

A Competency-based Typology of Technology Entrepreneurs: A Systematic Review of the Empirical Studies

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Abstract

Due to the importance of technology entrepreneurs' competencies in the creation and development of technological businesses, a distinct stream of research has been dedicated to this subject. However, given the nature of suchlike studies, it is difficult to reach a common understanding of the competencies. In fact, there is a need to provide some systematization to achieve advancements in the field. A review of 87 articles indexed on Scopus about technology entrepreneurs indicates that competencies of technology entrepreneurs can be classified under three groups of technological competencies, entrepreneurial competencies, and managerial competencies. This classification is used for two purposes, namely to categorize the technology entrepreneurs based on their competencies and to recommend new venues of research to study technology entrepreneurs. This paper can help technology entrepreneurs develop their competencies. It will also be useful in identifying entrepreneurs, and in training and developing the competency of academic entrepreneurs, technology incubators, and accelerators.

Keywords

Technology entrepreneur, Start-up, Systematic review, Competency approach, Typology.

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Introduction

Today, technological businesses play a pivotal role in the economic and social development. These businesses are the major sources of creating individual and regional wealth (Blanco & Therin, 2007), enhancing the technological capacity of an economy (Rojas & Huergo, 2016), compensating the downturn of traditional industries (Lindholm Dahlstrand, 2007), creating job opportunities for educated people (Brinckmann, 2008, p. 2; Tajeddini & Mueller, 2012), and changing the social and cultural norms (Aoyama, 2009). However, the success rate of these businesses is limited (Colombo & Grilli, 2005; Rojas & Huergo, 2016). They suffer from various internal and external drawbacks, especially the competencies of the technology entrepreneurs (Jones-Evans, 1995; Rojas & Huergo, 2016). Hence, a distinct stream of research has been developed to address this topic (Bailetti, 2012).

Despite the growing body of literature on the competencies of technology entrepreneurs, some divergences and fragmentations have emerged (Beckman, Eisenhardt, Kotha, Meyer, & Rajagopalan, 2012; Wright, Hmieleski, Siegel, & Ensley, 2007). One reason is the ambiguity of terms used for technology entrepreneurs. This has given rise to a fragmented and disjointed body of literature that hinders the development of a common understanding of competencies and ultimately impedes the coalition of the research (Crossan & Apaydin, 2010). In fact, this conceptual ambiguity in literature has inhibited the development of cumulative knowledge (Davidsson, 2015). Furthermore, little attention has been paid to distinguishing different types of technology entrepreneurs, which complicates the development of a practical framework for competencies (Proksch, Stranz, & Pinkwart, 2018). The presentation of a coherent categorization in this area of research will give us further insights into the competencies of technology entrepreneurs and their role in the creation and development of technological businesses (Yitshaki & Kropp, 2016). Therefore, there is an urgent need to foster coherence and systematization in this study to contribute to the advancement of this field (Liñán & Fayolle, 2015).

A systematic review is suitable for situations where enhanced systematization is required (Crossan & Apaydin, 2010; Denyer & Tranfield, 2009). Thus, this study is based on a systematic review of literature to help synthesize the divergent studies. To the best of our knowledge, there is a paucity of studies that systematically analyze literature on technology entrepreneurs (Bailetti, 2012; Ferreira et al., 2016). An overview of the competencies of technology entrepreneurs and their typology based on a systematic review of research over a long period of time can make important contributions to this field of research. It can also have implications for what is taught in

entrepreneurship courses and training programs (Morris, Webb, Fu, & Singhal, 2013). Moreover, it is crucial to increase support for technology entrepreneurs in centers such as technology incubators and accelerators. It also facilitates the negotiations and interactions of venture capital investors and business angels with entrepreneurs with respect to the competencies required for entrepreneurship. Finally, it offers new strategies to policy makers for the development of technology entrepreneurship.

The remainder of this paper is organized as follows. The first section describes the methodology of this review and the details of the search procedure. Then, the next section focuses on the classification of identified competencies and the typology of technology entrepreneurs. Finally, in the last section, conclusions are drawn, and theoretical and practical implications along with study limitations and suggestions for future research are provided.

Competencies of technology entrepreneurs

Technology entrepreneur can be defined as the founder of a technology business (Ezzedeen & Zikic, 2012; Gemmell, Boland, & Kolb, 2012) who is in charge of the design and setup (Jones-Evans, 1995). The true examples of technology entrepreneurs can be found throughout the human history and in different locations (Oakey, 2003), but they have been under spotlight since 1960s, when researchers gradually considered the role of entrepreneurs in achieving a complete image of the technological innovation (Phan & Der Foo, 2004). The first major study in this field was undertaken by Schrage (1965) on the characteristics of technology entrepreneurs in the USA. After the expansion of such studies in North America, they also developed in Europe in the 1970s (Watkins, 1971) and then in East Asia (Y. Zhang, 2004). Now, several studies have documented the direct positive effects of technology entrepreneur's characteristics on the performance of technological business (Rojas & Huergo, 2016).

