

Development of Opportunity in Corporate Technological Entrepreneurship Using the Technological Convergence Approach

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Abstract

Today, technological innovations are the key factors in the development and advancement of societies, and technological entrepreneurship is recognized as the main source of disruptive innovations through identification and effective exploitation of technological opportunities. Given the emerging concept of "convergence" in advanced technologies and the opportunities it offers, it is necessary to recognize various dimensions of this phenomenon, especially the process of identifying opportunities, as the first and most fundamental step of the technological entrepreneurship process. The research methodology is qualitative and the research strategy is multiple case studies. The required research data were collected through semi-structured interviews and from other evidence such as archival documents of Iranian companies active in the field of converging technologies. The results of the research reveal the significance of factors such as interdisciplinary understanding, converging open innovation and the type of human capital in the process of identifying opportunities by companies active in the field of converging technologies.

Keywords: Entrepreneurial Opportunity, Opportunity Identification, Technological Corporate Entrepreneurship, Converging Technologies, Interdisciplinary Studies.

Introduction

In the last two decades, the concept of opportunity has been emphasized as a central pillar of the entrepreneurial process (Shane and Venkataraman, 2001; Short et al., 2010). Meanwhile, despite developments in the corporate entrepreneurship literature in the past few years, the process of identifying opportunities at the organization level has yet to be developed and most existing research on identifying opportunities has been at the individual level. As a result, there is little knowledge of how individuals identify opportunities in a company, and research with an opportunity-oriented approach to corporate entrepreneurship is one gap to fill (Zahra et al., 2016). Identification and exploitation of opportunities are phenomena that can be achieved through collective action (within a company or through collaboration with other companies) and the success of companies depends on the ability of its employees in opportunity identification (Grégoire and Shepherd, 2015; Urban and Wood, 2015). On the other hand, the role of converging advanced technologies as the driving force of the economy of societies has attracted much attention. As the context of emergence and expansion of knowledge in converging technologies is within knowledge-based companies active in the field of the above technologies, the enjoyment of these companies from a coherent and effective entrepreneurial process, from discovering and creating ideas to exploitation is highly important.

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Considering the role played by "opportunity identification" as an important and critical stage of the entrepreneurial process, addressing it will have a significant role in the business success of these companies. While the convergence of technologies in itself is the source of opportunity, due to its interdisciplinary nature, special factors are effective in the process of identifying opportunities in active companies in the field of converging technologies. Accordingly, the current research seeks to develop a theory on the process of identifying opportunities in the field of converging technologies and filling the theoretical gap existing in the literature related to the subject and the field survey of the phenomenon.

Literature review

Entrepreneurship and Entrepreneurial Opportunities

Research in the area of entrepreneurship involves examining how, by whom and with what effects, opportunities are discovered, evaluated and exploited for the creation of goods and services (Shane and Venkataraman, 2001). They also believe that entrepreneurship does not make sense without an "entrepreneurial opportunity." Shane (2003) states that the development of entrepreneurship research can be summarized in two groups: research that focuses on individual entrepreneurs and research that focuses on external factors.

Several definitions are given for the concept of "opportunity" in the entrepreneurial literature. Given the nature of converging technologies and the importance of innovation in the integration of resources and technologies in active companies of the field, the definition of the current research on the concept of "opportunity" is derived from the definition provided by Ardichvili et al. (2003). They define "opportunity" as the ability to meet the market demand (demand, interest) through the innovative combination of resources to create a greater value. Identification of opportunity is a subprocess of the whole continuum of the entrepreneurial process and its starting point, and if correctly and accurately implemented, it has a significant impact on the entire process of entrepreneurship.

Corporate technological entrepreneurship

Corporate entrepreneurship is to engage in the process of identifying and exploiting the opportunity to create new value at the organization level (Zahra et al., 2016). In other words, organizational entrepreneurship involves innovation, venturing, or strategic renovation within an existing organization (Zahra, 1996). Zahra et al. (2016) state that understanding how to identify opportunities by individuals and the factors affecting the process of idea creation to the opportunity exploitation lead to an adequate and profound understanding of organizational work, which itself indicates the importance of the process of opportunity identification in corporate entrepreneurship. However, organizational entrepreneurship is generally a team-oriented entity, which itself reflects the "collective action" approach dominating the phenomenon. Innovation in the products and processes of an organization is an important factor for promoting competitive power, which indicates the importance of corporate technological entrepreneurship as the basis for innovation. According to Antonick and Prodan (2008), corporate technological entrepreneurship is a process within an organization in which a technical entrepreneur or a group of entrepreneurs engages in a risky process of creation or management of a company through research, development, innovation, and technology.

Converging technologies

Converging technologies are the synergic combination of four fields in science and technology (nano-biological - information-cognitive), each of which is growing rapidly and includes the following: 1) Nanoscience and Nanotechnology 2) Biotechnology and Biomedicine including genetic engineering 3) Information technology including advanced communication and engineering 4) Cognitive science including neuroscience (Roco and Bainbridge, 2002). In other words, converging technologies are empowering technologies and knowledge systems that help each other achieve common goals (Nordmann, 2004). In fact, convergence in this definition refers to the collaboration of these technologies with the goal of creating synergy. Converging technologies play a prominent role in shaping the economy and society and industrial infrastructure. With the introduction of new technologies, the economy's share of technology would increase day by day. Based on possible outcomes, converging technologies provide new opportunities for policy-makers and business executives, with scientists known as the driving engine of economics (Bainbridge and Roco, 2002).

