

# Entrepreneurial opportunity recognition: a bibliometric overview and clustering analysis

Entrepreneurial  
opportunity  
recognition

Navid Mohammadi and Saeed Heshmati  
*Entrepreneurship, University of Tehran, Tehran, Iran*

239

Received 13 April 2021  
Revised 27 May 2021  
Accepted 27 May 2021

## Abstract

**Purpose** – Entrepreneurship is the driving force of countries for sustainable economic development. The importance of this issue is to the extent that in recent years, countries have made great efforts to develop their entrepreneurial ecosystem. But the starting point for entrepreneurship is when an opportunity is identified and the entrepreneur rises to use it. Accordingly, opportunity recognition will be the foundation of entrepreneurship and ultimately sustainable development. Given the importance of this topic, this paper attempts to provide a large picture of the studies conducted in this field.

**Design/methodology/approach** – Given the importance of this topic, this paper attempts to provide a large picture of the studies conducted in this field by reviewing 868 articles published on the Web of Science database in the field of opportunity recognition. Accordingly, using statistical descriptions of articles, analyzing the communication network among elements such as authors, countries, institutions, keyword analysis in articles and examining their trends over time, identifying the most important articles using co-citation analysis and finally this macroimage has been mapped, clustered and identified in leading articles in the last decade by co-citation clustering.

**Findings** – The results of the clustering show that the five main clusters of recent decades have included entrepreneurial characteristics and opportunity recognition, macroeconomic opportunity recognition cluster (community and impact on economic development of the country), opportunity recognition process cluster, opportunity recognition cluster in serial and intra-entrepreneurship and opportunity recognition cluster in new venture internationalization.

**Originality/value** – Using a bibliometric analysis and co-citation analysis in the field of opportunity recognition and making a big picture of studies in this field of study is a contribution that can be used for future studies and researchers and managers in this field.

**Keywords** Opportunity recognition, Opportunity identification, Entrepreneurship, New venture creation, Co-citation clustering

**Paper type** Research paper

## 1. Introduction

According to Shane (2003), entrepreneurship is an activity created by identifying, evaluating and exploiting opportunities to introduce new product or service, organizational methods, markets, processes and new raw materials that did not exist in the past (Shane, 2003). As is evident in the definition of entrepreneurship, one of its key elements is opportunity. The concept of entrepreneurial opportunity is an umbrella that encompasses a wide range of activities to create new business (Wood, 2017). Entrepreneurial opportunity as a “Fundamental Concept” was first introduced in entrepreneurship research by Shane and Venkataraman in 2000 (Wood, 2017; Short *et al.*, 2010a). Gregor *et al.* (2010) consider opportunity as a planned approach for activities to provide a new or better supply–demand combination as well as a solution to reduce the supply and demand market imbalances (Song *et al.*, 2017; Can and Korkmaz, 2020). In other words, entrepreneurial opportunity is an activity whereby entrepreneurs come up with new ideas, new products and services (Foo *et al.*, 2015).

The number of published studies in the field of opportunity recognition is increasing and has reached its peak in the last (Angelsberger *et al.*, 2017). According to a trend analysis conducted by Busenitz *et al.* (2014), this trend will increase in the future and will soon



World Journal of Science,  
Technology and Sustainable  
Development  
Vol. 18 No. 3, 2021  
pp. 239-258

© Emerald Publishing Limited  
2042-5945  
DOI 10.1108/WJSTSD-04-2021-0042

become the most important issue in the field of entrepreneurship (Busenitz *et al.*, 2014). Even today, this issue is considered as the core of the entrepreneurial process (Angelsberger *et al.*, 2017; George *et al.*, 2016). Opportunity recognition is always influenced by several factors (Ardichvili *et al.*, 2003). Some of the most important factors include social capital, personality traits, knowledge of the environment, entrepreneurial alertness, systematic search, prior knowledge of individuals and many other such factors (George *et al.*, 2016; Shane, 2003).

In 2011, Hansen *et al.*, by studying 56 articles in the field of opportunity recognition, indicate that opportunity recognition is defined by different researchers from different perspectives and there is no agreement between these perspectives (Hansen *et al.*, 2011). Davidsson argues that experts in the field of opportunity recognition do not have the same ideas about the definition of this concept, and each of them looks at the issue from a different perspective. Some of them look at the issue from an individual perspective and others from an environmental perspective, and each has its own definitions (Davidsson, 2015). There are generally two categories of definitions for opportunity recognition in the literature. The first category is known as the Schumpeterian opportunity (Schumpeter and Nichol, 1934) and the second is the Kirznerian opportunity (Kirzner, 1973). The first category is known as innovation opportunity, and the second category is called arbitrage opportunity.

Research shows that there are generally four types of entrepreneurial opportunities. These four categories have been used in much research:

- (1) Bricolage: By using existing resources to create new value (Baker and Nelson, 2005; Garud and Karnøe, 2003).
- (2) Effectuation: Create a new combination using a set of possible tools with non-predictive control (Sarasvathy, 2001; Sarasvathy and Dew, 2005).
- (3) Improvisation: A conscious and fundamental integration of the design and implementation of a new product (Miner *et al.*, 2001; Crossan *et al.*, 2005).
- (4) Causation: Selecting between means to create an effect with predictive control (Sarasvathy, 2001).

One of the important points in the entrepreneurship literature is to address the possibility that opportunities are discovered or created (Maine *et al.*, 2015). Opportunity recognition theory assumes that vigilant entrepreneurs identify and exploit flaws in the market (Shane and Venkataraman, 2000). Some researchers agree that “opportunity, such as a mountain, exists as a real and objective phenomenon and is just waiting to be discovered and exploited” (Alvarez and Barney, 2007). In order to create this theory, the entrepreneur’s goal is to discover new opportunities, earlier than others and precise to create specific value as well as to create a new business (Shane, 2003; Kirzner, 1997). Opportunity creation theory assumes that the entrepreneurial tool or marketing plan is independent of the entrepreneur’s actions (Sarasvathy, 2001; Gartner, 1988; Alvarez and Barney, 2007). In fact, they believe that market opportunities do not exist objectively but must be created (Maine *et al.*, 2015). Given the distinction between these two perspectives, the focus of the present study is to explore and identify opportunities.

As stated, opportunity recognition is one of the key elements in entrepreneurship and is of particular importance (Shane and Venkataraman, 2000; Dimov, 2007). Opportunity recognition is a process that begins with the idea of the entrepreneur; and in this process, the idea is evaluated and validated. This process continues under uncertainty and with the risk-taking entrepreneur (Khalid and Sekiguchi, 2018; Haynie *et al.*, 2009). Overall it can be stated that the true spirit of opportunity recognition is in understanding the needs and wants of customers in the form of demand (Prandelli *et al.*, 2016). Shepherd *et al.* have argued that opportunity

recognition is a process for fully understanding the economic environment and its needs that entrepreneurial decision-making is only a small part of it (Shepherd *et al.*, 2015). Ozgen and Baron also believe that opportunity recognition is a set of activities that an entrepreneur does in seeking and identifying opportunities (Ozgen and Baron, 2007). In another study, Baron identifies opportunity recognition as a cognitive process through which individuals have identified an opportunity (Baron, 2006). Ozgen and Baron have similarly stated that opportunity recognition reflects the steps an entrepreneur takes to identify opportunities (Ozgen and Baron, 2007). Summing up the definitions provided by the researchers, it can be generally stated that opportunity recognition is a process (Shane, 2003; Kirzner, 1997) that goes by the entrepreneur in uncertain terms and is the central core of entrepreneurial activity (Song *et al.*, 2017). Opportunity recognition involves several steps, including identifying market needs, evaluating opportunities and entrepreneurial decision-making that may occur prior to the pre-startup, startup or business growth phase (Song *et al.*, 2017).

