste collection infrastructure; concentration or dispersion of waste-producing industries; focus on specific industrial hubs in a region with dedicated industrial waste management; scale and spatial dispersion of industrial waste resources in the region; ability to temporarily manage hazardous waste; safe storage of hazardous waste materials such as chemicals before processing
Economic-financial components	Reducing industrial waste management costs; increasing processed waste volume or cooperating with multiple industries; economies of scale in waste management; effects of managing network relationships in waste management; using crowdfunding for waste-recycling projects; attracting impact investors in industrial waste processing and management; implementing creative financing models for waste-recycling projects; tax exemptions for green businesses; government support for clean technologies; subsidies and fiscal/governmental incentives
Ecological and sustainability components	Assessing the reduction of water, soil and air pollution achieved by the proposed solution; ecological footprint; linking waste-management projects to global goals; sustainable industrial management within a given industrial set; responsible consumption of raw materials and energy in industrial waste management; alignment of industrial and manufacturing companies' performance with sustainable development goals; full life-cycle analysis of waste from generation to recycling to identify value-creation points; attention to product life-cycle patterns in waste management
Political-strategic components	National macro-policies on industrial waste management; circular-economy programs at national and regional levels; national priorities in waste management; cooperation with organizations such as the World Bank on environmental projects; relationships with international bodies in the field of environmental and municipal/industrial waste management; need for bricolage with domestic technologies due to sanctions on importing advanced recycling equipment; impact of sanctions or trade restrictions on tools and machinery for industrial waste recycling
Emerging-technology components	Predicting industrial waste volumes or optimizing collection routes using artificial intelligence; increasing transparency in the supply chain of recycled materials; tracking the origin of recycled metals; use of microorganisms to decompose hazardous waste; production of bio-materials; use of AI and data analytics in waste management; application of biotechnologies in waste recycling; use of blockchain to trace metallic and critical materials
Psychological and behavioral components	Changing industries' mindset from "waste as a cost" to "waste as a revenue source"; ability to convince stakeholders to accept new waste-management methods; willingness to pay higher prices for environmentally friendly products; stakeholders' understanding of the value of waste; resistance to change in industrial waste management; end-consumer behavior towards products made from recycled industrial and green waste

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Security and special-risk components	Managing risks related to chemical, radioactive or medical waste; data protection in smart systems for managing specific industrial waste in sensitive sectors (e.g. defense industries); security of data collected in industrial waste management; management of hazardous waste and compliance with occupational safety; dependence on imports of recycled raw materials from unstable countries; geopolitical risks
Foresight-oriented components	Hydrogen economy and industrial waste; smart cities and industrial waste; waste-as-a-service; co-evolution of industries; resource crises and the value of waste; climate change and adaptability; nanotechnology in recycling; 3D printing with recycled materials; robotics and advanced automation; grassroots anti-waste movements; waste diplomacy; carbon taxes and the added value of waste; changing perceptions of "eternal" waste; environmental ethics in business

To develop and validate the components influencing opportunity recognition with an entrepreneurial bricolage approach in the field of industrial waste management, the fuzzy Delphi technique was employed by a panel of experts. Accordingly, to achieve consensus among the experts regarding the validity of the identified steps, a closed-ended questionnaire was designed based on the results of open coding from the qualitative content analysis and using a Likert scale. This questionnaire was then provided to the experts to determine the importance of each factor. The statistical population of this stage, similar to the previous one, consisted of eight experts. Subsequently, the triangular fuzzy mean and the defuzzified value of each step were calculated.

In the first round of the Delphi method, the degree of disagreement between each expert's opinion and the average opinion of the expert panel was measured. Based on the results of the first round, another questionnaire was distributed, including each expert's previous response and the amount of deviation from the panel's average opinion. Then, the results of the first round were compared with those of the second round. Since the degree of disagreement among experts between the first and second rounds was less than the very low threshold (0.2), the Delphi process was stopped at the second round.

The results of this research step indicated that among the identified components, the highest level of expert agreement pertained to environmental components, organizational and resource-related components, and entrepreneurial individual components. The lowest level of agreement corresponded to logistical and operational components, as well as ecological and sustainability components.

Table 2 Experts' perspectives on components influencing opportunity recognition with an entrepreneurial bricolage approach in the industrial waste-management sector of Ardakan county (Second round of Delphi survey)

Effective Components in Opportunity Recognition	Triangular Fuzzy Mean (I,m, u)	Defuzzified Value (S2)	|S1 – S2|
Environmental Components	(0.66 – 0.91 – 1)	0.86	0.01
Entrepreneurial Individual Components	(0.61 – 0.88 – 0.97)	0.82	0.02
Organizational and Resource Components	(0.63 – 0.88 – 0.97)	0.83	0.01
Technological and Innovation Components	(0.56 – 0.82 – 0.97)	0.78	0.03
Institutional and Ecosystem Components	(0.59 – 0.84 – 0.95)	0.79	0.02