Converging technologies can lead to an improvement in human capabilities, community outcomes, national productivity, and quality of life. Given this, it provides a broad, timely and emerging opportunity for the benefit of individuals, society and humanity in the long run (Bainbridge and Roco, 2002).

In their theory, Bainbridge and Rocco (2016) introduce the convergence-divergence cycle in four stages as follows:

- A. The creative integration of the participation of different disciplines in order to form new ideas or concepts.
- B. Integration of the system into a combination or a new initiative for specific applications.
- C. Directing technological innovations toward new products and applications
- D. The stage of birth and access to solutions and new work that has not been possible before, as well as the creation of new business or infrastructure.

What is happening in the first half of the cycle (A, B) is, in fact, the combination of knowledge and technologies from different disciplines with each other. In the second half of the cycle (C, D), innovation emerges and it is exploited in the form of new products and applications. The results obtained from the second half, again, enter the first half as inputs to the convergence-divergence cycle. In fact, convergence is a kind of problem-solving approach that moves beyond interdisciplinary boundaries (NRC, 2014) and leads to disruptive opportunities for the development, enhancement and creation of benefits for human beings (Bainbridge and Roco, 2016).

Interdisciplinary Studies

Today, interdisciplinary studies are the phenomenon attracting the attention of the world's leading scientific circles. After centuries of overusing a diverging perspective in various sciences, more attention has been paid to the benefits of convergence in science. There is a simultaneous dependency on different fields of science in numerous phenomena, which defies the single-discipline analysis. Therefore, given the complexity of the phenomena, there is a need for a level beyond the single-discipline analysis. Interdisciplinary studies are the process of answering a question, solving a problem, or encountering an issue whose scope and complexity are such that it cannot be addressed with a single scientific discipline, resulting in numerous academic disciplines. Thus, the views of different disciplines are consulted to achieve a more comprehensive view (Klein and Newell, 1997).

Philosophical foundations of the research

Ontology is the study of truth (O'Gorman and Macintosh, 2014). It consists of two subjective and objective views. Objectivists believe that reality has been created without human intervention and from the point of view of subjectivists, a reality is not formed, except through human perceptions (O'Gorman and Macintosh, 2014). From a subjectivist perspective, opportunity is a socially-constructed phenomenon (Alvarez et al., 2014). In contrast, the objectivists are of the opinion that an opportunity can exist independent of an entrepreneur and entrepreneurial awareness makes it possible for entrepreneurs to identify and exploit it (Shane, 2003). There is a third perspective that places opportunity across a subjective-objective spectrum. Zahra (2008) states that intuition and creation can promote one another as a cycle. In this study, the concept of opportunity is considered across a subjective-objective spectrum from an ontological perspective. This means that opportunities can exist objectively based on the intuitive approach, there to be discovered by entrepreneurs and can be created in a process based on the creation approach. Epistemology seeks to know to what extent knowledge known to us is acceptable (Bell and Bryman, 2015). As an epistemological method, interpretivism focuses on understanding social functions (Bryman, 2004). Based on the subject and the social nature of this study, the interpretative epistemology was adopted for this research.

The conceptual framework of the research

A conceptual framework is a comprehensive and consistent frame based on the related literature, theories and other valid and relevant information. A conceptual framework is usually the basis for shaping research questions and formulating hypotheses or predictions (Teddlie and Tashakkori, 2009). Based on the existing literature on entrepreneurship opportunities and corporate entrepreneurship, the researcher has developed a conceptual framework (Figure 1). According to Shane's (2003) model, the factors affecting the entrepreneurial process associated with the concept of opportunity include individual and environmental factors. Singh (2000) also emphasizes the role of the two factors of entrepreneurs and the environment in shaping the business idea and entrepreneurial opportunity. On the other hand, Vogel (2016) classifies the factors influencing the identification and exploitation of opportunity into three factors: individual, environmental and opportunity triggers. The analysis in the current research is carried out on the organizational level. As an open system, the effective factors in this system are internal factors, close environmental factors and distant environmental factors (Chandan, 2014). Meanwhile, the interdisciplinary nature dominant in active companies in the field of converging technologies emphasizes the importance of "collective action" and introduces it as an important element of identifying opportunities in organizational entrepreneurship (Grégoire and Shepherd, 2015).

As shown in Fig. 1, the process of opportunity development involves identifying and exploiting entrepreneurial opportunities in companies active in the field of converging technologies, influenced by internal factors, environmental factors and opportunity triggers.