The necessity of dealing with the field of opportunity recognition and some of the most important articles in this field that are somehow underlying this field is fully explained in this section. The rising trend in the number of articles published in this field is another sign of the importance of addressing this issue. Accordingly, this study has attempted to provide a large picture of these articles by focusing on published articles in this field and using new methods of systematic analysis and review. For this purpose, bibliometric analysis and co-citation clustering, which is one of the new and widely used methods in the analysis of scientific fields and mapping of scientific maps, has been used. The contribution of this research is, using a new systematic literature review method using network analysis and a clustering method as a method of datamining in field of entrepreneurship. Also, this research makes a big picture of studies in the field of opportunity recognition and cluster, all of researches in five prominent clusters.

In the following, the research methodology and data are fully described and then in the third section, six layers of analysis of articles including distribution of research disciplines, authors of core articles, countries of articles' origin, research organizations, themes and fields of entrepreneurial ecosystem and top clusters of entrepreneurial environment research in the past decade are presented. Finally, in the final section, the research path, the results of this research and suggestions for future research are outlined.

## 2. Material and methods

### 2.1 Data collection

This research is designed to create a big picture of all the researches in the field of opportunity recognition. For this purpose, the Web of Science citation database was used to extract all valid published articles. To this end, the appropriate query is set for the February 1, 2020, article search, which incorporates opportunity recognition keywords such as opportunity recognition, opportunity identification, entrepreneurship and innovation.

The total of documentation identified in this query contains 1,194 items, which after finalizing articles indexed under two categories Science Citation Index Expanded (SCI-E) and Social Sciences Citation Index (SSCI), reached the final output of 868. These include 786 articles, 71 reviews, 20 proceeding papers and 1 book chapter. The first article published in this dataset is from 1991, and the largest number of published articles is from 2019, which is 121 articles. The upward trend in the number of articles in this field is quite evident and this growth rate has increased dramatically in the last two years. The largest number of published articles is related to the Journal of Business Venturing, which has 51 articles. The US is also the leader in this field with 356 articles. The following table shows the most prolific journals in this field (see Table 1).

Similarly, prolific writers in this field are also presented in the following table (see Table 2).

Further, more detailed and sophisticated analysis of all these elements are provided.

---

WJSTSD  
18,3

Source	Count
Journal of business venturing	51
Entrepreneurship theory and practice	46
Journal of small business management	24
Small business economics	24
International entrepreneurship and management journal	19
Strategic entrepreneurship journal	18
Sustainability	17
International journal of entrepreneurial behavior research	15

242

**Table 1.**  
Top rank sources

---

Author	Count
Baron, Robert A	15
Shepherd, Dean A	15
Lans, Thomas	12
Wright, Mike	12
Mulder, Martin	8

---

**Table 2.**  
Top rank authors

### 2.2 Bibliometric analysis

Bibliometric analysis as one of the statistical research methods was first introduced in 1990. There have been many applications to this method since then and other words such as Statistical Bibliography and SCIENSOMETRICS have been used (Osareh, 1996). In 1988, Potter divided this type of analysis into two categories. The first category is descriptive statistics, which include the amount of literature from a geographical perspective, authors, journals, years of publication and different fields. The second category, which requires further analysis, concerns the use of literature for the citation analysis (Potter, 1988), this method is based on references. Reference refers to the cases in which one article refers to another article, but citation refers to the cases in which one article is cited. Citation analysis does not mean simply referencing articles, but simultaneous analysis of citing and cited articles (Smith, 1981; Osareh, 1996). It is usually defined as the degree of relationship power between authors, based on the number of citations an author makes to another one. The same logic is used to measure the extent of communication power between countries, journals and articles (Osareh, 1996). Generally, citation analysis is defined as the analysis of the relationships between countries, authors and articles based on the extent of their citation (Diodato and Gellatly, 2013). Garfield noted in an article that citation analysis is used to show the progress of research (Garfield, 1983). Citation analysis has various types that can be defined such as direct citations (cited a new article by an older article), bibliographic coupling (relationship between articles) and co-citation coupling (relationship between documents cited) (Osareh, 1996). Bibliometric analysis as one of the most applicable statistical research methods has been used in numerous articles (Wu *et al.*, 2020; Shang *et al.*, 2020; Ekanayake *et al.*, 2019). Bibliometric analysis is also used in this paper to analyze articles in the field of opportunity recognition. For this purpose, first, the articles are analyzed using descriptive statistics and then the keywords and their citations are analyzed. Finally, the reviewed articles are clustered and the obtained clusters are also described.

This methodology has been used before for too many goals, such as supply chain (Xu *et al.*, 2018), sustainability and financial performance of small and medium sized enterprises (Bartolacci *et al.*, 2020), big data and dynamic capabilities (Rialti *et al.*, 2019), inclusive innovation (Mortazavi *et al.*, 2021) and too many other areas.

Number of papers in field of entrepreneurship and innovation management by bibliometric and clustering analysis is very low and need to expand, but other methods of systematic literature review, used too many times. For this reason, bibliometric analysis and clustering method has been used as a contribution for this research.

2.3 Paths of analysis

In this study, three types of analysis are generally used, including network analysis, keyword analysis and article clustering (Wu *et al.*, 2020). Network analysis is about analysis of the number of articles published, active countries, authors' collaboration networks, countries' collaboration networks, organizations' collaboration networks and more. Co-occurrence analysis and time zone chart of keywords include keyword analysis and the process of changing these keywords over time. The logic of the analysis at this stage is text mining. Clustering by co-citation clustering is including co-cited clustering core papers. In this way, the grid is drawn between the cited articles and the clusters of articles are separated based on the similarity of these articles based on the words used in their title, abstract and vocabulary. In order to identify the leading articles in this research, articles published in the last ten years have been used for analysis. After identifying the clusters in this method, the text of articles related to each cluster is studied and after analyzing the content, the description of each cluster and its main articles is analyzed and described.

3. Results and discussion

3.1 Publication trend

In this article, according to the purpose of the study, a total of 868 articles have been presented since 1991. The trend of article publishing in this area has been upward and the growth rate of this chart has grown substantially since 2015, reaching its highest level in 2019, reaching 121 articles. The number of articles published in 2020 is only 18. Given that the survey data were extracted on February 1, it is reasonable to underestimate it, as only 2 months have passed since 2020. The figure below illustrates this trend and the number of articles per year (see Figure 1).

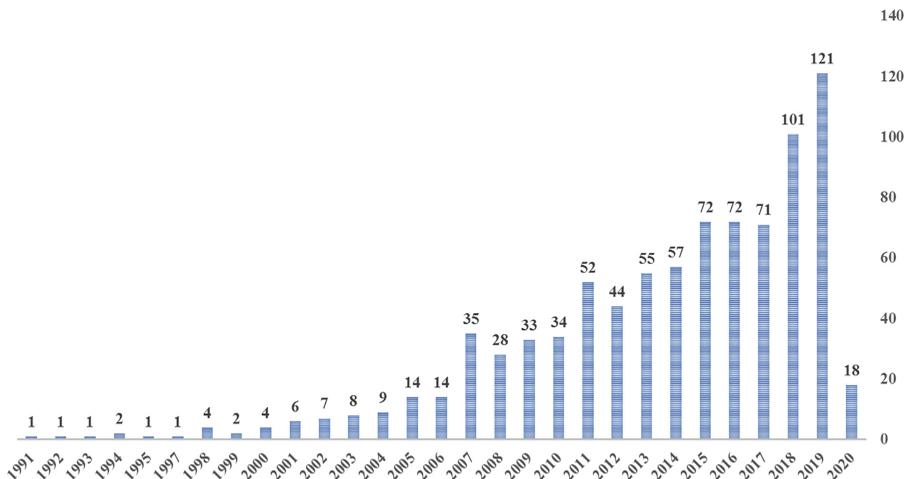


Figure 1.  
Trend of published  
papers

3.2 *Distribution of research disciplines*

In this section, the research disciplines map in the field of opportunity recognition is examined. To draw this map, the measure of betweenness-centrality among the disciplines is used. A total of 58 nodes (*n*) and 184 edges (*e*) have been identified in this analysis. The highest index of betweenness-centrality was in business and economics (0.76) and occupied 581 articles. Then engineering (0.25), healthcare sciences and services (0.22), management (0.18), psychology (0.12) and science and technology, other topics (0.11) are more than 0.1 centralized. Other categories have a centrality of less than 0.1. The largest number of articles were in business and economics (581), business (412), management (379), engineering (86), environmental sciences and ecology (58) and economics (56), respectively, with more than 50 articles in themselves. The following figure shows the map derived from these categories (see Figure 2).