In the literature on technology entrepreneurship, two major approaches can be identified for investigating the characteristics of technology entrepreneurs. The first is concerned with identifying traits, while the second seeks to explain success in terms of competencies. In the first approach, characteristics like "high need for achievement" and "moderate need for power" (Wainer & Rubin, 1969), "need for autonomy" and "locus of control" (Roberts, 1989), and "endurance" and "commitment" (Yang, Liu, Zhang, Chen, & Niu, 2015) are described as the key components of business creation and development. However, the findings in this area are conflicting (Myers, 1984), and to date their direct impact on entrepreneurial outcomes has not been confirmed (Wright et al., 2007). Furthermore, it can be argued that these

findings have limited potentials to improve business creation and development as these traits are considered to be fairly stable (McHenry, 2008). The second approach adopts a broader perspective by exploring competencies as qualifications of success (Colombo & Grilli, 2005). The notion of competency has been studied extensively in recent years across a variety of fields (Morris et al., 2013). The emphasis on the role of competencies as a means of identifying significant characteristics of entrepreneurs that influence business development is rooted in the early works of Boyatzis (1982) on managerial competence in large firms. Bird (1995) looked at the application of the competency approach in the entrepreneurial setting, concluding that competency can represent both a baseline for the creation and development of a business and a high standard for achieving sustainability and growth. In this view, traits are a part of competencies (Boyatzis, 1982). Thus, the concept of technology entrepreneur's competency has gradually moved away from a trait-based description toward a multi-dimensional view by considering knowledge, skills, and attitudes. For example, Sanchez and Perez (1998) have addressed the issue of competency, stating that a self-employed father, high education, and at least 9 years of experience before setting-up a business are three major factors of success. Likewise, Marvel and Lumpkin (2007) stressed the importance of experience, education, and knowledge of technology entrepreneurs. They declared that although general and specific human capital is essential, the familiarity of technology entrepreneurs with ways of serving a market increases the possibility of their use of technological knowledge for the creation of breakthrough innovations. In addition, Marvel and Droege (2010) stressed the role of a different type of knowledge, reiterating that previous experience in the development of products and services is vital for a successful technology business.

Methodology

The systematic review of studies in entrepreneurship (Phillips, Lee, Ghobadian, O'Regan, & James, 2015) and technology entrepreneurship (Ferreira et al., 2016) has been developed in recent years. The main feature of a systematic review is the utilization of transparent, well-documented, and replicable search processes through meta-synthesis of relevant studies in order to organize the literature (Denyer & Tranfield, 2009). The systematic review in the present study, which was based on the expanded review of literature in management and entrepreneurship, was conducted in four steps (Crossan & Apaydin, 2010).

Formulating questions and finding studies: First, the conceptual boundary of the study is defined. Competency refers to traits representing the ability of an entrepreneur to assume an entrepreneurial role (Man, Lau, & Chan, 2002). It can be considered as a set or

aggregation of knowledge, skills, abilities, and other characteristics (Hayton & McEvoy, 2006). This broad definition allowed us to cover a wide range of articles related to different types of technology entrepreneurs. According to the research objective, we were looking for articles related to the competency of technology entrepreneurs. However, since the concurrent search for the terms “competency” and “technology entrepreneur” provided limited results, the research scope was extended to include articles whose title, keywords or abstracts contained one of the equivalent terms of technology entrepreneur and their subject was related to competency. The Scopus database was selected for its wider coverage of journals. The inclusion criteria and their justification are presented in Table 1.

Table 1. Inclusion criteria

CRITERIA	REASON FOR INCLUSION
Terms Used For Technology Entrepreneurs	In literature, over 10 equivalents of <i>Technology entrepreneur</i> can be identified such as: Technological entrepreneur (Phan & Der Foo, 2004); Technical entrepreneur (Watkins, 1971); Technopreneur (Yitshaki & Kropp, 2016); Techno-entrepreneur (Tajeddini & Mueller, 2009); High-tech entrepreneur (Elston & Audretsch, 2011); R&D entrepreneur (Schrage, 1965); Founder of new technology-based firm (Colombo & Grilli, 2005)
Coverage Period: 1965-2017	To unravel the roots of studies and provide insights into the development process in this area and its establishment over time so far
All Sectors	To gain a wide picture - not just constrained to one area
All Countries	To ensure a cross-cultural view
Peer-Reviewed Journal Articles	Peer-reviewed journal articles are considered as the most valid sources. Books, book chapters, reviews, discussion papers and other non-refereed publications were excluded.
English Articles	Only articles written in English were included.