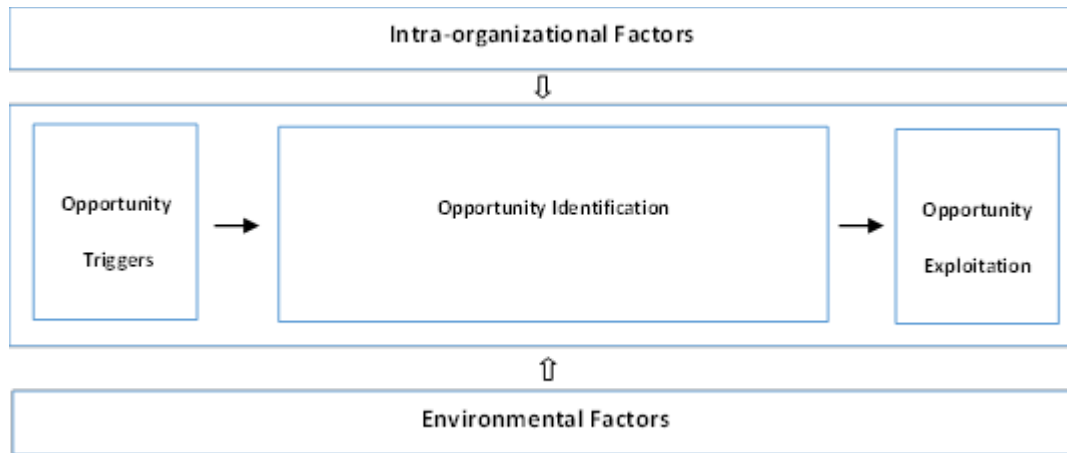


Fig. 1 The theoretical framework of the study

Methodology

There are different research strategies. In terms of excellence, Saunders et al. (2009) argue that researchers should choose strategies in accordance with the questions and goals set for research. Generally, research questions are in line with a theory and are based on a theory beyond the framework of that theory (Eisenhardt & Graebner, 2007). Multiple case study addresses the causes and ways in the unexplored research (Edmondson and McManus, 2007).

According to Yin (2009), a case study examines the depth and context of a current phenomenon and is at its best when research questions are about how and why. The purpose of this study was to understand how technology companies identify opportunities. This involves understanding the perceptions of individuals involved in the process of identifying opportunities at the corporate level. Researchers also argue that a multiple case study is appropriate when the topic of research is relatively unknown (Eisenhardt, 1989; Yin, 2009). Given the fact that the present study addresses the process of identifying opportunities in companies active in the field of converging technologies and research in this field is not clear, the multiple case-study approach has been used in the research.

An important factor in theorizing with case samples is the "replication logic" (Eisenhardt, 1989). This means that each item acts as a separate test and matters as a unit of analysis (Eisenhardt and Graebner, 2007). The theory-making process in the multiple case-study approach is carried out by probing into the data, the evolving theory and the existing work on the phenomenon under study (Eisenhardt and Graebner, 2007). Compared to a single case-study approach, a multiple case-study approach has a stronger basis for theorizing because the comparison between multiple cases is investigated in the research in different cases and the resulting propositions provide deeper grounds for evidence. The resulting empirical experience and the theories are more generalizable and measurable (Eisenhardt and Graebner, 2007).

The purpose of multiple case studies is to develop a theory rather than an experiment. Thus, only cases that can clarify the connections and logic between structures are fit to be selected, and thus the selection of the cases should be in the form of theoretical sampling (Eisenhardt and Graebner, 2007). Among the companies active in the field of converging technologies, only those were selected that had been able to market their products and make a significant profit. To collect the required data, semi-structured interviews were conducted with those of the companies that were actively involved in the process of opportunity identification. In terms of the number of samples required, the criterion is theoretical saturation and interviews with individuals continued until there was not a significant new topic to be added to the current one (Glaser and Strauss, 1967). Therefore, after interviewing 14 individuals from 9 companies, it was ensured that new information was not added from the interviews. In addition to documenting the processes from the interview design to coding, several individuals participated in coding and checking the data in order to increase the reliability of the research. The foundation of the interview protocol is questions that, based on the conceptual framework of the research, examine the various dimensions of the process of opportunity identification. This ensures that the focus of the interview is on the process of opportunity identification and the information extracted from all interview cases leads to convergence in the analysis and appropriate conclusions in the entire research process which increases its reliability. To increase the credibility of the research, we used multiple researchers, in-depth interviews with several cases rather than just one case, as well as the "member checking". In the process used in member checking, the research model was presented to the participants and they were requested to confirm that what the researcher had extracted was a correct interpretation of their arguments. Moreover, they were asked to confirm that the factors presented in the model were more logical and the participants confirmed. In addition to interviews with individuals in each of the study cases, other evidence such as archival documents and figures

that illustrate the process of opportunity identification of the companies were also considered to study the reliability of the research information.

Findings and Results

Table 1 presents the details of the 9 companies where the research data are derived from. The combination of technologies used in these companies includes the paired combination of information technology with cognitive technology, information technology with biotechnology, as well as nanotechnology with biotechnology. The opportunities identified in these companies are associated with cognitive equipment, nanomedicine, bio-equipment and cognitive software.

Table 1. the scope of activity, the opportunity identified and the combination of technologies in the companies

Company code	Product type	The identified opportunities	Technological integration
A	Cognitive system	Equipment for recording and processing brain signals	Information Technology - Cognitive Technology
B	Biomaterial and medicines	Biological nanomedicine with fewer complications and higher treatment success rate	Nanotechnology - Biotechnology
C	Diagnostic equipment and sensors	Equipment related to biotechnology	Information Technology- Biotechnology Biotechnology- Nanotechnology
D	Cognitive system	Game software for cognitive purposes and behavior change	Information Technology- Cognitive Technology
E	Cognitive system	Equipment for recording and processing of brain signals	Information Technology - Cognitive Technology
F	Cognitive system	Need for a method for detecting olfactory malingering	Information Technology - Cognitive Technology
G	Cognitive system	Need for an auto-pilot system	Information Technology - Cognitive Technology
H	Cognitive systems - Image Processing	A system for driver drowsiness detection and lack of focus for car and train drivers	Information Technology - Cognitive Technology
I	Diagnostic equipment and sensors	Extraction and analysis of genetic and biological markers	Biotechnology - Information Technology

Open, axial and selective codes were extracted by an in-case analysis of the interviewee responses in each company, as well as the cross-case analysis of the responses of the companies, which are presented below.