3.3 *Authors of core articles*

The authors' communication network was a total of 57 authors and 32 communication paths between them. Among these authors' network, 5 authors have more than 4 articles, most with ROBERT A BARON with 7 articles. Other authors with the most articles include THOMAS LANS (6), MIKE WRIGHT (6), DEAN A SHEPHERD (6) and ANDREW C CORBETT (4). The following figure illustrates the communication network between authors. The names of authors who have had more than 2 articles appear on this network (see Figure 3).

3.4 *Countries of articles' origin*

In this section, the communication network between authors' countries is shown. It has 39 nodes and 218 edges. The US is the largest node in the network, with 350 articles and a 0.55

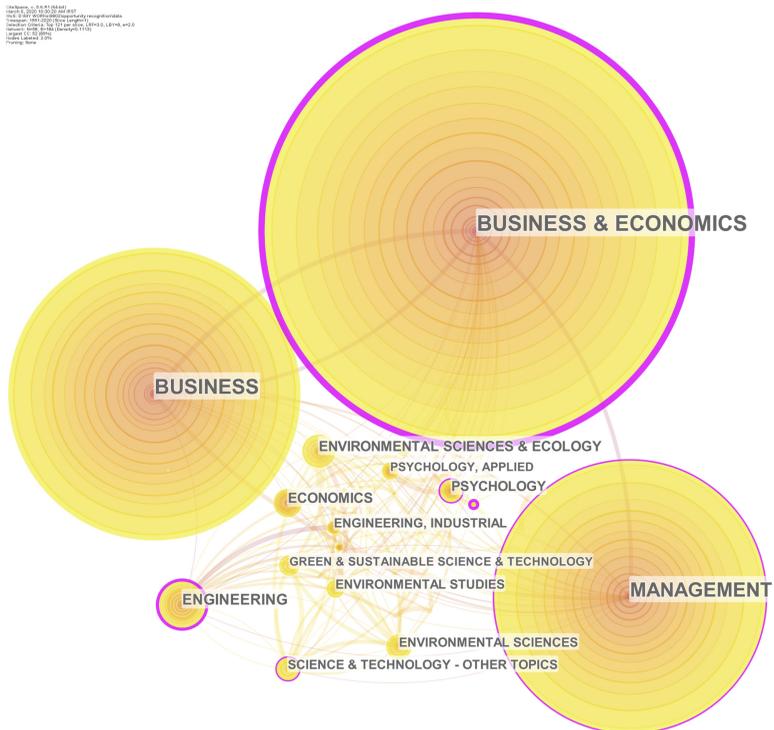
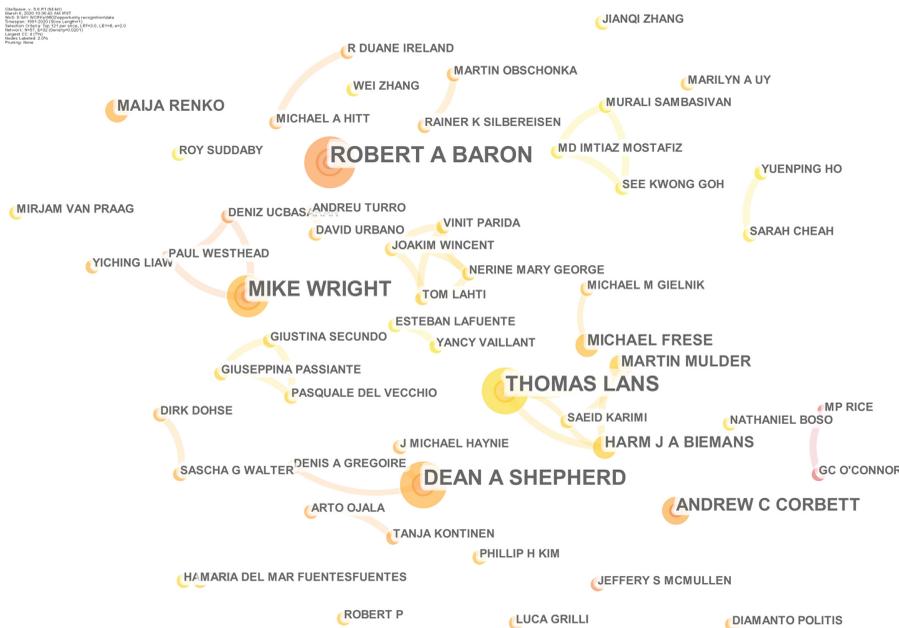


Figure 2.  
Distribution of main  
research disciplines

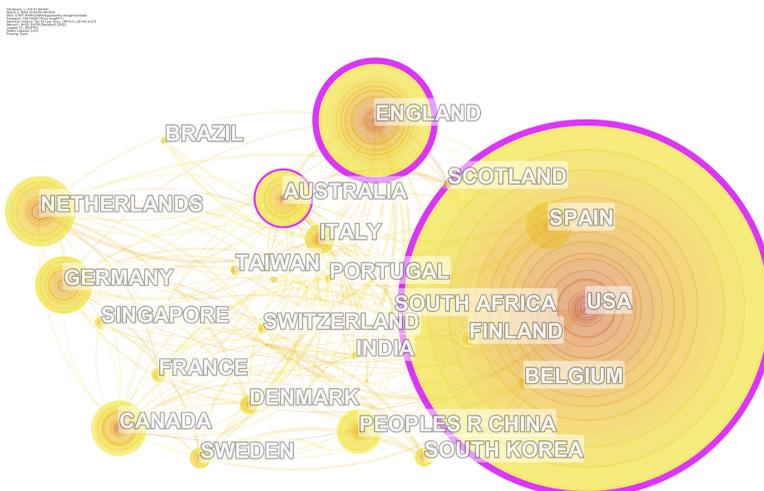


**Figure 3.**  
Authors' network of  
core articles

betweenness-centrality. The most prolific countries in this area are England with 115 papers and 0.44 papers and the Netherlands 72 papers and papers 0.04, Canada 61 papers 0.03, Germany 61 papers 0.03, Australia 55 papers 0.16 and Spain 50 papers 0.04. There are countries with more than 50 articles (see Figure 4).

### 3.5 Research organizations

Organizations active in a scientific field and collaborating with one another are one of the most important elements in scientific papers and research. In the area of opportunity



**Figure 4.**  
Main countries of  
articles' origin

recognition, 117 nodes and 60 edges have been identified, with a maximum of 18 published articles. Indiana University, Rensselaer Polytechnic Institute and Wageningen University and Research, National University of Singapore, The University of Queensland, University of Illinois and University College London have published more than 5 articles in this field (see Figure 5).

3.6 Themes and fields of entrepreneurial ecosystem

This section deals with keywords co-occurrence analysis and after removing some inappropriate words from the network, the desired analysis is performed. The analysis shows that the most commonly used words over time include performance (178), opportunity identification (173), opportunity recognition (170), innovation (147), entrepreneurship (130) and knowledge (99). On the other hand, the 10 keywords with the most centrality are performance, opportunity identification, opportunity recognition, knowledge and innovation, respectively. These keywords are more than 0.1 in the centrality index. In addition to the above, the most important keywords used after 2018 that have been repeated more than 5 times, including motivation, personality, market, entrepreneurship education, mediating role, enterprise, determinant, moderating role, opportunity recognition, intention, dynamic capability, behavior is exploration, work and sustainable entrepreneurship. The path to using keywords over time has been thoroughly outlined in the time zone section. The following image illustrates the keywords used in the articles under review that cover all of the items in this section (see Figure 6).