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Bricolage-Driving Components	(0.61 – 0.86 – 0.97)	0.81	0.02
Socio-Cultural Components	(0.56 – 0.82 – 0.97)	0.78	0.01
Logistical and Operational Components	(0.53 – 0.78 – 0.97)	0.76	0.05
Economic-Financial Components	(0.59 – 0.84 – 0.98)	0.80	0.01
Ecological and Sustainability Components	(0.53 – 0.78 – 0.97)	0.76	0.05
Political-Strategic Components	(0.59 – 0.84 – 0.95)	0.79	0.02
Emerging-Technology Components	(0.55 – 0.80 – 0.95)	0.77	0.03
Psychological and Behavioral Components	(0.56 – 0.82 – 0.97)	0.78	0.01
Security and Special-Risk Components	(0.56 – 0.82 – 0.97)	0.78	0.02
Foresight-Oriented Components	(0.59 – 0.84 – 0.95)	0.79	0.03

5 Discussion and conclusion

The proposed framework is grounded in the logic of resource constraint. In such contexts, scarcity does not only restrict action; it also stimulates entrepreneurial bricolage, defined as the creative recombination of resources at hand. Industrial waste, unused materials, existing technical knowledge, organizational capabilities, and local networks become inputs for opportunity recognition. Therefore, opportunity recognition emerges not from ideal resource endowment, but from the interaction between environmental pressure, institutional conditions, market demand, and the entrepreneur's bricolage capability. In this model, organizational, environmental, and individual factors function as core enablers, whereas logistics, technology, and sustainability-related constraints shape the feasibility and scope of opportunity exploitation.

This study was conducted with the aim of identifying the components influencing opportunity recognition with an entrepreneurial bricolage approach in the field of industrial waste management in Ardakan county. Overall, the results of the present research in the qualitative content analysis stage are as follows: After a comprehensive review of the literature and previous studies on the components influencing opportunity recognition in the regeneration of existing resources through entrepreneurial bricolage in industrial waste management and considering the theoretical framework, prior research, and expert interviews fifteen key components were identified. In the second step, among the identified components, the highest level of expert consensus corresponded to environmental components, organizational and resource-related components, and entrepreneurial individual components, while the lowest level of consensus was associated with logistical and operational components

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as well as ecological and sustainability-related components. Based on the obtained results, industrial waste management through a bricolage approach requires a deep understanding of key components and the complex interactions between them. According to reputable studies, the most influential factors can be categorized into several main dimensions. Access to unused resources serves as the foundation of this system. Research indicates that a large volume of industrial waste that is discarded can in fact be used as valuable raw material. This not only significantly reduces production costs but also contributes to solving environmental challenges associated with landfill disposal highlighting the importance of environmental components. Furthermore, environmental laws and regulations play a key driving role in this system. The experience of leading countries has demonstrated that strict regulations coupled with financial incentives can push industries toward recycling and reusing waste materials. These regulations create a binding framework that economic motivation alone cannot provide. Accordingly, organizational and entrepreneurial resource components, as well as governmental laws and community and financial inputs, influence industrial waste management in Ardakan County. Technical knowledge and bricolage capability distinguish this approach from traditional methods. Here, the type of advanced technology available is not the primary concern; rather, it is the ability to creatively combine existing resources and facilities to provide practical and low-cost solutions. This is the strength of entrepreneurs who work under resource constraints. This component an integration of individual entrepreneurial factors and elements such as innovation and the use of emerging technologies can have significant impacts on recycling and value creation from industrial waste. Market demand for recycled products acts as the economic engine of this system. Without real demand for final products, all recycling efforts and waste conversion reach an impasse.

The communication network and cooperation among different stakeholders serve as the connective link in this system. No single actor can manage the entire industrial waste management cycle alone. Creating strategic ties between waste producers, processors, and end-users of recycled materials is essential for the success of this model. Finally, support from governmental institutions and policymakers can act as a facilitator of this process. Such support may include financial facilities, tax exemptions, or shared infrastructure that reduce the risks faced by entrepreneurs in this field. Institutional and ecosystem components, as well as risk-related and challenge-related components that drive bricolage, can play an effective role in fostering positive change in industrial waste management in Ardakan county. The intelligent combination of these factors can create a dynamic ecosystem in which waste is viewed not as a problem but as a valuable resource. Successful experiences around the world have shown that this approach is not only environmentally sustainable but can also be highly profitable economically. The key to success lies in correctly understanding the interactions among these components and achieving balance between them. Considering the results obtained and the identification of fifteen components from interview analyses and comparison with previous studies, it can be stated that the findings on components influencing opportunity recognition with an entrepreneurial bricolage approach in industrial waste management align with the research results of [15, 17, 18]. In the second phase of the research, based on the expert validation of components influencing opportunity recognition through a bricolage approach in industrial waste management using a two-stage fuzzy Delphi technique, it can be concluded that all components extracted from semi-structured interviews and prior studies were confirmed by experts, minimizing potential researcher bias. Based on the presented findings, a conceptual model of the identified components for opportunity recognition through entrepreneurial bricolage in the industrial waste management of Ardakan County is designed and proposed.