Opportunity triggers

Opportunity triggers can be considered as a source of entrepreneurial ideas. The two main roots of the formation of the entrepreneurial idea are identified customer demand, known as the market pull (Maier et al., 2016), and knowledge sources and scientific research used in commercialization known as technological pressure (Brem and Voigt, 2009). Table 2 presents the results of the analysis of the interviews conducted in the companies regarding opportunity triggers.

Table 2. Opportunity triggers

Open code	Axial code	Selective code
<ul style="list-style-type: none"> - Identifying a gap and a need in a market is our main trigger for the development of the product needed by the market. - Due to customer relationships and ongoing market research, we know the market need. - By predicting future needs and through mechanisms like patents trends and analysis, we designed some tools and provided to the target customers. - Predictions and trends are one of the sources of opportunity perception and idea generation. - Search for trends and areas dominant with ideas and the need for it. We design tools to meet their needs. 	Market pull	Opportunity triggers

<ul style="list-style-type: none"> - Drawing on the technological potential of a company, we design and develop products to introduce to the market. - When the tools were offered to customers, they were amazed and confirmed they needed it. - We look into deficiencies and technological gaps as a status quo. So we seek to solve a problem and, thus, create an opportunity. 	Technology push	
<ul style="list-style-type: none"> - We worked on cell therapy which was used for tissue damage. In our search, we found that cell therapy is also used in cancer, and since we were ready and had the infrastructure in this area, an idea was created to work in the field. - We look at the needs in other areas and fill the gaps and produce a related product. We do this by understanding the knowledge capacities within the company and finding specialists in areas that can evolve the existing knowledge of the company to meet that need. 	Market pull + Technology push	

One of the interviewees said: “We first seek to identify possible defects in current products and provide better products. In some cases, we design and deliver new products based on our company's technological capabilities and perceptions of future needs.”

Each of the market pull factors and the technology push will help to change technological developments while each of these two factors contributes synergically to the development and promotion of the other. According to the pattern extracted from the interviews, opportunity triggers can be categorized under the titles of market pull, technology push and their mutual connection.

Opportunity identification

Identifying opportunity is a process in which individuals recognize, identify and discover a potential opportunity for the creation and development of a business, venture, market and technology (Wang, 2013). For Eckhardt and Shane (2003), the process of identifying opportunities is how individuals act independently or as an organization to understand ways to create a new tool-target framework that has not been previously seen or known. Table 3 presents the results of the analysis of the interviews conducted in the companies regarding opportunity identification.

Table 3. Identification of Opportunity

Open code	Axial code	Selective code
<ul style="list-style-type: none"> - The ideas extracted from the combination of technologies to respond to is a demand we identified. - Our ideas come from proficiency in different technologies and the ability to combine them. - Through systematic and well-known methods like brainstorming inside organizations, we are looking for ideas to meet market demands. - In some cases, ideas come from outside the organization. 	Integrated Idea generation	
<ul style="list-style-type: none"> - By gaining relative certainty about the proper diagnosis of market needs, a team of specialists was formed in the areas to explore the possibility of integrating technologies, meeting the needs and finding solutions. - In some cases, help is provided outside the organization to receive and nurture ideas. - After generating the initial idea in the process, it is necessary to pay attention to the characteristics of the market and customers. - The ability to combine technologies in a way that makes them synergistic is of paramount importance in the development of an idea. - Matching the market demands to integrate technologies based on resources results in the evolution of the concept of business. 	Integrated Idea Incubation	Identification Opportunity
<ul style="list-style-type: none"> - Relying upon the existing knowledge and experience, conducting feasibility studies and taking the internal capabilities of our company into account, we make sure of their practicality. - Continuous evaluation takes place at all stages and through interaction between people at different levels. - We will not engage with an idea if we are not able to afford the necessary resources including human resources. - An overall assessment of the opportunity is taken from the perspective of the constraints, conditions and resources available and infrastructure. 	Evaluation	

Also, one of the company's executives expressed the following statement about the idea generation phase: “We have weekly meetings with various technology experts to design the product in line with customer demand or on the basis of the technical ability of the company.”

According to Vogel (2016), an idea is an imperfect mental concept of a potential venture in the future. Ideas are a function of creativity and learning, and if developed well, it becomes an opportunity (Short et al., 2010). This mental concept can be related to the unmet needs of a customer or a combination of resources and capabilities. Hence, integrated conceptualization is the first step to the process of identifying opportunities. The idea in these companies is generated through converging technologies, systematic and formal methods such as brainstorming or interactions with external IT networks.

The second stage of the process of identifying opportunity is nurturing integrated ideas. In the next step, the process of conceptualization takes on the operational form. This stage of the process of identifying opportunities seeks to match the demands of the market and the customer and create convergence in technologies through the business concept. At the beginning of this stage, most organizations have a vague understanding of their future business components and the concept of business that emerges at this stage can be seen as the joining point between ideas and opportunities (Vogel, 2016).

An interviewee commented on the next stage of cultivating an integrated idea: "The choice between potential ideas depends on the resources and its feasibility and we have to make a choice between ideas through an evaluation mechanism."

Therefore, the third stage of the process of identifying opportunities is evaluation. Evaluation is the process of measuring the options an entrepreneur has. Opportunity assessment is the process of differentiating ideas and opportunities (Hills and Shrader, 1999). Opportunity evaluation is the stage before the opportunity exploitation. The purpose here is to take the necessary steps before measuring the aspects and challenges of a given opportunity. The result of the opportunity evaluation process can lead to a decision on exploitation or exclusion of opportunity. The most challenging stage is the process of opportunity identification. Opportunity evaluation is measured based on two criteria: feasibility and utility. According to Vogel (2016), if the outcome of the judgment about the opportunity to be evaluated indicates feasibility and utility, then a third-person opportunity is converted to a first-person opportunity and can be exploited. On the whole, it can be concluded from the pattern of the interviews that the process of opportunity identification occurs in three consecutive stages: integrated idea generation, integrated idea Incubation and evaluation.