In this section, time zone vocabulary is outlined to better understand the development process and the extent to which different keywords are used over time. The time zone shown in the image below shows all keywords from 1991 to 2020 continuously from left to right. The closer we get to the right, the closer we are to the present, and the closer we get to the left, we get closer to 1991. The large size of the nodes mark indicates the repeatability of them in all the articles reviewed. In the background of this figure, the differentiation of the years is

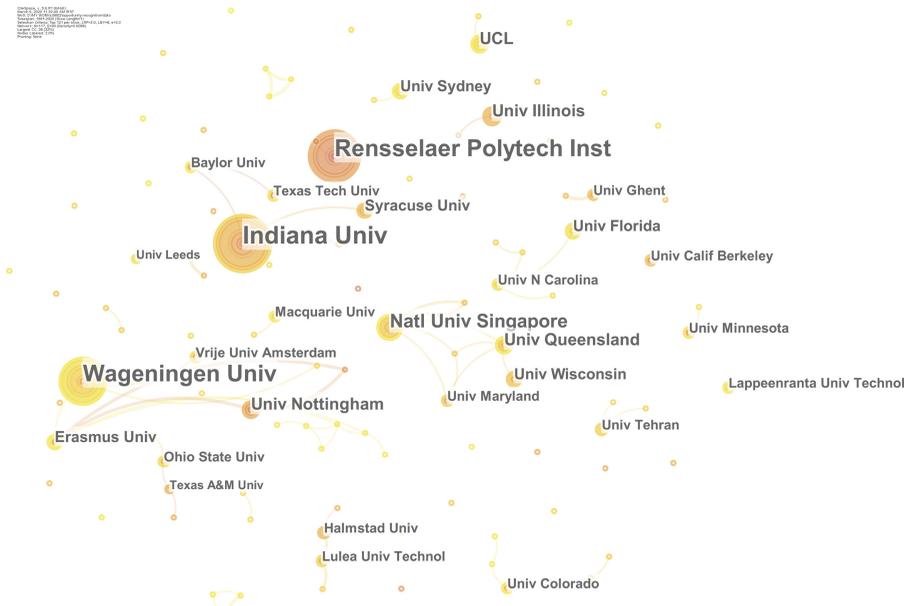


Figure 5.  
Main research  
organizations



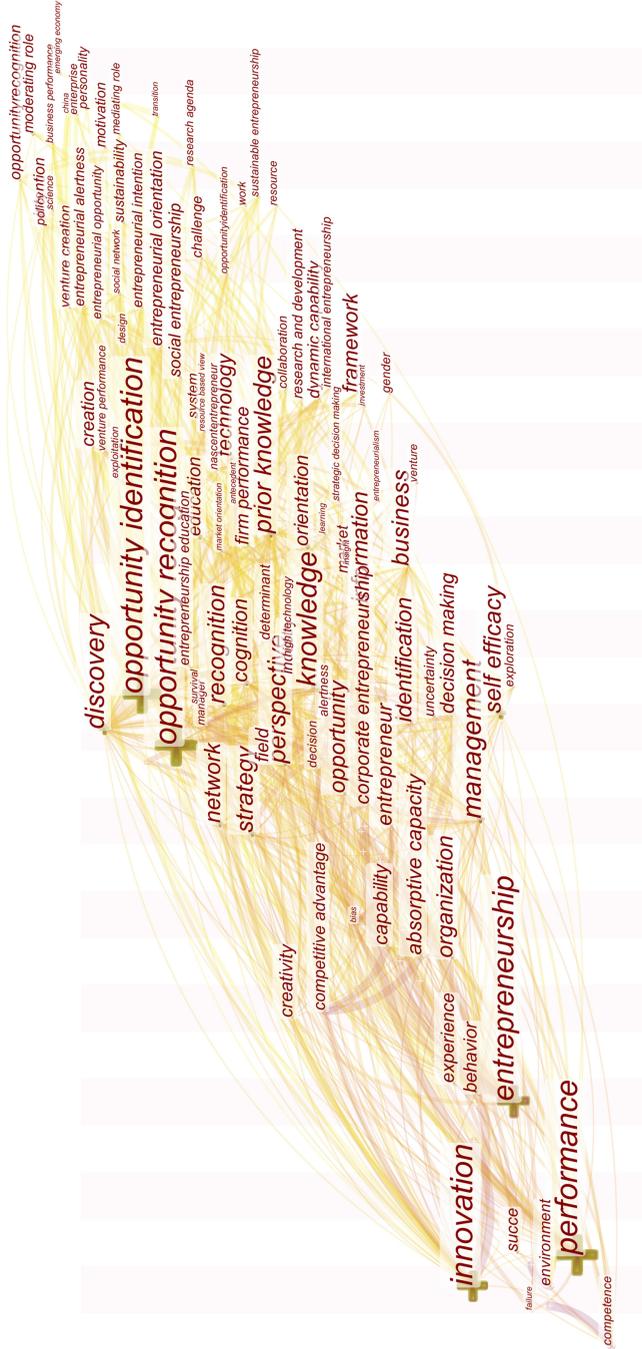
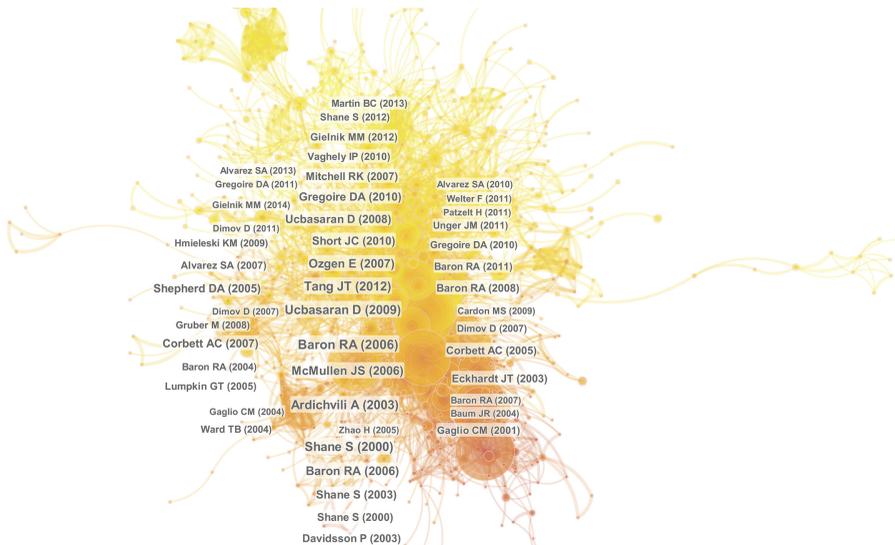


Figure 7.  
Time zone chart of  
keywords



**Figure 8.**  
Co-citation references

with the largest number of members and the largest distinction in mutual terms were selected and the articles related to each cluster were studied. The figure of the identified clusters is as follows (see Figure 9).

The Table 4 summarizes the information on these clusters. This table presents the number of clusters, the number of articles within the cluster, the silhouette index, the average year of publication of the cluster articles and the keywords commonly used among the articles in each domain.

**3.7.1 Cluster 1—entrepreneurial characteristics and opportunity recognition.** This cluster has the largest number of articles and holds 154 articles. Most of the articles in this cluster have examined the individual characteristics of an entrepreneur in identifying opportunities (Delgado García *et al.*, 2015). Among the most important relationships examined in the articles of this cluster are the relation between entrepreneurial behavior and opportunity recognition (Bird *et al.*, 2012), the relationship between psychological characteristics of entrepreneur and opportunity identifier (Frese and Gielnik, 2014), the relationship between cognitive factors and opportunity recognition (Grégoire *et al.*, 2015), the relationship between past experiences of entrepreneurship and opportunity recognition (Vandor and Franke, 2016; Clarysse *et al.*, 2011), the relationship between entrepreneurial passion and entrepreneurial alertness and opportunity recognition (Ma *et al.*, 2020; Bao *et al.*, 2017) and the relationship between entrepreneur self-efficacy and opportunity recognition (Trevelyan, 2011).