Evaluation and selection: Based on the defined procedure (Denyer & Tranfield, 2009), the articles identified in the previous step were evaluated in a few steps. In the first step, the titles of articles were reviewed and duplicates were deleted. Then, the abstracts of articles were reviewed and those unrelated to business and entrepreneurship were discarded. Finally, the articles that did not contain any result on the features and competencies of tech entrepreneurs were excluded. The remaining items consisted of 78 articles, which were used for further analyses. The full list of papers is not presented here due to space constraints, but it can be provided by the authors upon request.

Analysis and synthesis: In this step, to analyze the content of the relevant articles (87 articles), information such as the research subject, main findings, methodology, and competencies of technology

entrepreneurs was collected and coded. In systematic reviews based on meta-synthesis, validation is chiefly rooted in trustworthiness and credibility (Julien, 2008 p. 121). In this study, trustworthiness refers to the use of a transparent process for synthesizing valid data. For credibility, the multiple assessor method was applied. That is, all participating authors assessed the findings independently and these assessments were compared and discussed in several sessions in order to reach a consensus on the analysis criteria (Gast, Gundolf, & Cesinger, 2017).

Reporting the results: The final step of the systematic review is concerned with the presentation of results. In the present study, the results were presented in the following parts:

- An overall description of the reviewed articles;
- The classification of technology entrepreneurs' competencies;
- A typology of technology entrepreneurs based on different roles of competencies in the establishment and development of technological businesses;
- The suggestion of new directions for future studies on the competencies of technology entrepreneurs.

The process of systematic review is shown in Figure 1.

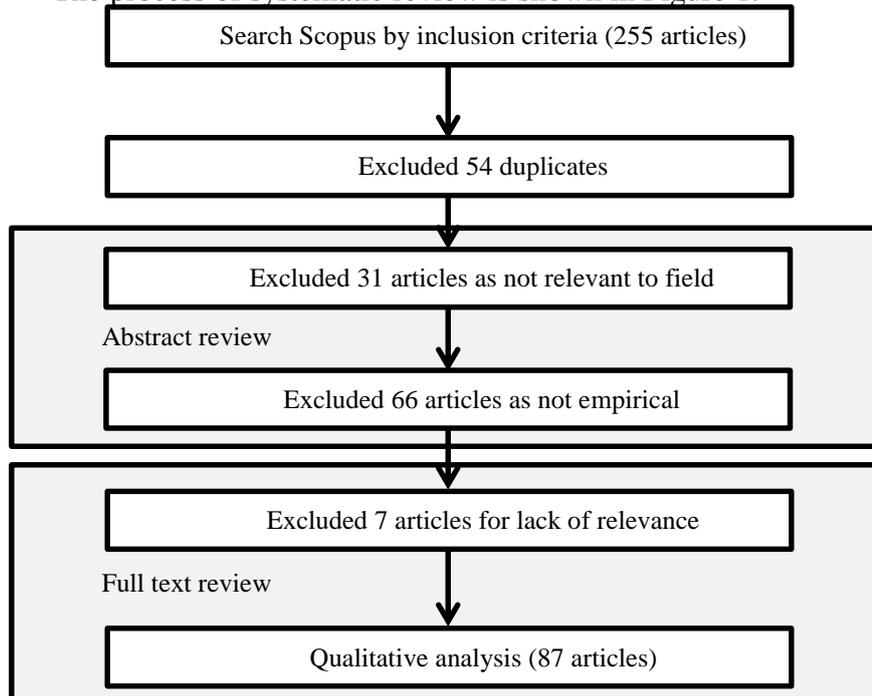


Figure 1. A summary of the SLR process

Analysis and results

Descriptive results

The studies are published in a wide range of journals (63), covering a range of different fields such as business and management, economics, social science, engineering, etc. The inclusion of a large number of journals in different fields indicates the desire to study competencies of technology entrepreneurs in various fields. The first article in this field was published in the journal of Applied Psychology in 1969 and the latest ones (9 articles in 2017) in 9 different journals. Generally, Technovation (5 articles), Journal of Business Venturing and Small Business Economics (4 articles each) are journals that published the highest number of articles on competencies of technology entrepreneurs.