Exploiting the opportunities

Opportunity exploitation involves the full and effective launch of a product or service from a business opportunity (Choi et al., 2008). In fact, the opportunity exploitation is a process in which the product or service resulting from an identified and evaluated opportunity is introduced to the market. Opportunity exploitation is a necessary stage for earning income and business success (Choi et al., 2008). Also, access to the required resources to create efficient and productive systems is important at this stage of the entrepreneurial process (Choi and Shepherd, 2004).

The results of the analysis of the interviews conducted with the companies on the relationship between the exploitation and identification phases are presented in Table 4.

Table 4. Opportunity exploitation

Open code	Axial code	Selective code
<ul style="list-style-type: none"> - Market conditions for a product introduced to the market (such as the process of prescribing) are evaluated regularly. This evaluation will result in the creation of a new product or modification of an existing one. - The tools we have been using to treat hyperactivity are not designed based on the feedbacks we received from the market. We will find out how to change the tools for treating migraines. - As the research institute I am working for as a faculty member is located inside the hospital, feedback from the patients helps to identify and generate ideas. 	The link between identification and exploitation	Exploiting the opportunities
<ul style="list-style-type: none"> - With respect to customers, the products introduced to the market and their new demands, we make sure that there is a new market and our risk is reduced. - If the demand is from the current customers, it will provide a high degree of certainty to meet it. 	Reducing the risk of failure	
<ul style="list-style-type: none"> - After ensuring the correct identification of an opportunity, we take action on an opportunity. - Resource is allocated after we do the necessary examinations on the diagnosis of opportunity. 	Exploitation after opportunity identification	

One of the interviewees said: "Feedbacks from customers will help identify new ideas."

Also, in another interview with one company manager, it was stated that: "Feedbacks help us learn how to change products to enter a new market. We use our customers as a source of product ideas for promoting products".

The conclusion of the interviewees reflects a relationship between the two phases, opportunity identification and opportunity exploitation.

Interdisciplinary understanding

The ultimate goal of interdisciplinary studies including studies on convergent technologies is to achieve interdisciplinary understanding and integrating knowledge. Technology is the means to achieve it. In fact, interdisciplinary understanding is the result of the customized integration of insights, knowledge, and technology from a variety of scientific disciplines. Interdisciplinary understanding requires delving into three disciplinary depth, disciplinary breadth, and interdisciplinary integration. Triangulation in interdisciplinary studies means creating a balance between these factors (Repko, 2012). The results of the analysis of the interviews conducted with the companies on the impact of the type of interdisciplinary understanding on the opportunity identification process are presented in Table 5.

Table 5. Interdisciplinary understanding

Open code	Axial code	Selective code
- Human resources that dominate both domains are highly important. - As the founder of the company, I am fully competent in the fields of neuroscience, computer science and electronics.	Disciplinary depth	Interdisciplinary understanding:
- In the idea generation phase, it is absolutely necessary for individuals to be familiar with both domains - At least, one person or a number of persons must master both domains in a company.	Disciplinary breadth	
- Obtaining the ability to integrate technologies by experts is important and the most important competency is the ability to integrate technologies in order to achieve the result. - Many of the ideas with multiple technology dimensions can be analyzed. There must be people who are familiar with both domains. - Being familiar with both areas is necessary and forming a team of different specialties without familiarity with other areas is not enough.	Interdisciplinary integration	

One of the interviewees expressed the following about the depth and proficiency of technology: “Mastering both areas is crucial for a company that operates in the field of convergent technologies.”

Disciplinary depth means achieving a level of knowledge required for each discipline, as well as the ability to identify conflicts between insights and creating an interdisciplinary understanding of the problem and testing that understanding (Repko, 2012). Hence, it is necessary for these types of companies to have a deep knowledge of any technology that is needed to enable the integration of technologies.

Disciplinary breadth means the adequacy of relevant knowledge and approaches appropriate for interdisciplinary studies (Repko, 2012). This means that the necessary condition for operating an integrated technology is the organization's access to all of the prior knowledge.

According to one of the interviewees: “At the stage in which an idea is being formed and evaluated, the interaction between individuals is on how to combine and how to integrate the technologies to achieve the intended result.”

Interdisciplinary integration involves understanding different scientific disciplines related to a challenge and the accuracy in evaluating and refining the elements of insights existing in those disciplines. In other words, the integration of insights in this process involves creating or discovering common grounds that can adopt different insights to the problem and lead to an interdisciplinary understanding (Repko, 2012). Integration does not merely mean knowledge domination; this involves the use of a triangulation activated mechanism between depth, breadth, and synthesis (Klein, 1996). In fact, integration means using disciplinary depth, integrated skills, integrated knowledge and thought.

A model that can be inferred from the respondents' answers to interdisciplinary understanding is that it affects the process of identifying opportunities.

Converging Open Innovation

In open innovation, it is assumed that by relying on advanced technology, companies use ideas external and internal to the organization. Open integrated innovation processes is a combination of internal and external initiatives through architecture and systems (Chesbrough, 2005).

In open innovative, organizations are not merely dependent on their own R&D and should use their absorption capacity to internalize external knowledge.

The combination of technological ideas internal and external to an organization is accomplished through various mechanisms of converging technologies. Due to the interdisciplinary nature of converging technologies and the convergence approach that governs companies active in this field, the innovation used can be called convergent innovation.