**3.7.2 Cluster 2—recognizing macro-level opportunity (community and impact on country's economic development).** Most papers in this cluster have explored the concept of opportunity recognition at the macro level. This level includes social entrepreneurship, sustainable development, economic development and etc. Social entrepreneurship and opportunity recognition for social purposes is one of the most important issues in this field and has received numerous articles (Zahra *et al.*, 2014; Yitshaki and Kropp, 2016; Wry and York, 2017; Perrini *et al.*, 2010). Among the main articles in this field are corner article (2010) entitled “How opportunities develop in social entrepreneurship” (Corner and HO, 2010). In addition to social entrepreneurship, the second batch of papers in this cluster focus on sustainable opportunity recognition, sustainable development and macroeconomic development (Ploum *et al.*, 2018; Filser *et al.*, 2019; Ceptureanu *et al.*, 2017; Belz and Binder, 2017). In total, it can be stated that

Count	year	Topic	Author
68	2006	Opportunity recognition as the detection of meaningful patterns: Evidence from comparisons of novice and experienced entrepreneurs <a href="#">Baron and Ensley (2006)</a>	Baron, RA
54	2012	Entrepreneurial alertness in the pursuit of new opportunities <a href="#">Tang et al. (2012)</a>	Tang, JT
54	2009	The extent and nature of opportunity identification by experienced entrepreneurs <a href="#">Ucbasaran et al. (2009)</a>	Ucbasaran D
51	2003	A theory of entrepreneurial opportunity identification and development <a href="#">Ardichvili et al. (2003)</a>	Ardichvili A
51	2000	The promise of entrepreneurship as a field of research <a href="#">Shane and Venkataraman (2000)</a>	Shane S
48	2006	Entrepreneurial action and the role of uncertainty in the theory of the entrepreneur <a href="#">McMullen and Shepherd (2006)</a>	McMullen JS
47	2006	Opportunity recognition as pattern recognition: How entrepreneurs “connect the dots” to identify new business opportunities <a href="#">Baron (2006)</a>	Baron RA
47	2007	Social sources of information in opportunity recognition: Effects of mentors, industry networks, and professional forums <a href="#">Ozgen and Baron (2007)</a>	Ozgen E
40	2010	The concept of “opportunity” in entrepreneurship research: Past accomplishments and future challenges <a href="#">Short et al. (2010b)</a>	Short JC
38	2008	The extent and nature of opportunity identification by experienced entrepreneurs <a href="#">Ucbasaran et al. (2009)</a>	Ucbasaran D
35	2003	A general theory of entrepreneurship: The individual-opportunity nexus <a href="#">Shane (2003)</a>	Shane S
34	2005	Prior knowledge, potential financial reward, and opportunity identification <a href="#">Shepherd and Detienne (2005)</a>	Shepherd DA
34	2007	Learning asymmetries and the discovery of entrepreneurial opportunities <a href="#">Shepherd and Detienne (2005)</a>	Corbett AC
34	2010	Cognitive processes of opportunity recognition: The role of structural alignment <a href="#">Grégoire et al. (2010)</a>	Gregoire DA
32	2005	Experiential learning within the process of opportunity identification and exploitation <a href="#">Corbett (2005)</a>	Corbett AC
32	2000	Prior knowledge and the discovery of entrepreneurial opportunities <a href="#">Shane (2000)</a>	Shane S
31	2003	Opportunities and entrepreneurship <a href="#">Eckhart and Shane (2003)</a>	Eckhardt JT
30	2008	The role of affect in the entrepreneurial process <a href="#">Baron (2008)</a>	Baron RA
29	2003	The role of social and human capital among nascent entrepreneurs <a href="#">Davidsson and Honig (2003)</a>	Davidsson P
28	2007	The central question in entrepreneurial cognition research 2007 <a href="#">Mitchell et al. (2007)</a>	Mitchell RK
27	2001	The psychological basis of opportunity identification: Entrepreneurial alertness <a href="#">Gaglio and Katz (2001)</a>	Gaglio CM
26	2010	Are opportunities recognized or constructed?: An information perspective on entrepreneurial opportunity identification <a href="#">Vaghely and Julien (2010)</a>	Vaghely IP
25	2007	Discovery and creation: Alternative theories of entrepreneurial action <a href="#">Alvarez and Barney (2007)</a>	Alvarez SA

**Table 3.**  
Top co-cited references  
(cited more than 25)

this cluster contains 108 articles examining opportunity recognition at the macro and community level and its impact on sustainable development.

*3.7.3 Cluster 3—opportunity recognition process.* A process perspective on opportunity recognition is another cluster identified in this study that includes 93 articles. In general, the articles in this cluster have focused on understanding how opportunity has been identified and discussed with different approaches ([Webb et al., 2011](#); [Tang, 2010](#); [Murphy, 2011](#)). Two of the main articles in this cluster are “Investigating how opportunity recognition in China” in 2010 and “Cognitive processes of opportunity recognition” in 2010 ([Gregoire et al., 2010](#)).



Cluster id	Size	Silhouette	Mean(year)	Top terms
1	154	0.606	2009	new venture team; information acquisition; information processing; dispositional positive; entrepreneurial experience; employment experience; activation influence; entrepreneur identity aspiration; cognitive perspective; Schumpeterian entrepreneur; innovative entrepreneurship; intentional pursuit; entrepreneurial-experience curve; entrepreneurial passion; entrepreneurial judgment; venture-specific experience; entrepreneurial intention; cognitive influence; entrepreneurial orientation; entrepreneurial alertness; entrepreneurial creativity
2	108	0.672	2010	entrepreneurial opportunity recognition; social entrepreneurship; sustainable development; influencing factor; medium enterprises; scaling-up social change; entrepreneurial opportunities; foreign market opportunities; nascent entrepreneurs personality attribute; sustainable entrepreneurship; individual moral antecedent; technology-market combination; sustainable opportunities
3	93	0.716	2005	entrepreneurship research; measuring opportunity-recognition belief; idea set; cognitive processes; philosophical foundation; radical Austrian approach; creating value; strategic entrepreneurship; opportunity recognition; institutional view; entrepreneurial opportunity identification; entrepreneurial discovery theory; entrepreneurial action; marketing activities
4	85	0.86	2014	serial entrepreneur; contextualizing entrepreneurship; funder self-efficacy; equity crowd funding; entrepreneurial resilience; subsequent venture; intrapreneurial employee; increased international propensity; demonstrating ambidextrous strategic agility; students innovation; entrepreneurship education influence
5	81	0.752	2014	entrepreneurial opportunity; peasant entrepreneurship; entrepreneurial effort; regional poverty level; non-productive entrepreneurship; institutional factor; social opportunity recognition; south Africa; moral judgment; international new venture; early development; cognitive theory perspective

**Table 4.**  
High-frequency  
clusters of co-citation  
clustering (top 5  
clusters)

#### 4. Conclusion

The purpose of this study is to provide a systematic literature review based on bibliometric analysis in the field of entrepreneurial opportunity recognition. For this purpose, all articles published in the field of opportunity recognition and identification in the Web of Science citation database were used in this study. Initial searches of the database comprise a total of 1,194, which, after filtering by two categories, the Science Citation Index Expanded (SCI-E) and the Social Sciences Citation Index (SSCI), left 868 scientific papers. These include 786 articles, 71 reviews, 20 proceeding papers, and 1 book chapter covering 1991 to 2020. The analysis performed in this paper comprises three different types of bibliometric analysis including network analysis, co-occurrence analysis and time zone chart of keywords and co-citation clustering analysis of the research fronts. In addition, other statistical data related to article data are also provided. This study attempts to present a large picture of the field of entrepreneurial opportunity recognition.