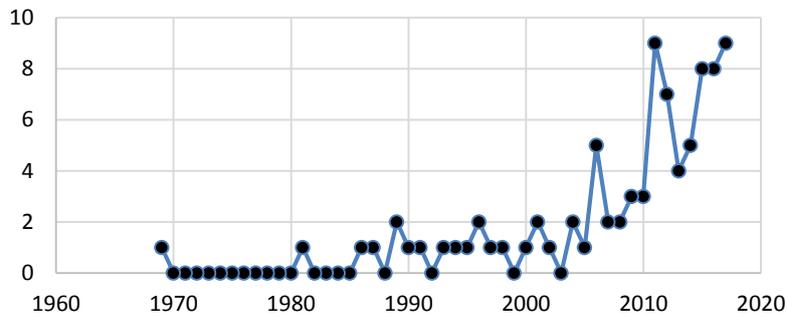


Figure 2. Publication trend

In terms of geographical distribution, authors from North America had made the highest contribution. In addition, 48, 46, and 6 percent of articles had adopted quantitative, qualitative, and mixed research methods, respectively (Figure 3).

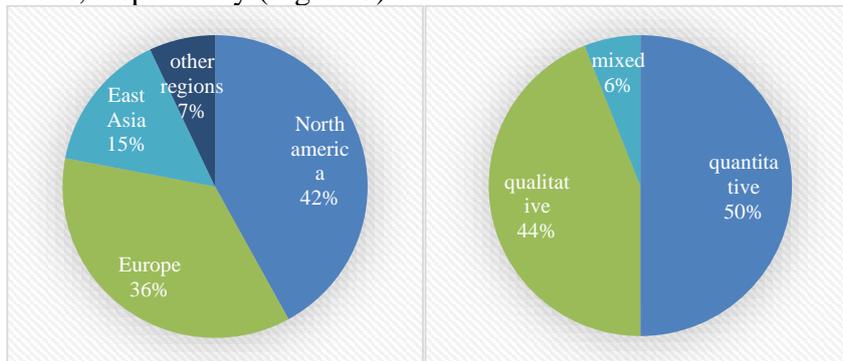


Figure 3. Geographical location and methodological approach of the reviewed articles

Competencies of technology entrepreneur

This part explores the image of technology entrepreneurs' competencies portrayed by previous studies. To this end, the reviewed articles were encoded based on their extracted competencies of technology entrepreneurs. Then, the competencies were assigned to three general groups:

Technological competencies: This set of competencies focuses on technology-related activities involved in establishing a technological business, and is composed of four parts as follows.

Technological problem-solving orientation: This refers to the technological innovation (Sullivan & Marvel, 2011) through communication with technological authorities together with perceived value of technology as an opportunity to make changes and solve problems (Rojas & Huergo, 2016). Armstrong and Tomes (2000) acknowledge that technology entrepreneurs focus on the effects and functions of science and technology rather than its understanding as a set of knowledge.

Technological problem-solving realization: It deals with the use of technological expertise to solve a problem. In this regard, there are two paths lying ahead of technology entrepreneurs. In the first path, they actively shape their ideas based on technological abilities and received feedback (Gemmell et al., 2012). The second path involves using the technological ideas of others to overcome barriers to technology (Pathak, Laplume, & Xavier-Oliveira, 2014).

Technological demonstration: Technology entrepreneurs believe that technology is the only valid means of solving problems. Therefore, it is crucial for them to demonstrate and prove this argument. Moreover, this is the way that enables technology entrepreneurs to pursue their self-actualization. This competency consists of patenting (Clarke & Reavley, 1981) to address concerns about technology (Carrier, Raymond, & Eltaief, 2004) and technological demonstrations to create credibility (Möllers, 2016). Yang et al. (2015) argue that this competency sometimes includes escalated commitment to technology.

Technology management: In a bid to realize the goals of previous technological products, technology entrepreneurs employ this competency to continue the process of technological innovation at the heart of their current business (Clarke & Reavley, 1981). During the establishment and development of a business, they move from a purely technological philosophy to a market-based view, seeking to connect technology to the market (Berry, 1996).

Entrepreneurial competencies: This set of competencies is related to the activities required for setting up technological businesses and includes the following three items.

Opportunity competency: This competency refers to the identification

of entrepreneurial opportunities and the utilization of market knowledge and commercialization to obtain a technological value. It denotes the capacity to perceive the transformed conditions or overlooked possibilities in a setting where the potential sources of profit are represented to a venture (Morris et al., 2013). Technology entrepreneurs concentrate on the identification of technology-based entrepreneurial opportunities while pursuing an optimistic approach to the foundation of a business based on these opportunities (Clarke & Reavley, 1981) before applying the knowledge of access to the market and customers (Marvel, 2012).