Table 6 presents the results of the analysis of the interviews conducted with the companies on the impact of the type of converging open innovation on the opportunity identification process.

Table 6. Converging open innovation

Open code	Axial code	Selective code
<ul style="list-style-type: none"> - After understanding opportunity and its initial evaluation, we develop an idea generation process to design and develop tools to satisfy needs by creating a journal club and weekly meetings between relevant specialists. - Ideas are included because members of the board are faculty members, too. As a result, they are connected with occupational groups with different expertise as well as with universities and scholars. This is the origin of an idea. - One of the communication mechanisms between universities and us is the journal club meetings. - Because of the close relationship with universities and participation in the field of academic and research in relevant fields, in fact, we are constantly facing new issues and ideas and this is very important. - We are academics and company owners, and this combination is very helpful and leads to the improvement of ideas in an atmosphere of research and discussion. - In the integrated field, the journal club has more effectiveness than single technologies. 	Journal Club	Converging Open Innovation
<ul style="list-style-type: none"> - Some new ideas are generated in workshops that are held for potential and current customers, which are the source of new products. - Workshops in a company and the topics discussed there provide good information about competitors and their products, and deficiencies and the merits of their products. - The workshops held for customers to provide a learning environment for the personnel. - As some customers are experts in some technologies, interaction with them is likely to provide solutions. 	Design thinking	
<ul style="list-style-type: none"> - We have outsourced some of the software development tasks to other organizations. - For a part of R&D requirements in ITC which requires programming and using mathematical models, the company uses other companies. - In some cases, the use of knowledge potentials outside the organization regarding knowledge about technologies is more logical and cost-effective. 	Outsourcing	

For example, one of the interviewees said: “Using mechanisms such as the Journal Club for developing the required knowledge is highly important for acquiring and generating ideas. Idea evaluation takes place in journal clubs. Meanwhile, idea generation occurs in the meetings, too.”

A journal club is a meeting where a number of experts discuss the articles of the day. The journal club framework is problem-based learning in which a structured interaction takes place between a subject provider and the listener. As a result of critical debates and the issue-centered nature of this type of meetings, many creative ideas are discussed. These companies are closely connected with universities because the presence of academics leads to the acquisition of knowledge and ideas from academics. The theoretical boundaries of knowledge are brought to the company through the journal club meetings with the active participation of academics. In fact, journal clubs are a converging mechanism between different fields of knowledge and technology.

One interviewee also said: “Through workshops and meetings that we hold with expert customers, their knowledge of complementary technologies is used to integrate the required technologies.”

In the open innovation model, customers play an active role as collaborators in the R&D process (Porter, 2007).

In design thinking used in product design, customers are at the heart of innovative processes and measures to solve problems. Design thinking focuses on studying the true expectations of customers from a product or service, re-testing, and optimizing this experience. In design thinking, a business examines how customers use a product or service, what their needs and wants are, and then new ideas are created based on these data (Lockwood, 2010).

Another interviewee said: “Because of the high level of expertise, the use of certain technologies and the inability to focus on them within the organization, some tasks are outsourced in some cases.”

Companies outsource part of the R & D process according to conditions and resources, based on a cost-benefit analysis (Porter, 2007). Outsourcing is referred to a method by which, for some reason, a company delegates a portion of its work to a person or another company. When a company aims at developing inter-tech convergence to create synergy and introduce a new product and the technical competence in the company is not enough, outsourcing is used to acquire the required knowledge from outside the company.

The result of the interviewees reflects the effect of converging open innovation through meetings at the Journal Club and the application of the design and outsourcing thinking mechanism on the process of identifying opportunities.

Types of Human Capital

Human capital is one of the main resources of the organization in value creation, especially in the knowledge-based economy (Zahra et al., 2016). Human capital represents the knowledge, skills, experiences and capabilities of individuals (Dessetal, 2003). Individuals with a higher level of human capital have more access to knowledge and, therefore, have a better judgment and assessment of the opportunities around them (Mitchell et al., 2002). According to Zahra (2016), the human capital in an organization can be categorized into two groups: Entrepreneurship-specific human capital and Firm-specific human capital.

Table 7 presents the analysis results of the interviews conducted in the companies on the impact of the type of human capital on the opportunity identification process.

Table 7. Types of Human Resources

Open Code	Axial Code	Selective code
<ul style="list-style-type: none"> - Part of the human resources from an entrepreneurial viewpoint works in the area of opportunity recognition and exploitation. - An initial analysis of ideas and opportunities takes place more at the level of the CEO and the chairman of the board of directors. - Senior management is often involved in the process of identifying business opportunities and its business aspects, and examining its justification. - With training, some personnel are capable of becoming entrepreneurs and reaching the point of decision-making and identifying opportunities. - The senior team and board of directors are more concerned with the ideating and feasibility and the aspects of opportunity and management. 	Entrepreneurial Human Resource	Type of Human Capital
<ul style="list-style-type: none"> - Part of the human resources are pure experts and only work on their limited area such as blending and formulation of materials for drug manufacturing. - Specialists have a less role to play in opportunity recognition and have an executive leverage in operational plans. They may offer information but they do not have a role in opportunity recognition. - It could be said that experienced specialists are only active at the stage of idea generation to find a solution for a proper mix of technologies in order to achieve the results. - If the specialists-only were able to provide managerial work and opportunity recognition, they would have established a company for themselves and would not have become an employee. - Some of the human resources are mere one-dimensional employees. They are very elite in designing and are more involved with ideating. 	Specialized Human Resources	

One of the interviewees commented:

"Opportunity analysis requires a different mind. Expecting opportunity recognition from some experts is sometimes destructive and expecting opportunity analysis with a multidimensional approach from a one-dimensional mind will hurt the individual and the company. This reflects the differences in the characteristics and expectations of a variety of human resources in these types of organizations.