The contribution of this research is, using new systematic literature review method using network analysis and clustering method as a method of data mining in field of entrepreneurship. Also, this research makes a big picture of studies in the field of opportunity recognition and cluster, all of researches in 5 prominent clusters.

The trend of articles in this field has been quite upward and started in 1991. The largest number of articles published in the years was 2019, with 121 records. Analyses show that the most commonly used terms in the articles, such as performance, opportunity identification, opportunity recognition, innovation and entrepreneurship, had the highest number of duplicates. In recent years, more research has been focused on sustainable development and opportunity recognition at the macro level, as well as investigating the impact of entrepreneur's individual characteristics on the opportunity recognition process. Examination of keyword time trends shows that the two terms opportunity identification and opportunity recognition have been used extensively in the literature since 2005 onwards.

After analyzing keywords, two main categories were analyzed using co-citation analysis. In the first section, the most important articles cited more than 25 times in the articles reviewed in this study are identified. The most important article, cited 68 times in total, is Baron's (2006) article entitled "opportunity recognition as the detection of meaningful patterns: evidence from comparisons of novice and experienced entrepreneurs" (Baron and Ensley, 2006). After that the article of Tang in 2012 with a total of 54 citations (Tang *et al.*, 2012) and Ucbasaran in 2009 with a total of 54 citations (Ucbasaran *et al.*, 2009) are the most cited articles in this field. In addition, in order to identify the most important clusters of the last decade, five main clusters have been identified among the 2010–2020 articles. Co-citation clustering is also used for this purpose. The identified clusters include entrepreneurial characteristics and opportunity recognition cluster, macroeconomic opportunity recognition cluster (community and impact on economic development of the country), opportunity recognition process cluster, opportunity recognition cluster in serial and intra-organizational entrepreneurship, opportunity recognition cluster and new venture internationalization. These 5 clusters have the largest number of articles; therefore, in view of the importance of these clusters, it is suggested that in future research, a systematic in-depth study of each of these 5 clusters should be done to minimize their dark spots. This will map out the researchers' roadmap for future research in the field of opportunity recognition.

In addition, it is suggested that in future research, the characteristics of the entrepreneur who affect the effectiveness of the individual in recognizing the opportunity be identified and this model be evaluated on different entrepreneurs. On the other hand, it is possible to identify effective environmental criteria and separately assess its impact on identifying the opportunity of entrepreneurs. Given that the macro level has been identified as an important level in opportunity recognition research, it is suggested that the impact of institutions on entrepreneurship in the opportunity recognition process be evaluated and using the case analysis method, several accelerators, incubators and the Science and Technology Park, analyzed and compared for this purpose. It is suggested that in future research, by using the method of systematic study of literature and also combining it with the methods of qualitative analysis, the process of opportunity recognition in different types of countries, including developed, developing and underdeveloped, be identified and compared between these processes. Comparing these processes can have a significant impact at the macro level and policymaking.

## References

- Alvarez, S.A. and Barney, J.B. (2007), "Discovery and creation: alternative theories of entrepreneurial action", *Strategic Entrepreneurship Journal*, Vol. 1, pp. 11-26.
- Angelsberger, M., Kraus, S., Mas-Tur, A. and Roig-Tierno, N. (2017), "International opportunity recognition: an overview", *Journal of Small Business Strategy*, Vol. 27, pp. 19-36.
- Ardichvili, A., Cardozo, R. and Ray, S. (2003), "A theory of entrepreneurial opportunity identification and development", *Journal of Business Venturing*, Vol. 18, pp. 105-123.

- Baker, T. and Nelson, R.E. (2005), "Creating something from nothing: resource construction through entrepreneurial bricolage", *Administrative Science Quarterly*, Vol. 50, pp. 329-366.
- Bao, J., Zhou, X. and Chen, Y. (2017), "Entrepreneurial passion and behaviors: opportunity recognition as a mediator", *Social Behavior and Personality: An International Journal*, Vol. 45, pp. 1211-1220.
- Baron, R.A. (2006), "Opportunity recognition as pattern recognition: how entrepreneurs 'connect the dots' to identify new business opportunities", *Academy of Management Perspectives*, Vol. 20, pp. 104-119.
- Baron, R.A. (2008), "The role of affect in the entrepreneurial process", *Academy of Management Review*, Vol. 33, pp. 328-340.
- Baron, R.A. and Ensley, M.D. (2006), "Opportunity recognition as the detection of meaningful patterns: evidence from comparisons of novice and experienced entrepreneurs", *Management Science*, Vol. 52, pp. 1331-1344.
- Bartolacci, F., Caputo, A. and Soverchia, M. (2020), "Sustainability and financial performance of small and medium sized enterprises: a bibliometric and systematic literature review", *Business Strategy and the Environment*, Vol. 29, pp. 1297-1309.
- Belz, F.M. and Binder, J.K. (2017), "Sustainable entrepreneurship: a convergent process model", *Business Strategy and the Environment*, Vol. 26, pp. 1-17.
- Bird, B., Schjoedt, L. and Baum, J.R. (2012), "Editor's introduction. Entrepreneurs' behavior: elucidation and measurement", *Entrepreneurship: Theory and Practice*, Vol. 36, pp. 889-913.
- Busenitz, L.W., Plummer, L.A., Klotz, A.C., Shahzad, A. and Rhoads, K. (2014), *Entrepreneurship Research (1985-2009) and the Emergence of Opportunities*, SAGE Publications Sage CA, Los Angeles, CA.
- Can, H. and Korkmaz, Ö. (2020), "The relationship between renewable energy consumption and economic growth: the case of Bulgaria", *International Journal of Energy Sector Management*, Vol. 13 No. 3, pp. 573-589, doi: [10.1108/IJESM-11-2017-0005](https://doi.org/10.1108/IJESM-11-2017-0005).
- Captureanu, E.G., Ceptureanu, S.-I., Orzan, M.C., Bordean, O.N. and Radulescu, V. (2017), "Empirical study on sustainable opportunities recognition. A polyvinyl chloride (PVC) joinery industry analysis using augmented sustainable development process model", *Sustainability*, Vol. 9, p. 1779.
- Clarysse, B., Tartari, V. and Salter, A. (2011), "The impact of entrepreneurial capacity, experience and organizational support on academic entrepreneurship", *Research Policy*, Vol. 40, pp. 1084-1093.
- Corbett, A.C. (2005), "Experiential learning within the process of opportunity identification and exploitation", *Entrepreneurship: Theory and Practice*, Vol. 29, pp. 473-491.
- Corner, P.D. and Ho, M. (2010), "How opportunities develop in social entrepreneurship", *Entrepreneurship: Theory and Practice*, Vol. 34, pp. 635-659.
- Crossan, M., Cunha, M.P.E., Vera, D. and Cunha, J. (2005), "Time and organizational improvisation", *Academy of Management Review*, Vol. 30, pp. 129-145.
- Davidsson, P. (2015), "Entrepreneurial opportunities and the entrepreneurship nexus: a re-conceptualization", *Journal of Business Venturing*, Vol. 30, pp. 674-695.
- Davidsson, P. and Honig, B. (2003), "The role of social and human capital among nascent entrepreneurs", *Journal of Business Venturing*, Vol. 18, pp. 301-331.
- Delgado García, J.B., DE Quevedo Puente, E. and Blanco Mazagatos, V. (2015), "How affect relates to entrepreneurship: a systematic review of the literature and research agenda", *International Journal of Management Reviews*, Vol. 17, pp. 191-211.
- Dimov, D. (2007), "Beyond the single-person, single-insight attribution in understanding entrepreneurial opportunities", *Entrepreneurship: Theory and Practice*, Vol. 31, pp. 713-731.
- Diodato, V.P. and Gellatly, P. (2013), *Dictionary of Bibliometrics*, Routledge, Binghamton, NY.
- Eckhart, J. and Shane, S. (2003), "Opportunities and entrepreneurship", *Journal of Management*, Vol. 29, pp. 333-349.