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Compared with prior studies, the present findings confirm the positive role of bricolage in opportunity recognition, but they also show that in industrial waste management the opportunity structure is more strongly shaped by environmental and organizational conditions than by a single entrepreneurial attribute. This difference is likely due to the specific characteristics of the Ardakan context, where industrial concentration, resource scarcity, and waste-related environmental pressure intensify the role of institutional support and operational constraints.

According to the model represents a dynamic system in which different components influence one another and the ultimate goal (successful opportunity recognition and exploitation). The core of this system is "bricolage opportunity recognition," carried out by an entrepreneur. The model shows that opportunity recognition is not an isolated process, but rather the outcome of the interaction between a bricolage entrepreneur (with specific individual and psychological characteristics) and a complex ecosystem of internal and external factors.

Bricolage entrepreneur (individual and psychological components):

This person, through their creativity, technical knowledge, and adaptability, receives, interprets, and combines the signals from other components in order to recognize the opportunity.

Environmental and economic components (foundation and motivation):

- Unused resources (waste): These are the primary raw material and the main basis of this system. Without them, no opportunity exists.
- Ecological components: They provide the environmental necessity and motivation to act.
- Economic–financial components: They create the economic justification and profit motive for pursuing the opportunity.

Institutional and market components (framework and demand):

- Institutional and political components: Strict regulations act as both incentives and deterrents, and define the legal framework of activity. Governmental support also reduces risk.
- Socio-cultural components: The existence of market demand for recycled products is vital. This demand is the economic driving force of the model.

Enabling components (organizational and technological):

- Organizational and resource components: They provide access to capital, human resources, and other organizational assets.
- Technological and logistical components: They offer the tools and methods required to turn an idea into an operational business. The emphasis is on low-cost solutions tailored to local conditions, not necessarily advanced technologies.

Future-oriented and risk components:

These components help the entrepreneur anticipate future trends and manage inherent risks in this domain (such as fluctuations in the prices of raw materials or products).

Bricolage driver:

The bricolage approach emerges precisely because of resource constraints and the need to creatively overcome these limitations. Success in recognizing and exploiting opportunities in this field depends not on one or two factors, but on the intelligent combination and dynamic interaction among all these components. The bricolage entrepreneur is like the conductor of an orchestra who must coordinate the performance of all these instruments so that the symphony of "creating value from waste" can be performed.

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5.1 Practical Recommendations

In light of the obtained results, the following practical strategies are proposed for the successful implementation of the bricolage approach in industrial waste management:

1. Establishing a comprehensive database of industrial waste streams at the regional level can help identify potential sources of raw materials. This database should include information on the type, volume, and location of industrial waste generation so that connections between waste producers and recyclers can be established.
2. Developing shared centers for waste-processing technologies and equipment is another practical solution. By providing affordable access to recycling machinery, these centers can enable small and medium-sized enterprises to operate. Such a model significantly reduces initial capital investment costs.
3. Designing hands-on training programs for entrepreneurs and the local workforce is essential. These programs should focus on low-cost methods of waste processing, safety in handling industrial waste, and the principles of bricolage. Technical and vocational training can develop the skills needed to convert waste into value-added products.
4. Creating collaborative networks between waste-producing industries and recycling units can close the material loop. These networks can establish a sustainable value chain by facilitating the exchange of information and raw materials. Forming specialized unions or cooperatives in this field will be beneficial.
5. Developing hybrid business models that both provide waste-management services and produce recycled products can increase the economic attractiveness of this domain. Such models make it possible to generate income from multiple sources and reduce financial risk.
6. Implementing incentive systems for industries that deliver their waste to recyclers can secure the supply of raw materials. These incentives may include discounts on waste-management fees or the granting of environmental certificates.
7. Using digital technologies, such as online platforms for direct communication between producers and consumers of recycled materials, can increase market efficiency. These platforms can enable material traceability, transparent pricing, and the facilitation of transactions.
8. Developing innovative products from industrial waste that meet real market needs is a key success factor. Market research is essential to identify product opportunities and align the characteristics of recycled materials with the needs of end consumers.

For the development of future research in the field of industrial waste management with a bricolage approach, the following research directions are proposed:

Research should examine the role of digital technologies in facilitating bricolage-oriented processes. This may include studying the applications of the Internet of Things, blockchain, and artificial intelligence in optimizing the collection, processing, and distribution of industrial waste. Such research can also analyze the impact of different incentive and punitive policy instruments on the development of this approach.

Analyzing the social and cultural impacts of adopting the bricolage approach in various industries can help to understand barriers and identify ways to change mindsets. This line of research can explore the role of education, awareness-raising, and community participation in the success of this approach.

A feasibility study on the development of bricolage-based industrial clusters can lead to the identification of collaboration opportunities between different industries.

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