The summing up of the comments in the interviews suggests that a part of human capital (called entrepreneurship-specific human capital) has an entrepreneurial viewpoint and seeks to understand opportunities by identifying the needs of the market or unused resources of the organization. This kind of human resource has a managerial view when identifying and exploiting opportunities and it affects the whole process of opportunity identification. On the other hand, it can be seen that another part of the human capital of firms (called firm-specific human capital) seeks to create a fit between the perceived opportunity and the resources of the organization. This type of human resource has a specialized operational and technical look to present an idea that is tailored to a perceived opportunity. This type of human resource influences the process of idea generation from the process of opportunity identification.

Development of Related Technologies

One of the environmental factors that affect the process of opportunity identification is rapid progress, especially in the field of advanced technologies including convergent technologies. The above-mentioned advances in convergent technologies not only can be used as a

tool for combining these technologies and realizing ideas, but can be also exploited as a source of capability and idea generation. In fact, convergence is a kind of problem-solving approach that goes beyond interdisciplinary boundaries (NRC, 2014) and leads to attractive opportunities for the development, enhancement and creation of benefits for human beings (Bainbridge & Roco, 2016). Consequently, convergence provides the development in each of the converging quadratic technologies, allowing for a new combination of resources and technologies and, hence, the identification and exploitation of new opportunities.

Table 8 presents the analysis results of the interviews conducted with the companies about the impact of the development of related technologies on the opportunity identification process.

Table 8. Development of related technologies

Open Code	Axial Code	Selective Code
<ul style="list-style-type: none"> - In addition to biotechnology, which is the technology adopted by the company, advances in nanotechnology are of great importance to us. - Changes and advances in nanotechnology can be used as a proper tool for achieving our goals in the main technology fields of the organization. - The advances made in information technology can be used as an appropriate tool for the development of biotechnological products of the company. 	Development of Complementary Technologies	Development of Related Technologies
<ul style="list-style-type: none"> - Developing and acquiring knowledge outside the organization in the area of technologies used by the company creates new grounds for idea generation and operationalization of existing ideas. - The availability of external knowledge related to the technologies used by an organization as a result of knowledge spillover by other companies or existing academic research increases the organization's idea generation capability. Some new ideas in a company are generated because of taking advantage of the advancements in related technologies outside the organization. 	Development of Applied Technologies	

As an example, one interviewee commented: "We are sensitive to the changes and development of technologies, especially advanced technologies that can play a complementary role in the current technologies of the company, and we are constantly monitoring them."

Another interviewee also said that: "With regard to the core technologies of the organization, we are constantly looking for changes and improvements that have come about in the world." In sum, it can be concluded that the development of technologies related to the core activity of the company has an impact on the process of identifying the opportunity.

Competition Status

Today, in the business environment which the rate of change is high, there is a tough competition between companies (Kettunen, 2009). The existence of deficiencies in products in the market and a lack of coverage of some market needs will provide the ground for ideas that respond to these needs. Companies active in the field of converging technology can meet some needs, not satiable before, based on their ability to integrate advanced technologies and deliver products. Otherwise, they can improve functions and remove the costs of some products previously integrated with advanced technologies. In fact, the innovations resulting from the combination of convergent technologies will lead to distortion of the existing competitive environment and, in some cases, lead to new levels of technology along with new competitive advantages.

Table 9 presents the analysis results of the interviews conducted with the companies about the impact of the development of related technologies on the process of opportunity identification.

Table 9. Competition Status

Open Code	Axial Coding	Selective Code
<ul style="list-style-type: none"> - We concluded that if we use information technology and its combination with the company's core expertise that is in the cell tissue, according to market conditions, we could deliver a product with a relatively high advantage in terms of cost and quality compared to competitors. - Since we hired the best specialists in the field of biotechnology and nanotechnology, we expect the results of this collaboration to be products with a high competitive edge in the market. 	Competitive Advantage	Competition Status
<ul style="list-style-type: none"> - Following the review, it was found that the identified need has not been answered so far and this made us more determined to turn our ideas into products. - Given that special knowledge capabilities are needed by our competitors to produce the same product as our product, in some way, we own the monopoly. 	Lack of Competition	

As an example, one interviewee said, "Given the relatively high cost of research and development in the field of advanced technologies, having a relative certainty of the existence of a reasonable market and competitive advantage for the idea being surveyed is highly significant."

Another interviewee also said, "The lack of rivals in the market, with the ability to combine the technologies needed to realize our desired idea, was an important factor in the continuation of the idea generation process."

Overall, it can be concluded that the competitive situation on the business side of convergent technology companies affects the process of identifying the opportunity. Figure 2 shows the final model of the research.