- Ekanayake, E.M.A.C., Shen, G. and Kumaraswamy, M.M. (2019), "Mapping the knowledge domains of value management: a bibliometric approach", *Engineering Construction and Architectural Management*, Vol. 26 No. 3, pp. 499-514, doi: [10.1108/ECAM-06-2018-0252](https://doi.org/10.1108/ECAM-06-2018-0252).
- Filser, M., Kraus, S., Roig-Tierno, N., Kailer, N. and Fischer, U. (2019), "Entrepreneurship as catalyst for sustainable development: opening the black box", *Sustainability*, Vol. 11, p. 4503.
- Foo, M.D., Uy, M.A. and Murnieks, C. (2015), "Beyond affective valence: untangling valence and activation influences on opportunity identification", *Entrepreneurship: Theory and Practice*, Vol. 39, pp. 407-431.
- Frese, M. and Gielnik, M.M. (2014), "The psychology of entrepreneurship", *Annual Review of Organizational Psychology and Organizational Behavior*, Vol. 1, pp. 413-438.
- Gaglio, C.M. and Katz, J.A. (2001), "The psychological basis of opportunity identification: entrepreneurial alertness", *Small Business Economics*, Vol. 16, pp. 95-111.
- Garfield, E. (1983), "How to use journal-citation-reports, including a special salute to the Johns-Hopkins-medical-journal", *Current Contents*, pp. 5-12.
- Gartner, W.B. (1988), "'Who is an entrepreneur?' is the wrong question", *American Journal of Small Business*, Vol. 12, pp. 11-32.
- Garud, R. and Karnøe, P. (2003), "Bricolage versus breakthrough: distributed and embedded agency in technology entrepreneurship", *Research Policy*, Vol. 32, pp. 277-300.
- George, N.M., Parida, V., Lahti, T. and Wincent, J. (2016), "A systematic literature review of entrepreneurial opportunity recognition: insights on influencing factors", *International Entrepreneurship and Management Journal*, Vol. 12, pp. 309-350.
- Grégoire, D.A., Barr, P.S. and Shepherd, D.A. (2010), "Cognitive processes of opportunity recognition: the role of structural alignment", *Organization Science*, Vol. 21, pp. 413-431.
- Grégoire, D.A., Cornelissen, J., Dimov, D. and Van Burg, E. (2015), "The mind in the middle: taking stock of affect and cognition research in entrepreneurship", *International Journal of Management Reviews*, Vol. 17, pp. 125-142.
- Gregoire, D.A., Shepherd, D.A. and Schurer Lambert, L. (2010), "Measuring opportunity-recognition beliefs: illustrating and validating an experimental approach", *Organizational Research Methods*, Vol. 13, pp. 114-145.
- Hansen, D.J., Shrader, R. and Monllor, J. (2011), "Defragmenting definitions of entrepreneurial opportunity", *Journal of Small Business Management*, Vol. 49, pp. 283-304.
- Haynie, J.M., Shepherd, D.A. and McMullen, J.S. (2009), "An opportunity for me? The role of resources in opportunity evaluation decisions", *Journal of Management Studies*, Vol. 46, pp. 337-361.
- Hitt, M.A., Ireland, R.D., Sirmon, D.G. and Trahms, C.A. (2011), "Strategic entrepreneurship: creating value for individuals, organizations, and society", *Academy of Management Perspectives*, Vol. 25, pp. 57-75.
- Khalid, S. and Sekiguchi, T. (2018), "The role of empathy in entrepreneurial opportunity recognition: an experimental study in Japan and Pakistan", *Journal of Business Venturing Insights*, Vol. 9, pp. 1-9.
- Kirwan, P., Ratinho, T., Van Der Sijde, P. and Groen, A.J. (2019), "The early development of International New Ventures: a multidimensional exploration", *International Journal of Entrepreneurial Behavior and Research*, Vol. 25 No. 6, pp. 1340-1367, doi: [10.1108/IJEBR-12-2017-0508](https://doi.org/10.1108/IJEBR-12-2017-0508).
- Kirzner, I. (1973), *Competition and Entrepreneurship*, University of Chicago Press, Chicago.
- Kirzner, I.M. (1997), "Entrepreneurial discovery and the competitive market process: an Austrian approach", *Journal of Economic Literature*, Vol. 35, pp. 60-85.
- Kiss, A.N., Danis, W.M., Nair, S. and Suddaby, R. (2019), "Accidental tourists? A cognitive exploration of serendipitous internationalisation", *International Small Business Journal*, Vol. 38 No. 2, pp. 65-89.

- Lafuente, E., Vaillant, Y., Vendrell-Herrero, F. and Gomes, E. (2019), "Bouncing back from failure: entrepreneurial resilience and the internationalisation of subsequent ventures created by serial entrepreneurs", *Applied Psychology*, Vol. 68, pp. 658-694.
- Ma, C., Yang, J., Chen, L., You, X., Zhang, W. and Chen, Y. (2020), "Entrepreneurs' social networks and opportunity identification: entrepreneurial passion and entrepreneurial alertness as moderators", *Social Behavior and Personality: An International Journal*, Vol. 48, pp. 1-12.
- Maine, E., Soh, P.H. and Dos Santos, N. (2015), "The role of entrepreneurial decision-making in opportunity creation and recognition", *Technovation*, Vol. 39, pp. 53-72.
- Mcmullen, J.S. and Shepherd, D.A. (2006), "Entrepreneurial action and the role of uncertainty in the theory of the entrepreneur", *Academy of Management Review*, Vol. 31, pp. 132-152.
- Miner, A.S., Bassof, P. and Moorman, C. (2001), "Organizational improvisation and learning: a field study", *Administrative Science Quarterly*, Vol. 46, pp. 304-337.
- Mitchell, R.K., Busenitz, L.W., Bird, B., Marie Gaglio, C., McMullen, J.S., Morse, E.A. and Smith, J.B. (2007), "The central question in entrepreneurial cognition research 2007", *Entrepreneurship: Theory and Practice*, Vol. 31, pp. 1-27.
- Mortazavi, S., Eslami, M.H., Hajikhani, A. and Vääätänen, J. (2021), "Mapping inclusive innovation: a bibliometric study and literature review", *Journal of Business Research*, Vol. 122, pp. 736-750.
- Murphy, P.J. (2011), "A 2x2 conceptual foundation for entrepreneurial discovery theory", *Entrepreneurship: Theory and Practice*, Vol. 35, pp. 359-374.
- Neessen, P.C., Caniels, M.C., VOS, B. and DE JONG, J.P. (2019), "The intrapreneurial employee: toward an integrated model of intrapreneurship and research agenda", *International Entrepreneurship and Management Journal*, Vol. 15, pp. 545-571.
- Osareh, F. (1996), "Bibliometrics, citation analysis and co-citation analysis: a review of literature I", *Libri - International Journal of Libraries and Information Services*, Vol. 46, pp. 149-158.
- Ozgen, E. and Baron, R.A. (2007), "Social sources of information in opportunity recognition: effects of mentors, industry networks, and professional forums", *Journal of Business Venturing*, Vol. 22, pp. 174-192.
- Perrini, F., Vurro, C. and Costanzo, L.A. (2010), "A process-based view of social entrepreneurship: from opportunity identification to scaling-up social change in the case of San Patignano", *Entrepreneurship and Regional Development*, Vol. 22, pp. 515-534.
- Ploum, L., Blok, V., Lans, T. and Omta, O. (2018), "Exploring the relation between individual moral antecedents and entrepreneurial opportunity recognition for sustainable development", *Journal of Cleaner Production*, Vol. 172, pp. 1582-1591.
- Potter, W.G. (1988), "Of making many books there is no end: bibliometrics and libraries", *Journal of Academic Librarianship*, Vol. 14, pp. 238a-38c.
- Prandelli, E., Pasquini, M. and Verona, G. (2016), "In user's shoes: an experimental design on the role of perspective taking in discovering entrepreneurial opportunities", *Journal of Business Venturing*, Vol. 31, pp. 287-301.
- Prashantham, S. and Floyd, S.W. (2019), "Navigating liminality in new venture internationalization", *Journal of Business Venturing*, Vol. 34, pp. 513-527.
- Rialti, R., Marzi, G., Ciappei, C. and Busso, D. (2019), "Big data and dynamic capabilities: a bibliometric analysis and systematic literature review", *Management Decision*, Vol. 57 No. 8, pp. 2052-2068, doi: [10.1108/MD-07-2018-0821](https://doi.org/10.1108/MD-07-2018-0821).
- Rigtering, J.C., Weitzel, G.U. and Muehlfeld, K.K. (2019), "Increasing quantity without compromising quality: how managerial framing affects intrapreneurship", *Journal of Business Venturing*, Vol. 34, pp. 224-241.
- Santos-Álvarez, V. and García-Merino, T. (2010), "The role of the entrepreneur in identifying international expansion as a strategic opportunity", *International Journal of Information Management*, Vol. 30, pp. 512-520.