Value creation: Using this competency, technology entrepreneurs forge a link between opportunities and business establishment. Furthermore, their startup activities are also conducted based on entrepreneurial attitude, intent, engagement as well as the application of entrepreneurial skills. By controlling the risk attitude (Elston & Audretsch, 2011) and pursuing their desire for domination (Morov, 2016), technology entrepreneurs attempt to progress actively, regardless of the rules and conventional customers (Marvel & Lumpkin, 2007). According to this competency, they are less concerned with wealth generation and chiefly focus on the establishment of new technological businesses through different decision-making models (Maine, Soh, & Dos Santos, 2015). The desire of technology entrepreneurs to establish a technological business compensates for the lack of essential skills by recruiting new individuals in the team.

Networking: This competency is associated with the social interaction skills, which enables an individual to establish, develop and maintain relationships with those who assist them in advancing their career (Morris et al., 2013). With a high level of social competency (Morov, 2016), technology entrepreneurs seek to develop their social relationships with the aim of acquiring resources, information, legitimization, and stabilization. Besides acquiring information independently, they engage in interactions with their social networks (Sullivan & Marvel, 2011). In addition, they know the extent to which they should invest in these social networks to eschew the risks of excessive or exclusive reliance. Moreover, these entrepreneurs benefit from social network as a source of evaluation and refinement of technological design (Gemmell et al., 2012) and also as a mechanism of legitimization (Marlow & McAdam, 2015).

Managerial competencies: This set of competencies, which deals with activities related to the administration of businesses, includes the following parts.

Human resources management: This competency embraces capabilities such as motivating and directing the expert workforce. Technology entrepreneurs are usually successful in establishing effective

relationships with their colleagues and staff, most of whom are experts and specialists, and they make most decisions cooperatively (Agogué, Lundqvist, & Middleton, 2015). They set shared values and missions for all staff and follow them up persistently. In addition, they constantly identify cultural differences and try to alleviate their impact on the performance of the technological business.

Administrative competency: It is basically related to the ability to run a technological business, and involves capabilities such as market development, financing, access to resources, and the application of management skills for business administration (Jones-Evans, 1995). Technology entrepreneurs tend to engage in critical business issues, locate their target market (Carrier et al., 2004), select the members of their management team, and develop business strategies despite the pressure of everyday activities (Timmons & Bygrave, 1986).

Figure (4) illustrates the competencies of technology entrepreneur.