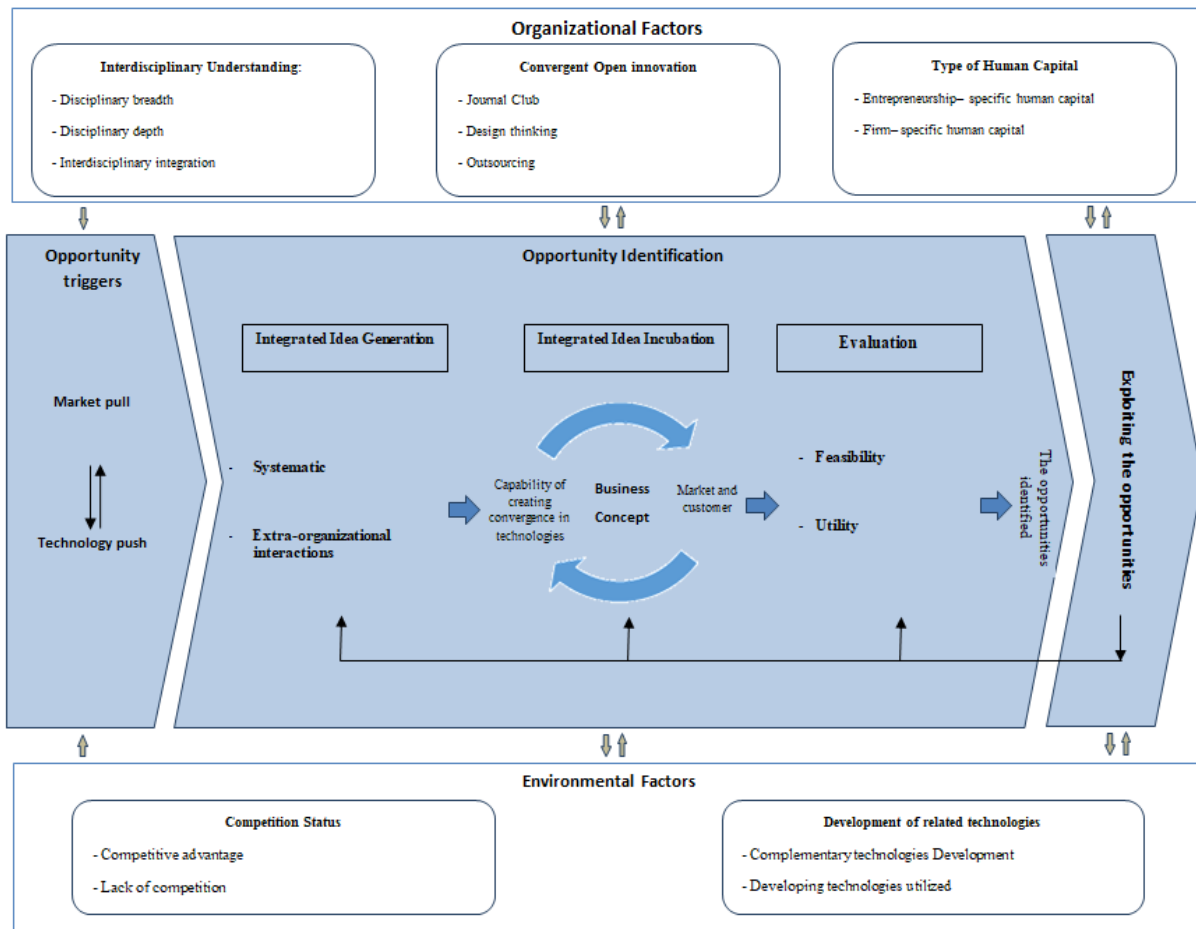


Fig. 2. Model of Research

Contribution and Innovation of the Study

In this research, the process of identification of technological opportunities was studied with a convergence approach. Since convergence of technologies is an emerging phenomenon and acts as a source of evolutionary opportunities, the convergence approach used in this research can be considered as its innovation. In the previous research in the field of opportunity identification, the focus has been on individual entrepreneurship and not so much attention has been paid to conducting research on identifying opportunities at the company level. This is while the success of the companies depends on the ability of its employees to identify opportunities. Therefore, one contribution of the research might be its implementation at an organizational level. On the other hand, understanding and recognizing the concept of technological opportunity identification and discovery in companies is limited and its broad nature has not been completely covered in previous studies and this research has contributed to its development. Combining the literature of interdisciplinary studies, entrepreneurial opportunity and convergence of technologies and addressing concepts such as interdisciplinary understanding, convergent open innovation in opportunity and entrepreneurship literature can also be seen as other innovations of this study.

Suggestions for Further Research

In this research, the process of opportunity identification was investigated in companies working in the field of double composition converging technologies. It seems that if opportunity identification in triple or quadruple composition converging technologies is investigated, there may be differences in comparing with double compositions due to the more complexities of processes and the combination of human resources and their interactions. Also, due to the considerable importance of human capital as the most important source for knowledge-based companies, the ability of companies to attract specialized human resources familiar with different fields of convergent technologies is very important. Therefore, research on how to recognize and recruit such individuals is recommended for these companies. Also, research on different ways of attracting ideas and participation of extra-organizational resources in the process of commercialization of ideas derived from convergent technologies is of particular importance and it is suggested to be considered for future research.

Conclusion

This research showed that the process of opportunity identification in the companies working in the field of convergent technology is influenced by organizational factors, environmental factors and opportunity triggers. Also, the process of opportunity identification takes place during the three stages of integrated idea generation, integrated idea nurturing, and idea evaluation, which leads to the exploitation of opportunity. Because of the axial role of knowledge in the activities of these companies, the process of attracting, converging and exploiting interdisciplinary knowledge is of great importance. Meanwhile, human capital plays a key role in this process. In this regard, the research identifies that human resource typology has different functions in different stages of the process of opportunity identification. Furthermore, the results showed that factors such as interdisciplinary understanding open convergence innovation and the development of related technologies influence the process of opportunity identification in the companies actively working in the field of convergent technologies.

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