- Sarasvathy, S.D. (2001), "Causation and effectuation: toward a theoretical shift from economic inevitability to entrepreneurial contingency", *Academy of Management Review*, Vol. 26, pp. 243-263.
- Sarasvathy, S.D. and Dew, N. (2005), "New market creation through transformation", *Journal of Evolutionary Economics*, Vol. 15, pp. 533-565.
- Schumpeter, J.A. and Nichol, A.J. (1934), "Robinson's economics of imperfect competition", *Journal of Political Economy*, Vol. 42 No. 2, pp. 249-259.
- Shane, S. (2000), "Prior knowledge and the discovery of entrepreneurial opportunities", *Organization Science*, Vol. 11, pp. 448-469.
- Shane, S.A. (2003), *A General Theory of Entrepreneurship: The Individual-Opportunity Nexus*, Edward Elgar Publishing, Cheltenham and Northampton, MA.
- Shane, S. and Venkataraman, S. (2000), "The promise of entrepreneurship as a field of research", *Academy of Management Review*, Vol. 25, pp. 217-226.
- Shang, T., Miao, X. and Abdul, W. (2020), "A historical review and bibliometric analysis of disruptive innovation", *International Journal of Innovation Science*, Vol. 11 No. 2, pp. 208-226, doi: [10.1108/IJIS-05-2018-0056](https://doi.org/10.1108/IJIS-05-2018-0056).
- Shepherd, D.A. and Detienne, D.R. (2005), "Prior knowledge, potential financial reward, and opportunity identification", *Entrepreneurship: Theory and Practice*, Vol. 29, pp. 91-112.
- Shepherd, D.A., Williams, T.A. and Patzelt, H. (2015), "Thinking about entrepreneurial decision making: review and research agenda", *Journal of Management*, Vol. 41, pp. 11-46.
- Short, J.C., Ketchen, D.J. Jr, Combs, J.G. and Ireland, R.D. (2010a), "Research methods in entrepreneurship: opportunities and challenges", *Organizational Research Methods*, Vol. 13, pp. 6-15.
- Short, J.C., Ketchen, D.J. Jr, Shook, C.L. and Ireland, R.D. (2010b), "The concept of 'opportunity' in entrepreneurship research: past accomplishments and future challenges", *Journal of Management*, Vol. 36, pp. 40-65.
- Smith, L.C. (1981), *Citation Analysis*, IL.
- Song, G., Min, S., Lee, S. and Seo, Y. (2017), "The effects of network reliance on opportunity recognition: a moderated mediation model of knowledge acquisition and entrepreneurial orientation", *Technological Forecasting and Social Change*, Vol. 117, pp. 98-107.
- Tang, J. (2010), "How entrepreneurs discover opportunities in China: an institutional view", *Asia Pacific Journal of Management*, Vol. 27, pp. 461-479.
- Tang, J., Kacmar, K.M.M. and Busenitz, L. (2012), "Entrepreneurial alertness in the pursuit of new opportunities", *Journal of Business Venturing*, Vol. 27, pp. 77-94.
- Trevelyan, R. (2011), "Self-efficacy and effort in new venture development", *Journal of Management and Organization*, Vol. 17, pp. 2-16.
- Ucbasaran, D., Westhead, P. and Wright, M. (2009), "The extent and nature of opportunity identification by experienced entrepreneurs", *Journal of Business Venturing*, Vol. 24, pp. 99-115.
- Urban, B. and Galawe, J. (2020), "The mediating effect of self-efficacy on the relationship between moral judgement, empathy and social opportunity recognition in South Africa", *International Journal of Entrepreneurial Behavior and Research*, Vol. 26 No. 2, pp. 349-372, doi: [10.1108/IJEBR-05-2019-0271](https://doi.org/10.1108/IJEBR-05-2019-0271).
- Vaghely, I.P. and Julien, P.-A. (2010), "Are opportunities recognized or constructed?: an information perspective on entrepreneurial opportunity identification", *Journal of Business Venturing*, Vol. 25, pp. 73-86.
- Vaillant, Y. and Lafuente, E. (2019), "The increased international propensity of serial entrepreneurs demonstrating ambidextrous strategic agility: a precursor to international marketing agility", *International Marketing Review*, Vol. 36 No. 2, pp. 239-259, doi: [10.1108/IMR-01-2018-0015](https://doi.org/10.1108/IMR-01-2018-0015).
- Vandor, P. and Franke, N. (2016), "See Paris ... and found a business? The impact of cross-cultural experience on opportunity recognition capabilities", *Journal of Business Venturing*, Vol. 31, pp. 388-407.

- Vedula, S., York, J.G. and Corbett, A.C. (2019), "Through the looking-glass: the impact of regional institutional logics and knowledge pool characteristics on opportunity recognition and market entry", *Journal of Management Studies*, Vol. 56, pp. 1414-1451.
- Wasowska, A. (2019), "Social-cognitive antecedents of new venture internationalization", *Baltic Journal of Management*.
- Webb, J.W., Ireland, R.D., Hitt, M.A., Kistruck, G.M. and Tihanyi, L. (2011), "Where is the opportunity without the customer? An integration of marketing activities, the entrepreneurship process, and institutional theory", *Journal of the Academy of Marketing Science*, Vol. 39, pp. 537-554.
- Weerawardena, J., Mort, G.S. and Liesch, P.W. (2019), "Capabilities development and deployment activities in born global B-to-B firms for early entry into international markets", *Industrial Marketing Management*, Vol. 78, pp. 122-136.
- Wood, M.S. (2017), "Misgivings about dismantling the opportunity construct", *Journal of Business Venturing Insights*, Vol. 7, pp. 21-25.
- Wry, T. and York, J.G. (2017), "An identity-based approach to social enterprise", *Academy of Management Review*, Vol. 42, pp. 437-460.
- Wu, Y., Wang, H., Wang, Z., Zhang, B. and Meyer, B.C. (2020), "Knowledge mapping analysis of rural landscape using CiteSpace", *Sustainability*, Vol. 12, p. 66.
- Xu, X., Chen, X., Jia, F., Brown, S., Gong, Y. and Xu, Y. (2018), "Supply chain finance: a systematic literature review and bibliometric analysis", *International Journal of Production Economics*, Vol. 204, pp. 160-173.
- Yitshaki, R. and Kropp, F. (2016), "Motivations and opportunity recognition of social entrepreneurs", *Journal of Small Business Management*, Vol. 54, pp. 546-565.
- Zahra, S.A., Newey, L.R. and Li, Y. (2014), "On the frontiers: the implications of social entrepreneurship for international entrepreneurship", *Entrepreneurship: Theory and Practice*, Vol. 38, pp. 137-158.

#### Corresponding author

Navid Mohammadi can be contacted at: [navid.m@ut.ac.ir](mailto:navid.m@ut.ac.ir)