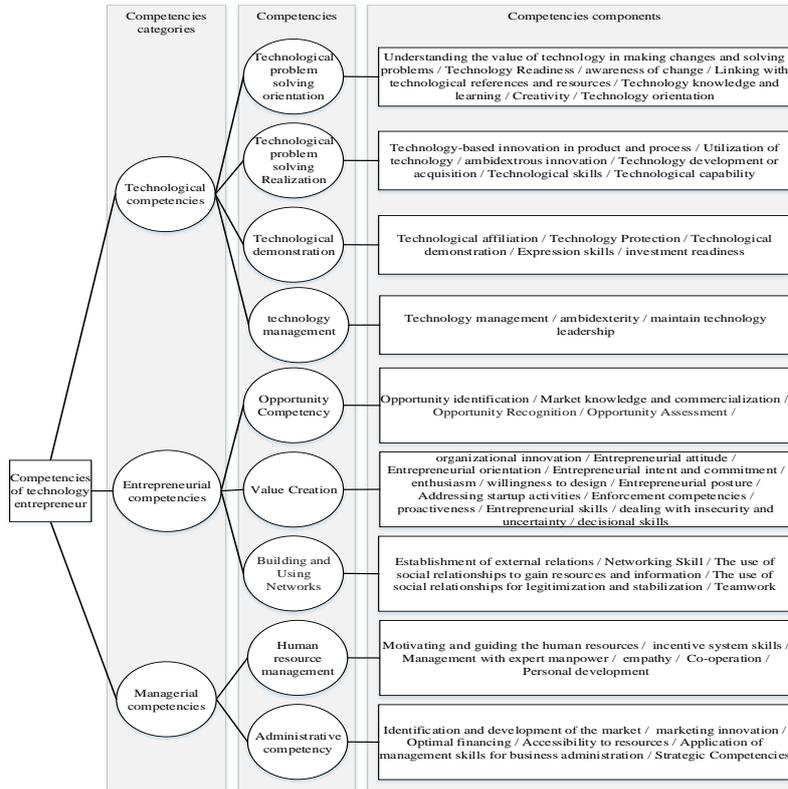


Figure 4. Categorization of technology entrepreneurs' competencies

Discussion; Typology of technology entrepreneurs

As the findings reveal, the diverse competencies of technology entrepreneurs can be divided into three categories. Considering the variety of technology entrepreneurs, a typology would offer an essential and efficient approach to technology entrepreneurship (Proksch et al., 2018), which can be informed by competencies. From a typological point of view, technology entrepreneurs should be perceived in comparison to other types of entrepreneurs or technologists. Moreover, given that technology entrepreneurs are dissimilar, a comparison would help identify different types of technology entrepreneurs, which is also an interesting area of research (Liao & Welsch, 2008). Based on the review of articles, we found that the competencies of technology entrepreneurs are dynamic, and they change during the establishment of a technological business. In most cases, the role of entrepreneurial competencies is overshadowed by the significance of managerial competencies. However, in the case of entrepreneurs who have established a technological business, technological competencies do not follow a similar pattern.

Technology-based entrepreneur (TbE)

This group of technology entrepreneurs neither has a high level of technological competency nor generates technological ideas, but they figure out the value of such ideas and exploit them. In fact, they rely on the technological competency of others to set up their own business. This is supported by the findings of Kassicieh (2011), who addressed this group of technology entrepreneurs as surrogate entrepreneurs, namely individuals who adopt the technological ideas of others and establish a company based on these ideas. Jones-Evans (1995) classified technology entrepreneurs based on working experiences, using terms such as “user technical entrepreneur” and “opportunistic technical entrepreneur” to refer to this group of entrepreneurs who have limited experience and ability in the field of technology. Nonetheless, this reliance on technological competencies changes during the establishment of technological business, and this group of technology entrepreneurs can be assigned to the following two categories:

Discovery-oriented technology-based entrepreneur (DTbE): The discovery-oriented entrepreneur recognizes entrepreneurial alertness and emerging technologies as objective opportunities (Alvarez & Barney, 2007). The role of technological competencies in the establishment of a technological business remains negligible. Merely focusing on the value of technology and technology specialists, this type of technology entrepreneur attempts to apply them as instruments in their businesses.

Creation-oriented technology-based entrepreneur (CTbE): The creation-oriented entrepreneur focuses on the creation of opportunities based on individual and technological development (Sarasvathy, Dew, Velamuri, & Venkataraman, 2003). The role of technological competency is initially restricted in this group of entrepreneurs, but gradually acquires importance for various reasons.

Technological entrepreneur (TE)

This group of entrepreneurs set up a business by their own technological competencies. They are often highly educated specialists with technical experience in this field. These entrepreneurs have been referred to as “technologists” by Kassicieh (2011). Jones-Evans (1995) argues that their work experience is either based on the scientific and technical development at universities and non-commercial laboratories or the manufacturing of technological products in commercial companies. Based on the technological competency variation, this group of technologists can be divided into two types:

Discovery-oriented technological entrepreneur (DTE): These entrepreneurs gradually abandon their technological competencies during business development and try to focus more on managerial competencies. Shinn and Lamy (2006), who classified technology entrepreneurs with respect to the academia-enterprise coordination mode, call this group as “pioneers”. These individuals seek to adapt themselves to business goals and make a shift from a technology-based philosophy to the management and market-based philosophy (Berry, 1996).

Creation-oriented technological entrepreneur (CTE): This group proceeds technological development even after setting up a business. They view a business as an opportunity for developing their technological activities rather than a context for creating economic value. In the classification proposed by Shinn and Lamy (2006), this type of technology entrepreneurs is referred to as “academics”, i.e. individuals who see business as a way of achieving academic goals and are closely tied with technological research and scientific references. However, this technological focus does not go so far as to prevent the establishment of a business.

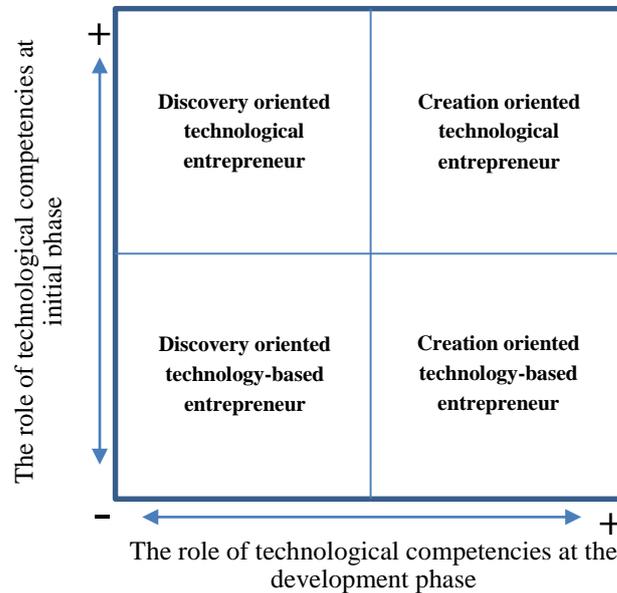


Figure 5. Typology of technology entrepreneurs

As illustrated in Figure 5, to understand the competencies of technology entrepreneurs, the three types of essential competencies and the – variety of technology entrepreneurs resulting from variations inherent in competencies should be taken into account. Despite the lack of consensus about the typology of technology entrepreneurs, these findings are compared with the literature. For example, the typology proposed by Jones-Evans (1995) (“researcher”, “producer”, “user” and “opportunist” as different types of technology entrepreneurs) corresponds to the typology presented in this article. Additionally, an analogy can be drawn to the study of Proksch et al. (2018), which revealed three types of technology entrepreneurs - the scientist, the practice-oriented technician, and the business professional. However, this is the first typology of technology entrepreneurs based on the dynamic of competencies during the life cycle of technological business.

Conclusion

Based on the systematic review and qualitative analysis of 87 articles, a classification of competencies was proposed in this paper. Then a new typology of technology entrepreneurs was provided with respect to the role of these competencies in technological businesses. Altogether, these results offer several theoretical and practical implications.

Theoretical implication

In a systematic review, theoretical implications are proposed by the identification of knowledge gaps and discussion of future directions. Hence, in this part, the research findings are discussed to propose new venues of research (Figure 6).

Areas of Study: Given the variety of interpretations and definitions provided for technology entrepreneurs, the competency-based approach is recommended to be applied to improve the definition and conceptualization of technology entrepreneurs. Moreover, most studies on technology entrepreneurs have been conducted in North America and Europe, irrespective of the fact that technology entrepreneurs, despite some similarities, have distinct characteristics and competencies in different parts of the world (Tajeddini & Mueller, 2009; Yitshaki & Kropp, 2016). In fact, although entrepreneurs are known as agents of change, their behavior is influenced by regional culture and rules (Aoyama, 2009). Therefore, given that the factors driving technology entrepreneurship in emerging economies maybe different from that of the developed societies (Pathak et al., 2014), the list of competencies obtained in one region should be studied and analyzed before being extended to other areas and different economic cycles. This provides a proper opportunity for comparative studies. For instance, J. Zhang and Wong (2008) compared technology entrepreneurs between an industrial economy (Singapore) and an emerging economy (China).

Methodological aspects: Although only 46% of the reviewed articles were qualitative, qualitative approaches can be still promising, especially considering the dynamism and complexity of the activities undertaken by technology entrepreneurs and the necessity of conceptualization in this field (Christensen, Olesen, & Kjær, 2005). Technology entrepreneurs take action based on the meaning they ascribe to their experiences and the world (Ezzedeen & Zikic, 2012). Their unique understanding of science and technology propels them towards technological innovation (Buang, Halim, & Mohd Meerah, 2009). In this regard, it seems that phenomenology is a well-suited methodology to study the competency of technology entrepreneurs. Accordingly, while focusing on dynamic aspects of technology entrepreneurs experience (Zikic & Ezzedeen, 2015), phenomenology puts an emphasizes a procedural examination of technology entrepreneurs that studies entrepreneurial activities from the perspective of technology entrepreneurs (Christensen et al., 2005). Moreover, technology entrepreneurship is a fairly unexplored subject that has great potentials for scholarly investigation. The unanswered questions can be surveyed through various perspectives. Since there is no ideal perspective for studying a phenomenon, a phenomenon should be evaluated from different views tailored to the nature of that

phenomenon. The results of this systematic review revealed that most studies have either failed to take advantage of theoretical views or relied on a limited range of theories. In the following, some of the foreground paths based on theoretical perspectives will be discussed.

First, there are two general views about the study of competencies. The first view sees competency as a set of knowledge, skills, abilities, and other characteristics (KSACs), while the second view defines it as an aggregation of the above, which plays a vital role in practice (Hayton & McEvoy, 2006). In reality, the latter complements the former. Among the reviewed articles, 47% had adopted the first view, which relies on the provision of a list of KSACs as competencies. Since the perception of entrepreneurial competency components (KSACs) should be linked to their relationship with performance, the second view is the preferred one in this regard.

Second, based on the philosophical assumptions, two general perspectives to competency can be defined. The first perspective underlines the educational background and refers to learning as a purposeful and logical process that is independent of the context. In this regard, entrepreneurship is distinct from the entrepreneur. In the second perspective, the focus is on the active and social nature of experience and its impact on the workplace. Accordingly, an action is not merely a response to the environmental stimuli and learning process involves a synthesis of implicit and explicit knowledge. Human is defined as a social being whose learning depends on the action, context, and culture in which that action is performed (McHenry, 2008, pp. 73-82).

Finally, most of the reviewed articles were conducted at the micro level, but multilevel studies in technology entrepreneurship have been on the rise (Pathak et al., 2014). These studies can establish a connection between micro, moderate, and macro approaches in order to achieve deeper insights into competencies of technology entrepreneurs, and their role in the establishment of technological firms and socioeconomic and industrial development.

Practical and managerial implications

Based on the findings of this study, both existing and imminent entrepreneurs can explore ideas and ways of reinforcing their competencies. However, identifying these competencies is especially important in education and training, detection of technology entrepreneurs, and policy-making.

First, educators, teachers, and instructors engaged in a technology entrepreneurship development program have the opportunity to nurture their students with their knowledge and to reflect on their own practices by looking at the classification of competencies and typology of technology entrepreneur. In particular, it is generally believed that

although competency-based technology entrepreneurship training is effective in entrepreneurial action (Sánchez, 2013), these training should primarily focus on three types of technological, entrepreneurial, and managerial competencies. In addition, these training should be tailored to the features of the potential technology entrepreneur. For example, considering the initial technical competence of engineering students, this group needs their own entrepreneurial and managerial training to successfully complete the process of becoming a technological entrepreneur. In fact, to develop competencies for them, educators should adopt the “entrepreneur technologist” approach rather than “technology-based entrepreneur” approach. It means that a great deal of attention should be paid to them as technologists in the training of entrepreneurship. The short-term competency-based courses for technical and engineering students can be provided by technical colleges. On the other hand, business and management students who are interested in creating a startup need to receive the necessary technical training or to resolve their technical gap using methods such as team building to succeed in becoming a technology-based entrepreneur. However, the unique, action-based nature of technology entrepreneurship may require pedagogical approaches that transcend the traditional lecture, discussion, and exam formats (Morris et al., 2013).

Second, one of the major problems in the entrepreneurship field is the identification of individuals who might find and grow technology businesses. Proksch et al. (2018) expressed that the technology entrepreneurs who rank lowest in entrepreneurial and managerial competencies and are least successful tend to raise the highest investments. In contrast, the practice-oriented technicians are the most successful. Therefore, the findings of the research suggest that technology entrepreneurs and their teams should be identified in accordance with the existing competencies and competency development programs. Failure to take these considerations into account will greatly diminish the probability of success. Besides, the prosperity of business angels, investors, accelerators, and technology incubators is highly dependent on the identification of right people and the provision of the appropriate support. For instance, engineers will not succeed in establishing and managing businesses without developing entrepreneurial and managerial competencies. Also, a person who lacks technological capabilities can apply for technology entrepreneurship if he/she has taken an appropriate program to bridge this competency gap. The results of the present study offer support to investors in improving their investment strategy.

Finally, policy makers at all levels can find relevant materials to rethink and improve their policies with the aim of increasing technology entrepreneurship. In particular, a successful development of technology

entrepreneurship requires four policy categories including technology, market, finance, and human resources policies, the last of which focuses on technology entrepreneurs. According to the findings of this research, two general strategies can be employed in line with this policy: introducing non-technological entrepreneurs to the tech field by offering technological opportunities to them, and paving the way for the exploitation of business opportunities for technologists and engineers. In general, it should be noted that the competencies required for human resources in technological businesses and start-ups vary on the business life cycle, and without considering this dynamism; the correct policy cannot be adopted.

Limitations

As far as the limitations are concerned, it should be acknowledged that the present study is no exception to the publication bias, as the research scope was restricted to the English-language articles published in the Scopus database. Second, despite the consideration of various precautions, the researchers recognize their subjectivity regarding the classification. However, since studies on technology entrepreneurs are conducted in different countries and languages, systematic reviews that summarize all the relevant articles in a specific language and present them in English can provide us with a deeper perception of findings in this field in various cultures and geographical areas. Although the tendency to study the role of technology, technical systems, and institutions in the process of the establishment of technological companies has diminished the share of studies on technology entrepreneurs in the technology entrepreneurship literature (Shane & Venkataraman, 2003), there are many research directions for the study of technology entrepreneurs and their competencies, which can be followed by different researchers, especially those involved in the interdisciplinary background and capabilities. The emphasis of this paper on the study of technology entrepreneurs as entrepreneur technologists rather than technology entrepreneurs can also be extended to many other areas of study on entrepreneurship to help understand people who decide to enter the realm of entrepreneurship from their specialized fields. In addition, the phrase “a typology” was used to stress the fact that other researchers can further develop this typology and categorization, and open up new paths.

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